Agnel Charities

Fr. C. Rodrigues Institute of Technology

Sector 9A, Vashi, Navi Mumbai, 400703, Maharashtra, India

www.fcrit.ac.in

An Autonomous Institute Affiliated to the University of Mumbai

Department of Mechanical Engineering

Curriculum Structure FY to B.Tech

&

First Year, Second and Third Year Syllabus

Approved By: Academic Council of Fr. C. Rodrigues Institute of Technology

Effective from :2025-26

Revision: FY 2025, SY & TY 2024.1

PREAMBLE - DEAN ACADEMICS

Accelerating Towards Excellence: Unveiling a New Era in Education

Dear Students, Faculty, and Stakeholders,

It is with great pleasure and anticipation that we introduce the newly designed curriculum for autonomy at Agnel Charities' Fr. C. Rodrigues Institute of Technology. This pioneering initiative aims to revolutionize engineering education, ensuring our graduates are equipped with not only technical prowess but also the holistic skills necessary for thriving in today's dynamic professional landscape.

1. **Purpose of Autonomy:** Our commitment to autonomy is rooted in the imperative to bridge the gap between academia and industry. We envision education as a catalyst for individual growth, fostering self-sustainability and enhancing employability. Through our curriculum, we strive to nurture engineers who not only excel in their fields but also contribute meaningfully to society.

2. **Curriculum Design: A Top-to-Down Approach:** Our curriculum is meticulously crafted with a top-to-down approach, encompassing all 12 attributes of Program Outcomes mandated by regulatory bodies. Emphasizing a blend of theoretical knowledge and practical application, it is designed to cultivate well-rounded professionals capable of tackling real-world challenges with confidence and competence.

3. **Alignment with National Education Policy-2020:** In adherence to the guidelines laid out in the National Education Policy-2020, our curriculum embodies a multidisciplinary approach, offering a diverse array of core and elective courses. It integrates hands-on learning experiences such as mini and major projects, skill-based labs, and one-semester internships to nurture innovation and problem-solving skills. Additionally, the inclusion of value-added courses, honours, and minors ensures a comprehensive educational journey tailored to individual interests and aspirations.

4. **Opportunities for Teachers in Innovation:** We recognize the pivotal role of our faculty in shaping the educational experience. Our curriculum provides ample opportunities for teachers to innovate in teaching-learning methodologies and evaluation techniques. Through continuous professional development programs and collaborative platforms, we empower our educators to experiment with innovative pedagogies, leverage technology for enhanced learning outcomes, and implement novel assessment strategies. By fostering a culture of innovation among our faculty, we aim to enrich the learning experience and inspire a passion for lifelong learning among our students.

As we embark on this transformative journey, we invite all stakeholders to join us in shaping the future of engineering education. Together, let us strive towards excellence, innovation, and societal impact.

Sincerely,

Dean of Academics Agnel Charities' Fr. C. Rodrigues Institute of Technology

PREAMBLE - BOS CHAIRMAN

Dear Students and Stakeholders,

It is with great pleasure and anticipation that Board of Studies of Mechanical Engineering introduce the newly designed curriculum at Agnel Charities' Fr. C. Rodrigues Institute of Technology. We are committed to fostering a culture of innovation, excellence, and service in the field of mechanical engineering. As an autonomous institution, we embrace the responsibility of shaping the future of our profession and empowering our students to become proficient engineers, leaders, and global citizens.

Department has taken a lead in incorporating philosophy of outcome-based education in the process of curriculum development. Curriculum is aligned with Institute, Department vision and mission and with National Education Policy-2020. Program outcomes are based as per the guidelines mentioned in the NBA SAR-January 2016. Our department stands as a beacon of knowledge, dedicated to advancing the frontiers of mechanical engineering through cutting-edge research, interdisciplinary collaboration, and industry partnerships. We believe in the transformative power of education to inspire creativity, critical thinking, and ethical decision-making among our students.

Positioning of learning in real world is ensured to keep abreast of latest trends and technologies as per industry requirement. Well thought has been given to selection of courses while structuring the curriculum. Core courses, elective courses, Lab courses, skill-based lab courses and Honors/Minor verticals such as Electric Vehicle Technology, Supply Chain, 3D Printing, Data Science, Aeronautical Engineering are identified. Mechanical Engineering course integrates a range of experiential learning opportunities, including internships, mini and major projects, industry projects and collaborative research initiatives. Additionally, emphasis is placed on promoting a culture of lifelong learning, encouraging students to stay abreast of emerging trends, engage in continuous professional development, and contribute meaningfully to the advancement of the field.

Department has taken an initiative to design course syllabus by adapting leaner centered approach through backward design method facilitating the creation of more cohesive, clear and intentional learning experiences for learners. While designing the syllabus teacher has identified the desired results through setting the course and learning objectives aligned with Bloom's taxonomy and Performance Indicators. Teacher has identified the assessments that students will complete in order to demonstrate evidence of learning and even progress towards achievement of learning objectives. Based on this teacher has planned the contents. While planning the content points are considered as what enabling knowledge & skills will learner need in order to achieve desired results, what ways they will be evaluated along the way, what activities will equip learner with needed knowledge and skills, what will need to be taught and how should it best be done using pedagogical and innovative methods. The draft scheme and syllabus were presented to all stakeholders for receiving critical feedback and suggestions. Important and relevant suggestions were incorporated.

We invite all stakeholders to join us on this transformative educational journey, where students are empowered to become catalysts of innovation, drivers of change, and leaders of tomorrow's digital landscape. By embracing a holistic approach to learning, grounded in academic rigor, practical relevance, and ethical values, we strive to nurture a new generation of Mechanical Engineers poised to make a positive impact on society and shape a brighter future for generations to come.

Sincerely,
Chairman, Board of Studies – Mechanical Engineering,
Agnel Charities' Fr. C. Rodrigues Institute of Technology

Contents

A. Abbreviations

AEC	Ability Enhancement Course
AU	Audit Course
BSC	Basic Science Course including Mathematics
BSL	Basic Science Laboratory Course
ELC	Experiential Learning Course
ESC	Engineering Sciences Course
ESL	Engineering Sciences Laboratory Course
HMC	Honours or Minor Core Course
HML	Honours or Minor Laboratory
HMP	Honours or Minor Mini Project
HSS	Humanities Social Sciences and Management Course
IKS	Indian Knowledge System Course
INT	Internship
L	Lecture
LBC	Laboratory Course
LLC	Liberal Learning Course
MDM	Multidisciplinary Minor Course
MDL	Multidisciplinary Laboratory Course
MJP	Major Project
MNP	Mini Project
OEC	Open Elective Course
P	Practical
PCC	Program Core Course
PEC	Program Elective Course
RPC	Research Project Coursework
RPR	Research Project
SBL	Skill Based Laboratory
SEC	Skill Enhancement Course
T	Tutorial
VEC	Value Education Course

B. Credit Structure

1. B. Tech in Mechanical Engineering											
Type of Course	Semester-wise Credit Distribution									FCRIT Credit Distribution	DTE Credit Distribution
	I	II	III	IV	V	VI	VII	VIII	Total		
Basic Science Course (BSC)	08	08	--	--	--	--	--	--	16	18	14-18
Basic Science Laboratory Course (BSL)	01	01	--	--	--	--	--	--	02		
Engineering Science Course (ESC)	05	02	--	--	--	--	--	--	07	16	12-16
Engineering Science Laboratory Course (ESL)	04	05	--	--	--	--	--	--	09		
Program Core Course (PCC)	--	--	14	13	06	03	03	--	39	50	44-56
Laboratory Course (LBC)	--	--	02	03	03	01	02	--	11		
Program Elective (PEC)	--	--	--	--	03	03	06	03	15	15	20
Multidisciplinary Minor (MDM)	--	--	03	03	03	04	--	--	13	13	14
Multidisciplinary Laboratory Course (MDL)	--	--	--	--	--	01	--	--	01	01	
Open Elective (OEC)	--	--	--	--	--	--	03	03	06	06	08
Skill Enhancement Course (SEC)	01	01	--	--	--	--	--	--	02	08	08
Skill Based Laboratory (SBL)	--	--	02	02	--	02	--	--	06		
Ability Enhancement Course (AEC)	--	03	--	--	02	--	--	--	05	05	04
Humanities Social Sciences and Management (HSS)	--	--	02	--	02	--	02	--	06	06	04
Indian Knowledge System (IKS)	--	02	--	--	--	--	--	--	02	02	02
Value Education Course (VEC)	02	--	--	02	--	--	--	--	04	04	04
Experiential Learning Course (ELC)	--	--	--	--	--	02	--	--	02	02	04
Mini Project (MNP)	--	--	01	01	01	01	--	--	04	10	04
Major Project (MJP)	--	--	--	--	--	--	02	04	06		
Internship (INT)	--	--	--	--	--	--	--	08	08	08	12
Liberal Learning Course (LLC)	--	--	--	--	--	02	--	---	02	02	04
Total Credits	21	22	24	24	20	19	18	18	166	166	160-176

C Curriculum Structure and Examination Scheme for B. Tech in Mechanical Engineering

(FY and SY with Effect from AY 2025-2026)
Curriculum Structure – FY Semester-I

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
BSC101	Engineering Mathematics I	4	--	--	4	--	--	4
BSC102	Engineering Physics-I	2	--	--	2	--	--	2
BSC103	Engineering Chemistry-I	2	--	--	2	--	--	2
ESC101	Engineering Mechanics	3	--	--	3	--	--	3
ESC102	Basic Electrical Engineering	2	--	--	2	--	--	2
BSL101	Engineering Physics-I Laboratory	--	1	--	--	0.5	--	0.5
BSL102	Engineering Chemistry-I Laboratory	--	1	--	--	0.5	--	0.5
ESL101	Engineering Mechanics Laboratory	--	2	--	--	1	--	1
ESL102	Basic Electrical Engineering Laboratory	--	2	--	--	1	--	1
ESL103	Programming Laboratory-I (C)	--	2*+2	--	--	2	--	2
SEC101	Basic Workshop Practice-I	--	2	--	--	1	--	1
VEC101	Universal Human Values	2	--	--	2	--	--	2
	Total	**15**	**12**	**--**	**15**	**6**	**--**	**21**

*** Instructions should be conducted for the entire class.**

NOTE 1: Compulsory Non-Credit Activities: Participation and/or coordination of co-curricular and extra-curricular events at the Institute or Department level is mandatory for all students from semesters 1 to 8 as part of non-credit liberal education. Please consult the department's Curriculum Book for more information. These activities do not yield credits. Upon successful participation or organization of activities, a certificate will be awarded at the conclusion of semester 8.

NOTE 2: Please note that during semesters 1 to 8 some of the non-technical courses such as Humanities Social Sciences and Management (HSSM), Open Electives (OE), Value Education Course (VEC), and Liberal Learning Course (LLC) may be conducted either online synchronously or asynchronously. For more information, please consult the curriculum book of your respective department.

Examination Scheme – FY Semester-I

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
BSC101	Engineering Mathematics-I	20	30	50	1.5	2	100
BSC102	Engineering Physics-I	15	20	40	1.0	1.5	75
BSC103	Engineering Chemistry-I	15	20	40	1.0	1.5	75
ESC101	Engineering Mechanics	20	30	50	1.5	2	100
ESC102	Basic Electrical Engineering	15	20	40	1.0	1.5	75
BSL101	Engineering Physics-I Laboratory	25	--	--	--	--	25
BSL102	Engineering Chemistry-I Laboratory	25	--	--	--	--	25
ESL101	Engineering Mechanics Laboratory	25	--	--	--	--	25
ESL102	Basic Electrical Engineering Laboratory	25	--	25	--	--	50
ESL103	Programming Laboratory-I (C)	50	--	50	--	--	100
SEC101	Basic Workshop Practice-I	50	--	--	--	--	50
VEC101	Universal Human Values	50	--	--	--	--	50
	Total	**335**	**120**	**295**	--	**--**	**750**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – FY Semester-II

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
BSC204	Engineering Mathematics-II	4	--	--	4	--	--	4
BSC205	Engineering Physics-II	2	--	--	2	--	--	2
BSC206	Engineering Chemistry-II	2	--	--	2	--	--	2
AEC201	Professional Communication and Ethics-I	2	2	--	2	1	--	3
ESC203	Basic Electronics Engineering	2	--	--	2	--	--	2
BSL203	Engineering Physics-II Laboratory	--	1	--	--	0.5	--	0.5
BSL204	Engineering Chemistry-II Laboratory	--	1	--	--	0.5	--	0.5
ESL204	Engineering Graphics Laboratory	--	2*+2	--	--	2	--	2
ESL205	Programming Laboratory-II (Java)	--	2*+2	--	--	2	--	2
ESL206	Basic Electronics Engineering Laboratory	--	2	--	--	1	--	1
SEC202	Basic Workshop Practice-II	--	2	--	--	1	--	1
IKS201	Indian Knowledge System	2	--	--	2	--	--	2
	Total	**14**	**16**	**--**	**14**	**8**	**--**	**22**

*** Instructions should be conducted for the entire class.**

Examination Scheme – FY Semester-II

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
BSC204	Engineering Mathematics-II	20	30	50	1.5	2	100
BSC205	Engineering Physics-II	15	20	40	1.0	1.5	75
BSC206	Engineering Chemistry-II	15	20	40	1.0	1.5	75
AEC201	Professional Communication and Ethics-I	50	--	--	--	--	50
ESC203	Basic Electronics Engineering	15	20	40	1.0	1.5	75
BSL203	Engineering Physics-II Laboratory	25	--	--	--	--	25
BSL204	Engineering Chemistry-II Laboratory	25	--	--	--	--	25
ESL204	Engineering Graphics Laboratory	50	--	50	--	--	100
ESL205	Programming Laboratory-II (Java)	50	--	50	--	--	100
ESL206	Basic Electronics Engineering Laboratory	25	--	25	--	--	50
SEC202	Basic Workshop Practice-II	50	--	--	--	--	50
IKS201	Indian Knowledge System	50	--	--	--	--	50
	Total	**390**	**90**	**295**	--	--	**775**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – SY Semester-III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPCC301	Engineering Mathematics-III	3	--	1	3	--	1	4
MEPCC302	Mechanics of Solids	3	--	1	3	--	1	4
MEPCC303	Material Science and Engineering	3	--	--	3	--	--	3
MEPCC304	Thermodynamics	3	--	--	3	--	--	3
XXMDM301*	--	3	--	--	3	--	--	3
MELBC301	Material Testing Laboratory	--	2	--	--	1	--	1
MELBC302	Industrial Electronics Laboratory	--	2	--	--	1	--	1
MESBL301	Python Programming Laboratory	--	4	--	--	2	--	2
MEMNP301	Mini Project-1A	--	3	--	--	1	--	1
HSS301	Product Design	2	--	--	2	--	--	2
	Total	**17**	**11**	**2**	**17**	**5**	**2**	**24**

***Four theory courses (Three 3-credit and one 4-credit) and One Laboratory course (1-credit) offered by other department has to be taken by Mechanical Engineering students, to complete the 14-credit requirement for MDM.**

Examination Scheme – SY Semester-III

Course Code	Course Name	Examination Scheme						Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)			
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End - Sem		
MEPCC301	Engineering Mathematics-III	20+25@	30	50	1.5	2		125
MEPCC302	Mechanics of Solids	20+25@	30	50	1.5	2		125
MEPCC303	Material Science and Engineering	20	30	50	1.5	2		100
MEPCC304	Thermodynamics	20	30	50	1.5	2		100
XXMDM301	--	20	30	50	1.5	2		100
MELBC301	Material Testing Laboratory	25	--	25	--	--		50
MELBC302	Industrial Electronics Laboratory	25	--	25	--	--		50
MESBL301	Python Programming Laboratory	50	--	50	--	--		100
MEMNP301	Mini Project-1A	50	--	--	--	--		50
HSS301	Product Design	50	--	--	--	--		50
	Total	**350**	**150**	**350**	--	--		**850**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – SY Semester-IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPCC405	Engineering Mathematics-IV	3	--	1	3	--	1	4
MEPCC406	Theory of Machines	3		--	3	--	--	3
MEPCC407	Thermal Engineering	3	--	--	3	--	--	3
MEPCC408	Manufacturing Technology	3	--	--	3	--	--	3
XXMDM402	--	3	--	--	3	--	--	3
MELBC403	Virtual Instrumentation Laboratory	--	2	--	--	1	--	1
MELBC404	Thermal Engineering Laboratory	--	2	--	--	1	--	1
MELBC405	Machine Shop Practice	--	2	--	--	1	--	1
MESBL402	CAD Modeling Laboratory	--	4	--	--	2	--	2
MEMNP402	Mini Project-1B	--	3	--	--	1	--	1
VEC402	Environment and Sustainability	2	--	--	2	--	--	2
	Total	**17**	**13**	**1**	**17**	**6**	**1**	**24**

Examination Scheme – SY Semester-IV

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
MEPCC405	Engineering Mathematics-IV	20+25@	30	50	1.5	2	125
MEPCC406	Theory of Machines	20	30	50	1.5	2	100
MEPCC407	Thermal Engineering	20	30	50	1.5	2	100
MEPCC408	Manufacturing Technology	20	30	50	1.5	2	100
XXMDM402	--	20	30	50	1.5	2	100
MELBC403	Virtual Instrumentation Laboratory	25	--	25	--	--	50
MELBC404	Thermal Engineering Laboratory	25	--	25	--	--	50
MELBC405	Machine Shop Practice	25	--	25	--	--	50
MESBL402	CAD Modeling Laboratory	50	--	50	--	--	100
MEMNP402	Mini Project-1B	50	--	50	--	--	100
VEC402	Environment and Sustainability	50	--	--	--	--	50
	Total	**350**	**150**	**425**	--	--	**925**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – TY Semester-V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPCC509	Mechanical Vibrations	3	--	--	3	--	--	3
MEPCC510	Fluid Mechanics and Machinery	3	--	--	3	--	--	3
XXMDM503	--	3	--	--	3	--	--	3
MEPEC501Y	Program Elective-I	3	--	--	3	--	--	3
MELBC506	Mechanical Vibrations Laboratory	--	2	--	--	1	--	1
MELBC507	Fluid Mechanics and Machinery	--	2	--	--	1	--	1
MELBC508	Computational Laboratory	--	2	--	--	1	--	1
AEC502	Professional Communication and Ethics-II	1	2	--	1	1	--	2
MEMNP503	Mini Project-2A	--	3	--	--	1	--	1
HSS502	Entrepreneurship	2	--	--	2	--	--	2
	Total	**15**	**11**	**--**	**15**	**5**	**--**	**20**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree programs.

Program Elective Course-I:
Students should take one PE from the following list of Program Elective Course- I.

Course Code	Program Elective-I
MEPEC5011	Finite Element Analysis
MEPEC5012	Computer Aided Engineering
MEPEC5013	Computational Fluid Dynamics

Examination Scheme – TY Semester-V

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid - Sem	End-Sem	
MEPCC509	Mechanical Vibrations	20	30	50	1.5	2	100
MEPCC510	Fluid Mechanics and Machinery	20	30	50	1.5	2	100
XXMDM503	--	20	30	50	1.5	2	100
MEPEC501Y	Program Elective-I	20	30	50	1.5	2	100
MELBC506	Mechanical Vibrations Laboratory	25	--	25	--	--	50
MELBC507	Fluid Mechanics and Machinery Laboratory	25	--	25	--	--	50
MELBC508	Computational Laboratory	25	--	25	--	--	50
AEC502	Professional Communication and Ethics-II	50	--	--	--	--	50
MEMNP503	Mini Project-2A	50	--	--	--	--	50
HSS502	Entrepreneurship	50	--	--	--	--	50
	Total	**305**	**120**	**275**	--	--	**700**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – TY Semester-VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPCC611	Machine Design	3		--	3	--	--	3
XXMDM604	--	4		--	4	--	--	4
MEPEC602Y	Program Elective-II	3	--	--	3	--	--	3
MELBC609	Machine Design Laboratory	--	2	--	--	1	--	1
XXMDL601	--	--	2	--	--	1	--	1
MESBL603	CNC & 3D Printing Laboratory	--	4	--	--	2	--	2
MEMNP604	Mini Project-2B	--	3	--	--	1	--	1
ELC601	Research Methodology	2	--	--	2	--	--	2
LLC601Y*	Liberal Learning Course	2	--	--	2	--	--	2
	Total	**14**	**11**	**--**	**14**	**5**	**--**	**19**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree prorams.

Program Elective Course-II:
Students should take one PE from the following list of Program Elective Course- II.

Course Code	Program Elective-II
MEPEC6021	Refrigeration and Air Conditioning
MEPEC6022	Heating, Ventilation and Air Conditioning
MEPEC6023	Cryogenic Engineering

***Liberal Learning Course:**
Every student should take Liberal Learning Course for Semester VI. Students can take this course from the following list of Liberal Learning Courses.

Liberal Learning Courses	
Course Code	**Course Name**
LLC6011	Art of Living
LLC6012	Yoga and Meditation
LLC6013	Health and Wellness
LLC6014	Diet and Nutrition
LLC6015	Personality Development

Examination Scheme – TY Semester-VI

<table>
<tr><th rowspan="3">Course Code</th><th rowspan="3">Course Name</th><th colspan="5">Examination Scheme</th><th rowspan="3">Total</th></tr>
<tr><th colspan="2">In-Semester Assessment$</th><th rowspan="2">End Sem. Exam (ESE)</th><th colspan="2">Exam Duration for Theory (in Hrs)</th></tr>
<tr><th>Continuous Assessment</th><th>Mid-Sem Exam</th><th>Mid-Sem</th><th>End-Sem</th></tr>
<tr><td>MEPCC611</td><td>Machine Design</td><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
<tr><td>XXMDM604</td><td>--</td><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
<tr><td>MEPEC602Y</td><td>Program Elective-II</td><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
<tr><td>MELBC609</td><td>Machine Design Laboratory</td><td>25</td><td>--</td><td>25</td><td>--</td><td>--</td><td>50</td></tr>
<tr><td>XXMDL601</td><td>--</td><td>25</td><td>--</td><td>25</td><td>--</td><td>--</td><td>50</td></tr>
<tr><td>MESBL603</td><td>CNC & 3D Printing Laboratory</td><td>50</td><td>--</td><td>50</td><td>--</td><td>--</td><td>100</td></tr>
<tr><td>MEMNP604</td><td>Mini Project-2B</td><td>50</td><td>--</td><td>50</td><td>--</td><td>--</td><td>100</td></tr>
<tr><td>ELC601</td><td>Research Methodology</td><td>50</td><td>--</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
<tr><td>LLC601Y</td><td>Liberal Learning Course</td><td>50</td><td>--</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
<tr><td colspan="2">Total</td><td>310</td><td>90</td><td>300</td><td>--</td><td>--</td><td>700</td></tr>
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$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – B. Tech Semester-VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPCC712	Advanced Manufacturing Technology	3	--	--	3	--	--	3
MEPEC703Y	Program Elective-III	3	--	--	3	--	--	3
MEPEC704Y	Program Elective-IV	3	--	--	3	--	--	3
OEC701Y	Open Elective-I	3	--	--	3	--	--	3
MELBC710	IOT & Smart Systems Laboratory	--	2	--	--	1	--	1
MELBC711	Maintenance Engineering Laboratory	--	2	--	--	1	--	1
MEMJP701	Major Project-A	--	6	--	--	2	--	2
HSS703	Financial Planning	2	--	--	2	--	--	2
	Total	**14**	**10**	**--**	**14**	**4**	**--**	**18**

Program Elective Course-III & IV:
Every student is required to take two Program Elective Courses for Semester VII. Students can take this course from the following list of Program Elective Course-III & IV.

Course Code	Program Elective-III
MEPEC7031	Mechanical System Design
MEPEC7032	Machine Tool Design
MEPEC7033	Process Equipment Design

Course Code	Program Elective-IV
MEPEC7041	Non-Destructive Testing
MEPEC7042	Condition Monitoring
MEPEC7043	Welding Technology

Open Elective Course-I:
Every student is required to take one Open Elective Course-I for Semester VII. Students can take this course from the following list of Open Elective Course-I.

Course Code	Open Elective Course-I
OEC7011	Product Lifecycle Management
OEC7012	Reliability Engineering
OEC7013	Management Information System
OEC7014	Design of Experiments
OEC7015	Operation Research
OEC7016	Cyber Security and Laws
OEC7017	Disaster Management and Mitigation Measures
OEC7018	Energy Audit and Management
OEC7019	Development Engineering

Examination Scheme – B. Tech Semester-VII

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
MEPCC712	Advanced Manufacturing Technology	20	30	50	1.5	2	100
MEPEC703Y	Program Elective-III	20	30	50	1.5	2	100
MEPEC704Y	Program Elective-IV	20	30	50	1.5	2	100
OEC701Y	Open Elective-I	20	30	50	1.5	2	100
MELBC710	IOT & Smart Systems Laboratory	25	--	25	--	--	50
MELBC711	Maintenance Engineering Laboratory	25	--	25	--	--	50
MEMJP701	Major Project-A	50	--	--	--	--	50
HSS703	Financial Planning	50	--	--	--	--	50
	Total	**230**	**120**	**250**	--	--	**600**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – B. Tech Semester-VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEPEC805Y	Program Elective-V	3	--	--	3	--	--	3
OEC802Y	Open Elective-II	3	--	--	3	--	--	3
MEMJP802	Major Project-B	--	12	--	--	4	--	4
INT801	Internship~	--	--	--	--	8	--	8
	Total	**6**	**12**	**--**	**6**	**12**	**--**	**18**

~ Students have the opportunity to engage in a three-month internship within industry, research organizations, foreign universities, or internal internship for research and product development during the 8th semester, provided they meet the semester requirements and receive approval from the institute.

Program Elective Course-V:

Every student is required to take Program Elective Course for Semester VIII. Students can choose program Elective Course-V, from one of domains listed below. The list of courses within the individual domains will be made available before the course registration.

Course Code	Program Elective-V
MEPEC8051	MEMS
MEPEC8052	Tribology
MEPEC8053	Robotics and Control
MEPEC8054	Industrial Safety Engineering
MEPEC8055	Noise Management and Control

Open Elective Course-II:

Every student is required to take one Open Elective Course-II for Semester VIII. Students can take this course from the following list of Open Elective Course-II.

Course Code	Open Elective Course-II
OEC8021	Project Management
OEC8022	Finance Management
OEC8023	Entrepreneurship Development and Management
OEC8024	Human Resource Management
OEC8025	Professional Ethics and CSR
OEC8026	Circular Economy
OEC8027	IPR and Patenting
OEC8028	Digital Business Management
OEC8029	Environmental Management

Examination Scheme – B. Tech Semester-VIII

<table>
<tr><th rowspan="3">Course Code</th><th rowspan="3">Course Name</th><th colspan="5">Examination Scheme</th><th rowspan="3">Total</th></tr>
<tr><th colspan="2">In-Semester Assessment$</th><th rowspan="2">End Sem Exam (ESE)</th><th colspan="2">Exam Duration for Theory (in Hrs)</th></tr>
<tr><th>Continuous Assessment</th><th>Mid-Sem Exam</th><th>Mid-Sem</th><th>End-Sem</th></tr>
<tr><td>MEPEC805Y</td><td>Program Elective-V</td><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
<tr><td>OEC802Y</td><td>Open Elective-II</td><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
<tr><td>MEMJP802</td><td>Major Project-B</td><td>50</td><td>--</td><td>50</td><td>--</td><td>--</td><td>100</td></tr>
<tr><td>INT801</td><td>Internship</td><td>50</td><td>--</td><td>50</td><td>--</td><td>--</td><td>100</td></tr>
<tr><td colspan="2">Total</td><td>140</td><td>60</td><td>200</td><td>--</td><td>--</td><td>400</td></tr>
</table>

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for theory, laboratory, and internship courses.

NOTE: Please note that due to the internship requirement in the 8th semester, theory courses during this semester will be conducted either online synchronously or asynchronously. For more information, please consult the curriculum book of your respective department.

D. Multidisciplinary Minor Courses Offered by the Department for the Other Program Students

Curriculum Structure for MDM Courses

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
MEMDM301	Elements of Mechanical Engineering	3	--	--	3	--	--	3
MEMDM402	CAD Modeling	3	--	--	3	--	--	3
MEMDM503	Product Design and Development	3	--	--	3	--	--	3
MEMDM604	Addivitve Manufacturing	4	--	--	4	--	--	4
MEMDL601	CAD Modeling and 3D Printing Laboratory	--	2	--	--	1	--	1
	Total	**13**	**2**	**--**	**13**	**1**	**--**	**14**

Examination Scheme for MDM Courses

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
MEMDM301	Elements of Mechanical Engineering	20	30	50	1.5	2	100
MEMDM402	CAD Modeling	20	30	50	1.5	2	100
MEMDM503	Product Design and Development	20	30	50	1.5	2	100
MEMDM604	Addivitve Manufacturing	20	30	50	1.5	2	100
MEMDL601	CAD Modeling and 3D Printing Laboratory	25	--	25	--	--	50
	Total	**105**	**120**	**225**	--	--	**450**

E. Honours, Minor, and Honours in Reseach Degree Program

The Honours, Minor, and Honours in Research degree programs aim to empower students by offering specialized courses/research internships or projects in emerging fields of their interest, thus enhancing their proficiency in those areas. Students who achieve a CGPI of 7.5 or higher by the end of the fourth semester are eligible to pursue an additional 18 credits from the fifth to eighth semesters to qualify for a B. Tech degree with Honours, Minor, or Honours in Research designation. Students need to refer to the Institute level Handbook for Honours/Minor/Honours in Research Degree Programs for further details.

Course Type	Course Code	Course Name	Credits
BSC	BSC101	ENGINEERING MATHEMATICS-I	04

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)	MSE	ESE	
Continuous Assessment	Mid-Semester Exam (MSE)				
20	30	50	1.5	2	100

Pre-requisite :

1. Differentiation of function of a single variable.
2. Types of matrices and their basic operations.
3. Integration

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO8: Individual and Collaborative Teamwork
4. PO 11: Life-long learning

Course Objectives:	
1.	To provide the basic knowledge of the concepts of Mathematics applicable to the field of engineering.
2.	To build a mathematical foundation of the methodology required for solving application based problems in the field of engineering.

Module	Detailed Contents	Hrs
00.	**Course Introduction** Mathematics is the fundamental step which creates a solid foundation for all Applied fields of Engineering. Professional Engineering applications have Mathematics as an integral part of their evolution. For example: Formulation in Mathematics to various engineering field using case study, Application of matrices in control systems, wireless signals and computer graphics, Introduction to function of several variables to apply in Marginal rate of technical substitution and Elasticity of substitution. Hence, Formulation Based Mathematics is a fundamental requisite to all fields of Engineering for analyzing their performances.	**01**

<table>
<tr><td rowspan="3">01.</td><td>Matrices - I
Learning Objective:
• Analysis and interpretation of the basic fundamentals of matrices.
• Determination of the rank of a matrix by applying the concepts of elementary transformation of a matrix.</td><td rowspan="3">06-08</td></tr>
<tr><td>Contents:
Introduction of Matrices through a discussion on the need to study matrices as they are essential tools for solving systems of equations, analyzing electrical circuits, performing structural analysis, and modeling complex systems in various engineering fields.
Type of Matrices and Properties, Symmetric, Skew-Symmetric, Orthogonal Matrices, Complex Matrix, Hermitian, skew-Hermitian, Unitary Matrices, Rank of a Matrix, Elementary transformation, Normal Form, Echelon Form.</td></tr>
<tr><td>Self-Learning Topics:
Learning Outcomes:
A learner will be able to
LO 1.1: Apply algebraic techniques to identify and classify different types of matrices, including symmetric, skew-symmetric, orthogonal, Hermitian, Skew-Hermitian, and unitary matrices. (P I 1.1.1, PI 11.1.3)
LO 1.2: Identify the structural properties of complex and real matrices by verifying conditions for symmetry, orthogonality, and unitarily. (P I 2.1.3)
LO 1.3: Identify the process of reducing a matrix to its Normal Form using elementary transformations to determine its rank. (PI 2.2.3)
LO 1.4: Apply the properties of special matrices (e.g., orthogonal or Hermitian) to solve problems in engineering contexts such as signal processing or structural analysis. (P I 1.2.1)
LO 1.5: Articulate the importance of staying updated with current matrix-based computational tools and methods, highlighting how this continuous learning fosters lifelong learning and enhances problem-solving skills in professional engineering practice. (PI 2.1.1, P I 11.2.1)</td></tr>
<tr><td rowspan="2">02.</td><td>Matrices – II
Learning Objective:
• Analysis of the differences between homogeneous and non-homogeneous simultaneous equations
• Application of these concepts to find their solutions, if they exist.</td><td rowspan="2">11-13</td></tr>
<tr><td>Contents:
Solution of system of Linear Equations, Condition for consistency of Non-Homogeneous Equations, Condition for consistency of Homogeneous Equations, Row Vector and Column Vector, Linearly dependence and Independence of vectors, Linear Combination of Vectors.</td></tr>
</table>

	Self-Learning Topics: Coding Theory ***Learning Outcomes:*** *A learner will be able to* *LO.2.1: Identify using relevant mathematical knowledge if the system of homogeneous / non-homogeneous linear equation is consistent and determine its type of solution (P I 2.1.3)* *LO.2.2: Identify the most appropriate method for solving a given system of linear equations and state if the system has one solution, no solution, or infinite solutions. (P I 2.2.3)* *LO 2.3: Identify the algebraic technique to solve a given system of equation. (P I 1.1.1)* *LO 2.4 Identify using relevant mathematical knowledge whether a set of vectors is linearly dependent or independent. (P I 2.1.3)* *LO 2.5: Identify relevant process to express a vector as a linear combination of other vectors by applying basic laws of mathematics (P I 1.2.1,)* *LO 2.6: Communicate clearly with team members while working as a team analyzing a problem on linearly dependent or independent vectors and resolve differences in approach during group work by listening and finding common solutions. (P I 8.2.1)* *LO 2.7: Collaboratively solve problems on linear combinations and linearly dependent / independent vectors using appropriate methods and present it with precision. (PI 8.3.1)*	
03.	**Matrices – III** ***Learning Objective:*** • *Analysis and computation of Eigen Values and Eigen Vectors.* • *Enumeration and application of the concept of Eigen value and Eigen vector to Engineering Models.* • *Application of the concepts of Eigen values and Eigen Vectors for finding the function of matrix using Cayley-Hamilton Theorem.*	**12-14**
	Contents: Introduction to Eigen Values, Characteristic equation, Characteristic roots & Eigen vectors. Finding Eigen values and Eigen vectors for different types of Matrices: Non Symmetric Matrices with non-repeated Eigen Values, Non Symmetric Matrices with Repeated Eigen Values, Symmetric Matrices with non-repeated Eigen Values, Symmetric Matrices with Repeated Eigen Values Cayley-Hamilton Theorem (Without proof), Statement and verification,	
	Self-Learning Topics: *Function of square matrix as an application of Eigen values and Eigen vectors.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1 Identify mathematical knowledge to form the characteristic equation of a square matrix to find its eigenvalues using basic algebraic operations. (P I 1.1.1)* *LO 3.2: Identify relevant solution method to calculate eigenvalues and eigenvectors for a given matrix. (P I 2.2.3)*	

	LO 3.3: Compare methods for finding eigenvalues of different matrix types and choose the most suitable one. (P I 2.2.4) *LO 3.4: Identify the appropriate method to determine Eigen vectors for corresponding Eigen values. (PI-2.1.3)* *LO 3.5: Identify the need to apply appropriate mathematical concept to verify the Cayley-Hamilton theorem for a given square matrix (P I 2.1.3, PI 11.1.3)* *LO 3.6: Apply the Cayley-Hamilton theorem effectively to express matrix functions by using basic laws of mathematics. (P I 1.2.1)*	
04.	**Differential Calculus of Several Variables-I** ***Learning Objectives:*** • *Analysis of the fundamentals of differentiations of functions of two or more independent variables* • *Application of this concept to determine differentiation of function of functions, composite functions and implicit functions.*	**05-07**
	Contents: Introduction to Partial differentiation through a discussion on how it is important for engineering students. As it helps analyze how systems change with respect to multiple variables, which is essential in fields like thermodynamics, fluid mechanics, and structural analysis. Introduction to Partial Differentiation, Geometrical meaning of Partial derivatives of first and higher order, Differentiation of function of function, Differentiation of composite function.	
	Self-Learning Topics: *Jacobian of two and Three variable* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Identify the basic concepts of partial differentiation (PD) with the prerequisite of differentiation of function of a single variable and apply suitable procedure to partially differentiate a function of several variables. (PI-2.2.3)* *LO 4.2: Apply the chain rule to differentiate a function of a function involving partial derivatives. (P I 1.1.1)* *LO 4.3: Apply the relevant concept to differentiate composite functions involving multiple variables and parameters using fundamentals laws of mathematics. (P I 1.2.1)* *LO 4.4: Compare direct and indirect methods of partial differentiation and select the most efficient one to solve a given problem. (P I 2.2.4, PI.11.1.3)* *LO 4.5: Analyze and state the need of how staying updated with current Partial Differentiation-based computational tools and methods contributes to lifelong learning and enhances problem-solving skills in professional engineering practice. (P I 11.2.1)*	

<table>
<tr><td>05.</td><td>Differential Calculus of Several Variables-II

Learning Objective/s:
• Application of the concept of PD to solve problems by using Euler ‘s Theorem on Homogeneous functions with two independent variables.
• Analysis of the learned concept of PD and apply it to find maxima and minima of functions of two variables</td><td rowspan="3">07-09</td></tr>
<tr><td></td><td>Contents:
Homogeneous functions, Euler‘s Theorem on Homogeneous functions with two Independent variables(With Proof) , Deductions from Euler‘s Theorem, Maxima and Minima of a function of two independent variables.</td></tr>
<tr><td></td><td>Self-Learning Topics:
Euler‘s Theorem on Homogeneous functions with three Independent variables

Learning Outcomes:
A learner will be able to

LO 5.1: Identify when Euler’s Theorem is applicable in a given partial differentiation problem. (P I 2.1.3)

LO 5.2: Identify the relevant method (Euler’s Theorem) to solve a problem of homogeneous function in partial differentiation. (P I 2.2.3)

LO 5.3: Identify the deductions derived from Euler’s Theorem which should be used effectively to solve a given problem. (P I 2.1.3)

LO 5.4: Apply the method to find the maxima and minima of functions of two variables using the laws of partial derivatives (P I 1.2.1)

LO 5.5: Identify the existing method of second derivative tests to determine whether a critical point is a maximum, minimum, or saddle point. (P I 2.2.3)

LO 5.6: Apply the solution method of maxima & minima to solve a real-world optimization problem. in a collaborative work as a team. (P I 1.1.1, P I 8.2.1)

LO 5.7: Formulate clear problem statements for optimization tasks involving functions of two variables and Present the final solution as a cohesive team, integrating individual findings into a unified explanation. (P I 2.1.1, P I 8.3.1)</td></tr>
<tr><td>06.</td><td>Beta and Gamma Functions

Learning Objective:
• Analysis and interpretation of the basic definition of Beta and Gamma Functions and their properties.
• Application of the definition and properties of Beta and Gamma Functions to solve definite integrals.</td><td rowspan="2">11-14</td></tr>
<tr><td></td><td>Contents:
Definitions, Gamma Function, Beta Function, Properties of Beta and Gamma Function, Relationship between Beta and Gamma Function, Duplication Formula.</td></tr>
</table>

	Self-Learning Topic: ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Identify the relevant process to e**valuate** Beta functions and Gamma functions for positive real numbers using standard formulas. (P I 2.2.3)* *LO 6.2: Apply the basic definition of beta and gamma function to solve the definite integral. (P.I.1.1.1)* *LO 6.3: Apply properties of Gamma and Beta functions to solve a definite integral problem by identifying the relevant concept. (P I 1.2.1)* *LO 6.4: Compare between duplication formula and relation between Beta and gamma functions to be used to solve a given definite integral problem and solve it. (P I 2.2.4)*	
	Course Conclusion	**01**
Total		**60**

Performance Indicators:

<u>**P.I. No.**</u>	<u>**P.I. Statement**</u>
1.1.1	Apply mathematical techniques as calculus/algebra to solve problems.
1.2.1	Apply laws of natural science to a Mathematical problem.
2.1.1	Articulate problem statements and identify objectives.
2.1.3	Identify the mathematical knowledge that applies to a given problem.
2.2.3	Identify existing processes/solution methods for solving the Problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills.
8.3.1	Present result as a team, with smooth integration of contributions from all individual efforts.
11.1.3	Identify various mathematical concepts/theorems which can be utilized in the field of application based engineering
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.

Course Outcomes:
A learner will be able to

1. Apply the concept of rank of a matrix to find the solution of homogeneous and non-homogeneous system of equations by analysing their consistency. *(LO 1.1, LO1.2, LO1.3, LO1.4, LO 1.5, LO 2.1, LO2.2, LO2.3, LO2.4, LO 2.5, LO 2.6, LO 2.7)*

2. Analyse the characteristic equation to determine the Eigen value, Eigen vector, also function of a matrix by applying Cayley-Hamilton theorem. (*LO 3.1, LO3.2, LO3.3, LO3.4, LO 3.5, LO 3.6)*
3. Implement the fundamentals of partial differentiation to evaluate the maxima and minima of functions of several variables. *(LO 4.1, LO4.2, LO4.3, LO4.4, LO 4.5, LO 5.1, LO5.2, LO5.3, LO5.4, LO 5.5, LO 5.6, LO 5.7)*

4. Implement the fundamentals of Beta and Gamma Function to evaluate the definite integral. (*LO 6.1, LO6.2, LO6.3, LO6.4)*

5. Analyse and apply all mathematical tools acquired through the course and exhibit the knowledge through written solutions through team and individual activities. *(LO 1.1, LO1.2, LO1.3, LO1.4, LO 1.5, LO 2.1, LO2.2, LO2.3, LO2.4, LO 2.5, LO 2.6, LO 2.7, LO 3.1, LO3.2, LO3.3, LO3.4, LO 3.5, LO 3.6, LO 4.1, LO4.2, LO4.3, LO4.4, LO 4.5, LO 5.1, LO5.2, LO5.3, LO5.4, LO 5.5, LO 5.6, LO 5.7, LO 6.1, LO6.2, LO6.3, LO6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSC101.1	3	3						3			3
BSC101.2	3	3									
BSC101.3	3	3						3			3
BSC101.4	3	3									
BSC101.5	3	3						3			3
Average	3	3						3			3

Text Books :

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication, forty fourth Edition, 2021
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited, Tenth Edition, 2011.
3. Advanced Engineering Mathematics, H.K.Das, S. Chand and Company Limited, Fourth Edition, 2018.

Reference Books:

1. Engineering Mathematics by Srimanta Pal and Subodh, C. Bhunia, Oxford University Press, First Edition, 2015
2. Engineering Mathematics by P. Sivaramakrishna Das and C. Vijayakumari, Pearson, First Edition, 2017

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a) One MCQ Test + One Class Test: 05+05 = 10 Marks

b) One Team Pair Solo (TPS) activity: 05 Marks

c) Regularity and active participation :05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
BSC	BSC102	Engineering Physics-I	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer and The World

Course Objectives:

1. To provide the Basic knowledge on the concepts of physics pertaining to the field of engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of physics in the field of engineering.

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Interference in Thin Film and Diffraction** ***Learning Objective:*** *•To study the basic concept of interference and diffraction phenomena in various measurements* *•To recognize the principles of interference and diffraction to solve practical problems.*	**6-8**
	Contents: Interference: Interference by division of amplitude; Interference in thin film of constant thickness: Application in Anti-reflecting films. Wedge shaped film: Newton's rings - Diameters of dark Newton's rings; Applications in determination of refractive index of liquid. Diffraction: Diffraction Grating, Diffraction due to grating; Resolving power of a grating; Applications of diffraction grating; Determination of wavelength of light using plane transmission grating.	
	Self-Learning Topics: *Origin of colours in thin film, Diameters of Bright Newton's rings, Determination of radius of curvature of the lens and wavelength of incident light using Newton's rings experiment.*	

	Learning Outcomes: *A learner will be able to* *LO 1.1: apply the concept of thin film interference and diffraction to determine various parameters of real life problems. (P.I.- 1.2.1)* *LO 1.2: apply the concepts of thin film interference and diffraction to solve problems. (P.I.- 1.3.1)* *LO 1.3: identify the parameters which affect the quality of optical components. (P.I.- 2.1.2)* *LO 1.4 identify the mathematical process and knowledge of interference to derive the conditions of maxima and minima for thin film interference. (P.I.- 2.1.3)*	
02.	**LASER** ***Learning Objective:*** • *To provide the knowledge of absorption and emission in production of laser.* • *To explore the use of lasers in technical fields and associate the impact of laser applications in environment and societal context.*	**3-5**
	Contents: Laser: Stimulated emission and multiplication process; Population inversion; Pumping; Metastable state: Resonant cavity; Helium Neon laser: construction and working; Nd:YAG laser: construction and working; Industrial and medical applications of LASER.	
	Self-Learning Topics: *Absorption, Spontaneous emission, Advantages, disadvantages of He-Ne and Nd:YAG laser.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: apply the knowledge of transitions of atoms within the material in the context of LASER production. (P.I.-1.2.1)* *LO 2.2: identify various parameters which affect LASER emission. (P.I.-2.1.2)* *LO2.3: Identify components and medium to produce LASER of different wavelengths. (P.I-.2.2.3)* *LO 2.4: identify the impact of using LASER in industrial and medical fields.* *(P.I.-6.1.2)*	
03.	**Fiber Optics** ***Learning Objective:*** *•To build the knowledge of optical phenomena in optical fibre and analyze the role of optical fibre in fibre optics communication* *•To study the principle of fibre optics to solve engineering problem.*	**3-5**
	Contents: Optical Fibre; Numerical aperture; Angle of acceptance; V-number; Types of optical fibres; Numerical aperture for step index fibre; Fibre optic communication system.	
	Self-Learning Topics: *Critical angle, Fractional index change, Modes of propagation.*	

	Learning Outcomes: *A learner will be able to* *LO 3.1: apply the knowledge of optical phenomena in propagation of light through optical fibre. (P.I.-1.2.1)* *LO 3.2: identify various parameters required for the fabrication of optical fibre. (P.I.- 2.1.2)* *LO 3.3: apply the concepts of fibre optics to solve problems (P.I.- 1.3.1)* *LO3.4: identify various parameters to differentiate types of optical fibre. (P.I.- 2.1.2)* *LO 3.5: identify the mathematical process and knowledge of optical phenomena to determine numerical aperture and acceptance angle of an optical fibre (P.I.-2.1.3)* *LO 3.6: identify the importance of fibre optic communication system to meet public need. (P.I.- 6.1.1)*	
04.	**Semiconductor Physics** ***Learning Objectives:*** *•To provide the fundamental knowledge of band gap in semiconductors* *•To familiarize the concept of fermi level in semiconductor for solving problems.*	**4-6**
	Contents: Energy bands in semiconductor; Direct & indirect band gap semiconductor; Determination of energy band gap in semiconductor. Fermi level; Fermi Dirac distribution, Fermi level in intrinsic semiconductors, Fermi level in extrinsic semiconductors: Effect of temperature and impurity concentration on fermi level in extrinsic semiconductors, Significance of Fermi level.	
	Self-Learning Topics: *Effect of temperature on fermi level in P-type semiconductor, Effect of impurity concentration on fermi level in N-type semiconductors.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: apply the knowledge of energy bands and Fermi levels to interpret semiconductors. (P.I.-1.2.1)* *LO 4.2: apply the knowledge of fermi level to solve the problems (P.I.-1.3.1)* *LO 4.3: identify various parameters to compare direct and indirect semiconductors. (P.I.-2.1.2)* *LO 4.4: identify the method to analyze the effect of temperature and impurities on fermi level in extrinsic semiconductor. (P.I.-2.2.3)*	
05.	**Semiconductor Devices** ***Learning Objective/s:*** *•To gain the fundamental knowledge of semiconductor in various semiconductor devices.* *•To recognize the impact of semiconductor devices in different societal issues.*	**3-5**
	Contents:	
	Semiconductor Devices: Hall sensor: Principle, construction, working and application; Semiconductor laser: Principle, construction, working	

	and application; Solar cell: Principle, construction, working, application and its importance in society.	
	Self-Learning Topics: *Light Emitting Diode (LED), Photodiode.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: apply physics of semiconductors in semiconductor devices. (P.I.-1.2.1)* *LO 5.2: identify physical phenomena in semiconductors, components and process for making various semiconductor devices (P.I.-2.1.2)* *LO5.3: identify the applications of semiconductor laser and solar cell to meet the public need. (P.I.- 6.1.1)*	
06.	**Superconductors**	**3-5**
	Learning Objective/s: *•To summarize the properties and applications of superconductors.* *•To familiarize the concept of superconductors to evaluate problems.*	
	Contents: Superconductivity, critical temperature, critical magnetic field, Meissner effect; Type I and Type II superconductors; Applications of superconductor in MAGLEV.	
	Self-Learning Topics: *High temperature superconductor and its importance.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: apply the knowledge of various parameters required to study superconductor. (P.I.-1.2.1)* *LO 6.2: apply the concepts of superconductor to solve problems (P.I.-1.3.1)* *LO 6.3: identify various parameters to differentiate the type of superconductors (P.I.-2.1.2)* *LO 6.4: identify the application of superconductors in MAGLEV train for public transportation. (P.I.- 6.1.1)* *LO 6.5: identify the impact of temperature in superconductor. (P.I.-6.1.2)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No. **P.I. Statement**

1.2.1 Apply laws of physics to an engineering problem.

1.3.1 Apply fundamental engineering concepts to solve engineering problems.

2.1.2 Identify engineering systems, variables, and parameters to solve the problems.

2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem

2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.

6.1.1 Identify and describe various role of science particularly as pertains to protection of the public and public interest at global, regional and local level.

6.1.2 Identify risks/impact in the life-cycle of an engineering product or activity.

Course Outcomes:

A learner will be able to -

1. Apply the fundamental knowledge of optical phenomena to analyse the relevant problems and draw the conclusions. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Apply the knowledge of Laser, fiber optics for societal issues by analysing the process of fabrication, their properties and various parameters. (*LO 2.1, LO2.2, LO 2.3, LO 2.4, LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6*)
3. Apply the fundamental knowledge of semiconductor physics to identify and analyse the various parameters to solve the problem. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
4. Identify the role and impact of the semiconductor devices and superconductors by knowing their process of fabrication and applications. (*LO 5.1, LO5.2, LO 5.3, LO 6.1, LO 6.2, LO 6.3,6.4,LO6.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSC102.1	3	3	-	-	-	-	-	-	-	-	-
BSC102.2	3	3	-	-	-	3	-	-	-	-	-

BSC102.3	3	3	-	-	-	-	-	-	-	-	-
BSC102.4	3	3	-	-	-	3	-	-	-	-	-
Average	3	3	-	-	-	3	-	-	-	-	-

Text Books :

1. A Textbook of Engineering physics, Dr. M. N. Avadhanulu and Dr. P. G. Kshirsagar Revised Edition, 2014, S. Chand Publishing.
2. Engineering physics, R. K. Gaur and S. L. Gupta, Revised Edition, 2012, Dhanpat Rai Publications.

Reference Books :

1. Fundamentals of Physics, Halliday /Resnick/Walker, Twelve Edition, 2021, Wiley
2. Optics, Ajoy Ghatak, Seventh Edition, 2020, Tata McGraw Hill

Introduction to solid state physics, Charles Kittel, Eighth Edition, 2005, Wiley

4. A textbook of Optics - N. Subramanyam, Brijlal and Avadhanulu, 23rd Edition, 2006, S.Chand Publishing.

Other Resources :

1. Online physics library, California State University:-Web link- https://phys.libretexts.org/
2. Physics website, The State University of New Jersey :-Web link- www.physics.rutgers.edu
3. NPTEL Course: Fundamentals of semiconductor devices, by Prof. Digbijoy N. Nath, IISc Bangalore:- Web link- https://nptel.ac.in/courses/108108122

A. IN-SEMESTER ASSESSMENT (35 MARKS)

1. Continuous Assessment - Theory-(15 Marks)

a) MCQ test: 4 marks
b) Class test: 4 marks
c) Open book test/Open notes test: 4 marks
d) Regularity and active participation: 3 marks

2. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (40 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
BSC	BSC103	ENGINEERING CHEMISTRY- I	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Pre-requisite:

1. Nil

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6 -The engineer and the world

Course Objectives:

1. To enable the students to apply the laws of chemistry to an engineering problem.
2. To enable the students to study material properties and their engineering applications.
3. To enable the students to analyse and select the most appropriate engineering material
4. To study the current developments in the field of nanotechnology, energy storage systems and green chemistry for sustainable development.

Module	Details	Hrs.
00.	**Course Introduction** Engineering chemistry provides the fundamental understanding of materials, substances and processes that engineers need to design, develop and manufacture products and systems.	01
01.	**Green Chemistry** ***Learning Objective:*** *To state the principles of green chemistry and apply them in the synthesis of various industrially important chemical substances and drugs in order to exhibit the social and environmental impact of chemical industry practices for the sustainable design and development.* **Contents:** Introduction, 12 principles of green chemistry with examples as Conventional and green synthesis of carbaryl, adipic acid, benzimidazole and Indigo with special emphasis on bioenzymes and catalyst. Numericals on atom economy. Carbon Sequestering and Carbon Credit.	4-6

	Green solvents:- water as green solvent, supercritical solvents and DMC.	
	Self-Learning Topics: *12 principles of green chemistry, latest research areas in the field of green chemistry.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Identify the hazards involved in traditional synthesis of carbaryl, adipic acid, benzimidazole and indigo for improving their benign nature. (2.2.3)* *LO 1.2: -Apply the principles of green chemistry for developing the safe green reactions in chemical industries. (1.3.1)* *LO 1.3: Identify and analyze the case of chemical disaster in industry. (2.1.3)* *LO 1.4: Identify the appropriate green solvents to be used in chemical processes to assess the public health and safety. (6.1.1)* *LO 1.5: Analyse the concepts of Carbon Sequestering and Carbon Credit for their impact on environmental sustainability. (6.1.2)* *LO 1.6: Apply the formula of atom economy to solve the numerical problems. (1.2.2)*	
02.	**Water quality management**	**4-6**
	Learning Objective: • *To classify water hardness into various types, state their causes and effects on industrial processes and use the modern methods of water treatment to improve the quality of water.* • *To state the impact of water pollution in order to practice the sustainable water quality management.*	
	Self-Learning Topics: *Basic stoichiometry, mole concept, expression of concentration via normality, molarity, writing molecular formulae and calculation of molecular weights of common salts of heavy metal ions.*	
	Contents: Quality of industrial water - Boiler troubles (Scale and Sludge, Boiler Corrosion, Caustic Embrittlement) Hardness and its types and numericals. Membrane filtration technology: - Ion exchange and reverse osmosis. Numericals based on ion exchange method. Water pollution: - Water quality indices- BOD and COD with numericals. Quality of drinking water – disinfection by chlorination and ozone treatment.	
	Learning Outcomes:	
	A learner will be able to *LO 2.1: Analyze the given sample of water for various types of hardness. (2.1.3)* *LO 2.2: Identify the chemical methods to solve the boiler problems. (2.2.3)* *LO 2.3: Identify various industrial and municipal water treatments for assessing the public health (6.1.1)* *LO 2.4 Apply the knowledge of fundamental chemistry to solve the numerical problems based on hardness, ion exchange method and water quality indices. (1.2.2)* *LO 2.5: Analyse the different water quality indices for controlling the pollution of*	

	water. (6.1.2) *LO 2.6: - Apply the knowledge of membrane filtration technology to improve the quality of drinking water. (1.3.1)*	
03.	**Science of Corrosion**	**4-6**
	Learning Objective: *To state the mechanisms of different types of corrosion and suggest the corrosion control methods for the same in Industry.*	
	Contents: Introduction to corrosion, mechanism of dry corrosion – Oxidation corrosion, Pilling Bedworth rule and wet Corrosion-Mechanisms of wet corrosion, Types of wet corrosion (galvanic, differential aeration, stress and Intergranular corrosion). Methods of prevention of Corrosion- cathodic protection (Sacrificial, impressed current) Protective coatings- Metallic coatings (tinning and galvanizing).	
	Self-Learning Topics: *Factors affecting rate of corrosion-size of electrodes, passivity, position of metal in galvanic series and polarization.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Identify the different types of corrosion to analyse the state of metals and alloys in engineering equipment. (2.1.3)* *LO 3.2: Apply the mechanism of oxidation corrosion for protecting the metals and alloys against dry corrosion. (1.3.1)* *LO 3.3: Apply the Pilling Bedworth rule to assess the nature of oxide layers (1.2.1)* *LO 3.4: Identify the mechanisms and conditions of different types of wet corrosion to analyse the state of metals and alloys. (2.1.3)* *LO 3.5: Apply the cathodic protection methods for improving the safety of metallic equipment and structures. (1.3.1)* *LO 3.6: Apply metallic coatings such as tinning and galvanizing to enhance corrosion resistance for protection of public health. (6.1.1)*	
04.	**Introduction to Thermodynamics** ***Learning Objectives:*** *To state the fundamentals of thermodynamics and apply them in engineering.*	**4-6**
	Contents: Concepts of system, types of systems, surroundings. Extensive and intensive properties, Macroscopic and microscopic approach, heat and work, Thermodynamic equilibrium, reversible and irreversible process, relation between pressure-volume and work, First law of thermodynamics – internal energy and enthalpy. Applications of thermodynamics in engineering, numericals	
	Self-Learning Topics: *Nil*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the knowledge of classification of systems to solve the real life problems. (1.3.1)*	

	LO 4.2: Apply the first law of thermodynamics to different types of systems. (1.2.1) *LO 4.3: Apply the formulae based on work, heat, internal energy, and enthalpy in various thermodynamic systems for solving the numerical problems. (1.2.2)* *LO 4.5: Identify the concepts of thermodynamics for analyzing engineering devices. (2.1.3)*	
05.	**Phase Equilibria** ***Learning Objective/s:*** *To interpret the various phase transformations using thermodynamics.*	**3-5**
	Contents: Gibb's Phase Rule, Terms involved with examples, One Component System (Water) and its applications, reduced Phase Rule, Two Component System (Pb- Ag), and Eutectic system: Applications in solder alloys, limitations of phase rule and numericals.	
	Self-Learning Topics: *Basic thermodynamics-concept of chemical system, equilibrium, Gibb's free energy, variable factor affecting the equilibrium of chemical systems.*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply Gibb's phase rule and reduced phase rule to the given system. (1.2.1)* *LO 5.2: Apply the phase rules to one and two component systems to determine the degrees of freedom at different phases at phase diagrams. (1.3.1)* *LO 5.3: Apply the phase rule equations and concept of eutectic for solving the numerical problems. (1.2.2)* *LO 5.4: Identify the concept of eutectic system for improving the operation of safety devices. (2.2.3)*	
06.	**Energy from non-conventional sources** ***Learning Objective/s:*** *To apply the knowledge of synthesis of non-conventional chemical fuels and deal with the challenges involved in their implementation with respect to sustainable development.*	
	Contents: Synthesis and applications of Biodiesel, Hydrogen production by steam reforming of methane and electrolysis of water, challenges in hydrogen storage and transport.	
	Self-Learning Topics: *Knowledge of conventional fuels and their types, problems associated with their use and need for renewable energy sources.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply the transesterification reaction for the production of biodiesel (1.3.1)* *LO 6.2: Analyse environmental aspects of biodiesel and electrolysis of water as green fuels for their impact on sustainability. (6.1.2)* *LO 6.3: Identify the environmental problems in the process of steam reforming of methane for analyzing the quality of hydrogen. (2.1.3)*	

	LO 6.4: *Identify the challenges in hydrogen production, storage and transport for assessing the public safety. (6.1.1)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.2.2	Apply the formulae based on the concepts of engineering chemistry for solving the numerical problems.(New PI)
1.3.1	Apply fundamental engineering chemistry concepts to solve engineering problems.
2.1.3	Identify the engineering chemistry concepts to analyse the given problem
2.2.3	Identify the existing processes/ solution methods for solving the problems.(Modified PI)
6.1.1	Identify and describe the various roles of materials particularly as pertains to protection of the public and public interest at global, regional and local level.
6.1.2	Analyse the environmental aspects of engineering materials or activities for their impact on sustainability.(Modified)
6.2.1	To identify and interpret standard guidelines for the safety and efficiency of chemical industries.

Course Outcomes: A learner will be able to -

1. Apply the laws of electrochemistry and thermodynamics for solving engineering problems. *(LO-3.1, LO-3.2, LO-3.3, LO-3.4,LO-3.5,LO-3.6, LO-4.1, LO-4.1, LO-4.2, LO-4.3, LO-4.4, LO- 5.1, LO- 5.2, LO- 5.3, LO- 5.4, LO- 6.1, LO- 6.2, LO- 6.3, LO- 6.4)*
2. Analyse the quality of water and challenges in non-conventional energy sources for solving the real-world problems *(LO-1.1, LO- 1.2, LO-1.3, LO-1.4, LO- 1.5, LO-1.6, LO- 2.1, LO- 2.2, LO- 2.3, LO- 2.4, LO- 2.5, LO- 2.6, LO- 6.1, LO- 6.2, LO- 6.3, LO- 6.4)*
3. Identify the suitable chemical product or material for the protection of environment and public health. *(LO-1.1, LO- 1.2, LO-1.3,LO-1.4,LO-1.5,LO-1.6, LO- 2.1, LO- 2.2, LO- 2.3,LO-2.4,LO-2.5,LO-2.6,LO- 2.7, LO-3.1, LO-3.2, LO-3.3, LO-3.4, LO-3.5,LO-3.6, LO- 3.7, LO-3.8, LO-3.9, LO- 6.1, LO- 6.2, LO- 6.3, LO- 6.4)*
4. Interpret the impact of modern chemical industrial practices and energy sources for sustainable development. *(LO-1.1, LO- 1.2, LO-1.3, LO-1.4, LO-1.5, LO-1.6, LO- 2.1, LO- 2.2, LO- 2.3, LO- 2.4, LO- 2.5, LO- 2.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSC103.1	3	3	-	-	-	3	-	-	-	-	-
BSC103.2	3	3	-	-	-	3	-	-	-	-	-
BSC103.3	3	3	-	-	-	3	-	-	-	-	-
BSC103.4	3	3	-	-	-	3	-	-	-	-	-
Average	**3**	**3**	-	-	-	**3**	-	-	-	-	-

Text Books :

1. A textbook of engineering chemistry by S. Dara, 2014 edition, Chand Publication.
2. A Textbook of chemistry by Shashi Chawla, First edition, 2019, Dhanpatrai and Co.
3. Textbook of green chemistry by AK Ahluwalia, 2008, Ane Book India

Reference Books :

1. Engineering Chemistry by Jain and Jain, 17th edition, 2018, Dhanpatrai Publications.
2. Engineering Chemistry by Raghupati Mukhopadhyay, First edition, 2007, New Age International Publisher
3. Engineering Chemistry by Payal Joshi and Shashank Deep, First edition, 2019, Oxford

Other Resources :

1. Online chemistry library for open access text books: https://chem.libretexts.org

A. IN-SEMESTER ASSESSMENT (35 MARKS)

1. Continuous Assessment - Theory-(15 Marks)

1. Numerical Assignment/s (min 20 problems):4 Marks
2. Class test based on numerical assignment: 4 Marks
3. Article reading & summarization: 4 Marks
4. Regularity and active participation: 3 Marks

2. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (40 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
ESC	ESC101	ENGINEERING MECHANICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO8: Individual and Collaborative Team work
4. PO9: Communication

Course Objectives:

1. To familiarize with the concepts of force, moment, Resultant and Equilibrium of system of coplanar force.
2. To acquaint with the basic concept of friction and its application in real-life problems.
3. To recognize the parameters required to quantify the Kinematics of Particle and Rigid body.
4. To introduce the parameters required to quantify the Kinetics of rigid body.
5. To acquaint with basic principles of centroid and its application

Module	Details	Hrs.
00.	**Course Introduction** The Engineering Mechanics Course marks the transition from physics to engineering applications. This course develops the ability to apply and analyze, which are paramount in engineering profession.	**01**
01.	***Coplanar force System: System of Coplanar Forces*** ***Learning Objective:*** *To impart the knowledge of fundamental concepts of Mathematics and Physics to analyze forces in engineering system.*	**07-09**
	Contents: Classification of force systems (Concurrent, Parallel and General Force systems). Principle of Transmissibility, Composition and Resolution of Forces. Resultant of Coplanar Force Systems: Resultant of coplanar force system (Concurrent, Parallel and non- concurrent non-parallel force systems). Moment of force about a point, Couples, Varignon's Theorem and its significance. Force couple system.	
	Self-Learning Topics: Application of Varignon's Theorem	

	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts for resolution of system of forces. (P.I.-1.3.1)* *LO 1.2: Apply mechanical engineering concepts to find resultant forces acting in a system under the action of load. (PI-1.4.1)* *LO 1.3: Identify unknown forces in engineering systems due to application of load. (PI-2.1.2)* *LO 1.4: Identify the relevant mathematical, physical, and engineering principles required to determine the magnitude, direction, and line of action of the resultant force acting on a structural member. (P.I.-2.1.3).*	
02.	**Equilibrium of Rigid Bodies in Statics. Equilibrium of Coplanar Force System:**	**06-08**
	Learning Objective: *To use fundamental concepts of engineering knowledge of equilibrium and to analyze reactions under the influence different types of loading conditions.*	
	Contents: Conditions of equilibrium for Concurrent, Parallel and General Force System (Non-Concurrent Non- Parallel forces) and Couples. Application of Equilibrium Concepts on rigid bodies in Equilibrium. **Equilibrium of Beams:** Different Types of Supports and Loading. Determination of reactions at supports for various types of loads including distributed system on beams. (Excluding problems on internal hinges). **Friction:** Concepts of Angle of Friction, Angle of Repose, Cone of Friction. Equilibrium of bodies kept on inclined plane. Application of Friction Concepts to problems involving ladders and the tipping over of bodies.	
	Self-Learning Topics: *Beam Reaction under Combined Loads*	
	Learning Outcomes: *A learner will be able to*	
	LO 2.1: Apply fundamental mathematical knowledge for application of equilibrium concepts on rigid bodies(P.I.-1.1.2) *LO 2.2: Apply mechanical concepts to coplanar force systems and calculate reactions in beams(P.I.-1.4.1)* *LO 2.3: Identify the key system variables and parameters such as coefficient of friction, normal reaction, and angle of repose required to analyze equilibrium of a rigid body under frictional forces. (P.I.-2.1.2)* *LO 2.4: Formulate mathematical models by applying scientific principles and engineering concepts to represent force and friction interactions in beams, inclined planes, and ladder problems. (P.I.-2.3.1)* *LO2.5: Implement agreed team roles, agendas, and communication norms to collaboratively solve equilibrium and friction problems on inclined planes and ladders. (P.I. – 8.1.2)* *LO2.6: Demonstrate leadership and conflict-resolution skills by guiding your team to agree on assumptions and methods when calculating support reactions in beam equilibrium problems. (P.I. – 8.2.1)*	

	LO 2.7: Prepare a report on equilibrium of beams, inclined planes, and ladders, using clear diagrams, step-by-step calculations, and concise technical language. (P.I. – 9.1.2) *LO 2.8: Present your analysis of support reactions and friction on inclined planes and ladders using clear engineering language, and respond effectively to peer questions. (P.I. – 9.2.1)*	
03.	**Kinematics of Particle** ***Learning Objective:*** *Learner will be able to understand kinematics, including variable acceleration, motion curves, curvilinear motion, and projectile motion, applying concepts to real-life situations through problem-solving.* **Contents:** Motion of particle with Variable Acceleration. Motion Curves (a-t, v- t, s-t curves). General Curvilinear Motion. Tangential and Normal Component of Acceleration. Projectile Motion: Trajectory Equation of Projectile. Application of the concepts of Projectile Motion in real life and related numerical. ***Self-Learning Topics:*** *Projectile Motion Basics, Variable acceleration concept* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Apply knowledge to identify the motion of the object using the equations of motion (P.I.- 1.2.1).* *LO 3.2: Apply the fundamental mathematics and mechanical engineering concepts to examine different types of motions (P.I.-1.4.1).* *LO 3.3: Identify system variables to formulate trajectory equation of projectile motion (P.I.2.1.2).* *LO 3.4: Identify the mathematical relationships, physical laws, and key parameters (e.g., initial velocity, angle of projection, acceleration due to gravity) required to model and predict the motion of a particle in real-life scenarios. (P.I.-2.1.3).*	**07-09**
04.	**Kinematics of Rigid Body** ***Learning Objectives:*** *To understand the parameters required to quantify the Kinematics of Particle and Rigid body.* **Contents:** Rigid Body Motions: Translation, Rotation and General Plane motion. Kinematics of Rotation and related numerical. The concept of Instantaneous center of rotation (ICR) for the velocity. Location of ICR for 2 link mechanism. Velocity analysis of rigid body using ICR. ***Self-Learning Topics:*** *Sine and Cosine Rule* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Apply engineering knowledge to identify the general plane motion(P.I.-1.3.1).* *LO 4.2: Apply mathematical knowledge to find translational, rotational and general plane motion of rigid bodies(P.I.-1.4.1).* *LO 4.3: Identify engineering systems and variables to find instantaneous center of*	**06-08**

<table>
<tr><td></td><td>rotation for link mechanism (P.I-2.2.1).

LO 4.4: Identify the mathematical models, kinematic equations, and key parameters (e.g., velocities, accelerations, link geometry) required to formulate an analytical solution for general plane motion of a rigid body. (P.I.- 2.1.3).</td><td></td></tr>
<tr><td rowspan="6">05.</td><td>Kinetics of Particle: D'Alembert's

Learning Objective:

To understand the concept of kinetics of particle and the different methods to solve the engineering problems.</td><td rowspan="6">04-06</td></tr>
<tr><td>Contents:</td></tr>
<tr><td>Introduction to basic concepts of D'Alembert's Principle, Concept of Inertia force, Equations of Dynamic Equilibrium, (Analysis limited to simple systems only.)

Work – Energy Principle: Work Energy principle for a particle in motion. Application of Work – Energy principle to a system consists of connected masses and Springs.

Impulse – Momentum Principle: Principle and Application of Impulse Momentum Principle to particles in motion.

Impact and Collisions: Law of conservation of momentum, Coefficient of Restitution, Direct Central Impact and Oblique Central Impact. Loss of Kinetic Energy in collision of inelastic bodies.</td></tr>
<tr><td>Self-Learning Topics: Dynamic Equilibrium</td></tr>
<tr><td>Learning Outcomes:

A learner will be able to</td></tr>
<tr><td>LO 5.1: Apply D'Alembert's Principle to investigate the particles in dynamic equilibrium, (P.I.-1.3.1)

LO 5.2: Apply mechanical engineering knowledge to use work-energy principle for mechanical systems(P.I.-1.4.1).

LO 5.3: Identify the key mathematical relationships and physical principles such as the work–energy equation and the impulse–momentum theorem required to model and analyze dynamic particle systems. (P.I.-2.1.3).

LO 5.4: Breakdown a multi-body collision scenario in a force system into sub-problems to facilitate structured problem-solving. (P.I-2.2.1).</td></tr>
<tr><td rowspan="5">06.</td><td>Centroid</td><td rowspan="5">04-06</td></tr>
<tr><td>Learning Objective:

To understand the importance of Centroid which can affect the stability of the objects in the real life situations.</td></tr>
<tr><td>Contents:

First Moment of Area. Centroid of Composite Plane Lamina.</td></tr>
<tr><td>Self-Learning Topics: Methods for calculating the First Moment of Area.</td></tr>
<tr><td>Learning Outcomes:</td></tr>
</table>

	A learner will be able to	
	LO 6.1: Apply fundamental knowledge to find first moment of area. (P.I.-1.1.1). *LO 6.2: Apply mechanical engineering knowledge to find centroid of composite body(P.I.-1.4.1).* *LO 6.3: Implement agreed team roles and norms to collaboratively divide a composite lamina into basic shapes and compute its centroid. (P.I.- 8.1.2)* *LO 6.4: Lead team discussions to select modelling assumptions and resolve conflicts when determining the centroid of complex shapes. (P.I.-8.2.1)* *LO 6.5: Write a concise technical note on centroids of composite areas, using clear diagrams, logical steps, and concise engineering language. (P.I. - 9.1.2)* *LO 6.6: Present your centroid analysis orally with proper engineering terminology and visual aids, and answer audience questions accurately. (P.I. - 9.2.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub problems.
2.3.1	Combine scientific principles and engineering concepts to formulate model(s) (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
8.1.2	Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective teamwork to accomplish a goal.
8.2.1	Collaborate effectively as part of a team in laboratory or real-world engineering tasks.
9.1.2	Communicate effectively in writing using diagrams, logical structure, and engineering terminology.
9.2.1	Prepare and present engineering information effectively in written form—such as technical reports, design documents, and project proposals—using clear, concise language, correct grammar, appropriate structure, and professional formatting.
9.2.2	Deliver effective oral presentations to technical and non-technical audiences.

Course Outcomes:

A learner will be able to -

1. Apply principles of equilibrium and friction to determine support reactions and resultant forces in various mechanical systems, and analyze coplanar force systems while effectively collaborating in teams and presenting solutions in a structured technical format. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7, LO 2.8)*
2. Apply mathematical and mechanical engineering principles to analyze and interpret linear and projectile motion of objects in real-life situations. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
3. Apply engineering and mathematical concepts to analyze the general plane motion of rigid bodies and mechanisms both graphically and analytically. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4)*
4. Apply principles of dynamics, work-energy, and impulse-momentum to analyze force systems in motion, including collisions and dynamic equilibrium. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
5. Apply principles of engineering mechanics to determine the centroid of composite bodies and communicate the results effectively in collaborative settings. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESC101.1	3	3	-	-	-	-	-	3	3	-	-
ESC101.2	3	3	-	-	-	-	-	-	-	-	-
ESC101.3	3	3	-	-	-	-	-	-	-	-	-
ESC101.4	3	3	-	-	-	-	-	-	-	-	-
ESC101.5	3	-	-	-	-	-	-	3	3	-	-
Average	**3**	**3**	-	-	-	-	-	**3**	**3**	-	-

Text Books :

1. Engineering Mechanics by A K Tayal, Fourteenth Edition, 2011 Umesh Publication.
2. Engineering Mechanics by Kumar, Fourth Edition, 2017 Tata McGraw Hill
3. Engineering Mechanics by F. L. Singer, Third Edition, 1975, Harper & Raw
4. Engineering Mechanics by R. C.Hibbeler , Fourth Edition, 2017, Pearson Education

Reference Books :

1. Engineering Mechanics by Beer &Johnston, Fourth Edition, 1987 ,Tata McGraw-Hill
2. Engineering Mechanics (Statics) by Meriam and Kraige, Fourth Edition, 1999 Wiley Books

Other Resources :

1. NPTEL Course: NOC Engineering Mechanics Statics and Dynamics by Prof. Mahesh Panchagnula offered by IIT Madras Web link: https://nptel.ac.in/courses/112/106/112106180

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

1. Numerical Assignments (minimum 20 problems): 5 Marks
2. Class Test based on similar problems which were given as an assignment: 5 Marks
3. Think-Pair and share: 5 Marks
4. Regularity and active participation: 5 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Assessment–Learning Outcome Mapping Matrix

CIA			MSE	ESE
Tool 1 (Numerical Assignments)	**Tool 2 (Class Test)**	**Tool 3 (Think-pair and share activity)**	**Based on Module 1 to 3**	**Based on Module 4-6 + 30% from Module 1 to 3**
LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 6.1, LO 6.2, LO 6.1, LO 6.2	LO 1.1, LO 1.2, LO 2.1, LO 3.1, LO 3.2, LO 4.1, LO 5.1, LO 5.2, LO 6.3, LO 6.4	LO 2.5, LO2.6, LO 2.7, LO 2.8, LO 6.3, LO 6.4, LO 6.5, LO 6.6	LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 3.1, LO 3.2, LO 3.3, LO 3.4	LO 1.2, LO 2.1, LO 2.2, LO 3.4, LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 6.1, LO 6.2, LO 6.3, LO 6.4

Course Type	Course Code	Course Name	Credits
ESC	ESC102	BASIC ELECTRICAL ENGINEERING	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The engineer and the world
4. PO8: Individual and teamwork

Course Objectives:

1. To impart knowledge on fundamentals of electrical power system, conventional and non- conventional energy sources.
2. To impart knowledge on basic electrical systems, DC circuits, AC circuits, Residential Electrical System, Residential Energy Metering and Electrical Machines to solve engineering problems.
3. To introduce concept to analyse DC circuits, AC circuits.
4. To introduce safety devices incorporated in residential electrical system for professional engineering practice.

Module	Detailed Content	Hrs
00	**Course Introduction** Overview of Basic Electrical Engineering, application of Basic Electrical Engineering in Industry/real life problem. It is a foundational course designed to provide students with a comprehensive understanding of fundamental electrical concepts and principles.	1
01.	**Introduction to Basic Electrical Systems** ***Learning Objective/s:*** *To acquire knowledge on various components of electrical powers system and compare different sources of electrical energy.*	2-4
	Contents: Components of Electrical power System, Role of each component, Structure of electrical power system, Introduction to transformer, Conventional sources of electric energy, Renewable energy sources, Comparison of various energy sources.	

	Self-Learning Topics: *Comparison of conventional and nonconventional energy sources.* ***Learning Outcomes:*** *A learner will be able to* *LO1.1 Apply the concepts of electrical engineering to understand role of each component of electrical power system. (P.I.-1.4.1)* *LO1.2Apply basic principles of transformers to understand their function within the electrical power system. (P.I.-1.3.1)* *LO1.3 Apply fundamental engineering concepts to compare different sources of electrical energy. (P.I.-1.2.1)*	
02.	**DC Circuits with independent sources** ***Learning Objective/s:*** *To apply the concepts of various theorems and laws to analyze DC circuits.*	**5-7**
	Contents: Ohm's Law, Kirchhoff's Laws, Star Delta transformation, Ideal and practical voltage and current sources, Mesh and Nodal Analysis, Superposition theorem, Thevenin's theorem, Maximum power transfer theorem.	
	Self-Learning Topics: *Series and parallel connections of resistances.* ***Learning Outcomes:*** *A learner will be able to* *LO2.1 Apply concepts of Ohm's law and Kirchoff's laws to solve DC circuits. (P.I.- 1.4.1)* *LO2.2 Apply concepts of star delta transformation to simplify DC circuits. (P.I.-1.3.1)* *LO2.3 Identify network theorems to determine current distribution in DC circuits. (P.I.- 2.1.3)* *LO2.4 Identify the impact of ideal and practical electrical sources on the analysis of DC circuits. (P.I.-2.1.2)*	
03.	**AC Fundamentals** ***Learning Objective/s:*** *To analyze AC circuit and interpret the condition of resonance by using concepts of current, voltage, power factor and power calculation in AC circuits.*	**5-7**
	Contents: Single-phase AC series circuits consisting of R, L, C, RL, RC, RLC combinations, definitions -real, reactive, and apparent power. Series Resonance.	
	Self-Learning Topics: *Parallel AC circuits.* ***Learning Outcomes:*** *A learner will be able to* *LO3.1 Produce phasor expressions for sinusoidal quantities in AC circuits and validate AC circuit analysis by applying concepts of phasor algebra. (PI – 2.4.2)* *LO3.2 Identify the behavior of single-phase AC series circuits with R, L, C, RL, RC, and RLC combinations using phasor diagrams and impedance concepts.*	

	(P.I.-2.1.2) *LO3.3 Apply concepts of AC power analysis to calculate real, reactive, and apparent power in single-phase AC series circuits. (P.I.-2.4.1)* *LO3.4 Identify condition of resonance and calculate resonant frequency by overserving current and reactance in series AC circuits. (P.I.-2.1.3)*	

04.	**Residential Electrical Systems** ***Learning Objective/s:*** *To acquire knowledge on residential electrical wiring incorporating suitable safety devices, testing and up-keeping of household electrical appliances and residential lighting system.*	**4-6**
	Contents: Components of residential electrical system, Residential wiring System, load calculation, Electrical safety Devices, Fuse, MCB, ELCB, grounding issues, safety precautions, testing of domestic appliances and up-keeping, Luminous flux, Luminous intensity, Lumination, Types of lamps in residential lighting. Case study on residential lighting.	
	Self-Learning Topics: *Basic requirements of electrical system.* ***Learning Outcomes:*** *A learner will be able to* *LO4.1 Apply knowledge of basic system requirements to identify and understand components of a residential electrical system. (P.I.-1.3.1)* *LO4.2 Apply basic electrical engineering concepts to test and repair domestic electrical appliances. (P.I.-1.4.1)* *LO4.3 Identify and explain the concepts of luminous flux, luminous intensity, and illumination, and differentiate between various types of lamps used in residential lighting. (P.I.-2.2.4)* *LO4.4 Identify variables and parameters required to solve illumination design problem. (P.I-2.1.2)* *LO4.5 Identify appropriate safety devices for protecting residential electrical systems based on the type and rating of the connected load. (P.I.- 6.1.1)* *LO4.6 Interpret codes and standards relevant to electrical protective devices. (P.I.- 6.2.1)* *LO4.7 Demonstrate teamwork by conducting and collaboratively presenting a case study on residential lighting system design. (P.I.-8.2.1, 8.3.1)*	
05.	**Introduction to Residential Energy Measurements** ***Learning Objective/s:*** *To acquire knowledge on residential energy metering, energy tariff and understanding the residential electricity bill.*	**2-4**
	Contents: Measurement of Energy, Understanding of electricity bill, energy tariff electricity bill calculation.	

	Self-Learning Topics: *Types of meters used for energy metering.* ***Learning Outcomes:*** *A learner will be able to* *LO5.1 Apply concepts of electrical engineering to calculate the electrical energy consumed over a specified time. (P.I.-1.4.1)* *LO5.2 Apply government regulations to calculate electrical energy tariff based on meter readings.(P.I.-1.3.1)*	

06.	**Introduction to Electrical Machines** ***Learning Objective/s:*** *To identify motors for given application using concepts of construction, working and characteristics of different machines.*	**4-6**
	Contents: Construction, working, characteristics and application of DC machines, Single phase Induction Motor, Servo motors, Brushless DC motor, Stepper motor. Factors to be considered for selection of motor and its rating. Selection of motors from motor and load characteristics.	
	Self-Learning Topics: *Working principle of electric motor.* ***Learning Outcomes:*** *A learner will be able to* *LO6.1 Apply fundamental engineering concepts to differentiate various machines based on their construction and working principles. (P. I-1.3.1)* *LO6.2 Apply Electrical engineering concepts to understand the characteristics and applications of various machines. (P. I-1.4.1)* *LO6.3 Identify and compare electrical motors for given application based on characteristics of load and motor. (P.I.-2.2.4)* *LO6.4 Identify the rating of motor by considering factors like power, speed, torque etc. of the given application. (P.I.-2.2.3)*	
	Course Conclusion	**1**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level.

6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public

8.2.1 Demonstrate effective communication, problem solving, and conflict resolution and leadership skills.

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes:

Learner will be able to

1. Apply fundamental engineering concept to interpret Basic Electrical Systems, Residential Electrical System and Residential Energy Metering. (*LO1.1, LO1.2, LO1.3, LO5.1)*
2. Apply concepts of electrical engineering to solve problems on DC circuits and AC circuits. *(LO2.1, LO2.2, LO2.3, LO2.4, LO3.1, LO3.2, LO3.3, LO3.4)*
3. Interpret and identify safety devices for professional engineering practice. (*LO4.5*, *LO4.6*)
4. Apply fundamental lighting engineering concepts to solve basic residential lighting design problems. *(LO4.1, LO4.2, LO4.3, LO4.4, LO4.7, LO5.2)*
5. Identify electrical motors based on requirement of application and characteristics of motor. *(LO6.1, LO6.2, LO6.3, LO6.4)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESC102.1	3	-	-	-	-	-	-	-	-	-	-
ESC102.2	3	3	-	-	-	-	-	-	-	-	-
ESC102.3	-	-	-	-	-	3	-	-	-	-	-
ESC102.4	3	-	-	-	-	-	-	3	-	-	-
ESC102.5	3	3	-	-	-	-	-	-	-	-	-
Average	**3**	**3**	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**

Text Books:

1. Electrical Power Systems,S.L. Uppal and Prof. Sunil S. Rao 15th Edition, Khanna Publishers
2. Basic Electrical Engineering, B.R Patil, 2nd Edition Oxford Higher Education, 2019
3. Art & Science of Utilization of electrical Energy, H Partab, Dhanpat Rai & Co., 2004.
4. Electrical and Electronic Measurements and Measuring Instruments, A K Sawhney Dhanpat Rai and Sons
5. Special Electrical Machines, E G Janardanan PHI 2014
6. Electrical Power Systems, S.L. Uppal and Prof. Sunil S. Rao, 15th Edition, Khanna Publishers

Reference Books:

1. Power System Engineering, D P Kothari and I J Nagrath, 3rd Edition, Mac Graw Hills,
2. Electrical Engineering Fundamentals, Vincent Del Toro, PHI Second edition, 2011
3. Utilization of Electric Power & Electric Traction, J B Gupta, 10th Edition, Dhanpat Rai

and Sons 2012.

4. Electrical Engineering, B.L.Theraja Vol-I and II
5. Basic Electrical Engineering, S.N.Singh PHI, 2011

Other Resources:

1. NPTEL course on Basic Electrical Technology, IISc Bangalore Prof. L. Umanand https://nptelvideos.com/course.php?id=460

A. IN-SEMESTER ASSESSMENT (35 Marks)

1. **Continuous Internal Evaluation of Theory (15 Marks)**

   Numerical Assignments (minimum 20 problems): 4 Marks

   Class Test based on similar problems which were given as an assignment: 4 Marks

   Open book test/Open notes test: 4 Marks

   Regularity and active participation: 3 Marks

2. **Mid Semester Exam (20 Marks)**

   Mid semester examination will be based on 40 % to 50% of the syllabus.

B. End Semester Exam (40 Marks)

End semester will be based on the syllabus coverage upto Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
BSL	BSL101	Engineering Physics-I Laboratory	0.5

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
25	-	-	-	-	25

Program Outcomes addressed:

1. PO1:Engineering Knowledge
2. PO4: Conduct investigations of complex problems
3. PO8: Individual and collaborative team work
4. PO9: Communication

Course Objectives:

1. To demonstrate the fundamental concepts of physics and evaluate the process of an experiment/project quantitatively and qualitatively.
2. To improve the knowledge gained in the theory course.
3. To develop the abilities of measurements, observations and analyzing data.
4. To develop the experimental skill in assembling and handling laboratory instruments.

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Experiment 1:** ***Learning Objective:*** ***To use Newton's rings for the determination of various physical quantities.***	
	Determination of the radius of curvature (R) of given plano convex lens using Newton's Rings	
	Learning Outcome: *LO 1.1: A learner will be able to* *apply the concepts of interference in thin film and analyze the experimental data to calculate radius of curvature of the given plano convex lens. (P.I.1.2.1, P.I.1.3.1, P.I. 4.3.1, P.I..4.3.3)*	
02.	**Experiment 2** ***Learning Objective:*** ***To study the applications of diffraction grating.***	**02**
	Measurement of wavelength of He-Ne laser by using grating	

	Learning Outcome: *LO 2.1: A learner will be able to apply the concepts of diffraction through multiple slit and analyze the experimental data to calculate wavelength of the laser source. (P.I.1.2.1, P.I.1.3.1, P.I. 4.3.1, P.I..4.3.3)*	
03.	**Experiment 3** ***Learning Objective:*** ***To determine the parameters which defines the characteristics of an optical fibre.***	**02**
	Measurement of Numerical aperture of an Optical Fibre.	
	Learning Outcome: *LO 3.1: A learner will be able to apply the knowledge of optical fibre and analyze the experimental data to calculate numerical aperture of the given fibre. (P.I.1.2.1, P.I.1.3.1, P.I. 4.3.1, P.I..4.3.3)*	
04.	**Experiment 4** ***Learning Objective:*** ***To determine various physical quantities by using Hall effect in semiconductors***	**02**
	Determination of magnetic field using Hall-effect setup.	
	Learning Outcome: *LO 4.1: A learner will be able to apply the concept of Hall effect phenomena and analyze the experimental data to calculate magnetic field generated by electromagnet. (P.I.1.2.1, P.I.1.3.1, P.I. 4.3.1, P.I..4.3.3)*	
05.	**Experiment 5** ***Learning Objective:*** ***To study V-I characteristics of semiconductor devices***	**02**
	Voltage-current (V-I) characteristic of photo diode	
	Learning Outcomes: *LO 5.1: A learner will be able to apply the working principle of photodiode and analyze the V-I characteristic curve to draw conclusion. (P.I.1.2.1, P.I.1.3.1, P.I. 4.3.1, P.I..4.3.3)*	
06.	**Course Project** ***Learning Objective/s:*** ***To explore the application of concept of physics in different fields by selecting a project.***	**03**
	Selection of a project based on physics concepts, Literature survey, and Topic presentation.	
	Learning Outcome: *LO 6.1: A learner will be able to identify a project based upon the concepts of physics and present the topic effectively as a team. (P.I.1.2.1, P.I.1.3.1, P.I..8..1.2, P.I. 8.3.1, P.I. 9.1.1, P.I. 9.2.2)*	
	Course Conclusion	**01**
	Total	**15**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.
8.1.2.	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective teamwork to accomplish a goal.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
9.1.1	Produce clear, well-constructed, and well- supported written engineering documents.
9.2.2	Deliver effective oral presentations to technical and non- technical audiences.

Course Outcomes: A learner will be able to -

1. A learner will be able to apply the fundamental knowledge of optical phenomena to determine various parameters through relevant experiments.(*LO 1.1, LO 2.1, LO3.1*)
2. A learner will be able to apply the fundamental knowledge of semiconductor devices to determine various parameters through relevant experiments. (*LO4.1, LO5.1*)
3. A learner will be able to apply the fundamental knowledge of physics to present proposed project work, write effective reports as a team. (*LO 6.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSL101.1	3	-	-	3	-	-	-	-	-	-	-
BSL101.2	3	-	-	3	-	-	-	-	-	-	-
BSL101.3	3	-	-	-	-	-	-	3	3	-	-
Average	**3**	**-**	**-**	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**-**

Text Books :

1. A Textbook of Engineering physics, Dr. M. N. Avadhanulu and Dr. P. G. Kshirsagar RevisedEdition, 2014, S. Chand Publishing.

2. Engineering physics, R. K. Gaur and S. L. Gupta, Revised Edition, 2012, Dhanpat RaiPublications

Reference Books :

1. Fundamentals of Physics, Halliday /Resnick/Walker, Twelve Edition, 2021, Wiley
2. Introduction to solid state physics, Charles Kittel, Eighth Edition, 2005, Wiley
3. Introduction to nanotechnology, Charles P Poole and Frank J Owens, 1 st Edition, Wiley-Interscience.

Other Resources :

1. Online physics library, California State University:-Web linkhttps://phys.libretexts.org/
2. Physics website, The State University of New Jersey :-Web linkwww.physics.rutgers.ed

IN-SEMESTER ASSESSMENT (25 MARKS)

1. Lab Performance: 10 Marks
2. Project (Final Report and Demonstration): 10 marks
3. Regularity and active participation: 5 marks

Course Type	Course Code	Course Name	Credits
BSL	BSL102	ENGINEERING CHEMISTRY - I LABORATORY	0.5

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
25	-	25	25	-	25

Pre-requisite:

1. Nil

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO4: Conduct investigation of complex problems
4. PO6: The engineer and the world
5. PO8: Individual and collaborative teamwork
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. To enable the students to utilize fundamental laboratory techniques for analysis and synthesis of chemical products.
2. To enable the students to learn various laboratory safety rules in standard laboratory practices.

Module	Details	Hrs.
00.	**Course Introduction** 1. Laboratory familiarization 2. Code of conduct in chemistry laboratory 3. Safety and precautions to be observed in chemistry laboratory 4. Orientation on evaluation of laboratory performance	**01**
01.	**Experiment 1** ***Learning Objective:*** *To estimate the total, temporary and permanent hardness of water using EDTA method to understand its quality for industrial use.*	**02**
	Estimation of Total, temporary and permanent hardness of water by EDTA method.	
	Self-Learning Topics: Nil	

	Learning Outcomes: *A learner will be able to* *LO-1.1 Analyse the quality of the industrial water by calculating the total hardness using complexometric titration method. (1.2.1) (1.3.1) (2.1.3) (2.2.3) (4.3.1) (4.3.3)*	
02.	**Experiment 2** ***Learning Objective:*** *To determine the chloride content of water to understand its suitability for domestic use.*	**02**
	Estimation of chloride content of water sample	
	Self-Learning Topics: Nil	
	Learning Outcomes: *A learner will be able to* *LO- 2.1 Analyse the quality of the drinking water by calculating the chloride content using precipitation titration method.* *(1.2.1) (1.3.1) (2.1.3) (2.2.3) (4.3.1) (4.3.3)*	
03.	**Experiment 3** ***Learning Objective:*** *To synthesize aspirin by using acetylation process and calculate it's percent yield and atom economy to determine the nature of reaction.*	**02**
	To synthesize aspirin from salicylic acid	
	Self-Learning Topics: Nil	
	Learning Outcomes: *A learner will be able to* *LO-3.1 Synthesize aspirin using acetylation process and calculate its percentage yield (1.2.1) (1.3.1) (2.2.3) (2.3.1) (4.3.1) (4.3.3)*	
04.	**Experiment 4** ***Learning Objective:***	**02**
	To calculate the enthalpy of dissolution of copper sulphate in water using simple calorimeter.	
	To determine the enthalpy of dissolution of copper sulphate at room temperature using water as a reaction medium.	
	Self-Learning Topics: Nil	
	Learning Outcomes:	
	A learner will be able to *LO-4.1 Calculate enthalpy of the given system using first law of thermodynamics.* *(1.2.1), (1.3.1), (4.1.3) (4.3.1) (4.3.3)*	
05.	**Experiment 5** ***Learning Objective:*** *To determine the effect of various factors affecting the rate of corrosion of iron*	**02**
	To determine the factors affecting the rate of corrosion.	
	Self-Learning Topics: Nil	

	Learning Outcomes: *A learner will be able to* *LO-5.1 Determine the effect of various factors on the rate of corrosion by applying the knowledge of electrochemistry (1.2.1) (1.3.1) (4.3.1) (4.3.3)*	
06.	**Designing of experiment and presentation:**	**03**
	Learning Objective/s: *To develop the basic knowledge of analytical chemistry using titrimetric experiments*	
	Standardization/estimation of chemical substances using titrimetric analysis.	
	Self-Learning Topics: *Nil*	
	Learning Outcomes: *A learner will be able to* *LO-6.1 Identify the existing titrimetric analysis to estimate the given substance and present the result as a team. (1.2.1) (1.3.1), (4.2.1) (4.3.1) (4.3.3) (8.1.1), (8.3.1) (9.1.1), (9.1.2), (9.1.3) (11.3.1) (11.3.2).*	
	Course Conclusion	**01**
	Total	**15**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering chemistry concepts to solve engineering problems.
2.1.3	Identify the engineering chemistry concepts to analyse the given problem
2.2.3	Identify the existing processes/ solution methods for solving the problems
2.3.1	Combine the scientific principles and engineering chemistry concepts to formulate a drug
4.2.1	Design and develop an experimental approach, specify appropriate equipment and procedures.
4.1.3	Apply appropriate instrumentation to make measurements of physical and chemical quantities.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.3	Represent data in tabular/ graphical forms so as to facilitate analysis and explanation of the data and drawing of conclusions.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.3.1	Present result as a team with smooth integration of contributions from all individual efforts.
9.1.1	Read, understand and interpret technical and non-technical information
9.1.2	Produce clear, well-constructed, and well-supported written project report.
9.1.3	Create flow in a document or presentation - a logical progression of ideas so

that the main point is clear

9.2.2 Deliver effective oral presentations to technical and non-technical audiences.

11.3.1 Source and comprehend technical literature and other credible sources of information

11.3.2 Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to -

1. Apply the laws of electrochemistry and thermodynamics for performing the practicals. *(LO-4.1, LO-5.1)*
2. Formulate a drug by applying the concepts of chemistry. *(LO-3.1)*
3. Analyse the quality of water for assessing the public health. *(LO-1.1, LO-2.1)*
4. Demonstrate an ability to work effectively in a team for project-based activity. *(LO-6.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSL102.1	3	-	-	3	-	-	-	-	-	-	-
BSL102.2	3	3	-	3		-	-	-	-	-	-
BSL102.3	3	3	-	3		-	-	-	-	-	-
BSL102.4	3	-	-	3	-	-	-	3	3	-	3
Average	**3**	**3**	**-**	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**3**

Textbooks:

1 Practical book in Engineering Chemistry by Dr. Pijus Khatua and Debashree Singh, First edition, 2016, Platinum Publishers

2 Textbook of green chemistry by AK Ahluwalia, 2008, Ane Book India

Reference Books:

1 Engineering Chemistry by Jain and Jain, 17^{th} edition, 2018, Dhanpatrai publications

2 Experiments in Engineering Chemistry by Payal Joshi, first edition, 2016, I.K. International Publishing House Pvt. Ltd.

Other Resources:

1 Online chemistry library for open access textbooks: https://chem.libretexts.org

2 Lab Simulation: https://vlab.amrita.edu/?sub=2&brch=190&sim=1546&cnt=1

IN-SEMESTER ASSESSMENT (25 MARKS)

1. Lab Performance: 10 Marks
2. Design experiment and presentation: 10 marks
3. Regularity and active participation: 5 marks

Course Type	Course Code	Course Name	Credits
ESL	ESL101	ENGINEERING MECHANICS LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam**	**Total Marks**
25	--	25

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering Tool Usage
4. PO8: Individual and team work
5. PO9: Communication

Course Objectives:

1. To demonstrate the equilibrium of coplanar forces
2. To demonstrate law of moments.
3. To determine coefficient of friction between two different surfaces in contact.
4. To analyse the motion of particle.

Module	Details	Hrs.
00.	**Course Introduction** The Engineering Mechanics Lab Course marks the transition from physics to engineering applications. This course develops the ability to apply and analyze, which are paramount in engineering profession.	**01**
01.	**Coplanar Force System** ***Learning Objective:*** *Learner will be able to apply fundamental engineering concepts to demonstrate the concept of equilibrium of coplanar forces.*	**08-10**
	Experiment 1: To verify polygon law of forces	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to verify the Law of Polygon of Forces by constructing force polygons graphically and solving for equilibrium conditions by identifying equilibrium equations in a team and document the results in a detailed report. (P.I.-1.3.1, P.I.-2.1.2, P.I.-8.2.1, P.I.-9.1.2)*	
	Experiment 2: To verify Lami's theorem using simple Jib Crane	
	Learning Outcomes: *A learner will be able to* *LO 1.2: Apply mechanical engineering concepts to verify Lami's theorem by identifying the equilibrium conditions and calculating forces both analytically and experimentally. Work Collaboratively to prepare a technical report with clear written analysis. (P.I.-1.4.1, P.I.-2.1.3, P.I.-8.2.1, P.I.-9.1.2)*	

	Experiment 3: To determine the reactions of simply supported beam.	
	Learning Outcomes: *A learner will be able to* *LO 1.3: Apply fundamental engineering concepts to determine support reactions by using equilibrium conditions at various load positions. Discuss in to compare observed and calculated reactions, analyze discrepancies, and prepare a detailed report with clear explanations and annotated diagrams. (P.I.-1.3.1, P.I.-2.1.3, P.I.-8.2.2, P.I.-9.1.2, P.I.-9.3.1)*	
02.	**Principle of Moment**	**02-04**
	Learning Objective: *Learner will be able to apply mechanical engineering concepts to demonstrate the principle of Moments using the Bell Crank Lever apparatus.*	
	Experiment 4: To verify moment equilibrium condition using bell crank lever.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental and mechanical engineering concepts to verify the Principle of Moments by measuring spring tensions and hanger forces at various arm positions. Collaborate in teams to conduct repeated trials and compare experimental values with theoretical results, and prepare a detailed report. (P.I.-1.3.1, P.I.-1.4.1, P.I.-2.1.3, P.I.-2.2.3, P.I.-8.2.1, P.I.-8.3.1, P.I.-9.1.2, P.I.-9.3.1)*	
03.	**Friction**	**04-06**
	Learning Objective: *Learner will be able to determine coefficient of friction between two different surfaces in contact.*	
	Experiment 5: To determine coefficient of friction using friction plane and angle of repose method.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply natural science laws and fundamental engineering concepts to measure static and kinetic friction coefficients by identify appropriate analytical approaches and justified assumptions. Collaborate in teams to conduct repeated trials and produce a clear written report with structured narrative and standard figures. (P.I.-1.2.1, P.I.-1.3.1, P.I.-2.1.3, P.I.-2.2.3, P.I.-8.2.1, P.I.-8.3.1, P.I.-9.1.2, P.I.-9.3.1)*	
04.	**Kinematics of particles**	**08-10**
	Learning Objectives: *Learner will be able to analyze the motion of particle.*	
	Experiment 6: To study the motion of the projectile.	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the laws of natural science and fundamental engineering concepts to measure range and impact velocity at varied launch angle by identifying variables and parameters to apply kinematics relations, coordinate with team members and prepare a technical report. (P.I.-1.2.1, P.I.-1.3.1, P.I.-2.1.2, P.I.-8.1.2, P.I.- 9.1.2)*	

	Experiment 7: To measure and verify average speed of the vehicle. **Learning Outcomes:** *A learner will be able to* *LO 4.2: Apply fundamental engineering concepts to identify necessary mathematical and engineering principles to calculate and verify the glider's average speed by positioning photogates at a known distance. Work in a team to process and interpret timing data in a logical manner to prepare a detailed written report. (P.I.-1.3.1, P.I.-2.1.3, P.I.-8.2.2, P.I.-9.1.1, P.I.- 9.1.2)*	
	Experiment 8: Study of linear and curved motion under low friction and plot distance, velocity, and acceleration as a function of time.	
	Learning Outcomes: *A learner will be able to* *LO 4.3: Apply mechanical engineering concepts to conduct linear and curved-track experiments using a wireless motion encoding car and data acquisition software to verify the relationships among displacement, velocity, acceleration by collaborating effectively in team to prepare a technical report. (P.I.-1.4.1, P.I.-5.1.1, P.I.-5.2.2, P.I.-8.2.1, P.I.-9.1.2)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problem.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering, and other relevant knowledge that applies to a given problem.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
5.1.1	Identify modern engineering tools, techniques, and resources
5.2.2	Demonstrate proficiency in using discipline-specific tools
8.1.2	Demonstrate the ability to function effectively as a member of a diverse, multidisciplinary team to achieve a common engineering goal.
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills.
8.2.2	Apply leadership and team-management skills to coordinate tasks, resolve conflicts, and uphold accountability among team members to achieve shared project objectives.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents.
9.3.1	Create engineering-standard figures, reports, and drawings to complement writing and presentations.

Course Outcomes:

A learner will be able to

1. Apply fundamental mechanics principles and analyze static equilibrium in coplanar force experiments by classifying force systems, constructing and resolving free-body diagrams, and calculating support reactions using both analytical equations and graphical methods. *(LO 1.1, LO 1.2, LO 1.3)*
2. Apply mechanical engineering concepts and analyze moments and couples through bell-crank lever experiments by formulating equilibrium equations, measuring spring tensions and hanger forces, and comparing theoretical and experimental results. *(LO 2.1)*
3. Apply laws of natural science and mechanical engineering principles to analyze frictional behaviour by measuring static and kinetic coefficients via friction-plane and angle-of-repose methods, evaluating multiple techniques, and interpreting surface and material effects. *(LO 3.1)*
4. Apply kinematic principles using modern instrumentation and analyze by conducting projectile, photogate, and wireless motion encoding car experiments to collect real-time data, and deriving displacement, velocity, acceleration, force, and energy relationships in clear technical reports. *(LO 4.1, LO 4.2, LO 4.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL101.1	3	3	-	-	-	-	-	3	3	-	-
ESL101.2	3	3	-	-	-	-	-	3	3	-	-
ESL101.3	3	3	-	-	-	-	-	3	3	-	-
ESL101.4	3	3	-	-	3	-	-	3	3	-	-
Average	**3**	**3**	-	-	**3**	-	-	**3**	**3**	-	-

Text Books :

1. Engineering Mechanics by A K Tayal, Fourteenth Edition, 2011 Umesh Publication.
2. Engineering Mechanics by F. L. Singer, Third Edition, 1975, Harper & Raw
3. Engineering Mechanics by R. C.Hibbeler , Fourth Edition, 2017, Pearson Education

Reference Books :

1. Engineering Mechanics by Beer &Johnston, Fourth Edition, 1987 ,Tata McGraw-Hill
2. Engineering Mechanics (Statics) by Meriam and Kraige, Fourth Edition, 1999 Wiley Books

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment – Lab Session

1. Practical performance based on all the experiments mentioned in the syllabus with proper understanding : 10 Marks
2. Oral evaluation on experiments conducted on Statics :5 Marks
3. Oral evaluation on experiments conducted on Dynamics:5 Marks
4. Regularity and active participation: 5 Marks

Course Type	Course Code	Course Name	Credits
ESL	ESL102	BASIC ELECTRICAL ENGINEERING LABORATORY	01

Examination Scheme		
Continuous Assessment	End Semester Exam(ESE)	Total Marks
25	25	50

Pre-requisite:

1. ESC102: Basic Electrical Engineering

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO 2: Problem Analysis
3. PO4: Conduct investigations of complex problems
4. PO8: Individual and teamwork
5. PO9: Communication

Course Objectives:

1. To impart the knowledge on the analysis and applications of D.C. circuits and single-phase AC circuits.
2. To impart the knowledge on the elements of residential electrical system, appliances and electrical safety.
3. To impart the knowledge on the construction, working principle of transformer and motors and selection of motor for a specific application.

Module	Detailed Contents	Hrs
00	**Course Introduction** The Basic Electrical Lab course is designed to introduce fundamental concepts in electrical engineering through hands-on laboratory experiments. Through a series of practical exercises, students will develop essential skills for working with basic electrical components and circuits.	**01**
01.	**Experiment:** Analyze DC circuit using mesh and nodal analysis by assembling the given circuit on a breadboard and verifying the results through manual calculations.	**04**
	Learning Outcomes: *A learner will be able to* *LO1.0 Assemble given circuit on breadboard to verify Ohm's law, Kirchhoff's laws, mesh analysis and nodal analysis practically by using DC power supply, multimeter, ammeter and voltmeter in a group. Compare practical results with theoretical calculations and prepare a detailed report. (P.I.-1.3.1,1.4.1, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
02.	**Experiment:** Analyze the given DC circuit using Thevenin's, Norton's, and Maximum Power Transfer theorems through practical implementation and theoretical calculations.	**03**

	Learning Outcomes: *A learner will be able to* *LO2.0 Assemble circuit on breadboard and use DC power supply, multimeter, ammeter and voltmeter for measuring current and voltage in DC circuits in a group to verify Thevenin's theorem, Norton's theorem and Maximum power transfer theorem in a DC circuit and summarize results in a report. (P.I.-1.3.1,1.4.1, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
03.	**Experiment:** Determine the inductance and resistance of the choke coil in series circuit and verify the results by manual calculation.	**02**
	Learning Outcomes: *A learner will be able to* *LO3.0 Determine the inductance of a choke coil by measuring the voltage across and current through a series and parallel connected resistance and choke coil and summarize the results in a report. (P.I.-1.3.1,1.4.1, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
04.	**Experiment:** Measure the resonant frequency in RLC series and parallel circuit and plot current vs frequency curve.	**04**
	Learning Outcomes: *A learner will be able to* *LO4.0 Measure the resonance frequency in RLC series and parallel circuit and plot resonance curve. (P.I.-1.3.1,1.4.1, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
05.	**Experiment:** Prepare test boards / extension boards and mount accessories like lamp holders, various switches, sockets, fuses, MCB, ELCB, MCCB etc. Identify make and rating of above devices used in your house.	**04**
	Learning Outcomes: *A learner will be able to* *LO5.0 Assemble small electrical circuits like test boards / extension boards similar to residential wiring system along with safety devices and submit a report. (P.I.-1.3.1,1.4.1, 2.1.2, 2.2.4, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
06.	**Experiment:** Wire up PVC conduit wiring to control one lamp from two different places.	**02**
	Learning Outcomes: *A learner will be able to* *LO6.0 Demonstrate the ability to design and implement a two-way control circuit using PVC conduit wiring to operate a lamp from two locations in a group. (Staircase wiring) (P.I.-4.1, 4.1,3, 4.1.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
07.	**Experiment:** Dismantle and assemble electrical parts of domestic electric appliances like electric iron, fan etc.	**02**
	Learning Outcomes: *A learner will be able to* *LO7.0 Maintenance and up-keeping of household electrical appliances and submit a report in a group. (P.I.- 1.4.1, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
08.	**Experiment:**	**02**

	Verify terminals, polarity, identify components and calculate transformation ratio of single-phase transformers. ***Learning Outcomes:*** *A learner will be able to* *LO8.0 Verify terminals, polarity, study the name plate details and calculate transformation ratio of single-phase transformers. (P.I.-2.1.2, 2.2.4, 8.1.1,8.1.2, 9.1.2, 9.1.3)*	
09.	**Experiment:** Identify and understand the construction and function of various parts of electric motors through visual inspection and hands-on exploration. ***Learning Outcomes:*** *A learner will be able to* *LO9.0 Recognize and explain the construction, components, and functional aspects of different types of electric motors through practical observation and interaction. (P.I.- 8.1.1, 8.1.2, 9.1.2, 9.1.3)*	**02**
10.	**Experiment:** Study and identify suitable types of electrical motors for specific applications based on their characteristics and operational requirements. ***Learning Outcomes:*** *A learner will be able to* *LO10.0 Identify and select appropriate types of electrical motors for various applications by analyzing their characteristics and functional requirements.(P.I.-2.1.2, 2.2.4, 8.1.1, 8.1.2, 9.1.2, 9.1.3)*	**04**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.2.1	Design and develop experimental approach, specify appropriate equipment and procedures
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents.
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

Course Outcomes:

Learner will be able to

1. Assemble the DC and AC circuits on breadboard and test the continuity. *(LO1.0, LO2.0, LO3.0, LO4.0, LO5.0)*

2. Select the meters to measure the required variables and analyse the performance of DC and AC circuits. *(LO1.0, LO2.0, LO3.0, LO4.0)*
3. Assemble simple residential electrical wiring incorporating safety devices. (*LO5.0, LO6.0)*
4. Select motor for household applications and test the transformer. (*LO7.0, LO8.0, LO9.0, LO10.0)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL102.1	3	-	-	3	-	-	-	3	3	-	-
ESL102.2	3	-	-	3	-	-	-	3	3	-	-
ESL102.3	3	3	-	3	-	-	-	3	3	-	-
ESL102.4	-	3	-	-	-	-	-	3	3	-	-
Average	**3**	**3**	-	**3**	-	-	-	**3**	**3**	-	-

Text Books:

1. Electrical Power Systems, S.L. Uppal and Prof. Sunil S. Rao 15th Edition, Khanna Publishers
2. Basic Electrical Engineering, B.R Patil, 2nd Edition Oxford Higher Education, 2019
3. Art & Science of Utilization of electrical Energy, H Partab, Dhanpat Rai & Co., 2004.
4. Electrical and Electronic Measurements and Measuring Instruments, A K Sawhney Dhanpat Rai and Sons
5. Special Electrical Machines, E G Janardanan PHI 2014
6. Electrical Power Systems, S.L. Uppal and Prof. Sunil S. Rao, 15th Edition, Khanna Publishers

Reference Books:

1. Power System Engineering, D P Kothari and I J Nagrath 3rd Edition, Mac Graw Hills,
2. Electrical Engineering Fundamentals, Vincent Del Toro, PHI Second edition, 2011
3. Utilization of Electric Power & Electric Traction, J B Gupta, 10th Edition, Dhanpat Rai and Sons 2012
4. Electrical Engineering, B.L.Theraja Vol-I and II
5. Basic Electrical Engineering, S.N.Singh PHI, 2011

Other Resources:

1. NPTEL course on Basic Electrical Technology, IISc Bangalore Prof. L. Umanand https://nptelvideos.com/course.php?id=460
2. Virtual Lab - https://asnm-iitkgp.vlabs.ac.in

CONTINUOUS ASSESSMENT (25 Marks)

1. Practical Exercises – 10 Marks

1. Readiness to perform experiment (2 Marks),
2. Performance (2 Marks),
3. Report writing (2 Marks),
4. Interpretation of result (2 Marks),

5. Regularity in submission (2 Marks).

2. **Practical Test 1** (Based on first 50% of practical list) – 5 Marks
3. **Practical Test 2** (Based on remaining 50% of practical list) – 5 Marks
4. Regularity and active participation – 5 Marks

END SEMESTER ASSESSMENT (25 Marks)

Two examiners, one internal and one external will do the evaluation

1. Students will be randomly allocated and experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table with relevant formulae. It will be checked by the examiners and evaluated out of 05 Marks.
2. Then the student will be allowed to start with the performance of the experiment.
3. Students will be given 1 hour to complete the circuit connection and take readings. The connections and output are verified by the examiners. The weightages 05 Marks.
4. Students will do sample calculations, draw relevant graphs and write conclusion of the experiment. It will be checked by the examiners and evaluated out of 05 Marks.
5. Students will be appearing for Oral test front of both Internal and External examiners. The weightage of Oral test will be of 10 marks.

Course Type	Course Code	Course Name	Credits
ESL	ESL103	PROGRAMMING LABORATORY-I (C)	02

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total Marks**
50	50	100

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering tool usage
4. PO11: Life-long learning

Course Objectives:

1. To provide exposure to problem-solving by developing an algorithm, flowchart and implement the logic using C programming language.
2. To familiarize basics of Conditional and Looping Control Structures in C.
3. To provide exposure about function definition, declaration and its usage and recursive functions.
4. To familiarize one and multi-dimensional arrays and strings in C.
5. To provide exposure about structure, pointers, operations on pointers and dynamic memory allocation in C programming language.

Module	Details	Hrs.
00.	**Course Introduction** Knowledge of problem solving and programming concepts is essential for those who develop applications for users. This course imparts basic knowledge in C programming along with the concepts of design and development of programs using C.	**01**
01.	**Introduction to Algorithm, Flowchart and C.** ***Learning Objective:*** *Learner is expected to recall basics of algorithm, flowchart and C. Also expected to understand problem-solving approach and apply the logic to implement program using C. Investigate the functioning of various components of the given control system as a team*	
	Contents: Basic Concept of Problem solving, Introduction to Algorithm and Flowchart. Character Set, Identifiers and keywords, Data types, Constants, Variables. Operators-Arithmetic, Relational and logical, Assignment, Unary, Conditional, Bitwise, Comma, other operators. Expression, statements, Library Functions, Preprocessor. Data Input and Output. Structure of C program. **Task 1:** Algorithm and flowchart to find greatest of three numbers, sum of N natural numbers. *LO 1.1: A learner will be able to apply fundamental problem solving technique to break the problem into logical steps using algorithm and use symbols of*	**07**

	flowchart to translate problem statements into visual representation. (P.I. - 1.1.1, P.I. - 1.3.1) **Task 2:** C program to calculate 40% da from basics, 20% hra from basics. Also calculate the gross salary of an employee. (GS=BS+DA+HRA) *LO 1.2: A learner will be able to identify the datatypes, variables and operators to be used to solve the problem and use tools like Devcpp to validate the result. (P.I. - 2.1.2, P.I. - 2.2.3, P.I.-5.3.2)*	
02.	**Control Structures in C** ***Learning Objective:*** *Learner is expected to recall basics of Control Structures and understand Conditional structures. Also expected to apply it to solve problems in C.* **Contents:** Branching - If statement, If-else Statement, Multiway decision. Looping – while, do-while, for Nested control structure- Switch statement, Continue statement, Break statement, Goto statement. Logic building exercise on branching and looping statements. **Task 3:** C Program to compare two numbers and determine whether they are odd or even. *LO 2.1: A learner will be able to identify the variables, datatypes and use if else branching statement to solve the problem and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.3, P.I.-5.3.2)* **Task 4:** C Program to find percentage marks of four subjects. Then determine whether the student has secured distinction, first class, second class or fail. Percentage >=75 Distinction, Percentage >= 60 First class, Percentage >= 40 second class etc. *LO 2.2: A learner will be able to identify the variables, datatypes and use else-if-else branching statement to solve the problem and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.3, P.I.-5.3.2)* **Task 5:** C Program to print numbers between 1 and 100 which are multiples of 5 by using do while loop. *LO 2.3: A learner will be able to identify the variables, datatypes and use for looping statement to solve the problem and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.3, P.I.-5.3.2)*	**16**
03.	**Functions in C** ***Learning Objective:*** *Learner is expected to recall function definition, declaration. and understand its usage. Also expected to apply it to solve problems in C.* **Contents:** Function -Introduction of Function, Function Main, Defining a Function, Accessing a Function, Function Prototype, Passing Arguments to a Function, Recursion. Storage Classes and its types. Logic building exercise on user defined functions. **Task 6:** C Program to create a user defined function with arguments and no return value for addition of two numbers.	**12**

	LO 3.1: A learner will be able to identify the variables, datatypes and use function with arguments and no return value to solve the problem and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.3, P.I.-5.3.2) **Task 7:** C Program to find Fibonacci series for given no of elements using recursive function. *LO 3.2: A learner will be able to identify the variables, datatypes and reframe the problem to use recursive function to get the solution and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.1, P.I.- 5.3.2)*	
04.	***Arrays, Strings in C*** ***Learning Objectives:*** *Learner is expected to recall one dimensional arrays and understand its usage and apply it to solve problems in C.*	**12**
	Contents: Array-Concepts, Declaration, Definition, Accessing array element, One-dimensional and Multidimensional array. String- Basic of String, Array of String, Functions in string.h. Logic building exercise on arrays and strings. **Task 8:** C Program to sort elements in ascending order in an array. *LO 4.1: A learner will be able to identify the variables, datatypes and reframe the problem to use arrays to get the solution and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.1, P.I.- 5.3.2)* **Task 9:** C Program to check if string is palindrome or not. *LO 4.2: A learner will be able to identify the variables, datatypes and reframe the problem to use strings to get the solution and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.1, P.I.- 5.3.2)*	
05.	**Structures and Pointers in C** ***Learning Objective/s:*** *Learner is expected to recall pointers, operations on pointers and its usage and apply it to solve problems in C.*	**12**
	Contents: Structure- Declaration, Initialization, structure within structure, Operation on structures, Array of Structure. Pointer: Introduction, Definition and uses of Pointers, Address Operator, Pointer Variables, Pointer Arithmetic, Pointers to Pointers, Pointers and Array, Passing Arrays to Function, Pointers and Function, Pointers and two-dimensional Array, Array of Pointers, Dynamic Memory Allocation. Logic building exercise on pointers. **Task 10:** C Program to create a structure to enter details for 5 students. The details are name, branch, roll no and marks of five different subjects. Also calculate the total marks and arrange them in ascending order. *LO 5.1: A learner will be able to identify the variables, datatypes and reframe the problem to use structure to get the solution and adapt and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I. - 2.2.1, P.I.- 5.1.2, P.I.- 5.3.2)* **Task 11:** C Program to create, initialize, assign and access a pointer variable. *LO 5.2: A learner will be able to identify the variables and use pointer to get the solution and adapt and use Devcpp to validate the result. (P.I. - 1.3.1, P.I. - 2.1.2, P.I.- 5.1.2, P.I.- 5.3.2)* **Task 12:** C Program to demonstrate dynamic memory allocation *LO 5.3: A learner will be able to identify the variables, datatypes and use pointer to get the solution, adapt and use Devcpp to validate the result and identify new updates like dynamic memory management in C for writing efficient programs*	

	(P.I. - 1.3.1, P.I. - 2.1.2, P.I.- 5.1.2, P.I.- 5.3.2, P.I- 11.1.1 P.I- 11.2.1)	
	Course Conclusion	**01**
	Total	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solve problems.
1.3.1	Apply engineering fundamentals.
2.1.2	Identifies processes/modules/algorithms of a computer based system and parameters to solve a problem
2.2.1	Reframe the computer-based system into interconnected subsystems
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use
11.1.1	Describe the rationale for the requirement for continuing professional development
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.

Course Outcomes: A learner will be able to -

1. Implement the basic terminology used in computer programming concept of data types, variables and operators using C. (*LO 1.1, LO 1.2*)
2. Use control structure concepts in C programming (*LO 2.1, LO 2.2, LO2.3*)
3. Develop functions and use it to solve problems in C using modern tools. (*LO 3.1, LO 3.2*)
4. Apply arrays and strings to solve problems in C. (*LO 4.1, LO 4.2*)
5. Demonstrate the use of structures, dynamic memory allocation and pointers in C. (*LO 5.1, LO 5.2, LO 5.3*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL103.1	3	3	-	-	3	-	-	-	-	-	-
ESL103.2	3	3	-	-	3	-	-	-	-	-	-
ESL103.3	3	3	-	-	3	-	-	-	-	-	-
ESL103.4	3	3	-	-	3	-	-	-	-	-	-
ESL103.5	3	3	-	-	3	-	-	-	-	-	3
Average	3	3	-	-	3	-	-	-	-	-	3

Text Books :

1. The C Programming Language, Brian W. Kernighan, Dennis M. Ritchie, Second Edition, 2015, Pearson Education India.
2. Programming with C, Byron S. Gottfried, Fourth Edition, 2018, Tata McGraw-Hill Publications.

3. Programming in ANSI C, E. Balaguruswamy, Eighth edition, 2019, Tata McGraw-Hill Publications.

Reference Books :

1. Programming in C, Pradeep Day and Manas Gosh, Second Edition, 2013, Oxford University Press.
2. Let Us C: Authentic Guide to C Programming Language, Yashwant Kanetkar, Nineteenth Edition, 2023, BPB Publication.

Other Resources :

1. NPTEL Course: Introduction to Programming in C By Prof. Satyadev Nandakumar, Department of Computer Science and Engineering, IIT Kanpur
   Web link- https://archive.nptel.ac.in/courses/106/104/106104128/
2. Problem Solving through Programming in C By Prof. Anupam Basu, Department of Computer Science and Engineering Engineering, IIT Kharagpur
   Web link- https://archive.nptel.ac.in/courses/106/105/106105171/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Task Execution (30 Marks)

Students will be given minimum 12 tasks.

Students are expected to

1. Identify variables, data types methods/approach required to write the code for the given task and apply the same.
2. Gain knowledge of Operators, data input and output concept
3. Recall basics of control structures and apply it to solve problems in C.
4. Execute given task for different inputs and verify the result
5. Execute the function and integrate the functions for task completion.
6. Create a 1D, 2D array to solve problem.
7. Apply structure concept to solve the problem.
8. Apply concept of pointers to solve the problem.

Students will be evaluated based on following:

1. Logic building for the given task (10 marks)
2. Rectifying logical errors and syntax errors (06 marks)
3. Well-structured and organized program (06 marks)
4. Verification of experiment output for different inputs (08 marks)

Refer the sample task given below.

Example: Write a menu driven C program to perform different calculations using function,

Students are expected to,

1. Identify variables, data types and functions to be used in the program.
2. Execute given task for different inputs and verify the result
3. Follow the coding standards
4. Identify errors and rectify the errors.

2. Regularity and active participation: (05 Marks)

3. Practical Test (15 Marks)

a) Task Execution: 10 Marks

1. Logic building for the given task (04marks)
2. Rectifying logical errors and syntax errors (02 marks)
3. Well-structured and organized program (02 marks)
4. Verification of experiment output for different inputs (02 marks)

b) Oral: 05 Marks

END SEMESTER EXAMINATION (Practical & Oral Exam) (50 Marks)

1. Task Execution: 15 Marks

   Students will be given task (different task for every student) to execute and will be evaluated as per the parameters mentioned in continuous evaluation
2. Presentation of Results and conclusion, Inferences drawn: 05 Marks
3. Multiple Choice Questions based on entire syllabus: 15 Marks
4. Oral based on entire syllabus: 15 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
SEC	SEC101	BASIC WORKSHOP PRACTICE I	01

Examination Scheme		
Term Work	**Practical /Oral**	**Total**
50	--	50

Pre-requisite :

There are no specific prerequisites for this course. However, students should have a willingness to learn and a commitment to safety.

Program Outcomes addressed :

1. PO1:Engineering knowledge
2. PO5: Engineering tool usage
3. PO6: The engineer and the world
4. PO8: Individual and collaborative team work
5. PO11: Life-long learning

Course Objectives :

1. To impart training to help the students develop engineering skill sets.
2. To inculcate respect for physical work and hard labour.
3. To get exposure to interdisciplinary engineering domain.

Module	Details	Hrs
00.	**Course Introduction** The Basic Workshop Practice I course is intended to give participants with the core information and abilities required for working safely and effectively in a workshop environment. This hands-on course introduces the fundamental principles, equipment, and techniques utilised in a variety of workshop scenarios, such as fitting, hardware and networking, and welding.	**01**
01.	***Learning Objectives:*** *1. To familiarize participants with reading and interpreting technical drawings, and schematics related to fitting tasks.* *2. To enhance participants' proficiency in fitting various components or materials together accurately and securely using various fitting tools.* *3. To make participants learn to use precision measuring tools to verify part dimensions and ensure quality control.*	**09**
	Content: Fitting • Use and setting of fitting tools for chipping, cutting, filing, marking, center punching, drilling, tapping. • Term work to include one job involving following operations: filing to size, one simple male- female joint, drilling and tapping.	
	Learning Outcomes :	

	A learner will be able to *LO1.1: Read and interpret technical drawings, or schematics related to fitting tasks, identifying dimensions, tolerances, and other specifications accurately. (P.I.- 1.3.1, 11.3.1)* *LO1.2: Demonstrate proficiency in fitting techniques. (P.I.- 5.3.1)* *LO1.3: Competent in the effective use of precision measuring tools to examine work pieces, confirm dimensions, and ensure adherence to quality requirements and standards. (P.I.- 1.4.1, 5.2.2, 11.3.1, 11.3.2)*	
02.	***Learning Objectives:*** *1. To gain a comprehensive understanding of computer hardware components and peripheral devices.* *2. To learn how to assemble a computer system, set up and configure network infrastructure components, including routers, switches, access points, and cables, to create a functional network environment.* *3. To develop the skills to diagnose and troubleshoot common hardware and network problems.*	**10**
	Content: Hardware and Networking • Dismantling of a Personal Computer (PC), Identification of components of a PC such as power supply, motherboard, processor, hard disk, memory (RAM, ROM), CMOS battery, CD drive, monitor, keyboard, mouse, printer, scanner, pen drives, disk drives, etc. • Assembling of PC, Installation of Operating System (Any one) and Device drivers, Boot-up sequence. Installation of application software (at least one). • Basic troubleshooting and maintenance. • Identification of network components: LAN card, wireless card, switch, hub, router, different types of network cables (straight cables, crossover cables, rollover cables) Basic networking and crimping.	
	Learning Outcomes : *A learner will be able to* *LO2.1: Identify and understand the various hardware components of a computer system. (P.I.- 5.1.2, 11.1.1)* *LO2.2: Assemble a computer system, set up and configure network infrastructure components to create a functional network environment. (P.I.- 1.2.1, 5.2.2, 11.2.1)* *LO2.3: Develop the skills to diagnose and troubleshoot common hardware and network problems. (P.I.- 1.3.1, 6.1.1, 6.3.1)*	
03.	***Learning Objectives:*** *1. To understand welding symbols and their meanings as per standard welding blueprints. Interpret welding drawings and specifications accurately.* *2. To become familiar with welding equipment, including welding machines, electrodes, torches, gas cylinders, filler metals, and other tools. Learn how to set up and operate welding equipment safely and efficiently.* *3. To develop proficiency in various welding techniques such as lap welding, butt welding, fillet welding, and groove welding. Practice achieving proper weld bead geometry, penetration and fusion.*	**08**
	Content: Welding	

	• Introduction to welding equipment. Edge preparation for welding jobs. Arc welding for different job like, lap welding of two plates, butt welding of plates with simple cover, arc welding to join plates at right angles. One job on gas welding.	
	Learning Outcomes : *A learner will be able to* *LO3.1: Interpret welding symbols and blueprints accurately, understanding weld joint designs, dimensions, and specifications as per industry standards. (P.I.- 8.3.1, 11.3.1)* *LO3.2: Produce welds that meet industry standards and specifications, demonstrating the ability to achieve proper weld penetration, fusion, and surface finish while minimizing defects such as porosity, lack of fusion, and undercutting. (P.I.- 1.3.1, 1.4.1, 5.2.2, 5.3.1, 6.1.1, 6.3.1, 8.1.1, 11.3.2)*	
04.	***Learning Objectives:*** *1. To gain knowledge of the different parts of a lathe machine, including the bed, headstock, tailstock, carriage, tool post, chuck, and various controls.* *2. To gain an understanding of lathe operations such as turning between centers, chucking, facing, taper turning, and threading. Understand the sequence of operations and the appropriate use of cutting tools and feeds for each operation.*	**02**
	Content: Machine Shop • Machine Shop (Demo of one simple lathe job) (Only for Mechanical Engineering students, other department students can utilized this time to complete the pending work, if any).	
	Learning Outcomes : *A learner will be able to* *LO4.1: Identify different parts of a lathe machine and understand operations that can be carried out on it. (P.I.- 11.1.1, 11.3.1)*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
5.3.1	Discuss limitations and validate tools, techniques and resources.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.

11.1.1 Describe the rationale for the requirement for continuing professional development.

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.

11.3.1 Source and comprehend technical literature and other credible sources of information.

11.3.2 Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to

1. Develop the necessary skill required to handle/use different fitting tools. (*LO 1.1, LO 1.2, LO 1.3*)
2. Develop skill required for hardware maintenance and installation of operating system. (*LO 2.1, LO 2.2, LO 2.3*)
3. Identify the network components and perform basic networking and crimping. (*LO 2.1, LO 2.2, LO 2.3*)
4. Prepare the edges of jobs and do simple arc welding. (*LO 3.1, LO 3.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
SEC101.1	3	-	-	-	3	-	-	-	-	-	3
SEC101.2	3	-	-	-	3	3	-	-	-	-	3
SEC101.3	3	-	-	-	3	3	-	-	-	-	3
SEC101.4	3	-	-	-	3	3	-	3	-	-	3
Average	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**3**	**-**	**-**	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Continuous Internal Assessment (CIA) - (50 Marks)

Job Work with complete workshop book : 40 Marks

Attendance and Active participation : 10 marks

Course Type	Course Code	Course Name	Credits
VEC	VEC101	UNIVERSAL HUMAN VALUES	02

Program Outcomes addressed:

1. PO6 : The Engineer & The World
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To help the student see the need for developing a holistic perspective of life.
2. To sensitize the student about the scope of life – individual, family (inter-personal relationship), society and nature/existence
3. To strengthen self-reflection.
4. To develop more confidence and commitment to understand, learn and act accordingly

Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
Welcome and Introductions	Getting to know each other	Self-exploration
Aspirations and Concerns	Individual academic, career… Expectations of family, peers, society, nation… Fixing one's goals	Basic human aspirations Need for a holistic perspective Role of UHV
Self-Management	Self-confidence, peer pressure, time management, anger, stress… Personality development, self-improvement…	Harmony in the human being
Health	Health issues, healthy diet, healthy lifestyle Hostel life	Harmony of the Self and Body Mental and physical health
Relationships	Home sickness, gratitude towards parents, teachers and others Ragging and interaction Competition and cooperation Peer pressure	Harmony in relationship Feelings of trust, respect… gratitude, glory, love
Society	Participation in society	Harmony in the society
Natural Environment	Participation in nature	Harmony in nature/existence
Total no. of hours: **30**		

Course Outcomes :

1. Analyze the significance of value inputs provided in formal education along with skills and develop a broader perspective about life and education
2. Formulate their aspirations and concerns at different levels of living, and the way to fulfill them in a sustainable manner.
3. Evaluate their current state of understanding and living, and model a healthy lifestyle
4. Examine the issues of home sickness, interactions with seniors on the campus, peer pressure with better understanding and feel grateful towards parents, teachers and others
5. Develop more confidence and commitment for value-based living in family, society and nature

Text Books :

1. Human values & Professional Ethics by R. R.Gaur, R Sangal, G. P.Bagaria, 2010, Excel Books , New Delhi

Reference Books :

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, Published by 2004 by New Age Intl. Publishers, New Delhi.
3. The Story of Stuff by Annie Leonard, published in 2010 by Free Press.
4. Small is Beautiful by E. F. Schumacher, published in 1973 by Harper & Row.
5. Slow is Beautiful by Cecile Andrews, published in 2006 by New Society Publishers

Other Resources :

1. NPTEL Course: Exploring Human Values: Visions of Happiness and Perfect Society, By Prof. A.K. Sharma, Department of Humanities and Social Sciences, IIT Kanpur:-Web link- https://nptel.ac.in/courses/109104068
2. NPTEL Course: Moral Thinking: An Introduction To Values And Ethics By Prof. Vineet Sahu, IIT Kanpur:-Web link- https://onlinecourses.nptel.ac.in/noc23_hs89/preview

Course Type	Course Code	Course Name	Credits
BSC	BSC204	ENGINEERING MATHEMATICS-II	04

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)	MSE	ESE	
Continuous Assessment	Mid-Semester Exam (MSE)				
20	30	50	1.5	2	100

Pre-requisite :

1. Differentiation of several variable I & II
2. Integration
3. Beta and Gamma Function

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO8: Individual and Collaborative Teamwork
4. PO 11: Life Long Learning

Course Objectives:

1. To provide the Basic knowledge of the concepts of Mathematics applicable to the field of engineering.
2. To build a mathematical foundation of the methodology required for solving application based problems in the field of Engineering.

Module	Detailed Contents	Hrs
00.	Mathematics is the fundamental step which creates a solid foundation for all Applied fields of Engineering. Professional Engineering applications have Mathematics as an integral part of their evolution. For example: Formulation in Mathematics to various engineering field using case study. Introduction to differential equations from Electrical circuit. Introduction to Multiple Integration from real life application. Hence, Formulation Based Mathematics is a fundamental requisite to all fields of Engineering for analyzing their performances.	**01**
01.	**Differential Equations of First Order and First Degree** ***Learning Objective/s:*** *Learner will be able to* 1. *Analysis and interpretation of the basic fundamentals of differential equations (D.E) of first order & first degree.* 2. *Determination of the solution of a first order D.E by applying the basic concepts of exact and linear DE.*	**08-10**

	Contents: Definition, Formation of Differential equation, Exact differential Equations, Non Exact Differential Equation, Integrating Factors, Rules for finding the integrating factor, Linear Differential Equations, Equation reducible to Linear form , Bernoulli's equation.	
	Self-Learning Topics: *Application of differential equations of First Order and First Degree in electrical circuits and thermodynamics.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1 : Apply the differential techniques to identify and classify different differential equations including exact, linear and Bernoulli's equation. (PI;1.1.1, PI: 11.1.3)* *LO 1.2 : Identify whether the given differential equation is exact and linear DE. (PI: 2.1.3).* *LO 1.3: Identify the process of reducing given DE into linear DE and solve it. (PI: 2.2.3).* *LO 1.4 : Apply the fundamental engineering concepts to model a first order DE and demonstrate solution process and results within a team .(PI; 1.3.1 , PI: 8.2.1)* *LO 1.5) : Engage in a team-based project where members individually contribute to different aspects of solving and interpreting a first-order differential equation derived from a given engineering problem, culminating in a coordinated group presentation.(PI: 8.3.1)* *LO 1.6: Identify the differential equation and recognize how advancements in engineering applications (such as control systems, fluid mechanics, and electrical circuits) historically required continuous learning in differential equation methods to stay current with technological innovations.(PI: 11.2.1)*	
02.	**Linear Differential Equations with Constant Coefficients of Higher Order type f(D)y = X** ***Learning Objective:*** *Learner will be able to* *1. Analysis and interpretation of the basic fundamentals of higher order differential equations (HODE).* *2. Determination of the solution of a HODE by applying the basic concepts of complementary function and particular integral.*	**12-14**
	Contents: **Complementary Function, Particular Integral, Type 1. X = e^{ax}, Type 2 X = x^n ,Type 3 X = $cos(ax+b) or\ sin(ax+b)$,Type 4 X = $e^{ax}V$** **Type 5 X = xV, General Type - Method of variation of parameters**	

	Self-Learning Topics: 1. *Differential equations with Variable Coefficients* 2. *(Cauchy's and Legendre's Linear Differential Equations)* 3. *Applications of Higher Order Linear Differential Equations to develop a mathematical model of linear differential equations.*	
	Learning Outcomes: *LO 2,1: Identify the correct type of non-homogeneous term (e.g., exponential, polynomial, trigonometric) and select the appropriate solution method. (PI :2.2.3)* *LO 2.2: Apply the method of variation of parameters to solve nonhomogeneous second-order differential equations. (PI: 1.1.1)* *LO 2.3: Identify the appropriate method to determine the complementary function and particular integral for getting the general solution of HODE.(PI: 2.1.3)* *LO 2.4: Apply the appropriate method to determine the general solution of HODE.(PI: 1.2.1)*	
03.	**Double Integration in Cartesian coordinate** ***Learning Objectives:*** 1. *Analysis of the fundamentals of Double integration in different coordinate systems (Cartesian and polar) and apply it to solve problem.* 2. *Application of the concepts of double integrations to evaluate area and mass of the Lamina*	**13-15**
	Contents: **Tracing of standard curve** **Definition, Evaluation of Double Integrals,** **Change the order of integration, Evaluation of double integrals by changing the order of Integration, Evaluation of integrals over the given region.**	
	Self-Learning Topics: Double integration in Elliptical polar coordinate	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Compare the efficiency of solving double integrals by direct evaluation versus changing the order of integration and select the best one to solve the given problem.. (P.I.-2.2.4)* *LO 3.2: Reframe a complex region of integration into sub-regions to simplify the evaluation of a double integral. (P.I.-2.2.1).* *LO 3.3: Apply the fundamentals of integration of a function of single variable to solve problem in double integration in Cartesian coordinate system. (P.I.-1.1.1)* *LO 3.4: Apply the appropriate method to evaluate a double integral in Cartesian coordinate system by using the law of integration. (PI :1.2.1)* *LO 3.6: Identify the need of double integration in Cartesian coordinates and utilise the relevant concepts to solve real-world problems like heat transfer in thermal systems, fluid flow in pipelines, and electrical potential in electromagnetic fields.(PI: 11.1.3)* *LO 3.7: Analyze and state the need of how staying updated with current double integral in Cartesian coordinates-based computational tools and methods contributes to lifelong learning and enhances problem-solving skills in professional engineering practice. (P I 11.2.1)*	

04.	**Double Integration in Polar coordinate** ***Learning Objective/s:*** *1. Analysis of the fundamentals of Triple integration in different coordinate systems and application of it to solve problem.* *2. Application of the concepts of triple integrations to evaluate volume of a solid.*	**10-12**
	Content: **Tracing of standard curve(Polar)** **Evaluation, Evaluation of double integrals by changing to polar Co-ordinates, Evaluation of integrals over the given region.** **Application of double integrals to compute Area, Mass of a lamina.**	
	Self-Learning Topics: Moment of inertia of a plane lamina	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the fundamentals of integration of a function of single variable to solve problem in double integration in polar coordinate system. (P.I.-1.1.1)* *LO 4.2: Apply the knowledge of Jacobian when changing from Cartesian to polar coordinates in order to evaluate a double integrals.(PI: 1.2.1)* *LO 4.3: Compare the efficiency of solving double integrals by direct evaluation versus changing into polar coordinate system of integration and select the best one to solve the given problem.. (P.I.-2.2.4)* *LO 4.4: Reframe a complex region of integration into sub-regions to simplify the evaluation of a double integral in polar coordinate system.. (P.I.-2.2.1).* *LO 4.5: Lead a group project or presentation on the applications of double integrals (area and Mass of Lamina) by demonstrating problem solving and analytical thinking,. (PI: 8.2.1)* *LO 4.6: Collaborate in teams to present solution involving area under curves and mass of a Lamina using double integral, showcasing effective communication and individual contribution. (PI: 8.3.1)*	
05.	**Triple integration** ***Learning Objective/s:*** *1. Analysis of the fundamentals of Triple integration in different coordinate systems and apply it to solve problem.* *2. Application of the concepts of triple integrations to evaluate volume of a solid.*	
	Contents: **Definition, Evaluation of Triple Integral using Cartesian coordinates, Evaluation of Triple Integral using cylindrical coordinates, Evaluation of Triple Integral using Spherical coordinates.** **Application of triple integrals to compute Volume and Mass of solid.**	**9-11**
	Self-Learning Topics: Moment of inertia of a solid.	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply the fundamentals of integration of a function of single variable to solve problem in triple integration in different coordinate system. (P.I.:1.1.1)* *LO 5.2: Apply the knowledge of Jacobian when changing from Cartesian to spherical polar*	

	and cylindrical polar coordinates in order to evaluate a triple integrals(PI: 1.2.1) *LO 5.3 : Compare alternative integration approaches (evaluation in different coordinate systems) and select the optimal solution path to evaluate the integral.(PI 2.2.4)* *LO 5.4: Identify the appropriate mathematical knowledge of triple integrals and different coordinate systems needed to solve problems involving three-dimensional solids.(PI: 2.1.3)*	
06.	**Numerical solution of ordinary differential equations of first order and first degree** ***Learning Objective/s:*** *Application of the concepts of numerical methods to solve the ordinary differential equation.*	**9-11**
	Contents: Numerical solution of ordinary differential equation using (a) Taylor's series method (b) Euler 's method (c) Modified Euler method, (d) Runge-Kutta fourth order method	
	Learning Outcomes: *The learner will be able to* *LO 6.1: Identify numerical methods such as Taylor's series method, Euler's method, modified Euler's method and R K method of fourth order for solving ODE.(PI: 2.1.3)* *LO 6.2: Identify appropriate process based on the type of the given differential equation for solving the DE numerically.. (PI: 2.2.3)* *LO 6.3: Apply appropriate method to solve the differential equation numerically.(PI : 1.1.1)* *LO 6.4: Apply engineering systems such as electrical circuits, mechanical vibrations, or fluid flow to formulate the ODE and solve it numerically.(PI: 1.3.1)* *LO 6.5: Compare analytical and numerical solutions for the same differential equation* ***and*** *evaluate accuracy.(PI: 2.2.4)*	
	Course Conclusion	**01**
Total		**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques as calculus/algebra to solve problems.
1.2.1	Apply laws of natural science to a mathematical problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problem.
2.1.1	Articulate problem statements and identify objectives.
2.1.3	Identify the mathematical knowledge that applies to a given problem.
2.2.1	Reframe complex problems into interconnected sub-problems
2.2.3	Identify existing processes/solution methods for solving the Problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine mathematical principles and engineering concepts to formulate mathematical models of an engineering problem.
8.2.1	Demonstrate effective communication, problem solving, and conflict resolution and leadership skills.
8.3.1	Present result as a team, with smooth integration of contributions from all individual efforts.
11.1.3	Identify various mathematical concepts/theorems which can be utilised in the field of application based engineering.

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.

Course Outcomes:

A learner will be able to

1. Apply the fundamentals of first order Differential equation to analyze an Exact , Linear DE and solve it by applying the appropriate method (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6*)
2. Implement the fundamentals of Higher order DE to analyse the procedure to find complementary function and particular integral of higher order differential equation in order to evaluate the general solution.*(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Apply the fundamentals of double integration to analyse and evaluate the area and mass of a lamina. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7,LO 4.1 , LO 4.2, LO 4.3, LO 4.4, LO 4.5 , LO 4.6)*
4. Apply the fundamentals of triple integration to analyse and evaluate the volume and mass of a solid. *(LO 5.1 , LO 5.2, LO 5.3, LO 5.4)*
5. Implement the fundamentals of numerical methods to solve ordinary differential equation.(*LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSC204.1	3	3	--	--	--	--	--	3	--	--	3
BSC204.2	3	3	--	--	--	--	--	--	--	--	--
BSC204.3	3	3	--	--	--	--	--	3	--	--	3
BSC204.4	3	3	--	--	--	--	--	--	--	--	--
BSC204.5	3	3	--	--	--	--	--	--	--	--	--
Average	3	3	--	--	--	--	--	3	--	--	3

Text Books :

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication, forty fourth Edition, 2021
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited, Tenth Edition, 2011.
3. Advanced Engineering Mathematics, H.K.Das, S. Chand and Company Limited, Fourth Edition, 2018.

Reference Books:

1. Engineering Mathematics by Srimanta Pal and Subodh, C. Bhunia, Oxford University Press, First Edition, 2015
2. Engineering Mathematics by P. Sivaramakrishna Das and C. Vijayakumari, Pearson, First Edition, 2017
3. Applied Numerical Methods with MATLAB for Engineers and Scientists by Steven

Chapra, McGraw Hill,2017

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a. One MCQ Test + One Class Test: 05+05 = 10 Marks

b. One Team Pair Solo (TPS) activity: 05 Marks

c. Regularity and active participation :05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
BSC	BSC205	ENGINEERING PHYSICS-II	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer and The World

Course Objectives:

1. To provide the Basic knowledge on the concepts of physics pertaining to the field of engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of physics in the field of engineering.

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Crystal Structure** ***Learning Objective:*** • *To provide the fundamental knowledge of crystal structures.* • *To study the unit cell characteristics of a simple cubic structure .*	**3-5**
	Contents: Crystals: Unit cell: Space lattice, Basis and Crystal structure: Cubic Structures (SC, BCC and FCC): Unit cell characteristics for simple cubic: Unit cell volume, Number of atoms per unit cell, Coordination number, Atomic radius, Nearest neighbour distance, Packing fraction, Percentage of void space and Density.	
	Self-Learning Topics: *Crystals: Lattice parameters.*	
	Learning Outcomes: *A learner will be able to* *LO1.1: apply the knowledge of Lattice parameters of unit cell of a crystal to identify crystal structures. (P.I.- 1.2.1)* *LO1.2: apply the knowledge of unit cell characteristics to solve problems. (P.I.1.3.1)*	

	LO1.3: identify various parameters to study simple cubic structure. (P.I.- 2.1.2) *LO 1.4: identify the mathematical process to derive the unit cell characteristics of a simple cubic structure. (P.I.- 2.1.3)*	
02.	**Analysis of Crystal Structure** ***Learning Objective:*** • *To familiarize the concept of Miller Indices to represent the crystal planes.* • *To provide the knowledge of X-ray diffraction in analysis of crystal structure.*	**4-6**
	Contents: Crystal planes and Miller indices; Interplanar spacing: Relation between interplanar spacing and Miller indices for cubic unit cell. Diffraction of X-ray and Bragg's law; Bragg's spectrometer: Principle, Construction and working; Determination of crystal structure using Bragg's spectrometer.	
	Self-Learning Topics: - *Crystals: Lattice parameters.*	
	Learning Outcomes: *A learner will be able to* *LO2.1: apply the knowledge of miller indices to identify various planes in a crystal. (P.I.- 1.2.1)* *LO2.2: Additional: apply the knowledge of X-rays and diffraction in analysis of crystal structure. (P.I.- 1.3.1)* *LO2.3: apply the knowledge of miller indices, crystal planes and Bragg's law to solve the problems. (P.I.- 1.3.1)* *LO2.4: identify the mathematical process and knowledge of miller indices to derive the interplanar distance in a simple cubic structure (P.I.- 2.1.3)* *LO2.5: identify the mathematical process and knowledge of crystal planes to derive Bragg's law. (P.I.- 2.1.3)* *LO2.6: identify physical phenomena, components and process to analyse the crystal structure by using Bragg's spectrometer. (P.I.- 2.2.3)*	
03.	**Non-Crystalline Materials**	**3-5**
	Learning Objective: • *To gain the basic knowledge of non-crystalline solids.* • *To recognize the solids with amorphous structure and their importance in various applications.*	
	Contents: Structure: order and disorder, importance of short range order, properties of non-crystalline solid; Classes: metals/metalloid glasses, alloys of transitions metals with rare earth atoms. Silica glasses and related alloys.	
	Self-Learning Topics: Application of non-crystalline materials.	

	Learning Outcomes: *A learner will be able to* *LO3.1: apply the knowledge of various models to interpret the structure of non-crystalline material. (P.I.- 1.2.1)* *LO3.2: apply the knowledge of order and disorder to study the properties of non-crystalline material and differentiate them from crystalline material. (P.I.- 2.1.2)* *LO3.3: identify the component elements to differentiate the types of non-crystalline solids and their application. (P.I.- 2.1.2)*	
04.	**Magnetic and Dielectric Materials**	**6-8**
	Learning Objectives: • *To explore the properties of magnetic and dielectric materials.* • *To enhance the knowledge of magnetic and dielectric materials for practical applications.*	
	Contents: Magnetic materials: Ferromagnetism: Magnetization of ferromagnetic materials, hysteresis loop: soft and hard magnetic materials, Magnetoresistive materials, Applications of magnetic materials. Dielectric materials: Dielectric materials: Dielectric constant; Dielecctric polarization; Dielectric susceptibility; Dipoles; Nonpolar and polar dielectric, Applications of dielectric materials.	
	Self-Learning Topics: *Magnetization of materials.*	
	Learning Outcomes: *A learner will be able to* *LO4.1: apply the knowledge of physics of materials to study the magnetic and dielectric materials (P.I.- 1.2.1).* *LO4.2: apply the concept of magnetic and dielectric phenomena in materials to solve the problems. (P.I.- 1.3.1)* *LO4.3: identify various parameters to differentiate types of ferromagnetic materials and dielectric materials (P.I.- 2.1.2)* *LO4.4: identify the method to analyze the variation of magnetic flux density with magnetizing force in ferromagnetic materials. (P.I.-2.2.3)* *LO4.5: identify the applications of magnetic materials and dielectric materials to meet the public need. (P.I.- 6.1.1)* *LO4.6: identify the impact of retentivity and coercivity in soft and hard magnetic materials. (P.I.-6.1.2)*	
05.	**Nanomaterials** ***Learning Objective/s:*** • *To explore the basics of nanomaterials.* • *To recognize the applications of nanomaterials in current technology.*	**3-5**
	Contents: Introduction; Properties (Optical, electrical, magnetic, mechanical); Surface to volume ratio; Two main approaches in nanotechnology to	

	synthesize Nanomaterials (Bottom up technique and Top down technique); Synthesis methods: Ball milling; Chemical vapour deposition; Applications.	
	Self-Learning Topics : *Advantages and disadvantages of Ball milling and Chemical vapour deposition methods*	
	Learning Outcomes : *A learner will be able to* *LO5.1: apply the knowledge of physics of materials to study the properties and applications of nanomaterials. (P.I.- 1.2.1)* *LO5.2. apply the concept of surface area to volume ratio in nanomaterials to solve the problems. (P.I.- 1.3.1)* *LO5.3: identify top-down and bottom-up approaches to classify various synthesis methods of nanomaterials. (P.I.2.1.2).* *LO5.4: identify the components, process in various methods for the preparation of different nanomaterials. (P.I.-2.2.3)*	
06.	**Characterization Techniques of Nanomaterials**	**3-5**
	Learning Objective/s: • *To familiarize the tools for specific characterization of nanomaterials.*	
	Contents: Tools for characterization of Nanomaterials: Scanning Electron Microscope (SEM): Principle, construction, working and application; Transmission Electron Microscope (TEM): Principle, construction, working and application; Atomic Force Microscope (AFM) Principle, construction, working and application.	
	Self-Learning Topics: *Difference between optical and electron microscope*	
	Learning Outcomes: *A learner will be able to* *LO6.1: apply the knowledge of propagation of electrons to construct electron microscope. (P.I.1.3.1)* *LO6.2: identify the components, process and the physical phenomena involved in different characterizing tools (SEM, TEM and AFM) of nanomaterials. (P.I.-2.2.3)* *LO 6.3: identify the resolution of a device using light and electron beam to differentiate optical and electron microscope (P.I.2.1.2)* *LO6.4: identify the application of SEM, TEM and AFM for public use. (P.I.- 6.1.1)* *LO6.5: identify the impact environmental conditions which affect life cycles of SEM and TEM. (P.I.-6.1.2)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of physics to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
6.1.1	Identify and describe various role of science particularly as pertains to protection of the public and public interest at global, regional and local level.
6.2.2	Interpret and explain the limitations in the usage of devices for protection of the public.

Course Outcomes:

A learner will be able to -

1. Learner will be able to apply the knowledge of various parameters to study crystalline and non-crystalline solids.
(*LO1.1, LO1.2, LO1.3, LO1.4, LO3.1, LO3.2, LO3.3*)
2. Learner will be able to apply the fundamental knowledge of x-ray diffraction to analyse crystal structure (*LO2.1, LO2.2, LO2.3, LO2.4, LO2.5, LO2.6)*
3. Learner will be able to apply the fundamental knowledge of magnetic and dielectric materials in various technical fields by analyzing their intrinsic behaviours.
(*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*
4. Learner will be able to use the basic knowledge of nanomaterials and their characterization techniques to identify their applications in societal issues.
(*LO 5.1, LO 5.2, LO 5.3, LO 5.4,, LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO6.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSC205.1	3	3	-	-	-	-	-	-	-	-	-
BSC205.2	3	3	-	-	-	-	-	-	-	-	-
BSC205.3	3	3	-	-	-	3	-	-	-	-	-
BSC205.4	3	3	-	-	-	3	-	-	-	-	-
Average	**3**	**3**	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**

Text Books :

1. A Textbook of Engineering physics, Dr. M. N. Avadhanulu and Dr. P. G. Kshirsagar Revised Edition, 2014, S. Chand Publishing.
2. Engineering physics, R. K. Gaur and S. L. Gupta, Revised Edition, 2012, Dhanpat Rai Publications.

Reference Books :

1. Fundamentals of Physics, Halliday /Resnick/Walker, Twelve Edition, 2021, Wiley
2. Introduction to solid state physics, Charles Kittel, Eighth Edition, 2005, Wiley
3. The Physics of Amorphous Solids, Richard Zallen, Wiley - VCH
4. Introduction to nanotechnology, Charles P Poole and Frank J Owens, 1st Edition, Wiley- Interscience.
5. Nano: The essentials: Understanding Nanoscience and Nanotechnology, T Pradeep, 1 st Edition, 2017, McGraw Hill.

Other Resources :

1. Online physics library, California State University:-Web link- https://phys.libretexts.org/
2. Physics website, The State University of New Jersey :-Web linkwww.physics.rutgers.edu
3. Theory of the structure of Non-Crystalline Solids, Conference Review Paper, Int. conf. on
4. Theory of the structure of Non-Crystalline Solids. Jozef Bicerano et al.
5. NPTEL Course: Nano structured materials-synthesis, properties, self-assembly and applications by Prof. A. K. Ganguli, IIT Delhi:- Web linkhttps://nptel.ac.in/courses/118102003.

A. IN-SEMESTER ASSESSMENT (35 MARKS)

Continuous Assessment - Theory-(15 Marks)

1. MCQ test: 4 marks
2. Class test: 4 marks
3. Open book test/Open notes test: 4 marks
4. Regularity and active participation: 3 marks

Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. END SEMESTER EXAMINATION (40 MARKS)

End semester will be based on the syllabus coverage upto Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
BSC	BSC206	ENGINEERING CHEMISTRY- II	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6 -The engineer and the world

Course Objectives:

1. To enable the students to apply the laws of chemistry to an engineering problem.
2. To enable the students to appreciate material properties and their engineering applications.
3. To enable the students to analyse and select the most appropriate engineering material.
4. To study the current developments in the field of nanotechnology, energy storage systemsand green chemistry for sustainable development.

Module	Details	Hrs.
00.	**Course Introduction** This course provides the insights into the properties, composition and behavior of materials and enables engineers to understand how differentmaterials react under various conditions, allowing them to select appropriate materials for specific applications.	01
01.	**Alloys** ***Learning Objective:*** *To classify the different types of alloys and interpret their properties and applications in industry and to comprehend the concept of powder metallurgy.*	4-6
	Contents: Introduction, Significance of alloying, Ferrous Alloys-classification, Plain carbonsteels and special steels: - Role of special elements in alloy steels. Shape memory alloys: definition, properties and uses. Powder metallurgy – introduction, methods of metal powder	

	production:- atomization, compacting by cold powder extrusion, sintering and its applications.	
	Self-Learning Topics: *Applications of ferrous alloys in various industries. Applications of powder metallurg.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1 Identify the significance of alloying in enhancing the properties of metals. (2.2.3)* *LO-1.2 Apply the knowledge of different types of ferrous alloys in improving the quality of materials used in engineering industry. (1.3.1)* *LO- 1.3 Identify the role of Carbon and special elements in improving the properties of plain carbon steels and alloy steels. (2.1.3)* *LO- 1.4 Apply the concept of shape memory effect to the specified alloys for solving the real life as well as industrial problems (1.3.1)* *LO- 1.5 Apply the knowledge of shape memory alloys in various fields for the societal benefits. (6.1.1)* *LO- 1.6 Identify the steps in powder metallurgy for improving the quality of metallic tools and equipment used in industries.(2.2.3)*	
02.	**Polymers**	**4-6**
	Learning Objective: *To use the knowledge of synthesis, properties and uses of various polymers in industry. This will aid in identifying the impact of disposal of plastics on general health and the environment.*	
	Contents: Preparation, properties and uses of Phenol formaldehyde, PMMA, Kevlar. Effect of heat on the polymers (Glass transition temperature). Molecular weight of polymer and numericals. Conducting polymers and their applications. Electroluminescent polymer, Biodegradable polymers.	
	Self-Learning Topics: *Classification of polymers, Thermoplastic and Thermosetting plastics.*	
	Learning Outcomes:	
	A learner will be able to *LO 2.1 Apply fundamental engineering chemistry concepts to thermoplastic and thermosetting polymers. (1.3.1)* *LO -2.2 Identify the synthesis, reactions and properties of PMMA, Kevlar and Bakelite for industrial use.* (2.2.3) *LO-2.3 Apply the formulae for number and weight average molecular weight and polydispersity index for solving the numerical problems. (P.I.-1.2.2)* *LO-2.4 Identify the polymeric material for the protection of public health. (6.1.1)* *LO-2.5 Identify the factors affecting the glass transition temperature for deciding the utility of industrial polymers. (2.1.3)* *LO-2.6 Apply the knowledge of various types of conducting and electroluminescent polymers for improving the quality of industrial polymers. (1.3.1)*	
03.	**Advanced Functional materials**	**4-6**
	Learning Objective:	

	To familiarize with the composite materials, their properties and applications in various industries and for the protection and safety of society.	
	Contents: Introduction, Constitution- i) Matrix phase ii) Dispersed phase. Classification- (A) Particle - reinforced composites- i) Large – particle reinforced composites ii) Dispersion – strengthened composites. (B) Fiber – reinforced composites- i) Continuous – aligned ii) Discontinuous – aligned (short)- (a) aligned (b) randomly oriented (C) Structural Composites- i) Laminates (ii) Sandwich Panels. Their applications in aeronautical engineering and other industries.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO-3.1 Identify the properties of composites to analyse the materials used in engineering industry. (2.2.3)* *LO-3.2 Identify the role of constituents of composites for improving the quality of composite materials. (2.1.3)* *LO- 3.*3 Apply the knowledge of various types of composite materials and their properties for further advancement in automobile and aeronautical industries. *(P.I.-1.3.1)*	
04.	**Carbon Nanomaterials** ***Learning Objectives:*** *To use carbon nanomaterials on the basis of their mechanical and electrical properties in various industrial applications and modern devices.*	**3-5**
	Contents: Introduction to nanomaterials, comparison between nanomaterials and their bulk counter parts. structure and properties of graphite as a precursor for carbon nanomaterials. structure, electrical and mechanical properties of Carbon Nanomaterials like graphene, CNTs and Fullerenes. Methods of preparation of carbon nanomaterials: Laser ablation method Application of Nanomaterials in various industries.	
	Self-Learning Topics: *Inorganic nanomaterials like metals, metal oxides etc.*	
	Learning Outcomes:	
	A learner will be able to *LO-4.1 Apply the fundamental engineering concepts to compare the properties of bulk materials with their respective nanomaterials to improve the quality of products in pharma, cosmetic and electrical industries. (1.3.1)* *LO-4.2 Identify the engineering chemistry concepts to analyze the structure as well as electrical and mechanical properties of carbon nanomaterials for their potential applications in engineering. (2.1.3)*	

	LO-4.3 Identify the methods of preparation of carbon nanomaterials to enhance their properties for the betterment of the quality of engineered products. (2.2.3)	
05.	**Batteries**	**4-6**
	Contents: Introduction and Characteristics of batteries. Construction, working and applications of Lithium-ion batteries, Hydrogen oxygen alkaline fuel cells. E-waste Management, Battery e-waste management.	
	Self-Learning Topics: *Classification of batteries.*	
	Learning Outcomes: *A learner will be able to* *LO-5.1 Identify the concepts of electrochemistry for analyzing the types of batteries. (2.1.3)* *LO-5.2 Apply the knowledge of electrochemistry in the construction and working of lithium-ion and fuel cell batteries for improving the efficiency of devices. (1.3.1)* *LO-5.3 Identify the existing battery technologies such as Li-ion and Fuel cell for solving real-world problems. (2.2.3)* *LO-5.4 Identify the impact of disposal of toxic components of batteries for the public safety.(6.1.1)* *LO-5.5 Analyse the e-waste recycling methods of batteries for their effect on sustainable development. (6.1.2)*	
06.	**Spectroscopic Techniques**	**3-5**
	Learning Objective/s: *To differentiate between the various ranges of electromagnetic spectrum used in the different types of spectroscopic techniques like absorption and emission spectroscopy*	
	Contents: Spectroscopy - Principle, atomic and molecular spectroscopy. Beer lambert's law and UV-Visible Spectroscopy, Selection rules. Introduction to fluorescence and phosphorescence, Jablonski diagram. Numericals based on Beer Lambert's Law.	
	Self-Learning Topics: *Electromagnetic radiation, characteristics of electromagneticradiation, electromagnetic spectrum.*	
	Learning Outcomes:	
	A learner will be able to *LO-6.1 Identify a type of spectroscopic technique by analyzing the transitions occurring in a compound. (P.I.-2.1.3)* *LO-6.2 Identify the allowed and forbidden transitions from selection rules for feasibility of a spectroscopic technique. (2.2.3)* *LO-6.3. Apply the formulae based on Beer Lambert's law to calculate absorbance, concentration and molar extinction coefficient of given compounds. (1.2.2)* *LO-6.4 Identify the various radiative and non-radiative transitions occurring in a photo excited electron to analyze Jablonsky diagram for use in various spectroscopic techniques. (2.1.3)*	
	Course Conclusion	

		01
Total		**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.2.2	Apply the formulae based on the concepts of engineering chemistry for solving the numerical problems.
1.3.1	Apply fundamental engineering chemistry concepts to solve engineering problems.
2.1.3	Identify the engineering chemistry concepts to analyse the given problem
2.2.3	Identify the existing processes/ solution methods for solving the problems
6.1.1	Identify and describe the various roles of materials particularly as pertains to protection of the public and public interest at global, regional and local level
6.1.2	Analyse the environmental aspects of engineering problems for its impact on sustainability.

Course Outcomes: A learner will be able to -

1. Apply the concepts of engineering chemistry for solving the engineering problems (*LO-1.1, LO-1.2, LO-1.3, LO-1.4, LO-1.5, LO-1.6, LO-2.1, LO-2.2, LO-2.3, LO-2.4, LO-2.5, LO-2.6, LO-3.1, LO-3.2, LO-3.3, LO-4.1, LO-4.2, 4.3, LO-5.1, LO-5.2, LO-5.3, LO-5.4, LO-5.5, LO-6.1, LO-6.2, LO-6.3, LO-6.4)*
2. Analyse the quality and properties of engineering materials for solving real world problems. (*LO-1.1, LO-1.2, LO-1.3, LO-1.4, LO-1.5, LO-1.6, LO-2.1, LO-2.2, LO-2.3, LO-2.4, LO-2.5, LO-2.6, LO-3.1, LO-3.2, LO-3.3, LO-4.1, LO-4.2, 4.3, LO-5.1, LO-5.2, LO-5.3, LO-5.4, LO-5.5, LO-6.1, LO-6.2, LO-6.3, LO-6.4)*
3. Identify the suitable engineering material for the protection of the environment and public health. (*LO-2.1, LO-2.2, LO-2.3, LO-2.4, LO-2.5, LO-2.6, LO-3.1, LO-3.2, LO-3.3, LO-5.1, LO-5.2, LO-5.3, LO-5.4, LO-5.5,)*
4. Apply the knowledge of e-waste management and biodegradable polymers for the sustainable development. (*LO-2.1, LO-2.2, LO-2.3, LO-2.4, LO-2.5, LO-2.6, LO-5.1, LO-5.2, LO-5.3, LO-5.4, LO-5.5,)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

BSC206.1	3	3	-	-	-	3	-	-	-	-	-
BSC206.2	3	3	-	-	-	3	-	-	-	-	-
BSC206.3	3	3	-	-	-	3	-	-	-	-	-
BSC206.4	3	3	-	-	-	3	-	-	-	-	-
Average	**3**	**3**	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**

Text Books :

1. A textbook of engineering chemistry by S. Dara, 2014 edition, Chand Publication.
2. Engineering Chemistry by Jain and Jain, 17th edition, 2018, Dhanpatrai publications.

Reference Books :

1. Engineering Chemistry by Jain and Jain, 17th edition, 2018, Dhanpatrai publications
2. Elements of 2017 by Y. R. Sharma, Spectroscopy 29th edition, Pragati Prakashan
3. Nano forms of carbon and its Applications by Prof Maheshwar Sharon and Dr. Madhuri Sharon, First edition, 2007, Monad nanotech Pvt Ltd

Other Resources :

1. Online chemistry library for open access text books: https://chem.libretexts.org

A. IN-SEMESTER ASSESSMENT (35 MARKS)

1. Continuous Assessment - Theory-(15 Marks)

1. Assignment on live problems: 8 marks
2. Poster making: 4 marks
3. Regularity and active participation: 3 marks

2. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (40 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
AEC	AEC 201	PROFESSIONAL COMMUNICATION & ETHICS-I	02+01

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	--	--	--	50

Pre-requisite:

1. Keen desire to build confidence, develop language skills and reduce fear of public speaking
2. Intermediate knowledge of Spoken English
3. Intermediate level grasp of English Grammar and Vocabulary

Program Outcomes addressed:

1. PO 7: Ethics
2. PO 8: Individual and Collaborative Teamwork
3. PO 9: Communication
4. PO 11: Life-long learning

Course Objectives:

1. To demonstrate the fundamental concepts of interpersonal and professional communication.
2. To encourage active listening with focus on content, purpose, ideas and tone.
3. To facilitate fluent speaking skills in social, academic and professional situations.
4. To train in reading strategies for comprehending academic and business correspondence.
5. To promote effective writing skills in business, technology and academic arenas.
6. To inculcate confident personality traits along with grooming and social etiquettes.

Module	Details	Hrs.
00.	**Course Introduction** Every learning should lead toward the building of a holistic individual and a good citizen. Communication Skills and Ethics as a subject is the very fundamental requirement of a human being in any social and/or professional ecosystem. The syllabus has been compiled with the strategic idea of helping individual students to enhance, incorporate and implement the four pillars of Communication, Listening, Speaking, Reading and Writing (LSRW Skills), in all walks of life. There is an added emphasis on Ethical behavior and communication which is an integral value that every good human being, who also aims at being an impressive professional, should imbibe. The learner will also gain basic skills in professional writing and public speaking, exude confidence in presenting themselves and their work, with hands-on training in real time.	01

01.	***Fundamentals of Communication*** ***Learning Objective:*** *To aid the learner in understanding the importance of communication in the spoken and written form so that they can express themselves effectively and ethically in any professional or social setting.* *To encourage active listening with focus on content, purpose and ideas which can then be shared using ICT tools, ethical use of social media and appropriate professional etiquette, as individuals and team members.*	**7**
	Contents: 1.1 Introduction to Theory of Communication a) Definition b) Objectives c)The Process of Communication 1.2 Methods of Communication i. Verbal (Written & Oral) ii. Non-verbal a. Non-verbal cues perceived through the five senses: (Visual, Auditory, Tactile, Olfactory and Gustatory cues) b. Non-verbal cues transmitted using: (Body, Voice, Space, Time and Silence) 1.3 Barriers to Communication a) Mechanical/External b) Physical/Internal c) Semantic & Linguistic d) Psychological e) Socio-Cultural 1.4 Communication at the Workplace a) Corporate Communication - Case Studies b) Short Group Presentations on Business Plans c) Selecting Effective Communication Channels 1.5 Professional Etiquette a) Formal Dress Code b) Cubicle Étiquette c) Formal Dining Étiquette d) Responsibility in Using Social Media e) Showing Empathy and Respect f) Learning Accountability and Accepting Criticism g) Demonstrating Flexibility and Cooperation	
	Self-Learning Topics: *Visit nearby Government offices e.g. Passport/Post/Electricity/Telephone, as such, communicate with employees and get related information. Evaluate your communication with them & find out the flaws and/or barriers in the communication process that you faced. Document it for further discussion.*	

<table>
<tr><td></td><td>Reading up on various case studies depicting barriers in communication which led to conflicts; finding alternative methods of resolving them</td><td></td></tr>
<tr><td></td><td>Learning Outcomes:
A learner will be able to
LO1.1: Demonstrate competence in verbal and non-verbal communication and apply suitable cues to communicate effectively as an individual or in a group . (7.2.2, 8.2.1, 8.2.3, 9.2.3)
LO1.2: Exhibit ethical use of social media, flexibility and empathy in the professional space. (7.2.2, 8.2.2 ,8.2.3, 11.1.1)
LO1.3: State the need for and implement appropriate grooming and ethical way of presenting oneself. (11.1.1)
Activity:
1.Group Discussion , Debates on various socially relevant topics - Minimum three rounds to be conducted for facilitating enough practice.</td><td></td></tr>
<tr><td>02.</td><td>Verbal Aptitude For Employment
Learning Objective:
To facilitate clear comprehension, interpretation, and evaluation of verbal technical and non-technical data.
To facilitate fluent and precise presentation skills, in social, academic, and professional situations, with correct syntax, lexicon and semantics.</td><td>3</td></tr>
<tr><td></td><td>Contents:
2.1 Vocabulary Building
a) Meaning of Words in Context
b) Synonyms & Antonyms
c) Avoiding redundancy
d) Word Form Charts
e) Prefixes & Suffixes
2.2 Grammar
a) Identifying Common Errors
b) Subject - Verb Agreement
c) Articles
d) Preposition
e) Pronunciation</td><td></td></tr>
<tr><td></td><td>Self-Learning Topics:
Maintain a journal of new vocabulary; add, learn and apply in conversation 3 new words daily.</td><td></td></tr>
<tr><td></td><td>Learning Outcomes:</td><td></td></tr>
</table>

	A learner will be able to *LO2.1: Identify the commonly found grammatical errors in the written and spoken format of communication. (9.1.1, 9.1.2)* *LO2.2: Apply appropriate words and parts of speech such as prefixes, suffixes, synonyms , antonyms , idioms , proverbs and cliches in the written and oral form of communication. (9.1.1,9.2.2)* *LO2.3: Listen to grammatically correct input , understand and analyse the same .(11.3.1)* *Activity : Solving Two verbal Aptitude Tests as assignment work .* *Solving grammar practice tests based on the module .*	
03.	***Developing Basic Language Skills-LSRW Skills*** ***Learning Objective:*** *To listen, read, write, summarise and present concrete technical and non-technical data precisely with minimum errors keeping the audience in mind.* *To generate and deliver a speech and/or presentation using both rational and out of the box thinking.*	**5**
	Contents: 3.1 Listening Skill- Listening to recordings of Formal and Informal communication situations. 3.2 Speaking Skill- Developing and Delivering Short Speeches, Informative Speeches (that center on people, events, processes, places, or things), Persuasive Speeches (to persuade, motivate or take action) and Special Occasion Speeches- (anchoring, hosting, compering events in institute) a) Pair-work Conversational Activities / Role play b) Introducing Self and/or a Classmate 3.3 Reading Skill Reading Short and long passages for comprehension. 3.4 Writing Skill- Summarization of non-technical passages, reports. Writing review of Short Stories - *Lamb to the Slaughter- by Roald Dahl, The Green Leaves* by Grace Ogot, *Uncle Podger Hangs a Picture* by Jerome K Jerome, R.K. Narayan (*Malgudi Days*), Ruskin Bond (*Celestial Omnibus*). Writing review of Movies- Toilet :Ek Prem katha, Padman, Dangal, Taare Zameen Par, Masan, Gulabi. a) Graphic Organizers for Summaries i. Radial Diagrams like Mind Maps ○ Flow Charts ○ Tree	

	Diagrams Cyclic Diagrams ii. Linear Diagrams like Timelines ○ Pyramids ○ Venn Diagrams b) Point-form Summaries c) One-sentence Summaries of Central Idea	
	Self-Learning Topics: *Read either autobiography or biography of A.P.J. Kalam, Nelson Mandela, or any such revolutionary thinker and write its summary.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Listen to team members, peers respectfully, without prejudice to understand ideas and opinions in various formal, informal situations. (8.2.2, 8.2.3, 9.2.1, 9.2.3)* *LO3.2: Create and deliver effective formal/ informal speeches in a professional set up. (8.2.4, 9.2.2, 9.3.2, 11.1.1)* *LO3.3 Read and comprehend long/short, technical/non-technical passages along with summarising it in paragraph format / graphical organisers. (9.1.1, 9.1.3, 9.2.1)* *Activity:* *1.Listening skill - Listening to audio and video content of various types like Monologues, dialogues, formal talk and discussion about the same.* *2. Self-Introduction and introducing others - Learning formal self-introduction and introducing colleagues through practice activity.* *3.Reading of short stories/ watching movies - writing summaries and learning to critically evaluate them – Students will be given a selected list of short stories/ movies with social messages and guided for writing summaries after critical evaluation of the same.*	
04.	***Business Correspondence*** ***Learning Objectives:*** *To train in writing strategies for comprehensive academic and business correspondence.* *To promote competent writing skills in business, technology and academic areas using effective media.* *To find and fill gaps in knowledge required for basic written business correspondence and continued professional growth.*	**7**
	Contents: 4.1. Seven Cs of Business Correspondence 1) Completeness 2) Conciseness 3) Consideration 4) Concreteness 5) Clarity 6) Courtesy 7) Correctness	

	4.2. Parts of a Formal Letter and Format 1) Parts/Elements of a Formal Letter i. Letterhead and/or Sender's Address ii. Dateline iii. Reference Number iv. Inside Address v. Attention Line (Optional) vi. Salutation vii. Subject Line / Caption Line / Reference Line viii. Body of the Letter ix. Complimentary Close x. Signature Block xi. Identification Marks xii. Enclosures/Attachments xiii. Carbon Copy Notation (courtesy copy) xiv. Postscript 2)Complete/ Full Block Format 4.3 Emails 1) Format of Email 2) Features of Effective Emails 3) Language and style of Emails 4.4 Types of Letters in Both Formal Letter Format and Emails - 1. Enquiry letter (internship, placement, workshop) 2. Request/Permission Letters (Leave letter, apology letter, seeking permission for facilities)	
	Self-Learning Topics: *Collect Official letters and evaluate them for language, tone, format and content*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the 7 C's of correspondence to basic official correspondence. (7.1.1, 7.2.2)* *LO 4.2: Draft an Enquiry /Request/Permission letter in both letter and Email format, for various professional situations. (9.3.2, 11.1.1)* *Activity:* *1.Assignment on Business Correspondence- practice for drafting various business letters*	
05.	***Basic Technical Writing*** *Learning Objective/s*: *To promote effective technical writing skills in business, technology and academic arenas.* *To create easy to understand technical documents with logical flow of ideas keeping the end user in mind.* *To identify gaps in research papers and attempt to source information for the same.* *To comprehend the need for ethical concepts such as Plagiarism checks and Copyright in professional writing.*	**6**

Contents:

5.1. Introduction

1) What is Technical Writing?
2) Importance and Principles of Technical Writing
3) Difference between Technical Writing & Literary Writing

5.2. Writing User Instructions

1) User Instructions
2) Hazard Notations /Special Instructions- (Note, Precaution Warning, Caution and Danger)

5.3 Basics of Research

1) Importance of Research
2) Types of research
3) How to select a topic
4) Structure of a Technical Research Paper
5) Referencing styles (APA, IEEE)

5.4 Intellectual Property Rights -

1) Understanding the importance of Copyrights
2) Paraphrasing, referencing and In-text citations
3) Running a Plagiarism Check on Paraphrased Passages
4) Ethical behaviour: case studies

Self-Learning Topics: *Collect User Manuals and study them for language and tone of instructions, hazard notations, and order of instructions.*

Learning Outcomes :

A learner will be able to

LO5.1: Write and present a clear set of instructions for the end user for a particular task. (9.1.3, 9.2.2)

LO5.2 :Critically choose a research topic and write the problem statement and Hypothesis (11.3.1)

LO5.3: Identify the utility and importance of Copyrights . (7.2.2, 9.3.1, 11.1.1)

LO5.4: Generate plagiarism reports by running a plagiarism check on the select document. (7.2.2, 9.3.2, 11.3.1)

Activity:

1.Assignment on writing accurate technical instructions for the end user.

2. Selection of Ethical Case Study, Analysis, discussion and report documentation followed by a presentation .

	Activities for Practical: *1. Listening skill - Listening to audio and video content of various types like Monologues, dialogues, formal talk and discussion about the same.*	**2**
	2. Self-Introduction and introducing others - Learning formal self-introduction and introducing colleagues through practice activity.	**2**
	3. Group Discussion on various socially relevant topics - Minimum three rounds to be conducted for facilitating enough practice.	**6**
	4. Debates on several socially relevant issues- Two rounds to be conducted.	**4**
	5. Selection of Ethical Case Study, Analysis, discussion and report documentation followed by a presentation .	**3**
	6. Reading of short stories/ watching movies - writing summaries and learning to critically evaluate them – Students will be given a selected list of short stories/ movies with social messages and guided for writing summaries after critical evaluation of the same.	**3**
	7.Selecting a socio-psychological or socio-technical or socio economic problem, creating a short paper in the relevant format. Detailed discussion about format for a technical paper will be held. Students will create a short research paper using the given template followed by a presentation.	**2**
	8. Assignment on Barriers to communication - Students will document their observations about the barriers faced during the self learning activity and present the possible solutions for the same.	**2**
	9. Assignment on Business Correspondence- practice for drafting various business letters. Students will refer to the various sample business letters collected as self learning activity.	**2**
	10. Assignment on writing accurate technical instructions for the end user. Students will refer to the various sample user manuals collected as self learning activity.	**2**
	11.Assignment on Verbal Aptitude Test - Two verbal Aptitude Tests will be conducted .	**2**
	Course Conclusion	**01**
	Total	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
7.2.2	Examine and apply moral & ethical principles to known case studies
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills

8.2.2	Treat other team members respectfully
8.2.3	Listen to other members
8.2.4	Maintain composure in difficult situations
9.1.1	Read, understand and interpret technical and non-technical information
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others
9.2.2	Deliver effective oral presentations to technical and non-technical audiences
9.2.3	Apply efficient and effective communication, keeping in mind the diversity and uniqueness in the team.
9.3.1	Create technical figures, reports with data to complement reports and presentations
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation
11.1.1	Describe the rationale for the requirement for continuing professional development
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Evaluate information they listen to and present effectively , convincingly and ethically before an audience . (*LOs 1.2, 1.3, 2.1, 3.1,3.2, 5.1)*
2. Read and analyse objectively, summarize graphically and paraphrase effectively. (*LOs 2.1, 2.2, 3.3,)*
3. Communicate effectively and ethically along the various channels of communication within a business organization and follow the general code of conduct and professional etiquette of the organization. (*LOs 1.1, 1.3, 3.2, 4.1, 4.2)*
4. Write a set of effective and easy to understand academic articles and technical instructions and convey the same using global information technology and Netiquette. *(LOs 1.3, 2.2, 4.1, 4.2, 5.1, 5.3)*
5. Conduct ably and ethically within the social circles with empathy and confidence, thus exhibiting a well-groomed and balanced personality. (*LOs 1.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
AEC201.1	-	-	-	-	-	-	3	3	3	-	3
AEC201.2	-	-	-	-	-	-	-	-	3	-	3
AEC201.3	-	-	-	-	-	-	-	-	3	-	3
AEC201.4	-	-	-	-	-	-	3	-	3	-	3
AEC201.5	-	-	-	-	-	-	-	-	3	-	3
Average	-	-	-	-	-	-	**3**	**3**	**3**	-	**3**

Text Books :

1. Sanjay Kumar, Pushp Lata(2018).CommunicationSkills,NewDelhi:OxfordUniversityPress

2. Rizvi, A. M. (2010). Effective Technical Communication: A guide for Scientists and Engineers.

3. Dahl, R. (1953), "Lamb to the Slaughter". *Harper's Magazine*. Harpers.

4. “The Green Leaves*”, Land without Thunder, Short Story* by Grace Ogot, East African Publishing House, Kenya, 1068

5. Sanjay Kumar & Pushp Lata (2018). Communication Skills, New Delhi: Oxford University Press

Reference Books:

1. Soft Skills, Dr. k. Alex, S. Chand Publication, 2009
2. English Grammar and Composition, S.C. Gupta, Arihant Publication, 2014
3. Oxford handbook of Commercial Correspondence, A. Ashley, Raman, M., & Sharma, S. (2016). Technical Communication: Principles and practice. New Delhi: Oxford University Press
4. Lewis, N. (2014). Word power made easy. Random House USA.

CONTINUOUS INTERNAL EVALUATION (50 Marks)

1. Listening, Speaking
   GD/Debating Skills + group dynamics (10)
2. Ethical Case Study project (10)
   (Continuous work as individual with set due date)
3. Critical Analysis of a Short Story/ Movie and presentation (10)
   (Continuous work as a team with set due date)
4. Short Technical Paper on any Socio-Technical problem and PPT presentation.(10)
   (Continuous work as individual with set due date)
5. Assignments (05)
6. Regularity and active participation (05)

Course Type	Course Code	Course Name	Credits
ESC	ESC203	BASIC ELECTRONICS ENGINEERING	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
15	20	40	1	1.5	75

Pre-requisite:

1. ESC102- Basics of Electrical Engineering
2. BSC102- Engineering Physics-I

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solutions
4. PO11: Life-long learning

Course Objectives:

1. To impart the knowledge to demonstrate competence in comprehending the concepts of semiconductor diodes and solve the problems to analyse its applications.
2. To demonstrate the ability to execute a solution process and analyse results to design real life applications such as an amplifier, switch, etc.
3. To introduce number system and use logic gates to analyse and design circuits for a given expression.
4. To recognize the utilisation of measuring devices and its working.
5. To introduce various transducers and sensors to adapt to the current technologies regarding new developments in the relevant fields.

Module	Details	Hrs.
00.	**Course Introduction** Electronics is a branch of engineering that has grown exponentially in recent years, and now electronics has become a very important part of our lives. This is foundation course deals with fundamental concepts of semiconductors devices, transistors, number system, logic gates, measuring instruments, transducers and sensors. With the growing popularity and production of electric vehicles (EVs) in India, it is projected that semiconductor use in fields including safety, electrification, communication, and networking would rise.	**01**
01.	**Introduction to Basic Electronic system**	**5-7**

<table>
<tr><td></td><td> Learning Objective:
To demonstrate competence in engineering fundamentals and specialized engineering knowledge to comprehend the concepts of semiconductor diodes.
To identify the engineering systems, variables, and parameters to solve the problems for analyzing the applications of semiconductor diodes.
Contents:
Semiconductor Diode - Ideal versus Practical, Characteristics and Parameters, Diode Approximations, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Diode as clipper and clampers; Zener diode- Operation and Applications; Opto-Electronic Devices – LEDs, Photo Diode and Applications.
Self-Learning Topics: LASER diode
Learning Outcomes:
A learner will be able to
LO 1.1: Apply fundamental engineering concepts to comprehend the characteristics and parameters of semiconductor diodes. (P.I.-1.3.1)
LO 1.2: Apply concepts of electronics and communication engineering and allied disciplines to comprehend diode equivalent circuit and its load line analysis. (P.I.-1.4.1)
LO 1.3: Identify engineering systems to analyze the applications of diode such as switch, rectifier, clipper, clampers etc. (P.I.-2.1.2)
LO 1.4: Identify existing methods for analyzing voltage, currents of zener diode and opto –electronic devices. (P.I.-2.2.3) </td><td></td></tr>
<tr><td>02.</td><td> Introduction to Transistor
Learning Objective:
To demonstrate competence in engineering fundamentals and specialized engineering knowledge to comprehend the concepts of bipolar junction transistor.
To identify the engineering systems, variables, and parameters for analyzing the applications of bipolar junction transistor as an amplifier and also as a switch.
Contents:
Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Potential Divider Bias circuit; DC load line analysis, Q point, comparison of characteristics of transistors in different configurations, Applications: Transistor as an amplifier, transistor as a switch.
Self-Learning Topics: Self-biasing.
Learning Outcomes:
A learner will be able to </td><td>6-8</td></tr>
</table>

	LO 2.1: Apply fundamental engineering concepts to comprehend the concept of biasing with potential divider bias circuit. (P.I.-1.3.1) *LO 2.2: Apply concepts of electronics and communication engineering and allied disciplines to comprehend the types and characteristics of bipolar junction transistor. (P.I.-1.4.1)* *LO 2.3: Identify engineering systems to find gain, operating point of bipolar junction transistor etc. (P.I.-2.1.2)* *LO 2.4: Identify solution methods to use bipolar junction transistor as an amplifier and switch. (P.I.-2.2.3)*	
03.	**Introduction to Number system and Logic gates** ***Learning Objective:*** *1. To analyze the number systems, different types of numbers and Boolean algebra.* *2. To Demonstrate the ability to generate alternative design solutions using logic gates.*	**5-7**
	Contents: Number System: Binary Numbers systems, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers, Negative numbers representation, 1's, 2's, Complements, BCD codes, Gray code. Boolean Algebra, Basic Theorems and properties of Boolean Algebra, Logic gates: Truth Tables and Functionality of Logic Gates – NOT, OR, AND, NOR, NAND, XOR and XNOR Integrated Circuits (ICs).	
	Self-Learning Topics: *Flip- flops*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Integrate mathematical tools to perform conversion in number System. (P.I.- 2.2.2)* *LO 3.2: Compare alternative solutions to select the best methodology to implement logic gates. (P.I.-2.2.4)* *LO3.3: Determine design objectives to implement electronic circuits using logicgates (P.I.-3.1.6)* *LO3.4: Apply formal design principles to build simplified circuits using universal gates. (P.I.-3.3.3)*	
04.	**Electronic Instruments** ***Learning Objectives:*** *To identify and describe the components of a generalized measurement system and explain key performance characteristics of measurement instruments*	**1-3**
	Contents: Introduction to Basic instruments: Components of generalized measurement system Concept of accuracy, precision, linearity, sensitivity, resolution, hysteresis, calibration.	

	Self-Learning Topics: ----	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to comprehend generalized measurement system (P.I.-1.3.1)* *LO 4.2: Apply concepts of electronics and communication engineering and allied disciplines to explain key performance characteristics of measurement instruments. (P.I.-1.4.1)* *LO 4.3: Comprehend technical datasheets of instruments. (P.I.-11.3.1)*	
05.	**Introduction to Transducers** ***Learning Objective/s:*** *To demonstrate competence in engineering fundamentals to introduce the concept transducer for the desired application.*	**2-4**
	Contents: Transducers, classification of transducers, selection of transducers, Resistance- temperature detector (RTD), inductive transducers, Linear variable differential transformer (LVDT).	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to comprehend the concept of transducers and its working. (P.I.-1.3.1)* *LO 5.2: Apply concepts of electronics and communication engineering to comprehend various types of transducers used in electronics. (P.I.-1.4.1)*	
06.	**Introduction to Sensors** ***Learning Objective/s:*** *To demonstrate competence in engineering fundamentals to comprehend the concepts of sensor as per the application.*	**3-5**
	Contents: Definition, Classification & selection of sensors, Proximity sensors: Inductive & Capacitive, Use of proximity sensor as accelerometer and vibration sensor, Flow Sensors: Ultrasonic & Laser, Level Sensors: Ultrasonic & Capacitive.	
	Self-Learning Topics: *Sensors used in IOT.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply laws of natural science to an engineering problem to understand the concept of sensors. (P.I.-1.2.1)* *LO 6.2: Apply concepts of electronics and communication engineering and allied disciplines to comprehend the types of sensors. (P.I.-1.4.1)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify/ assemble/integrate mathematical tools to information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solutions to select the best methodology.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.3.3	Identify relevant data from the given resources and arrive at an optimal design solution for particular specifications.
11.3.1	Source and comprehend technical literature and other credible sources of information.

Course Outcomes: A learner will be able to -

1. Apply the fundamentals of engineering to demonstrate the concepts of semiconductor diodes and analyse its applications. *(LO 1.1, LO 1.2, LO1.3, LO1.4*)
2. Apply the fundamentals of engineering to design transistor-based applications such as an amplifier, switch, etc. *(LO 2.1, LO 2.2, LO2.3, LO2.4*)
3. Formulate mathematical models to introduce number system and use logic gates to design circuits for a given expression. *(LO 3.1, LO 3.2, LO3.3, LO3.4*)
4. Recognize the utilisation of measuring devices and its working. *(LO 4.1, LO 4.2, LO 4.3*)
5. Apply the fundamentals of engineering to introduce various transducers and sensors to adapt to the current technologies regarding new developments in the relevant fields. *(LO 5.1, LO 5.2, LO6.1, LO6.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESC203.1	3	3	-	-	-	-	-	-	-	-	-
ESC203.2	3	3	-	-	-	-	-	-	-	-	-
ESC203.3	-	3	3	-	-	-	-	-	-	-	-
ESC203.4	3	-	-	-	-	-	-	-	-	-	2
ESC203.5	3	-	-	-	-	-	-	-	-	-	-

Average	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**

Text Books :

1. Electronic Devices and Circuit Theory (11th Edition), Robert Boylestad, Pearson Education Limited 2014.
2. Electronics A Systems Approach, Neil Storey, 2011, 4th edition, Pearson Education Publishing Company Pvt. Ltd.
3. Electronic Devices and Circuits, Salivahanan, N Suresh Kumar, 2013, 3rd edition, McGraw Hill Publications.
4. Modern Digital Electronics (4th Edition), R. P. Jain, Tata McGraw Hill Education Private Limited.
5. Sensors and Transducers (3^{rd} Edition), Ian Sinclair, BSP Professional Books, 2001.

Reference Books :

1. Electronic Devices and Circuits, David A Bell, 2016, 5th Edition, Oxford.
2. The Art of Electronics 3rd Edition by Horowitz and Hill, 3rd edition, 2015.
3. Digital Logic and Computer Design, M. Morris Mano, 2008 ISBN-978-81-203-0417-8, PHI Learning.
4. Electronic Instrumentation and Measurements (3rd Edition) – David A. Bell, 2013, Oxford University Press.
5. Electronic Communication Systems, George Kennedy, 4th Edition, TMH, 2009.

Other Resources :

1. NPTEL Course: Introduction to Basic Electronics By Prof. T.S. Natarajan, Basic Electronics andLab, IIT Madras :-Web link- https://nptel.ac.in/courses/122106025
2. NPTEL Course: Digital Electronic Circuits By Prof. Goutam Saha, NOC:Digital ElectronicCircuits, IIT Kharagpur :-Web link- https://nptel.ac.in/courses/108105132
3. NPTEL Course: Introduction to Microcontrollers & Microprocessors By Prof. Dr. S.P. DasMicrocontrollers and Applications, IIT Kanpur,
   Web link- https://nptel.ac.in/courses/107/106/10710608

A. IN-SEMESTER ASSESSMENT (35 MARKS)

1. Continuous Assessment - Theory-(15 Marks)

1. *Numerical Assignment/s (min 20 problems) – 04 Marks*
2. *Class test based on above numerical assignment – 04 Marks*
3. *Open book test/ Open notes test: 04 Marks*
4. *Regularity and active participation:03 Marks*

2. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (40 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 30% weightage, and the syllabus covered from MSE to ESE carrying 70% weightage.

Course Type	Course Code	Course Name	Credits
BSL	BSL203	ENGINEERING PHYSICS-II LABORATORY	0.5

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
25	-	-	-	-	25

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO4: Conduct investigations of complex problems
3. PO8: Individual and Collaborative Team Work
4. PO9: Communication

Course Objectives:

1. To demonstrate the fundamental concepts of physics and evaluate the process of an experiment/project quantitatively and qualitatively.
2. To improve the knowledge gained in the theory course.
3. To develop the abilities of modelling, measurements, observations and analysing data.
4. To develop the experimental skill in assembling and handling laboratory instruments.

Module	Details	Hrs.
00.	**Course Introduction**	01
01.	**Experiment 1** ***Learning Objective:*** *To use the concept of miller indices to identify principal crystal planes in simple cubic structure.*	02
	Determination of interplanar distance for principal planes in simple cubic structure.	
	Learning Outcome: *LO1.1: A learner will be able to apply the concept of miller indices and analyze principal crystal planes to determine the interplanar distance in simple cubic structure. (P.I.- 1.2.1, 1.3.1, 4.3.1, 4.3.3)*	
02.	**Experiment 2**	02
	Learning Objective: *To simulate XRD pattern for a given crystal system*	

	Simulation of X-ray Diffraction (XRD) pattern of Sodium Chloride structure to find lattice parameters.	
	Learning Outcome: *LO2.1. A learner will be able to apply the knowledge of x-ray diffraction and analyze the crystal structure of sodium chloride by simulating XRD pattern using software and write the result. (P.I.- 1.2.1, 1.3.1, 4.1.3, 4.3.3)*	
03.	**Experiment 3** ***Learning Objective:*** *To study the hysteresis loop of a ferromagnetic material.*	**02**
	Determination of area of hysteresis curve (B-H curve) of a ferromagnetic material.	
	Learning Outcome: *LO 3.1: A learner will be able to apply basic concepts of magnetization and analyze the B-H curve of a ferromagnetic material and write the result. (P.I.- 1.2.1, 1.3.1, 4.3.1, 4.3.3)*.	
04.	**Experiment 4** ***Learning Objectives:*** *To determine the parameters which characterize a dielectric material.*	**02**
	Determination of dielectric constant of Bakelite material.	
	Learning Outcome: *LO4.1: A learner will be able to apply the knowledge of dielectrics and analyse experimental data to determine the dielectric constant of the given material and write the result. (P.I.- 1.2.1, 1.3.1, 4.3.1, 4.3.3)*	
05.	**Experiment 5** ***Learning Objective/s:*** *To simulate and visualize structures of various nanomaterials.*	**02**
	Simulation of structures of carbon nanomaterials to find C-C bond length.	
	Learning Outcome : LO5.1: *A learner will be able to apply the knowledge of nanomaterials and analyse the structure using simulation software and write the result. (P.I.- 1.2.1, 1.3.1, 4.1.3, 4.3.3)*	
06.	**Course Project** ***Learning Objective/s:*** *To explore the application of concept of physics in different fields by demonstrating a chosen project.*	**03**
	Report writing and Demonstration of the project.	
	Self-Learning Topics: -	

	Learning Outcomes: *A learner will be able to* *LO6.1: apply the concepts of physics to execute, demonstrate and present the project effectively as a team. (P.I.- 1.2.1, 1.3.1, 4.2.1, 4.3.1, 8.1.2, 8.3.1,9.1.2, 9.2.2)*	
	Course Conclusion	**01**
	Total	**15**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of physics to an engineering problem.
1.2.2	Apply the formulae derived from the concept to solve engineering problem.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.2.1	Design and develop experimental approach, specify appropriate equipment and procedures.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective teamwork, to accomplish a goal.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
9.1.2	Produce clear, well-constructed, and well- supported written engineering documents.
9.2.2	Deliver effective oral presentations to technical and non- technical audiences.

Course Outcomes:

1. Learners will be able to apply the fundamental knowledge of different materials to determine various parameters through relevant experiments.
(*LO 1.1, LO3.1, LO 4.1*)
2. Learners will be able to apply the basic concept of different materials to simulate their structures and diffraction pattern using relevant software. (*LO 2.1, LO5.1*)
3. Learners will be able to apply fundamental knowledge of physics for the execution, presentation of the chosen project as a team and write effective report. (*LO 6.1*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSCLC203.1	3	-	-	3	-	-	-	-	-	-	-
BSCLC203.2	3	-	-	3	-	-	-	-	-	-	-
BSCLC203.3	3	-	-	3	-	-	-	-	-	-	-
BSCLC203.4	3	-	-	3	-	-	-	3	3	-	-
Average	**3**	**-**	**-**	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**-**

Text Books :

1. A Textbook of Engineering physics, Dr. M. N. Avadhanulu and Dr. P. G. Kshirsagar Revised Edition, 2014, S. Chand Publishing.
2. Engineering physics, R. K. Gaur and S. L. Gupta, Revised Edition, 2012, Dhanpat Rai Publications.

Reference Books :

1. Fundamentals of Physics, Halliday /Resnick/Walker, Twelve Edition, 2021, Wiley
2. Introduction to solid state physics, Charles Kittel, Eighth Edition, 2005, Wiley
3. Introduction to nanotechnology, Charles P Poole and Frank J Owens, 1st Edition, Wiley-Interscience.

Other Resources :

1. Online physics library, California State University:-Web link- https://phys.libretexts.org/
2. Physics website, The State University of New Jersey :-Web linkwww.physics.rutgers.edu

IN-SEMESTER ASSESSMENT (25 MARKS)

Lab Performance: 10 marks

1. Project (Final Report and Demonstration): 10 marks
2. Regularity and active participation: 5 marks

Course Type	Course Code	Course Name	Credits
BSL	BSL204	ENGINEERING CHEMISTRY II LABORATORY	0.5

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
25	-	25	25	-	25

Pre-requisite: Nil

Program Outcomes addressed:

1. PO1: Engineering Knowledge:
2. PO2: Problem Analysis
3. PO4:Conduct investigation of complex problems
4. PO6: The engineer and the world
5. PO8: Individual and collaborative teamwork
6. PO9:Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
7. PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

Course Objectives:

1. To enable the students to apply the laws of chemistry to an engineering problem.
2. To acquaint the students with practical knowledge of the basic concepts of chemistry to gainexperimental skill.
3. To enable the students to utilize the fundamental laboratory techniques for analysis.

Module	Details	Hrs.
00.	**Course Introduction** 1. Code of conduct in chemistry laboratory 2. Safety and precautions to be observed in chemistry laboratory 3. Orientation on evaluation of laboratory performance	01

01.	**Experiment 1** ***Learning Objective/s:*** ***To calculate percentage of iron in plain carbon steel and relate it with the classification of plain carbon steel.*** To determine the percentage of iron present in a plain carbon steel ***Self-Learning Topics: Nil*** ***Learning Outcomes:*** *LO -1.1 A learner will be able to calculate the percentage of iron in plain carbon steel by redox titration method.(1.2.1) (1.3.1), (2.2.3), (4.2.1), (4.3.1), (4.3.3)*	**02**
02.	**Experiment 2** *Learning Objective/s:* *To apply the knowledge of condensation polymerization for the synthesis of urea formaldehyde.* **Synthesis of Urea formaldehyde.** ***Self-Learning Topics: Nil*** ***Learning Outcomes:*** *LO-2.1 A learner will be able to synthesize thermosetting resin using condensation polymerization reaction and calculate its yield and state its societal benefits.(1.2.1) (1.3.1), (2.2.3), (4.2.1),(4.3.1),(4.3.3),(6.1.1).*	**02**
03.	**Experiment 3** ***Learning Objective/s:*** *To compare the viscosity of pure solvent and the solution of polymer for calculating the molecular weight of polymer.* To Determine molecular weight of a polymer using Ostwald's viscometer. ***Self-Learning Topics: Nil*** ***Learning Outcomes:*** *LO-3.1 A learner will be able to c*alculate the specific viscosity of polymer with respect to pure solvent and its molecular weight using Ostwald's Viscometer (1.2.1), (1.3.1), (2.2.3), (4.1.3), (4.2.1), (4.3.1), (4.3.3)	**02**
04.	**Experiment 4** ***Learning Objective/s:*** *To construct the Daniel cell and calculate its E^0 using Nernst equation.* To determine the emf of galvanic cell-Daniel cell. ***Self-Learning Topics: Nil*** ***Learning Outcomes:*** *LO-4.1 A learner will be able to construct and calculate E^0 of Daniel cell using electrode reactions and compare with theoretical values to conclude whether Daniel cell is working or not. (1.2.1), (1.3.1), (2.2.3), (4.1.3), (4.2.1), (4.3.1),(4.3.3)*	**02**

05.	**Experiment 5** *Learning Objective/s:* *To determine the concentration of iron and verify Beer Lambert's law.*	**02**
	To determine iron from the given sample using UV-Visible spectrophotometer.	
	Self-Learning Topics: Nil	
	Learning Outcomes :	
	LO-5.1 A learner will be able to measure the absorbance of standard and unknown concentrations of given analyte using UV-Visible spectrophotometer and verify Beer Lambert's law (1.2.1), (1.3.1), (2.2.3), (4.1.3),(4.2.1),(4.3.1),(4.3.3).	
06.	***Demonstration*** ***Learning Objective:*** *To develop the basic knowledge of analytical chemistry using titrimetric experiment.*	**04**
	Demonstration of titrimetric experiment and conclusion.	
	Self-Learning Topics: Nil	
	Learning Outcomes: *LO-6.1 A learner will be able to analyze and calculate the proposed substances in an experiment using fundamental laws and basic concepts of engineering chemistry and demonstrate the results as a team (1.2.1), (1.3.1),(2.1.3,(2.2.3),(4.2.1),(4.3.1),(4.3.3), (8.1.1), (8.3.1),(9.1.2), (9.1.3), (11.3.2), (11.3.3)*	
	Total	**15**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering Problem.
1.2.2	Apply the formulae based on the concepts of engineering chemistry for solving the numericalproblems.
1.3.1	Apply fundamental engineering chemistry concepts to solve engineering problems.
2.1.3	Identify the engineering chemistry concepts to analyse the given problem
2.2.3	Identify the existing processes/ solution methods for solving the problems
4.1.3	Apply appropriate instrumentation to make measurement of physical and chemical quantity. (modified)
4.2.1	Design and develop an experiment approach, specify appropriate equipment and procedures.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.3	Represent data in tabular/ graphical forms so as to facilitate analysis and explanation of the data and drawing of conclusions.

6.1.1 Identify and describe the various roles of materials particularly as pertains to protection of thepublic and public interest at global, regional and local level

8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.

8.3.1 Present result as a team with smooth integration of contributions from all individual efforts.

9.1.1 Read, understand and interpret technical and non-technical information

9.1.2 Produce clear, well-constructed, and well-supported written project report.

9.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

9.2.2 Deliver effective oral presentations to technical and non-technical audiences.

11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

11.3.3 Demonstrate an ability to identify and analyse new chemical processes and analytical skills in open ended experiments.(New)

Course Outcomes: A learner will be able to -

1. Apply the laws of electrochemistry and spectroscopy for performing the practicals. (*LO- 4.1, LO-5.1)*
2. Analyze the materials for engineering applications. (*LO-1.1, LO-3.1, LO-5.1)*
3. Synthesize the polymer and use it for societal benefits. (*LO-2.1)*
4. Demonstrate an ability to work effectively in a team for the project. (*LO-6.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
BSL204.1	3	-		3	-	-	-	-	-	-	-
BSL204.2	3	-	-	3	-	-	-	-	-	-	-
BSL204.3	3	-	-	3	-	-	-	-	-	-	-
BSL204.4	3	3	-	3	-	-	-	3	3	-	3
Average	**3**	**3**	-		-	-	-	**3**	**3**	-	**3**

Text Books :

1. Practical book in Engineering Chemistry by Dr. Pijus Khatua and Debashree Singh, First edition, 2016, Platinum Publishers
2. Textbook of green chemistry by AK Ahluwalia, 2008, Ane Book India

Reference Books :

1. Experiments in Engineering Chemistry by Payal Joshi, first edition, 2016, I.K. International Publishing House Pvt. Ltd.

Other Resources :

1. Online chemistry library for open access text books: https://chem.libretexts.org
2. https://vlab.amrita.edu/?sub=2&brch=190&sim=1546&cnt=1

IN-SEMESTER ASSESSMENT (25 MARKS)

1. Lab Performance: 10 Marks
2. Demonstration of the experiment: 10 marks
3. Regularity and active participation: 5 marks

Course Type	Course Code	Course Name	Credits
ESL	ESL204	ENGINEERING GRAPHICS LABORATORY	02

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total Marks**
50	50	100

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO5: Engineering tool usage
4. PO9: Communication

Course Objectives:

1. To inculcate proper understanding of the theory of projection.
2. To enable students to understand and represent three-dimensional objects on a two-dimensional surface in a way that accurately conveys their shape, size, and orientation.
3. To acquaint students with representing internal features of a three-dimensional object by way of section that accurately conveys their internal orientation.
4. To communicate proper ideas by representing the two-dimensional views into a three dimensional object.
5. To enable students to read and interpret a given orthographic projection to draw the missing view.

Module	Details	Hrs.
00.	**Course Introduction** This is foundation course which deals with fundamental concepts oftechnical drawing and modern tools associated with it. This course will empower the imagination and visualization which will help in communicating the technicality of the product.	**01**
01.	**Introduction to Engineering Graphics** ***Learning Objective:*** *To identify different types of lines and dimensioning standards as per IS system.*	**06-08**
	Contents: Principles of Engineering Graphics and their significance, Types of Lines, Dimensioning Systems as per IS conventions. Introduction to CAD tool (AutoCAD): An overview of AutoCADsoftware to make simple drawings.	
	Lab Activity: To demonstrate the basic commands in AutoCAD software.	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply mathematical and engineering principles and CAD tools to produce precise 2D engineering drawings by selecting appropriate scales, line types, dimensioning practices, and IS-standard conventions; utilizing AutoCAD commands to generate professional-quality figures. (P.I.-1.1.1, P.I.-1.3.1, P.I.-5.1.1, P.I.-5.2.2, P.I.-9.1.2, P.I.-9.3.1)*	

02.	**Orthographic and Sectional Orthographic Projections**	**18-20**
	Learning Objective: *To develop the imagination in creating the orthogonal and sectional orthographic views for communicating the features in the product.*	
	Contents: **Projection of Points and Lines:** Projection of points in differentquadrants. Projection of lines keeping the ends in different quadrants. **Orthographic Projections:** Concept of First Angle and Third Angle Projection. Fundamentals of Orthographic Projections. Different views ofa simple machine part as per the first angle projection method recommended by I.S. Multi view drawing from pictorial views using CADSoftware (AutoCAD) **Sectional Orthographic Projections:** Full or Half Sectional views of the Simple Machine parts. Sectional view using CAD Software (AutoCAD).	
	Lab Activity 1: To demonstrate the ability to project points and lines located in all four quadrants onto the principal planes by constructing accurate front and top views of each point and line segment ensuring correct reference lines and quadrantal positions.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental and mechanical engineering concepts to produce accurate orthographic and sectional projections, classifying true and apparent line lengths in quadrants, constructing first angle front, top, and side views, interpreting full and half sections, and applying justified corrections to projection errors. (P.I.-1.3.1, P.I.-1.4.1, P.I.-2.1.3, P.I.-2.2.3)*	
	Lab Activity 2: To demonstrate the ability to convert the isometric drawings into orthogonal and sectional orthographic drawings.	
	Learning Outcomes: *A learner will be able to* *LO 2.2: Apply essential AutoCAD commands to reproduce orthographic and sectional drawings by applying layers, snaps, object tracking, dimensioning, section lines, hatch patterns, and legends to create clear, IS-compliant visuals that support technical reports and presentations. (P.I.-5.1.1, P.I.-5.2.2, P.I.-9.1.2, P.I.-9.3.1)*	
03.	**Isometric Views**	**10-12**
	Learning Objective: *To develop the ability in visualization of the two-dimensional views of the object to produce the isometric drawing.*	
	Contents: Isometric Drawing: Principles of Isometric Projection, Isometric Views, Conversion of Orthographic Views to Isometric Views. (Excluding Sphere). Construction of Isometric View from Orthographic views with CAD Software (Auto CAD)	
	Lab Activity: To demonstrate the principles of isometric projection by manually constructing an accurate isometric drawing from given orthographic views	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering principles to interpret two-dimensional orthographic projections and manually construct precise isometric drawings that accurately convert orthographic views into three-dimensional representations (P.I.-1.3.1, P.I.-2.2.1, P.I.-9.1.2, P.I.-9.3.1).*	

	Lab Activity: To demonstrate the ability to convert the orthographic views into isometric drawings using Auto CAD.	
	Learning Outcomes: *A learner will be able to* *LO 3.2: Apply mechanical engineering principles to interpret and construct accurate isometric projections by identifying geometric features of components, selecting and justifying manual construction methods, and using AutoCAD commands to generate precise isometric views. (P.I.-1.4.1, P.I.-2.1.3, P.I.-2.2.3, P.I.-5.1.1, P.I.-5.2.2)*	
04.	**Reading of Orthographic Views**	**05-06**
	Learning Objectives: *To develop the ability of the students to read the orthographic and sectional orthographic projections to draw the missing views.*	
	Contents: **Orthographic Reading:** The identification of missing views from the givenviews. Creation of the third view from the two available views so that all the details of the object are obtained using CAD Software (AutoCAD).	
	Lab Activity: To interpret orthographic and sectional projections, identify any missing views, and manually construct the third view from two given projections to fully represent all features of the object.	
	A learner will be able to *LO 4.1: Apply fundamental engineering concepts to analyze and reconstruct complete orthographic and sectional projections by breaking down two-view drawings to locate missing views, drafting sectional views that expose internal details, and generating sectional projections using projection theory. (P.I.-1.3.1, P.I.-2.2.1, P.I.-9.1.1, P.I.-9.1.2)*	
	Lab Activity: To demonstrate the ability to visualize and interpret the missing views of Orthographic projections.	
	Learning Outcomes: *A learner will be able to* *LO 4.2: Apply mechanical engineering principles and leverage AutoCAD drafting commands to interpret two-view projections, generate missing elevations, and produce accurate orthographic and sectional drawings that fully reveal internal features. (P.I.-1.4.1, P.I.-2.2.3, P.I.-9.1.2, P.I.-9.3.1)*	
05.	**Projection of Planes and Solids** ***Learning Objective:*** *To develop the ability to imagine the solid geometries and represent the views in a two dimensional space.*	**12-14**
	Contents: **Projection of Planes:** Projection of Triangular, Square, Rectangular, Pentagonal, Hexagonal or Circular planes inclined to either HP or VP only. **Projection of Solids:** Solid projection (of Prism, Pyramid, Cylinder, Cone only) with the axis inclined to HP or VP. (Exclude Spheres, Composite, Hollow solids and frustum of solids). Use change of position or Auxiliary plane method. **Section of Solids:** Section of Prism, Pyramid, Cylinder and Cone cut by plane perpendicular to at least one reference plane and incline to other in simple positions of the solid. (Section in initial position only)	

	Task 1: Projection of Planes: Draw the true shape of a flat surface such as a triangle, pentagon, hexagon or circle, when it is inclined to one or both principal planes, by using auxiliary views to reveal its actual dimensions.	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to construct auxiliary views that reveal the true shape and dimensions of inclined planes such as triangles, pentagons, hexagons, and circles by selecting and justifying appropriate projection methods. (P.I.-1.3.1, P.I.-2.2.3)*	
	Task 2: Projection of Solids: Draw the orthographic projection of three-dimensional objects like prisms, pyramids, cylinders, and cones whose axes are inclined to the reference planes to capture their true orientations.	
	Learning Outcomes: *A learner will be able to* *LO 5.2: Apply fundamental engineering concepts to generate orthographic projections of prisms, pyramids, cylinders, and cones with inclined axes by employing change-of-position and auxiliary-plane methods, and compare these approaches to select the most accurate representation.* (P.I.-1.3.1, P.I.-2.2.4)	
	Task 3: Section of Solids: Draw sectional orthographic projections of solid (e.g., prism, pyramid, cylinder, or cone) with a plane perpendicular to one reference plane and inclined to another, to expose its internal features, and then illustrating the cut surface in an orthographic section view with appropriate hatching.	
	Learning Outcomes: *A learner will be able to* *LO 5.3: Apply mechanical engineering concepts to produce sectional orthographic projections of solids cut by planes inclined to reference planes with correct hatching, annotations, and dimensions; employ justified approximations to resolve complex orientations; and produce clear technical notes with standardized symbols. (P.I.-1.4.1, P.I.-2.2.3, P.I.-9.1.2, P.I.-9.3.1)*	
	Total	**60**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve engineering problems.
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.1	Identify standard procedures and justified assumptions applicable to problem-solving.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution processes to select the best process.

5.1.1 Identify modern engineering tools such as computer aided drafting, modelling and analysis; techniques and resources for engineering activities

5.2.2 Demonstrate proficiency in using discipline specific tools.

9.1.2 Produce clear, well-constructed, and well-supported written engineering documents.

9.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations.

Course Outcomes: A learner will be able to -

1. Apply mathematical and engineering principles and CAD software tools to produce, annotate, and document precise 2D engineering drawings by selecting correct line types, scales, dimensioning practices, and IS-standard conventions to generate professional-quality figures. *(LO1.1)*
2. Apply projection principles and CAD techniques to produce accurate orthographic and sectional views by converting isometric drawings into orthographic and sectional projections with appropriate hatching, and annotations per IS standards. *(LO2.1, LO2.2)*
3. Apply engineering principles to interpret orthographic projections and develop isometric views from orthographic projections by applying geometric visualization and CAD commands. *(LO3.1)*
4. Apply fundamental and natural science principles and analyze orthographic and sectional projections to identify and reconstruct missing views by decomposing drawings into sub-problems and employing CAD tools to generate accurate third and sectional projections. *(LO4.1)*
5. Apply natural science and engineering principles to create true-shape auxiliary views of inclined planes, orthographic projections of solids with inclined axes, and sectional views with correct hatching and annotations using auxiliary-plane and change-of-position methods to ensure accuracy. *(LO5.1, LO5.2, LO5.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL204.1	3	-	-	-	3	-	-	-	3	-	-
ESL204.2	3	3	-	-	3	-	-	-	3	-	-
ESL204.3	3	3	-	-	3	-	-	-	3	-	-
ESL204.4	3	3	-	-	3	-	-	-	3	-	-
ESL204.5	3	3	-	-	-	-	-	-	3	-	-
Average	**3**	**3**	-	-	**3**	-	-	-	**3**	-	-

Text Books :

1. Engineering Drawing (Plane and solid geometry), N.D. Bhatt, 54th Edition, 2023, Charotar Publishing House Pvt. Ltd.
2. Engineering Drawing, N.H.Dubey, 16th Edition, 2015, Nandu Publications

3. Machine Drawing, N.D. Bhatt & V.M. Panchal, 49th Edition, 2014, Charotar Publishing House Pvt. Ltd.

Reference Books :

1. Engineering Drawing, Narayana, K.L. & P Kannaiah ,3rd Edition, 2012, Scitech Publisher
2. AutoCAD 2024: A Problem-Solving Approach, Basic and Intermediate, , Prof. Sham Tickoo, 30th Edition, 2023, CADCIM Technologies

Other Resources :

1. NPTEL Course: Engineering Drawing by Prof. P.S. Robi, Department of Mechanical Engineering, IIT Guwahati:-Web link- https://nptel.ac.in/courses/112103019.
2. NPTEL Course: Engineering Graphics and Design by Prof. S.R.Kale, Department of Mechanical Engineering, IIT Delhi :-Web link- https://onlinecourses.nptel.ac.in/noc21_me128

In-Semester Assessment (50 Marks)

1. **AutoCAD Assignments (10 Marks):** AutoCAD assignments will be evaluated as a part of continuous laboratory experiments which will be done in AutoCAD software. The Assignments will be based on the following topics:
   i. Redraw the given views using basic AutoCAD Commands. (2 Problems)
   ii. Orthographic Projections (2 Problems)
   iii. Sectional Orthographic Projections (2 Problems)
   iv. Isometric Projections (3 Problems)
   v. Reading of Orthographic Drawings (1 Problems)
2. **Sketchbook Assignments (10 Marks)*:*** Regular Assignments will be given based on the topic covered in the class and will be evaluated at regular intervals as a part of continuous assessment. The Assignments will be based on the following topics:
   1) Projection of Lines (2 Problems)
   2) Orthographic Projections (2 Problems)
   3) Sectional Orthographic Projections (2 Problems)
   4) Reading of Orthographic Projections (1 Problems)
   5) Isometric Projections (2 Problems)
   6) Projection of Planes (2 Problems)
   7) Projections of Solids (2 Problems)
   8) Section of Solids (2 Problems)
3. **Regularity and active participation: 5 marks**

4. **Laboratory Tests (25 Marks):**
   A. **AutoCAD Exam (15 Marks):** The test will be based on Orthographic Projections on AutoCAD software.

   Evaluation Criterion:
   1. Completion and accuracy of the drawing.
   2. Presentation of labels, dimensions, title block on the sheet.

   B. **Manual Drawing Lab Exam (10 Marks):** The test will be based on projections of lines and projections of Solids.

   Evaluation Criterion:
   1. Completion and accuracy of the drawing.
   2. Neatness of the drawing.
   3. Proper space management of the sheet.

End Semester Examination (50 Marks)

Topics for the End Semester Practical Examination (AutoCAD) (2.5 hours)

1. **Isometric drawing. (1 problem) (20 Marks) (Excluding the curves on an inclined plane):**

   The two-dimensional views will be provided such as Front view, Top View and Side view of the object. The task will be to convert the given views in to an isometric drawing (three-dimensional model)
2. **Sectional Orthographic Projection (1 problem). (15 Marks):**

   An isometric figure will be given and the task will be to convert the isometric figure in a sectional 2D view which will include the sectional Front view, Top View and Side view of the three-dimensional figure.
3. **Reading of Orthographic Projections (1 problem) (15 Marks):**

   The two views of the object will be given as an orthographic views and the task will be to draw the missing view of the given object.

Note:

1. Printout of the answers have to be taken preferably in A4 size sheets and should be assessed by External Examiner only.

2. Knowledge of Auto CAD software, concepts of Engineering Graphics related to specified problem and accuracy of drawing should be considered during evaluation.

Two examiners, one Internal and one External will do the evaluation

Course Type	Course Code	Course Name	Credits
ESL	ESL205	PROGRAMMING LABORATORY-II (JAVA)	02

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total Marks**
50	50	100

Pre-requisite:

1. ESL103: Programming Laboratory-I (C)

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering tool usage
4. PO11: Life-long learning

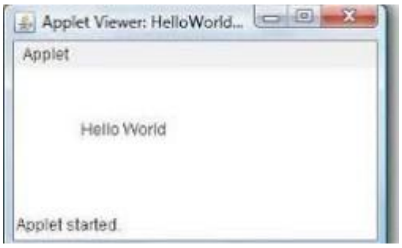
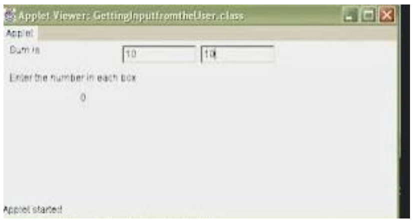
Course Objectives:

1. To impart the knowledge in object-oriented paradigm in the Java programming language.
2. To inculcate the importance of Classes & objects along with constructors,
3. To impart skills of inheritance, interface and packages and demonstrate the concept of reusability for faster development.
4. To introduce usage of Exception Handling, Multithreading, Input Output streams in variousapplications.
5. To impart the knowledge of designing, implementing, testing, and debugging graphical user interfaces in Java using applets.

Module	Details	Hrs.
00.	**Course Introduction** Java is platform independent, open-source object oriented programming language enriched with free and open source libraries. In current industrial scenario Java has the broad industry support and is prerequisite with many allied technologies like Advanced Java, Java Server Pages, and Android Application Development. Thus, current industrial trends necessitate acquiring Java knowledge for graduates.	**01**
01.	**Introduction to Java** ***Learning Objective:*** *Learner is expected to gain proficiency in concept of programming tokens like variables, data types, operators, control structures, function. Also expected to apply the concepts for writing program* **Contents:** Java Architecture, Language Basics: Path, class path, command line argument, keywords, basic data types and types of operators, Flow control Statements: if, if-else, nested if, switch, while, do-while, for, enhanced for, break and continue, Arrays: one- and two-dimensional array **Task 1:** Write a Program that accepts two Strings as command line	**11**

	arguments and generate the output in the required format. Example: If the command line arguments are ABC and Mumbai then the output generated should be: ABC Technologies Mumbai [Note: It is mandatory to pass two arguments in command line] *LO 1.1: The learner will be able to implement command-line argument handling in Java and apply basic input validation to generate formatted output (P.I. -1.3.1, P.I.-1.4, 1 P.I. -5.1.1, P.I. -5.1.2)* **Task 2**: (Any one task) **a.** Write a program to check if a given integer number is odd or even **b.** Write a program to accept gender ('Male' or 'Female') and age from command line arguments and print the percentage of interest based on the given conditions. If the gender is 'Female' and age is between 1 and 58, output is 8.2%. If the gender is 'Female' and age is between 59 and 100, the output is 9.2%. If the gender is 'Male' and age is between 1 and 58, the output is 8.4%. If the gender is 'Male' and age is between 59 and 100, the output is 10.5%. *LO 1.2: Learners will be able to apply language basics and conditional logic in Java to solve basic decision-making problems (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)* **Task 3:** Write a program to initialize an integer array and print the sum and average of the array. *LO 1.3: Learners will be able to implement array operations in Java to compute and validate results (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)*	
02.	**Class and object** ***Learning Objective:*** *1. Learner is expected to gain knowledge of class, object. Also expected to write program using class and object.* *2. To grasp the fundamental concept of input output. Also expected to write program using different input output constructs.*	**08**
	Contents: Classes, objects, Abstraction, Encapsulation, Polymorphism, Input and output functions in Java, scanner class **Task 4:** Create a simple Java class representing an entity Person with attributes like id, name, contact number and instantiate the objects of the class. *LO 2.1: A learner will be able to apply fundamental concept of class and objects and take input from user and identify attributes and methods to implement java program using IDE like eclipse to validate the result. (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)* **Task 5:** Create a student class with private variables roll no and marks. Write getter and setter methods to take user input and display. *LO 2.2: A learner will be able to apply fundamental concept of encapsulation and identify private variables and methods to implement java program using*	

	IDE like eclipse to validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2) **Task 6:** Write a Java program that initializes variables using constructors and prints out information about entity (eg. Student) *LO 2.3: A learner will be able to apply fundamental concept of constructors and take input from user and identify attributes and methods to implement java program using IDE like eclipse to validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)*	
03.	**Inheritance, Interfaces, Packages** ***Learning Objective:*** 1. *Learner is expected to gain knowledge of code reusability. Also expected to write program using inheritance.* 2. *Learner is expected to grasp the concept of multiple inheritance Also expected to apply interface concept to achieve multiple inheritance.* 3. *Learner is expected to gain the knowledge in concept of grouping related classes, interfaces, and sub-packages. Also expected to apply the concept of packages to write well-structured application.*	**16**
	Contents: Types of inheritance, Method overriding, super, Abstract class and abstract method, final, Interface. Define package, types of package, naming and creating packages.accessing package. **Task 7:** Create a program to manage employee details using where Base class Person should store name and age, while the derived class Employee should store details such as employee ID and department. *LO 3.1: A learner will be able to apply fundamental concept of inheritance and identify the variables and inherit the features of one class and adapt IDE like eclipse to implement java program and validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)* **Task 8:** Develop a program to calculate the area of different shapes using an interface. Define an interface Shape with a method calculate_area(). Implement this interface in two classes: Rectangle and Circle. *LO 3.2: A learner will be able to apply fundamental concept of interface and identify the variables and use multiple inheritance and adapt IDE like eclipse to implement java program and validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)* **Task 9:** Create user defined package for the given problem. *LO 3.3: A learner will be able to apply fundamental concept of packages and adapt IDE like eclipse to implement java program and validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -2.1.2, P.I. –2.4.1, P.I. -5.1.1, P.I. -5.1.2)*	
04.	**Exception Handling and Multi-threading** ***Learning Objectives:*** 1. *To impart skills that can enable students to check and handle the proper functioning of applications. Also expected to apply the exception handling for proper functioning of applications.* 2. *Learner is expected to know the concept of multithreading. Also expected to apply it for multitasking.*	**08**

	Contents: Exception handling using try, catch, finally, throw and throws, Multipletry and catch blocks, user defined exception. Thread lifecycle, thread class methods, creating threads using extends andimplements keyword. **Task 10:** Write a program for handling the given exception using try, catch, finally, throw and throws. *LO 4.1: A learner will be able to apply concept of exception handling and adapt IDE like eclipse to implement java program and validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -5.1.1, P.I. -5.1.2)* **Task 11:** Create threads to run the given multiple processes in the given program. *LO 4.2: A learner will be able to apply concept of threads and adapt IDE like eclipse to implement java program and validate the result (P.I. -1.3.1, P.I. -1.4.1, P.I. -5.1.1, P.I. -5.1.2)*	
05.	**Graphical User Interface** ***Learning Objective/s:*** 1. *Learner will gain the knowledge of handling events through GUI. Also expectedto apply it for creating small applications.* 2. *Learner is expected to develop proficiency in the concept of swing. Also expected to apply it for developing GUI with good look and feel* 3. *Learner will learn the concept of connecting database with business logic. Alsoexpected to apply it for retrieving and saving data.*	**16**
	Contents: Applet and applet life cycle, creating applets, graphics class functions, parameter passing to applet, Font and color class. Event handling using event class.Introduction to JDBC, JDBC-ODBC connectivity **Task 12:** Develop a program for GUI using appletExample   *LO 5.1: A learner will be able to apply concept of GUI and adapt IDE like eclipse to implement java program and validate the result, illustrate path from CLI to GUI and summarize the advantages of GUI (P.I. -1.3.1, P.I. -1.4.1, P.I. -5.1.1, P.I. -5.1.2, P.I. -11.2.1, P.I. -11.2.2)*	
	Course Conclusion	
	Total	**60**

Self-Learning Topics

- **Micro-projects**

  A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

1. Mini Banking System for handling deposits and withdrawal.
2. Medical Store Stock Management System.
3. Bus Reservation System.
4. Student Information System
5. Library Management System
6. Attendance Management System.

Guidelines for developing micro projects:

1. Declare four to five classes and may include Interfaces if required.
2. Must use Most of the Object Oriented Concepts.
3. Must implement concepts of Inheritance and Exception Handling.
4. Must Create Own Package.
5. May use the constructor overloading and overriding.
6. May Use Multithreading if required.

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply computer science concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.4.1	Able to apply computer engineering principles to solve the problems
5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
11.2.1	Identify historic points of technological advance in engineering that required practitioners toseek education in order to stay current
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep currentregarding new developments in your field

Course Outcomes: A learner will be able to -

1. Install java environment and write a java program using fundamental concepts. *(LO 1.1, LO 1.2, LO 1.3*)
2. Apply concepts of classes, objects, members of a class and the relationships among them needed for a finding the solution to specific problem*(LO 2.1, LO 2.2, LO 2.3*)
3. Achieve reusability in programming by using concept of Inheritance, Interface and Packages. *(LO 3.1, LO 3.2, LO 3.3*)
4. Implement concept of Multithreading, and exceptions to obtain robust and faster programmed solutions to problems. *(LO 4.1, LO 4.2*)
5. Design and develop application using Abstract Window Toolkit, Swings with database connectivity *(LO 5.1*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL205.1	3	3	-	-	3	-	-	-	-	-	-
ESL205.2	3	3	-	-	3	-	-	-	-	-	-
ESL205.3	3	3	-	-	3	-	-	-	-	-	-
ESL205.4	3	-	-	-	3	-	-	-	-	-	-
ESL205.5	3	-	-	-	3	-	-	-	-	-	3
Average	**3**	**3**	-	-	**3**	-	-	-	-	-	**3**

Text Books :

1. Java: The Complete Reference, Herbert Schildt, Ninth Edition, 2017, McGraw Hill Education.
2. Programming with Java, E. Balagurusamy, Seventh Edition, 2019, McGraw Hill Education

Reference Books :

1. Beginning JAVA, Ivor Horton, Seventh Edition, 2011, Wrox.
2. JAVA Programming Black Book, by D.T. Editorial Services, 2015, Dreamtech Press.
3. Java One Step Ahead, Anita Seth, B.L.Juneja, First Edition, 2017, oxford university press.

Other Resources :

1. NPTEL Course: Programming in Java, By Debasis Samanta, Computer Science and Engineering, Indian Institute of Technology Kharagpur.:-Web link- https://onlinecourses.nptel.ac.in/noc23_cs74/co
2. Web link-www.w3schools.com
3. Web link-www.tutorialspoint.com

A. IN-SEMESTER ASSESSMENT (TERM WORK) (50 MARKS)

1. Task Execution (30 Marks)

Students will be given minimum 12 experiments.
Students are expected to

1. Identify variables, data types methods/approach required to write the code for the given task and apply the same.
2. Execute given task for different inputs and verify the result
3. Create a simple Java class representing an entity (e.g., Person, Car) with attributes and methods. Instantiate objects of the class and demonstrate basic operations.
4. Apply simple inheritance and multilevel inheritance.
5. Import a Java Built-in API package and also create user’s own package
6. Handle the proper functioning of applications by applying the exception handling.
7. Develop proficiency in the concept of applet and apply it for creating small applications (GUI)

Students are evaluated based on following:

1. Logic building for the given task (10 marks)
2. Rectifying logical errors and syntax errors (06 marks)
3. Well-structured and organized program (06 marks)
4. Verification of experiment output for different inputs (08 marks)

Refer the sample task given below.
Example:
Create a Persona class to add details of the person, inherit features of person class into Employee class and display details using method.
Students are expected to.

1. Identify Variables, data types methods/approach required to create teacher class and add methods to display details of a given teacher
2. Execute given task for different inputs and verify the result
3. Follow the coding standards
4. Identify errors and rectify the errors.

2. Regularity and active Participation (05 Marks)

3. Mid Semester Examination (15 Marks)

a) Task Execution: 10 Marks

Students are evaluated based on following:

1. Logic building for the given task (04 marks)
2. Rectifying logical errors and syntax errors (02 marks)
3. Well-structured and organized program (02 marks)
4. Verification of experiment output for different inputs (02 marks)

b) Oral: 05 Marks

B. END SEMESTER EXAMINATION (Practical & Oral Exam) (50 Marks)

1. Task Execution: 15 Marks
   Students will be given task (different task for every student) to execute and will be evaluated as per the parameters mentioned in continuous evaluation
2. Presentation of Results and conclusion, Inferences drawn: 05 Marks
3. Multiple Choice Questions based on entire syllabus: 15 Marks
4. Oral: 15 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
ESL	ESL206	BASIC ELECTRONICS ENGINEERING LABORATORY	02

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total Marks**
25	25	50

Pre-requisite:

1. ESC102- Basic Electrical Engineering
2. BSC102- Engineering Physics I

Program Outcomes addressed:

1 PO2: Problem Analysis
2 PO3: Design / Development of Solutions
3 PO4: Conduct investigations of complex problems
4 PO5: Engineering tool usage
5 PO6: The engineer and the world
6 PO8: Individual and Team work
7 P09: Communication
8 P11: Life-long learning

Course Objectives:

1. To familiarize with electronics components, measuring devices, source devices for building and analyse analog/digital circuits
2. To provide practical exposure to sensors and transducers and build a basic data acquisition system
3. To provide hands-on experience in designing real time application circuits.

Module	Details	Hrs.
00.	**Course Introduction** Electronics is pervasive in the modern era which provides a platform to comprehend the basics of components, ICs devices with some practical application. This provides a roadmap to venture in the field of electronics. The electronic circuits form the integral part for almost all used in industrial machinery, computers, microprocessors, household appliances, medical equipment, internet and e-commerce.	**01**
01.	**Electronic Devices (Expected to perform all)** ***Learning Objective:*** ***Learner is expected to analyze experimental results to validate theoretical concepts and understand practical implications. Evaluate circuit parameters to achieve desired performance characteristics.***	**8**
	Contents: **Experiment 1: Study of CRO & Measurement of Voltage Amplitude & Frequency.** *LO 1.1: A learner will be able to identify the features of CRO and able to measure the amplitude and frequency for a specific signal source and extract desired understanding and conclusions consistent with objectives in a team. (P.I. - 1.3.1,*	

	P.I-2.4.4, P.I-8.3.1, P.I-11.1.3) **Experiment 2: Testing of Components using Instruments and fault detection.** *LO 1.2: A learner will be able to identify the components, apply the relevant knowledge, measure the values manually and validate it with the help of instruments. (P.I. – 1.4.1, P.I. - 2.1.3, P.I.-2.4.2)* **Experiment 3: V.I Characteristics of Si or Ge and Zener Diode** *LO 1.3: A learner will be able to identify the important features of the electronic device through data sheets and interpret the VI graph to determine the diode parameters like knee voltage, saturation current etc.in a team to access new source of information. (P.I. – 1.4.1, P.I.-2.3.2, P.I. – 4.1.4, P.I-8.1.1, P.I-11.3.1)* **Experiment 4: Applications of Diode – Clipper/Clamper/Rectifiers** *LO 1.4: A learner will be able to identify the working principles of diode-based clipper, clamper, and rectifier circuits, correctly interprets results and relates them to circuit structure uses CRO/multimeter to take accurate measurements and documents the results in the form of waveforms. (P.I. – 1.4.1, P.I.-2.3.2, P.I. – 4.1.4, P.I-8.1.1, P.I-11.3.1).* **Experiment 5: Characteristics of BJT in Common Emitter Configuration.** LO 1.5: *A learner will able to identify the proper choice of devices with given specifications, uses voltmeter/ammeter/CRO to take correct readings at various bias levels and accurately plot graph in a team. (P.I. – 1.4.1, P.I.-2.3.2, P.I. – 4.1.4, P.I-8.1.1, P.I-11.3.1).*	
02.	**Digital Circuits (Any 3)** ***Learning Objective:*** *Learner is expected to recall basics of Digital Circuit Design. Also expected to apply it to solve any Boolean expression.* **Contents:** Experiment 6: Introduction to Logic Gates – NOT, AND, OR, NAND NOR and XOR. *LO 2.1: A learner will be able to identify and analyze various IC's required for a digital system, use systematic techniques to test and verify with the help of truth table as a team. (P.I- 1.3.P.I.-2.4.1, P.I.-8.3.1)* **Experiment 7: For a given Boolean expression, design and verify the circuit using Universal Gates.** *LO 2.2: A learner will be able to identify the ICs required for the design for given specifications, devise a best fitting design solution, verify a given Boolean expression and validate the theoretical results with hardware in a team or make an attempt to independently tackle the problem with the help of instructor materials. (P.I- 1.4.1, P.I-2.4.2, P.I.- 3.3.3, P.I.- 9.3.1, P.I-11.1.3)* **Experiment 8: Basics of AND gate and its application in car wiper control** **Experiment 9: Basics of NOT gate and its application in fuel level Indicator.** *LO 2.3: A learner will be able to identify the ICs required for the above given application, devise a best fitting design solution, verify a given Boolean expression and validate the theoretical results with hardware in a team or find the gap on using the particular IC and close the gap. (P.I- 1.4.1, P.I-2.4.2, P.I.- 3.3.3, P.I.- 9.3.1, P.I-11.1.2)*	**8**
03.	**Sensor/ Transducer Applications (Any one)**	

<table>
<tr><td></td><td> Learning Objective: Learner is expected to know the fundamentals of sensor/transducer and model or trouble shoot the basic data acquisitionsystem. Contents: Sample List Intruder detection using IR sensor
Collision avoidance using ultrasonic sensor
Fire alarm system using temperature sensor
Movement detection using flex sensor
Light detection using LDR
Interactive doorbell system using Proximity sensor
Gas detection using gas sensors LO 3.1: A learner will be able to identify and analyze various sensors required for a particular application, breakdown the problem into sub parts collect the data, test, check/troubleshoot for the working, sustainability and verify with the help of equipment's ((CRO, multimeter) as a team. (P.I- 1.3.P.I.-2.2.1, P.I-4.3.1, P.I-6.3.1, P.I.-8.3.1, , P.I.-9.3.1, P.I-11.1.3) </td><td>4</td></tr>
<tr><td>04.</td><td> Real Time Applications (Any one) Learning Objectives: Learner is expected to develop practical electronic skills through designing and implementing real-lifeapplications.. Contents: Sample List Regulated Power Supply using transistor and zener diode
Electronic lock using basic logic gates
Cockpit warning light control using basic logic gates.
Universal NOR gate and its application in automobile alarm system
Universal NAND gate and its application in level monitoring inchemical plant
Mosquito Trap bat.
Electronic safety lock using vibration sensor
Water Level Indicator
Smoke Detector
Smart Trash Bin
Virtual Piano
Voltage Doubler Circuit LO 4.1: The learner will be able to recognize any real time application which can be one of the above or of own interest, that is only to test with software/hardware, their troubleshooting skills in implementing the simple real-life applications in a team and identify and solve the gap if required. (P.I- 1.4.1,.P.I.-2.2.1, P.I-4.3.1, P.I-5.3.3,P.I-6.3.1, P.I.-8.3.1,P.I.- 9.3.1, P.I-11.3.1) </td><td>8</td></tr>
<tr><td></td><td>Course Conclusion</td><td>01</td></tr>
<tr><td colspan="2" align="right">Total</td><td>30</td></tr>
</table>

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and accepted practice areas to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.1	Breakdown complex problem into interconnected sub parts and analyse by proper assumptions/ justification from information and resources.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
2.4.1	Apply engineering mathematics and computations to solve mathematical models
2.4.2	Produce and validate results through skilful use of contemporary engineering techniques.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.3.3	Identify relevant data from the given resources and arrive at a best fitting design solution for particular specifications.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data
5.3.3	Recognize sources of error in measurements, modelling or simulations and verify credibility of results.
6.1.1	Recognize sources of error in measurements, modelling or simulations and verify credibility of results.
6.3.1	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Apply knowledge about the electronic equipment such as oscilloscopes, function generators, multimeter, timers etc. for analog testing, measuring the parameters electronics devices such as diode, Zener diode, Transistor etc (*LO 1.1, LO 1.2*, *LO1.3, LO1.4, LO1.5*)
2. Demonstrate and analyze the use of basic gates and apply it in various applications in digital domain. (*LO 2.1, LO 2.2, LO 2.3*)
3. Analyse sensors/transducers and assemble a prototype for a basic data acquisition system. (*LO 3.1*)
4. Design analyse, test, and ensure functionality of real-life electronic applications using acquired skills and electronic test instruments. (*LO 4.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ESL206.1	3	3	-	3	-	-	-	3	-	-	3
ESL206.2	3	3	2	3	-	-	-	3	-	-	3
ESL206.3	3	3		3	-	2	-	-	2	-	3
ESL206.4	3	3	2	3	-	2	-	-	2	-	3
Average	**3**	**3**	**2**	**3**	-	**2**	-	-	**2**	-	**3**

Text Books:

1. Basic Electronics By B.L.Theraja,S Chand Publications.
2. Basic Electronics Engineering. Satya Sai Srikant, Prakash Kumar Chaturvedi, Springer, Year:2020
3. A Textbook of Basic Electronics, Dr. Barun RayChaudhuri Chhaya Prakashan Pvt. Ltd.

Reference Books :

1 Learning Art of Electronics: A Hands-on Lab Course By. Paul Horowitz and Thomas, C. Hayes, 2020

2 Basic Electronics--theory and practice J. A. Sam Wilson, Publisher, Gregg Division,McGraw-Hill, 1977.

3 Practical Electronics for Inventors, 4th Edition by Paul Scherz, Simon Monk, 2016

4 Getting started in Electronics – Forest M. Mims Publisher. Fort Worth: Radio Shack,12th edition, 1994.

5 Self-teaching guide: All new electronics – Harry Kybett and Earl Boysen, 3rd edition 2008.

Other Resources :

1. Basic Electronics Course – NPTEL By Dr. M.B. Patil, IIT Bombay.
2. Virtual Lab of Basic Electronics. Basic Electronics (iitkgp.ac.in).

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(25 Marks)

1. Lab Experiments: 10 Marks
2. Internal Assessment:

   i. Practical Test 1 (Based on 50% of the Practical list): 5

   ii. Practical Test 2 (Based on remaining 50% of the Practical list):5

3. Regularity and active participation: 5 marks

B.END SEMESTER EXAMINATION (Pract. /Oral Exam) (25 Marks)
Performance of experiments based on the course content.

Students will have to:

1. Draw the circuit diagram.: 03 Marks
2. Identify the components.: 01Marks
3. Make proper connections on breadboard.:03Marks
4. Take accurate readings from instruments.:03 Marks
5. Tabulate the readings and plot graphs if required.:05 Marks
6. Orals:10 Marks

Two examiners, one Internal and one External will do the evaluation

Course Type	Course Code	Course Name	Credits
SEC	SEC202	BASIC WORKSHOP PRACTICE II	01

Examination Scheme		
Term Work	**Practical /Oral**	**Total**
50	--	50

Pre-requisite:

1. SEC101- Basic Workshop Practice I

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO5: Engineering tool usage
3. PO6: The engineer and the world
4. PO8: Individual and collaborative team work
5. PO11: Life-long learning

Course Objectives :

1. To impart training to help the students develop engineering skill sets.
2. To inculcate respect for physical work and hard labour.
3. To get exposure to interdisciplinary engineering domain.

Module	Detailed Contents	Hrs
00.	**Course Introduction** The Workshop Practice II course is intended to give students with the core information and abilities required for developing engineering skill sets and getting an exposure to work in an interdisciplinary engineering domain including basic electronic work shop. This hands-on course introduces the fundamental principles, equipment, and techniques utilised in workshop scenarios, such as carpentry, sheet metal working, brazing and forging.	**01**
01.	***Learning Objectives:*** *1. To gain proficiency in accurate measuring, marking, and layout techniques, including the use of squares, levels, and other layout tools.* *2. To develop proficiency in the use of basic carpentry hand tools such as hammers, saws, chisels, planes, and measuring devices.* **Content: Carpentry** • Use and setting of hand tools like hacksaws, jack planes, chisels and gauges for construction of various joints, wood turning and modern wood turning methods. • Term work to include one carpentry job involving a joint and report on demonstration of a job involving wood turning.	**09**

	Learning Outcomes : *A learner will be able to* *LO1.1: Accurately measure and layout components of carpentry projects using appropriate tools and techniques, ensuring precision and alignment. (P.I. - 1.3.1, 5.2.1, 11.3.1)* *LO1.2: Exhibit proficiency in the use of common carpentry hand tools and power tools, including accurate handling, operation, and maintenance. (P.I. - 1.4.1, 5.2.2, 11.3.2)*	
02.	***Learning Objectives:*** *1. To provide hands-on experience in measuring instruments, electronic components, PCB circuit design and to familiarize students with PCB fabrication process.* *2. To provide hands-on experience in assembly and testing of electronics circuit.* **Content: Basic Electronic work shop** • Introduction to measuring instruments and electronic components like resistors, capacitors, inductors, diodes, transistors, etc. • Demonstration of PCB simulation software for making the layout, layout transfer to PCB, etching, drilling and soldering technique. • Assembling and testing the circuit for correct functionality. ***Learning Outcomes :*** *A learner will be able to* *LO2.1: Select appropriate electronic components based on design requirements and place them effectively on the PCB layout. (P.I. - 5.2.1, 5.2.2, 11.3.1)* *LO2.2: Demonstrate a clear understanding of what PCBs are, how they function, and their importance in electronic devices and systems. (P.I. - 8.2.1, 8.3.1)* *LO2.3: Comprehend the basic principles of PCB design, including component placement, routing, signal integrity, and manufacturability. (P.I. - 6.1.1, 6.4.2, 8.2.1, 8.3.1, 11.3.2)*	**10**
03.	***Learning Objectives:*** *1. To become proficient in the use of various sheet metal working tools and equipment, such as shears, brakes, punches, rollers, and spot welders.* *2. To grasp the fundamental principles and techniques involved in forging, which includes heating, shaping, and cooling metal through the application of force.* **Content: Sheet metal working, Brazing and Forging (Smithy)** • Use of sheet metal, working hand tools, cutting, bending, spot welding. One job covering maximum operation with soldering or brazing. • At least one forging job to be demonstrated and a simple job to be made for Term Work in a group of 4 students. ***Learning Outcomes :*** *A learner will be able to* *LO3.1: Use various sheet metal working tools and equipment proficiently. (P.I. - 5.2.2, 5.3.2, 11.1.1, 11.3.2)* *LO3.2: Demonstrate competence in operating forging equipment and tools, including heating furnaces, power hammers, presses, and hand tools, to manipulate metal effectively. (P.I. - 5.2.2, 8.1.1, 8.3.1, 11.1.1, 11.3.2)*	**10**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
5.2.1	Identify the strengths and limitations of tools for creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.
6.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
11.1.1	Describe the rationale for the requirement for continuing professional development.
11.3.1	Source and comprehend technical literature and other credible sources of information.
11.3.2	Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes :

A learner will be able to

1. Develop the necessary skill required to handle/use different carpentry tools. (*LO 1.1, LO 1.2*)
2. Identify different electronic components to design, fabricate and assemble PCB. (*LO 2.1, LO 2.2, LO 2.3*)
3. Develop the necessary skill required to use different sheet metal and brazing tools. (*LO 3.1*)
4. Demonstrate the forging operation with the help of a simple job. (*LO 3.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
SEC202.1	3	-	-	-	3	-	-	-	-	-	3
SEC202.2	-	-	-	-	3	3	-	3	-	-	3
SEC202.3	-	-	-	-	3	-	-	3	-	-	3
SEC202.4	-	-	-	-	3	-	-	3	-	-	3
Average	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**3**	**-**	**-**	**3**

Continuous Internal Assessment (CIA) - (50 Marks)

Job Work with complete workshop book: 40 Marks

Attendance and Active participation: 10 marks

Course Type	Course Code	Course Name	Credits
IKS	IKS201	INDIAN KNOWLEDGE SYSTEM	02

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO6 : The engineer & The World
3. PO7 : Ethics
4. PO11: Life-long learning

Course Objectives :

1. To introduce fundamentals of Ancient Indian Educations to understand the pattern and purpose of studying vedas, vedangas, upangas, upveda, purana & Itihasa
2. To help students to trace, identify and develop the ancient knowledge systems.
3. To help to understand the apparently rational, verifiable and universal solution from ancient Indian knowledge system for the holistic development of physical, mental and spiritual wellbeing
4. To build in the learners a deep rooted pride in Indian knowledge, committed to universal human right, well-being and sustainable development..

Module	Details
01.	**Indian Knowledge System** Caturdaśa Vidyāsthānam, 64 Kalas, Shilpa Śāstra, Four Vedas, Vedāṅga, Indian Philosophical Systems, Vedic Schools of Philosophy (Sāṃkhya and Yoga, Nyaya and Vaiśeṣika, Pūrva-Mīmāṃsā and Vedānta), Non-Vedic schools of Philosophical Systems (Cārvāka, Buddhist, Jain), Puranas (Maha-puranas, Upa-Puranas and Sthala-Puranas), Itihasa (Ramayana, Mahabharata), Niti Sastras, Subhasitas
02.	**Foundation concept for Science & Technology** Linguistics & Phonetics in Sanskrit (panini's), Computational concepts in Astadhyayi Importance of Verbs, Role of Sanskrit in Natural Language Processing, Number System and Units of Measurement, concept of zero and its importance, Large numbers & their representation, Place Value of Numerals, Decimal System, Measurements for time, distance and weight, Unique approaches to represent numbers (Bhūta Saṃkhya System, Kaṭapayādi System), Pingala and the Binary system, Knowledge Pyramid, Prameya – A Vaiśeṣikan approach to physical reality, constituents of the physical reality, Pramāṇa, Saṃśaya
03.	**Indian Mathematics & Astronomy in IKS** Indian Mathematics, Great Mathematicians and their contributions, Arithmetic Operations, Geometry (Sulba Sutras, Aryabhatiya-bhasya), value of π, Trigonometry, Algebra, Chandah Sastra of Pingala, Indian Astronomy, celestial coordinate system, Elements of the Indian Calendar Aryabhatiya and the Siddhantic Tradition Pancanga – The Indian Calendar System Astronomical Instruments (Yantras) Jantar Mantar or Raja Jai Singh Sawal.

04.	**Indian Science & Technology in IKS** Indian S & T Heritage ,sixty-four art forms and occupational skills (64 Kalas) Metals and Metalworking technology (Copper, Gold, Zinc, Mercury, Lead and Silver), Iron & Steel, Dyes and Painting Technology), Town & Planning Architecture in India, Temple Architecture, Vastu Sastra
05.	**Humanities & Social Sciences in IKS** Health, Wellness & Psychology, Ayurveda Sleep and Food, Role of water in wellbeing Yoga way of life Indian approach to Psychology, the Triguṇa System Body-Mind-IntellectConsciousness Complex. Governance, Public Administration & Management reference to ramayana, Artha Sastra, Kauṭilyan State
Total no. of hours: **30**	

Course Outcomes :

1. Explore the diverse realms of the Indian Knowledge System, spanning philosophy, literature, and ethics, to appreciate its holistic approach to education.
2. Understand foundational concepts in Science and Technology from ancient Indian perspectives, including linguistics, mathematics, and astronomy.
3. Discover the rich heritage of Indian Mathematics, Astronomy, and Science, exploring their contributions to global knowledge and technological advancement.
4. Engage with interdisciplinary perspectives in Humanities and Social Sciences rooted in ancient Indian wisdom, fostering critical thinking and holistic development.
5. Apply insights from ancient Indian knowledge systems to contemporary challenges, promoting innovation and sustainable solutions.
6. Cultivate a deeper appreciation for Indian heritage while developing analytical skills and interdisciplinary insights for real-world application.

Text Books :

1. Exploring the Indian Knowledge System: Insights from Prof. B Mahadevan, Prof. B Mahadevan, IIM Bengaluru Press
2. Kapur K and Singh A. K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust,Bombay, 1995.
3. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008

Reference Books :

1. Reshmi ramdhoni, Ancient Indian Culture and Civilisation, star publication ,2018
2. Supriya Lakshmi Mishra, Culture and History of Ancient India (With Special Reference of Sudras), 2020.
3. DK Chakkrabarty, Makkhan Lal, History of Ancient India (Set of 5 Volumes), Aryan book Internation publication, 2014

Other Resources :

1. NPTEL Course: Indian Knowledge System(IKS): Concepts and Applications in Engineering, By By Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghava, Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore :-Web link- https://onlinecourses.swayam2.ac.in/imb23_mg53/preview

2. NPTEL Course: Indian Knowledge System(IKS): Humanities and Social Sciences, By Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghavan, Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore :-Web link- https://onlinecourses.swayam2.ac.in/imb23_mg55/preview

Course Type	Course Code	Course Name	Credits
PCC	MEPCC301	ENGINEERING MATHEMATICS-III	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)	MSE	ESE	
Continuous Assessment	Mid-Semester Exam (MSE)				
20+25*	30	50	1.5	2	125

Tutorial

Pre-requisite :

1. BSC101 Engineering Mathematics-I
2. BSC204 Engineering Mathematics-II

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives :

1. To provide the basic knowledge on the concepts of Mathematics in the field of Engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of Mathematics to the field of Engineering.

Module	Details	Hrs
	Course Introduction To introduce the Laplace and inverse Laplace transform and explore its applications for co-ordinate transformation in mechanical engineering. Apply Fourier series for discretization techniques for different functions. To solve one dimensional heat and wave equations using partial differential equations and concept of complex variables to address the problems related to harmonic vibrations.	**01**
01	**Laplace Transform** ***Learning Objective/s:*** *To analyses the standard Laplace Transforms using basic definitions and apply it to solve mathematical problems.*	**7-9**
	Contents:	
	Definition of Laplace Transforms, Condition of existence of Laplace Transform, Laplace Transforms of standard functions: $e^{at}, sinat, cosat, sinhat, coshat, t^n\ n > 0.$ Properties of Laplace Transform: Linearity, First Shifting Theorem, Change of scale Property, Multiplication by t, Division by t Laplace Transform of derivatives and integrals, Heaviside's Unit Step function.	
	Self-Learning Topics:	
	Second Shifting Theorem, Laplace Transform of Periodic functions.	

	Learning Outcomes : *A learner will be able to* *LO1.1 Interpret standard Laplace transforms and its applicability to a given mathematical problem. (P.I.- 1.1.1)* *L01.2 Apply the properties of Laplace Transform and use it for solving advanced mathematical problems. (P.I.- 1.1.2)* *LO1.3 Identify unit steps functions to solve engineering problems. (P.I-2.1.2)* *LO1.4 Identify the correct properties of Laplace Transform applicable to a given problem (P.I.-2.1.3)*	
02	**Inverse Laplace Transform** ***Learning Objective/s:*** *To analyses and apply the techniques of Laplace and inverse Laplace transform to solve differential equations. .*	**6-8**
	Contents: Definition of Inverse Laplace Transform, Properties of Inverse Laplace Transform: Linearity, Shifting Theorem, Finding Inverse Laplace Transform using partial fraction, Finding Inverse Laplace Transform using differentiation Property, Solution of Differential equations-initial value problem and Boundary Value Problem.	
	Self-Learning Topics: *Convolution Theorem.* ***Learning Outcomes :*** *A learner will be able to* *LO2.1 Interpret standard Inverse Laplace transforms and its applicability to a given mathematical problem. (P.I.-1.1.1)* *LO2.2 To solve initial and boundary value problems of differential equation by applying advanced mathematical techniques. (P.I.-1.1.2)* *LO2.3 Identify the correct properties of inverse Laplace Transform applicable to a given problem (P.I.-2.1.3)* *LO 2.4 Identify the types of partial fraction method to find the solution of inverse Laplace transform. (P.I.-2.2.3)*	
03	**Fourier Series** ***Learning Objective/s:*** *To analyses various wave forms and use the knowledge of periodic wave forms in determining a function in terms of its sine and cosine counterparts.*	**7-9**
	Contents:	
	Dirichlet's conditions, Definition Periodic function and graphical representation of periodic function: sine wave form, cosine wave form, square wave form, saw tooth wave form, Definition of Fourier series, Fourier series of periodic function with period 2π and Fourier series of periodic function with period $2l$, Fourier series of even and odd functions, Half range Sine and Cosine Series.	
	Self-Learning Topics:	

	Parseval's Identity, Complex form of Fourier Series, Orthogonal and orthonormal set of functions. ***Learning Outcomes :*** *A learner will be able to* *LO 3.1 To apply mathematical techniques of algebra and calculus in determining Fourier coefficients. (P.I.-1.1.1)* *LO 3.2 To apply fundamental concept of mathematics to solve engineering problems. (P.I.-1.3.1)* *LO 3.3 Articulate and interpret the basics of periodic functions and series. (P.I.-2.1.1)* *LO 3.4 Identify the knowledge of periodic functions to solve given engineering problems. (P.I.-2.1.3)* *LO 3.5 To synthesize the information about any given mathematical function and express it in terms of sine and cosine waveforms. (P.I.-2.1.3)*	
04	**Partial differential equations** ***Learning Objective/s:*** *To Solve Partial differential equations by applying numerical solution and analytical methods for one dimensional heat and wave equations.*	**6-8**
	Contents: Introduction of Partial Differential equations, method of separation of variables, Vibrations of string, Analytical method for one dimensional heat and wave equations. Crank Nicholson method, Bender Schmidt method.	
	Self-Learning Topics: *Analytical methods of solving two and three dimensional.* ***Learning Outcomes :*** *A learner will be able to* *LO 4.1 To apply mathematical techniques to solve Partial differential equations.(P.I.- 1.1.1)* *LO 4.2 To apply fundamental concept of mathematics to solve engineering problems. (P.I.- 1.3.1)* *LO 4.3 To identify the appropriate numerical techniques to solve one-dimension heat and wave equation. (P.I.- 2.1.3)* *LO 4.4 To identify and solve linear, non-linear boundary value problem using Bender Schmidt method. (P.I.- 2.2.3)*	
05	**Complex Variables-I** ***Learning Objective/s:*** *To analyses if a given complex function is analytic or not by applying basic definitions and theorems of Complex Variables.*	**6-8**
	Contents:	
	Statement of D'Moivre's Theorem, Expansion of sinn θ, cosnθ in terms of sines and cosines of multiples of θ ,Expansion of sinnθ, cosnθ in powers of sinθ, cosθ .Complex Variables, Calculus of Complex Variables: Limit, Continuity Differentiability.	

	Analytic Functions: Necessary and sufficient conditions for f(z) to be analytic, Cauchy-Riemann equations: Cartesian coordinate and Polar coordinates.	
	Self-Learning Topics: *Roots of a complex number, Conformal mapping.* ***Learning Outcomes :*** *A learner will be able to* *LO 5.1 To apply mathematical techniques such as calculus and algebra to solve mathematical problems of complex variables and functions. (P.I-1.1.1)* *LO 5.2 To apply the fundamental concept of complex functions to solve engineering problems. (P.I.-1.3.1)* *LO 5.3 To interpret complex functions using the knowledge of complex variables. (P.I-2.1.2)* *LO 5.4 Identify if given complex function is analytic or not using Cauchy Riemann Equations. (P.I-2.1.2)* *LO 5.5 To identify the concept of analyticity by using Cauchy-Riemann equations to solve given problem. (P.I-2.1.3)* *LO 5.6 To Identify if the derivatives of a given complex function exist or not by applying the theory of complex variables to a given problem. (P.I-2.1.3).*	
06	**Complex Variables-II**	**5-7**
	Learning Objective/s: *To analyses if a given function has its harmonic conjugate and apply it for finding the Orthogonal Trajectories of a given mathematical function using the concept of Complex Variables.*	
	Contents: Milne-Thomson method: Determine analytic function f(z) when real part (u) is given, Determine analytic function f(z) when imaginary part (v) is given, Determine the analytic function when the combination of Real and Imaginary part is given, Harmonic function, and Harmonic conjugate, Orthogonal trajectories.	
	Self-Learning Topics: *Linear mapping, bilinear mapping, cross ratio, fixed points.*	
	Learning Outcomes : *A learner will be able to* *LO 6.1 To apply the mathematical techniques of calculus and algebra for determining the analytic function using Milne Thomson Formula. (P.I.-1.1.1)* *LO 6.2 To apply the fundamental concept of complex Variables to solve engineering problems. (P.I.-1.3.1)* *LO 6.3 Identify the harmonic function and determine its harmonic conjugate. (P.I.-2.1.2)* *LO 6.4 Identify the analytic functions to solve orthogonal trajectory.(P.I.-2.1.3)*	

	Course Conclusion Engineering Mathematics provides the quantitative tools and problem solving skills necessary for Mechanical engineering to design, analyze and optimize mechanical system.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.1.2	Apply advanced mathematical techniques to model and solve engineering problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions.

Course Outcomes :

1. Analyse the techniques of Laplace and inverse Laplace transform and apply it to determine the solutions of differential equations. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
2. Analyse the periodic functions and expand it by using Fourier series to solve complex engineering problems. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5)*
3. Analyses the appropriate numerical methods and apply it to solve partial differential equations. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4)*
4. Apply the concept of complex variables to analyse the function is holomorphic or not and also determine orthogonal trajectory. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC301.1	3	2	--	--	--	--	--	--	--	--	--
MEPCC301.2	3	2	--	--	--	--	--	--	--	--	--
MEPCC301.3	3	2	--	--	--	--	--	--	--	--	--
MEPCC301.4	3	2	--	--	--	--	--	--	--	--	--
Average	**3**	**2**	--	--	--	--	--	--	--	--	--

Text Books :

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication.
2. Advanced engineering mathematics, H.K. Das, S. Chand, Publications.

Reference Books :

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited.

2. Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education.
3. Higher Engineering Mathematics B.V. Ramana, McGraw Hill Education.
4. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series.

Other Resources :

1. NPTEL Course: Laplace Transform, IMSc By Prof. Indrava Roy
   Web link- https://nptel.ac.in/courses/111/106/111106139/

IN-SEMESTER ASSESSMENT (75 MARKS)

1. Continuous Assessment of Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per Gate exam pattern/ level	:	05 Marks
One Class test	:	05 Marks
One Team-pair- Solo	:	05 Marks
Regularity and attentiveness	:	05 Marks

2. Continuous Assessment of Tutorial (25 Marks)

Suggested breakup of distribution

Students must be encouraged to write at least 6 class tutorials. At least 6 Class tests will be conducted based on class tutorials on entire syllabus. Each class tests carries 20 Marks. Average will be taken of all class tests.

Minimum six Tutorials	:	20 Marks
Regularity and active participation	:	05 Marks

3. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% of the syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End semester examination will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% -30% weightage, and the syllabus covered from MSE to ESE carrying 70% - 80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC302	MECHANICS OF SOLIDS	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20 + 25*	30	50	1.5	2	125

Tutorial

Pre-requisite:

1. ESC101 Engineering Mechanics

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions

Course Objectives:

1. To acquaint with the basic concept of stress and strain developed in mechanical components under various types of loadings for safer design of components.
2. To familiarize with the basic concepts of shear stress and bending stress distribution in beams for analysis of mechanical components.
3. To comprehend the basic principles mechanics of material, including buckling and torsion.

Module	Details	Hrs.
	Course Introduction Overview of course, application of course in Industry/real life problem. This is foundation course which deals with fundamental concepts of mechanics of rigid bodies, force flow and its effect on mechanical components (stress and strain). The fundamental concepts of this subject are essential for designing the mechanical components on strength criteria.	1
01.	**Basic Concepts of stresses and strains in mechanical components** ***Learning Objective:*** *To apply basic concepts of mechanics of solids such as stress, strain for analysis of mechanical system.*	7-9
	Contents: Introduction into Mechanics of deformable solids, definition of Stress, strain, types of direct and indirect stresses, Hooke's Law for axial loads, Stress-Strain diagrams for ductile and brittle materials, factor of safety, Constants of elasticity: Young's modulus, shear modulus, bulk modulus, Poisson's ratio, and their relation, Uniaxial, biaxial and tri-axial stress	

	system, Calculation of stresses in straight, stepped section, Composite sections, Stresses due to temperature change in composite bars. ***Self-Learning Topics:*** *Uniaxial, biaxial and tri-axial stress system.* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Differentiate between deformable and non-deformable bodies by using engineering concept of mechanics of solids. (1.3.1)* *LO 1.2: Apply the concepts of mechanics of solids such as stresses and strain in mechanical components. (1.4.1).* *LO1.3: Analyze stress and strain in given components. (2.1.2).* *LO 1.4: Identify stress and strain in mechanical components. (2.1.3)*	
02.	**Principal stresses and principal planes** ***Learning Objective:*** *To analyse stresses in mechanical system using graphical tools.* **Contents:** Concept of principal stresses and principal Planes, analytical and graphical method (Mohr's circle) to find principal stresses and location of principal planes (2-dimensional system). Maximum shear stress. ***Self-Learning Topics:*** ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Determine principal stresses. (1.3.1)* *LO 2.2: Determine location of principal plane. (1.4.1)* *LO2.3: Identify maximum and minimum stresses in mechanical components. (2.1.2)* *LO 2.4: Plot and analyses Mohr's circle for 2D stress system. (2.1.4)* ***(new PI)***	**5-7**
03.	**Shear force, bending moment and deflection in beams** ***Learning Objective:*** *To apply fundamental knowledge of mechanics of materials for finding Shear force, bending moment in beams for analyzing beam structures.* **Contents:** Introduction to shear force and bending moment, Relationship between loads, shear forces and bending moments, Shear force and bending moments of simply supported beam, cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed load and UVL, maximum shear force location and point of contra flexure (no numerical on internal hinge). **Deflection in beams:** Introduction to deflection, deflection and slope of simply supported and cantilever beam, relation between slope, deflection and radius of curvature. Macaulay's methods, Double integration method.	**9-11**

	Self-Learning Topics: *Radius of gyration, Derivation of slope deflection equation*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply basic engineering knowledge to determine shear force in beams under various loading condition. (1.3.1)* *LO 3.2: Apply basic engineering knowledge to determine and bending moment in under various loading condition. (1.4.1)* *LO 3.3: Apply mathematical and engineering knowledge to predict maximum deflection in beams to solve engineering problem related to beams. (2.1.3)* *LO 3.4: Predict deflection and location of maximum deflection in given beam. (2.2.4)* ***(new PI)***	
04.	**Bending stresses and shear stresses in Beams** ***Learning Objectives:*** *To analyse bending stresses, shear stresses and design/create appropriate plane/section for high strength of mechanical system.*	**7-9**
	Contents: **Bending stresses in beams:** Introduction, pure bending theory, Assumptions, derivation of bending equation, modulus of rupture, flexural rigidity, section modulus of various sections and bending stress distribution for various sections such as rectangular, circular, T, I, channels. **Shear stress in beams:** Expression for transverse shear stress in beams, Derivation of shear stress formula – Shear stress distribution across various beams sections.	
	Self-Learning Topics: *Parallel axis theorem, Moment of inertia for standard shapes.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Plot shear stress and bending stress distribution in various mechanical components. (2.1.4)* *LO 4.2: Use graphical technique to predict maximum shear stress and maximum bending stress. (2.1.3)* *LO 4.3: Identify maximum bending and shear stresses for various cross-section. (3.2.3)* *LO 4.4: Select appropriate section/plane of beams for high strength of beam. (3.1.6).* *LO 4.5: Determine section modulus of given section. (3.2.3)*	
05.	**Torsion** ***Learning Objective/s:*** *To design shafts for power transmission based on torsional strength.*	**5-7**
	Contents:	
	Torsion of circular shafts, Derivation of torsion equation assumptions made in it, polar moment of inertia, strength and rigidity criteria for	

	design of shafts, torque transmitted by hollow and circular shaft, shaft in series and shaft in a parallel arrangement.	
	Self-Learning Topics:	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Determine polar moment of inertia of given section. (1.3.1)* *LO 5.2: Determine power transmitted by shaft. (1.4.1)* *LO 5.3: Determine power and torque transmitted by rotating shafts using design strategies. (3.1.6)* *LO 5.4: Predict suitable diameter of power shaft using strength and rigidity criteria. (3.2.2)*	
06.	**Thin cylinder and columns** ***Learning Objective/s:*** *To apply knowledge of basic concepts of mechanical engineering to mechanical system and analyze stresses in thin cylinder subjected to internal pressure.*	**4-6**
	Contents: **Thin cylinder** Introduction to thin cylinder, difference between thin and thick cylinder, Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and volumetric strains – changes in diameter, and volume of thin cylinders. **Columns** Introduction to columns, difference between short column and long column, Failure of long and short column, slenderness ratio, assumptions made in Euler’s column theory, Expression for crippling load for various end conditions, effective length, limitation of Euler’s formula. (no eccentric loading for column).	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Determine stresses and strain in pressure vessel subjected to internal pressure. (1.3.1)* *LO 6.2: Determine crippling load in columns. (1.4.1)* *LO 6.3: Analyse different stresses in thin-walled shells subjected to internal pressure. (2.1.3)* *LO 6.4: Determine different types of stresses in column such as buckling stress and crushing stress using formal decision-making tools. (2.1.3).*	
	Course Conclusion The knowledge in this course is essential for engineers and professionals for safer, appropriate design and analysis of mechanical systems/components.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.1.4 (new PI)	Desired inferences need to be drawn from graphical tool/ representation of engineering quantities of mechanical system.
2.2.4	Compare and contrast alternative solution processes to select the best process
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.2	Build models/prototypes to develop diverse set of design solutions.
3.2.3	Identify suitable criteria for evaluation of alternate design solutions.

Course Outcomes: A learner will be able to -

1. Analyse stress and strain in mechanical component under different loading conditions. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
2. Plot shear force and bending moment diagram and Predict deflection of beam under the different loading conditions. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
3. Predict shear stress and bending stress distribution in different cross-section of beams. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5)*
4. Predict dimension of shaft based on rigidity and strength criteria. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
5. Analyse stresses in thin-walled cylinder and buckling phenomena in columns. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC302.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC302.2	3	3	--	--	--	--	--	--	--	--	--
MEPCC302.3	3	--	3	--	--	--	--	--	--	--	--
MEPCC302.4	3	--	3	--	--	--	--	--	--	--	--
MEPCC302.5	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	--	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. S. Ramamrutham and R. Narayanan, Strength of Materials, 18th ed., New Delhi, India: Dhanpat Rai Publishing Company, 2014.
2. S. S. Rattan, Strength of Materials, 3rd ed., New Delhi, India: Tata McGraw Hill Education Pvt. Ltd., 2011.
3. F. P. Beer and E. R. Johnston, Mechanics of Materials, 3rd ed., New Delhi, India: Tata McGraw Hill, 2006.
4. R. K. Rajput, Strength of Materials, New Delhi, India: S. Chand Publishing, 2018.
5. S. S. Bavikatti, Strength of Materials, 4th ed., New Delhi, India: Vikas Publishing House, 2018.
6. R. K. Bansal, Strength of Materials, New Delhi, India: Laxmi Publications, 2017.

Reference Books :

1. Mechanics of Materials , Gere G.M and Timoshenko, 5th Edition, 2005, CBS Publishers & Distributors.
2. Strength of Materials, Ryder and Macmillan, 3rd Edition, 1975, Palgrave Macmillan.
3. Strength of Material, William Chrales Popplewell, , 1907, Oliver and Boyd.

Other Resources :

1. NPTEL Videos: Strength Of Materials - IITM - Course by Prof. R. K Ramesh Online: https://onlinecourses.nptel.ac.in/noc23_me140/preview

IN-SEMESTER ASSESSMENT (75 MARKS)

1. **Continuous Assessment - Theory-(20 Marks)**

Suggested breakup of distribution

Numerical Assignment/s (min 20 problems):	05 Marks
Class test based on above numerical assignment/s:	05 Marks
Regularity and active participation:	05 Marks
Think-pair-share worksheets:	05 Marks

2. **Continuous assessment (tutorial/test):25 marks**

Suggested breakup of distribution:

Students will be encouraged to write at least five tests based on the tutorial, five class tests will be conducted on the entire syllabus (one test per module). Each class test will carry 20 marks and the average of all class test scores will be taken into account.

Minimum five Tutorial :20 Marks

Regularity and active participation: 05 Marks

3. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC303	MATERIALS SCIENCE AND ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC205 Engineering Physics -II
2. BSC206 Engineering Chemistry -II

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions

Course Objectives:

1. To familiarize the structure -property correlation in materials.
2. To acquaint with the processing dependency on the performance of the various materials.
3. To study the role of alloying in the development of steels.
4. To familiarize with the advances in materials development, material testing and material selection process.

Module	Details	Hrs
	Course Introduction Materials are basic building blocks of any structure/ system. Selection of material is a crucial step in design and fabrication of a component. To have an ability to select an appropriate material for a specific application, needs the knowledge of wide range of materials, their properties and behavior at various operating conditions. As a mechanical engineer, the scope of material science is in every type of industry, where material selection is to be done on the ground of fundamental concepts covered in this subject .	01
01.	**Engineering materials and their properties** ***Learning Objective/s:*** *To apply the fundamentals of material properties and crystal imperfections for identifying the deformations in materials.*	5-7
	Contents:	

	Introduction to engineering materials, Properties of all classes of engineering materials. **Crystal Defects:** Crystal Imperfections classification, significance of imperfections - point defects, line defects, surface defects and volume defects. **Dislocations and its mechanisms.** Slip systems and deformability of FCC, BCC and HCP lattice systems. Frank-Reed source, Critical Resolved shear stress.	
	Self-Learning Topics: *crystal structures*	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Apply the knowledge of material properties in the process of material selections for a specific requirement/application. (P.I.-1.3.1)* *LO 1.2: Apply the concept of slip planes and directions for various crystal structures, so as to find possible directions of dislocation movements. (P.I.-1.4.1)* *LO 1.3: Identify different types crystal defects and provide significance of the same. (P.I.-2.1.3)* *LO 1.4: Identify different types of dislocations and evaluate minimum value of critical resolved sheer stress the material can sustain. (P.I.-2.2.2)*	
02.	**Phase diagrams**	**9-11**
	Learning Objective/s: *Use phase diagrams and cooling curves for identifying the microstructure, and phases of metals and alloys.*	
	Contents: **Mechanism of crystallization**: Homogeneous and Heterogeneous nucleation and growth. Solidification of metals and alloys. **Introduction to phase Diagrams**: Binaryphase diagram, Eutectic type and Peritectic type. **Iron-Iron carbide phase diagram** – Invariant reactions, microstructural changes of hypo and hyper-eutectoid steel, TTT and CCT Diagram, Hardenability and its tests, Graphitization in cast irons.	
	Self-Learning Topics: *Allotropic forms of iron*	
	Learning Outcomes : *A learner will be able to* *LO 2.1: Identify the various phases of Iron-Iron carbide phase diagram and its relevance with respect to properties of materials. (P.I.-2.1.2)* *LO 2.2: Compare various cooling curves on CCT diagrams based on microstructure changes. (P.I.-2.2.4)*	
03.	**Heat treatment processes**	**8-10**
	Learning Objective/s: *Apply basic knowledge of phase diagram to select an appropriate heat treatment, based on the property/ microstructure needed, for specific functional requirement.*	

	Contents: **Strain hardening and recrystallization annealing:** Dislocation theory of strain hardening, effects of strain hardening on engineering behavior of materials, stages of recrystallization annealing and factors affecting it. **Heat treatment:** Overview, annealing and types, normalizing, hardening and tempering, austempering, martempering, microstructure changes in each mentioned type of heat treatment. **Surface hardening processes:** Carburizing, nitriding, cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam hardening. **Alloy Steels:** Stainless steels, Tool steels, Maraging steels and Ausformed steels.	
	Self-Learning Topics: *Advanced treatments done on materials for increasing hardness.*	
	Learning Outcomes : *A learner will be able to* *LO 3.1: State effect of various alloying elements on properties of steels. (P.I. 1.3.1)* *LO 3.2: Suggest type of materials which can be used for surface hardening by Carburizing (P.I.-1.4.1)* *LO 3.3: Identify various parameters to be considered before finalizing type of heat treatment. (P.I.-2.2.2)* *LO 3.4: Compare between heat treatment processes to propose heat treatment to heat treatment for specific application. (P.I.-2.2.4)*	
04.	**Failure modes of materials**	**6-8**
	Learning Objective/s: *Identify various types of failure occurring in engineering materials considering safety risks.*	
	Contents: **Fracture of metals:** Ductile Fracture, Brittle Fracture, Ductile to Brittle Transition Temperature (DBTT), Griffith's criteria and Orowan's modification **Fatigue:** Endurance limit of ferrous and non-ferrous metals, Fatigue test, S-N curves, factors affecting fatigue. **Creep:** Mechanism of creep, stages of creep, creep test, creep resistant materials.	
	Self-Learning Topics: *Different types of stresses resulting failures*.	
	Learning Outcomes : *A learner will be able to* *LO 4.1: Apply fundamental concepts of material failure for brittle and ductile materials. (P.I.-1.3.1)* *LO 4.2: Apply the concept of various modes of failure to identify type of failure that may occur in the structure. (P.I.-1.4.1).*	

	LO 4.3: Determine various conditions/ factors, which affect the health of the structures (P.I.-2.1.2) *LO 4.4: Compare between ductile and brittle fracture. (P.I.-2.2.4)*	
05.	**Introduction to new materials** ***Learning Objectives:*** *Apply knowledge of new materials so as to provide the solutions in terms of better alternative materials.*	**4-6**
	Contents: **Composites:** Introduction to composite materials, classification, processing of composites, advantages over metallic materials, applications of composite materials. **Nano Materials:** Introduction, Concepts, synthesis of nanomaterials, applications of Nanomaterials. **Smart materials:** Overview of smart materials, shape memory materials, shape memory polymers, smart composites.	
	Self-Learning Topics: *Nano fluids, Nano fabrication Testing of ceramic, composites and Nano materials* ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Select new materials for better performance. (P.I.-1.3.1)* *LO 5.2: List different applications of new materials and know various methods in their synthesis. (P.I.-1.4.1)* *LO 5.3: Identify a possible new material for alternate solution. (P.I.-3.2.3)* *LO 5.4: Identify current methods of material synthesis in advanced materials. (P.I.-3.4.1)*	
06.	**Testing and selection of Materials** ***Learning Objective/s:*** *Apply knowledge of all properties of material and other environmental aspects for selection of material for specific application..*	**6-8**
	Contents: **Testing of Materials**: Non-Destructive Testing, Dye penetrant, magnetic particle testing, ultrasonic testing, radiographic testing. Material characterization techniques: X-ray diffraction, Electron Microscopy, scanning electron microscopy, Transmission electron microscopy, Electron back scattering (EBSD), X-ray microanalysis (EDS, WDS), Scanning probe microscopy, Spectroscopy techniques: IR, UV. **Material Selection Process:** Design requirements, Material selection criteria (physical and environmental aspects), Potential materials, Evaluation of materials (properties and economic aspects), Selection of material.	
	Self-Learning Topics: *Destructive Testing*	

	Learning Outcomes : *A learner will be able to* *LO 6.1: Know requirement of material testing for design development. (P.I.-1.3.1)* *LO 6.2: Know various methods in material testing. (P.I.-1.4.1)* *LO 6.3: Select a material required for any given application. (P.I.-3.2.3)* *LO 6.4: Identify latest material testing method having more exposure to the material properties as compared to the traditional methods. (P.I.-3.4.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No. **P.I. Statement**

1.3.1 Apply fundamental engineering concepts to solve engineering problems.

1.4.1 Apply mechanical engineering concepts to solve engineering problems.

2.1.2 Identify engineering systems, variables, and parameters to solve the problems

2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem

2.2.2 Identify, assemble and evaluate information and resources

2.2.4 Compare and contrast alternative solution processes to select the best process.

3.2.3 Identify suitable criteria for the evaluation of alternate design solutions

3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources)

Course Outcomes: A learner will be able to -

1. Identify the various classes of materials and comprehend their properties. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Apply phase diagram concepts to engineering applications.(*LO 2.1, LO 2.2*)
3. Apply particular heat treatment for required property development. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4*)
4. Identify the probable mode of failure in materials and suggest measures to prevent them. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
5. Apply an appropriate method to select new materials for better performance and to evaluate different components in service. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 6.1, LO 6.2, LO 6.3, LO 6.4*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC303.01	3	3	--	--	--	--	--	--	--	--	--
MEPCC303.02	--	3	--	--	--	--	--	--	--	--	--
MEPCC303.03	3	3	--	--	--	--	--	--	--	--	--
MEPCC303.04	3	3	--	--	--	--	--	--	--	--	--
MEPCC303.05	3	--	3	--	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	--	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. A Textbook of Material Science and Metallurgy, O. P. Khanna, Dhanpat Rai Publications.
2. Callister's Materials Science and Engineering, R.Balasubramanium, 2nd edition- Wiley India Pvt. Ltd
3. Engineering Materials and Metallurgy, R K Rajput, S Chand Publishing
4. Materials Science & Engineering, by P.S. Gill, Publisher- S.K. Kataria & Sons.
5. Materials Science and Engineering: A First Course, Raghavan V, Publisher -Prentice Hall India Learning Private Limited

Reference Books :

1. Introduction to Materials Science for Engineers; 8th Edition by James F. Shackelford Pearson
2. Introduction to Physical Metallurgy, by Sidney Avner, 2nd edition Tata McGraw Hill
3. Mechanical Metallurgy, by GH Dieter, 3rd edition, Tata McGraw Hill
4. Fundamentals of Materials Science and Engineering: An Integrated Approach, by William D. Callister, Jr., David G. Rethwisch, 5th Edition Wiley & Sons.

Other Resources :

1. NPTEL Course: Material science By Prof. Rajesh Prasad, Department of Mechanical Engineering, IIT Delhi :-Web link- https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-me01/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level: 05 Marks
One Class test: 05 Marks
Article reading & summarization: 05 Marks
Regularity and active participation:05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC304	THERMODYNAMICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC102 Engineering Physics-I
2. BSC103 Engineering Chemistry-I
3. BSC205 Engineering Physics-II
4. BSC206 Engineering Chemistry-II

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis

Course Objectives:

1. To impart the knowledge of Energy: heat and work and to solve the problems related to real life applications.
2. To inculcate the laws of thermodynamics and to differentiate grades of energy.
3. To inculcate the effect of energy, transfer on properties of substances in the form of charts and diagrams.
4. To familiarize the application of various power cycles applied to heat engine and power plant.

Module	Details	Hrs.
	Course Introduction This is foundation course of mechanical engineering (thermal science) which deals with fundamental concepts of heat and work along with the laws of thermodynamics and its applications in a real life system. The fundamental concepts of this subject are essential for designing, analyzing the utilities of turbomachinery, refrigeration, air conditioning, ventilation and renewable energy systems.	**01**
01.	**First law of thermodynamics, it's application to closed and open systems** *Learning Objective/s:* *To apply the fundamental concepts of Heat and Work interaction and first law of thermodynamics to the real life thermodynamic systems.*	**7-9**
	Contents: Macroscopic and Microscopic approach, Quasi-static process & Equilibrium, Heat and Work. Concept of PdV work. First Law of	

	Thermodynamics: First Law of Thermodynamics: Concept of Internal energy, Statement & Equation, first law for cyclic process, PMM-1, First law applied to flow system: Concept of the steady flow process, Energy balance in a steady flow, Application of steady flow energy equation, Relation between flow and non-flow work.	
	Self-Learning Topics: *Zeroth law of thermodynamics, Enthalpy, Specific Heat. Concept of PdV work.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamentals of thermodynamics to identify different engineering systems with its significance. (P.I.-1.3.1)* *LO 1.2: Differentiate closed and open systems, use this knowledge to identify a suitable system for real life applications. (P.I.-2.1.2)* *LO 1.3: Apply steady flow energy equations to various mechanical engineering systems. (P.I.-1.2.1 & 1.4.1)* *LO 1.4: Use natural law principle to understand the significance of energy conservation. (P.I.-1.2.1)* *LO 1.5: Formulate macroscopic approach to solve real life problems of thermodynamic systems. (P.I.-2.1.3)*	
02.	**Second Law of Thermodynamics and Entropy** *Learning Objective/s:* *To apply the knowledge of second law of thermodynamics and entropy to solve the engineering problems.*	**7-9**
	Contents: Second Law of Thermodynamics, Concept of heat engine, Heat pump and Refrigerator, Statement of the second law of thermodynamics, Reversible and irreversible Process, Causes of irreversibility, PMM-2, Carnot cycle, Carnot theorem. Entropy: Clausius theorem, Entropy is property of a system, Temperature-Entropy diagram, Clausius inequality, Increase of entropy principle, T ds relations, Entropy change during a process.	
	Self-Learning Topics: *Thermal reservoir, Carnot cycle.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Formulate the kelvin-plank and Clausius equations applied to heat engine and heat pump with the help of block diagrams. (P.I.-2.1.2)* *LO 2.2: Use entropy concepts to draw T-S diagram for mechanical systems and then to verify the physical existence of process. (P.I.-2.1.3)* *LO 2.3: Apply the thermodynamics concepts to solve the problems related to heat engine, refrigeration and heat pump. (P.I.-1.3.1)* *LO 2.4: Use mechanical engineering knowledge to derive the Clausius in-equality concepts and apply it to the mechanical systems. (P.I.-1.4.1)*	
03.	**Availability and thermodynamic relations** ***Learning Objective/s:*** *Apply concepts of the quantification and grades of energy with the help of thermodynamic relations to analyze the thermodynamic systems.*	**5-7**

	Contents: High grade and low-grade energy, Available and Unavailable energy, Dead State, Useful work, Irreversibility, Availability of closed system& steady flow process. Helmholtz and Gibbs function Thermodynamic Relations: Maxwell relations, Clausis-Clapeyron Equation, Joule Thomson coefficient ***Self-Learning Topics:*** *Causes of Irreversibility.* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Apply laws of natural science (thermodynamics) to determine quantification/grades of energy. (P.I.-1.2.1)* *LO 3.2: Use the engineering mathematics and functions to solve the availability and un- availability functions. (P.I.-2.1.2)* *LO 3.3: Analyse the given Irreversibility functions with the help of grades of energy and to verify the existence of the process. (P.I.-2.1.3)* *LO 3.4: Use concepts of Internal energy and entropy to derive thermodynamic relations and to solve the mechanical engineering problems. (P.I.-1.4.1 & 2.1.3)*	
04.	**Pure substances and vapour power cycle** ***Learning Objectives:*** *Use steam table and mollier chart to analyze the phase transition properties of substances and the performance of steam power cycle.* **Contents:** Phase change process of water, Terminology associated with steam, Different types of steam. Property diagram: T-v diagram, p-v diagram, p-T diagram, Calculation of various properties of wet, dry and superheated steam using the steam table and Mollier chart. Vapour Power cycle: Principal components of a simple steam power plant, Carnot cycle and its limitations as a vapour cycle, Rankine cycle with different turbine inlet conditions, Mean temperature of heat addition, Reheat Rankine Cycle, Regeneration Rankine cycle. ***Self-Learning Topics:*** *Principal components of a simple steam power plant. Properties enthalpy, specific heat.* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Analyze the phase transition phenomena of pure substance with the help of various thermodynamic properties diagram. (P.I.-2.1.2)* *LO 4.2: Use steam table and mollier diagram to analyse the various conditions of steam. (P.I.-1.4.1)* *LO 4.3: Identify the coordinates of points on the liquid and vapor saturated curve to analyze the transient behavior of the system. (P.I.-2.1.3)* *LO 4.4: Determine the efficiency of the Rankine cycle with the help of phase transition characteristics of working fluid and analyze the performance of mechanical engineering systems. (P.I.-1.3.1 & P.I.-2.1.3)*	**7-9**
05.	**Gas power cycles** ***Learning Objective/s:*** *Apply the terminology of heat engine to analyze the performance of various power cycle with the help of P-V and T-S diagram.*	**6-8**

	Contents: Nomenclature of a reciprocating engine, Mean effective pressure, Assumptions of air Standard Cycle, Otto cycle, Diesel Cycle and Dual cycle, Comparison of Otto and Diesel cycle for same compression ratio, Brayton Cycle, Numerical. Sterling Cycle. ***Self-Learning Topics:*** *Components of an engine, Carnot cycle.* ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Use mechanical engineering knowledge to Identify the various P-V and T-S diagram of power cycles. (P.I.-1.4.1)* *LO 5.2: Use engineering mathematics to solve and analyze the problems related to the performance and characteristics of power cycles. (P.I.-1.1.1 & P.I.-2.1.2)* *LO 5.3: Differentiate the various power cycles based on their utilities and physical existence applied to mechanical engineering systems. (P.I.-2.1.2)*	
06.	**Compressible fluid flow** ***Learning Objective/s:*** *Apply the knowledge of compressible fluid flow to analyze its behavior for different geometry of flow considering real life applications.* **Contents:** Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Stagnation properties, Application of continuity, momentum and energy equations for steady-state conditions; Steady flow through the nozzle, Isentropic flow through ducts of varying cross-sectional area, effect of varying back pressure on nozzle performance, Critical pressure ratio. ***Self-Learning Topics:*** *Compressible fluid properties.* ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Formulate the equation for propagation of sound waves through the disturbance created in the medium and analyze it to various conditions. (P.I.-1.1.1 & P.I.-2.1.2)* *LO 6.2: Use engineering mathematics to determine properties of compressible fluid in a stagnation conditions. (P.I.-1.1.1 & 2.1.3)* *LO 6.3: Analyze the impact of compressible fluid flow nature when passes through a different geometry. (P.I.-2.1.2)*	**5-7**
	Course Conclusion At the end of the course, students would be expected to be able to demonstrate an understanding of the laws of thermodynamics and solve problems involving heat and work interactions, with various working substances.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem

Course Outcomes: A learner will be able to -

1. Apply mathematical knowledge to solve the problems related to the laws of thermodynamics. (*LO 1.4, LO 2.1, LO 2.3, LO2.4, LO3.1, LO3.2,*)
2. Apply mechanical engineering concepts to solve engineering problems. (*LO 1.1, LO 1.2, LO 1.3, LO 1.5, LO 2.2, LO 3.3, LO 3.4*)
3. Use steam table and mollier chart to analyse thermodynamic interactions. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
4. Determine the performance characteristics of various power cycles. (*LO 5.1, LO 5.2, LO 5.3*)
5. Apply the fundamentals of compressible fluid flow to analyse the compressible fluid behaviour for different geometry of flow. (*LO 6.1, LO 6.2, LO 6.3*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC304.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC304.2	3	3	--	--	--	--	--	--	--	--	--
MEPCC304.3	3	3	--	--	--	--	--	--	--	--	--
MEPCC304.4	3	3	--	--	--	--	--	--	--	--	--
MEPCC304.5	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	--	--	--	--	--	--	--	--	--

Text Books :

1. Thermodynamics by P K Nag, 6th Edition, 2017, McGraw Hill
2. Thermodynamics: An Engineering Approach by Yunus A. Cengel and Michael A. Boles, 9th edition, 2017, McGraw Hill

3. Engineering Thermodynamics by P Chattopadhyay, 2nd edition, 2016, Oxford University Press India
4. Thermodynamics by C P Arora, 1st edition, 2017, McGraw Hill
5. Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanics, by S.C. Garg, R.M. Bansal, C.K. Ghosh, 2nd edition, 2017, McGraw Hill

Reference Books :

1. Thermodynamics by J P Holman, 4th Edition McGraw-Hill
2. Thermodynamics by W.C. Reynolds, 1st edition, McGraw-Hill
3. Fundamentals of Classical Thermodynamics by Van Wylen G.H. & Sonntag R.E., 9th Edition, JohnWiley& Sons

Other Resources :

1. NPTEL Course: Thermodynamics By Prof. Anand T. N. C., Department of Mechanical Engineering at IIT Palakkad :-Web link- https://onlinecourses.nptel.ac.in/noc23_me76/preview
2. NPTEL Course: Engineering Thermodynamics By Prof. V. Babu, Department of Mechanical Engineering at IIT Madras :-Web link- https://archive.nptel.ac.in/courses/112/106/112106310/
3. NPTEL Course: Basic Thermodynamics By Prof. Suman Chakraborty, Professor and Dean at IIT, Kharagpur:- Web link- https://nptel.ac.in/courses/112105123

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Numerical Assignments (min 20 problems): 05 marks
One Class test:05 marks each
Flip Classroom/Mentimeter: 05 Marks
Regularity and active participation:05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on **40% to 50%** syllabus

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination(MSE) carrying 20% weightage, and the syllabus covered from MSE to ESE carrying 80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	MELBC301	MATERIAL TESTING LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite:

1. ESC101 Engineering Mechanics
2. BSC203 Engineering Chemistry

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO4: Conduct investigations of complex problems

Course Objectives:

1. To familiarize with microstructure and hardenability of medium carbon steel specimen subjected to different heat treatment processes.
2. To impart the knowledge on different mechanical properties of material and material testing methods.
3. To impart knowledge on material strength under different loading conditions.

Module	Details	Hrs.
	Course Introduction This is a foundation course which deals with fundamental heat treatment processes to improve mechanical properties of material and effect of heat treatment processes on microstructure. This subject also deals with different methods/ tools to require for testing materials for determination mechanical properties of material. The fundamental knowledge of material properties of this subject are essential for designing the mechanical components/system.	**01**
01.	***Learning Objective:*** *To Apply fundamental knowledge of heat treatment processes to improve mechanical properties and analyse properties after processes.*	**09**
	Experiment: Analyze the microstructure of given sample after heat treatment process. List of experiments: 1. Study of Characterization techniques and Metallographic sample preparation and etching.	

	2. Comparison of Microstructures and hardness before and after Annealing, Normalizing and quenching for medium carbon steel. 3. Determination of hardenability of steel using Jominy end Quench test.	
	Self-Learning Topics: ------	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Use metallographic microscope for inspection of microstructure. (1.4.1)* *LO 1.2: Demonstrate different heat treatment processes. (1.3.1)* *LO 1.3: Demonstrate the effect of heat treatment process on metallurgical structure of different metals. (1.4.1)* *LO 1.4: Analyze microstructure of given sample. (2.2.4)* *LO 1.5: Use required heat treatment process for improving mechanical properties. (2.4.4)*	
02.	***Learning Objective:*** *To Apply fundamental concepts of material testing to analyse and investigate mechanical properties of given material using appropriate approach/tool.*	**20**
	Experiment:	
	To determine mechanical properties/strength of material under different loading conditions. List of experiments**:** 1. Determination of the tensile properties of mild steel. 2. Determination of hardness number by using Hardness testing techniques. (Brinell and Rockwell) 3. Determine impact strength of given material. (Charpy and Izod impact test) 4. Determine fatigue strength of material. 5. Determine torsional strength of given material.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Use appropriate technique to determine required mechanical property. (1.4.1).* *LO 2.2: To predict the strength of material. (1.3.1)* *LO 2.3: Interpret key mechanical properties derived from the tensile test. (4.1.3)* *LO 2.4: Use hardness testing machine to determine hardness number of material. (3.3.1)* *LO 2.5: Perform hardness test to determine hardenability of material (3.4.2)* *LO 2.6: Select appropriate hardness test as per characteristics of given material (4.1.3).* *LO 2.7: Analyze and interpret stress-strain curves obtained from the tensile test (4.3.1).*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.

2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development
3.4.2 Generate information through appropriate tests to improve or revise design.
4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.3.1 Use appropriate procedures, tools and techniques to conduct experiments and collect data.

Course Outcomes: A learner will be able to -

1. To analyse microstructure of given specimen after heat treatment process. *(LO 1.1, LO 1.4)*
2. Use an appropriate heat treatment process to achieve required material properties. *(LO 1.2, LO 1.3, LO 1.5)*
3. To determine the strength of given specimen under different loading configuration. *(LO 2.1, LO 2.2, LO 2.3, LO 2.7)*
4. To determine hardness number of given specimen. *(LO 2.4, LO 2.5, LO 2.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC301.1	3	3	--	--	--	--	--	--	--	--	--
MELBC301.2	3	3	--	--	--	--	--	--	--	--	--
MELBC301.3	3	--	3	3	--	--	--	--	--	--	--
MELBC301.4	3	--	3	3	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	**3**	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Mechanical Metallurgy, GH Dieter ,3rd edition, TataMcGraw Hill
2. Mechanics of Material, Beer and Johnston, 3rd edition, 2006, T*ata McGraw Hill*
3. Mechanical behaviour and testing of material, Bhargava A K and C P Sharma, 1st Edition, 2014, PHI Learning Pvt. Ltd.

Reference Books :

1. Testing of Engineering materials, Davis H E, G. E. Troxell and G.F.W Hauck, 4th Edition, 1982, McGraw Hill publishing company.
2. Callister' Materials Science and Engineering, R.Balasubramanium, 2nd edition, Wiley India Pvt. Ltd

IN-SEMESTER ASSESSMENT (25 Marks)

		Marks
1.	Performance based on experiment. Marks will be awarded to students based on experiment performance with proper understanding	10
2.	An oral will be conducted based on each experiments.	10
3.	Regularity and Active Participation	05

END SEMESTER EXAMINATION (25 MARKS)

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to write appropriate procedure, observation and observation table if required for the same. The experiment procedure is checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- The Students will be allocated 1 hour to complete the execution. The students are required to perform the given experiment complete calculation and draw graph if required. Then students required to write conclusion and inferences drawn from results. The experimental performance will be checked by both the examiners for its correctness. The weightage is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	MELBC302	INDUSTRIAL ELECTRONICS LABORATORY	02

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite :

1. ESC102 Basic Electrical Engineering

Program Outcomes addressed :

1. PO2: Problem analysis
2. PO3: Design/Development of Solutions
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO8: Individual and team work

Course Objectives:

1. To develop practical skills in implementing, and analysing power electronic devices and circuits.
2. To impart knowledge on design and implantation of Buck converter and Boost converter.
3. Analyse output waveform of different Analog and Digital circuits.
4. Use appropriate software tool for Arduino based speed control of different motors.

Module	Detailed Contents	Hrs
	Course Introduction	
01.	**Semiconductor devices and circuits:** ***Learning Objective:*** *To identify components, their values and implement converter circuits to analyze their performance.* **Content:** SCR Construction, Operating Principle and V-I characteristics. DC-DC Converter: Operation of Buck converter, Boost converter. Inverters: Basic principle of single phase Inverter, Operation of Single phase half bridge voltage source inverter with R load, Operation of single phase full bridge inverter with R load. **Experiments** **1. Perform experiment to draw V-I characteristics of SCR with and without gate and label all the points in the characteristics.** **2. Perform experiment to draw V-I characteristics of MOSFET.** **3. Hardware implementation of gate driver circuit.**	**08**

	4. Design and implementation of dc-dc buck converter. **5. Design and implementation of dc-dc boost converter.** **6. Single phase bridge inverter with resistive load.**	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Predetermine, plot and analyse V-I characteristics of SCR and MOSFET on a graph to compare results with theoretical concepts. (P.I. 2.4.2) (P.I.4.3.3) (P.I. 8.1.2)* *LO 1.2: Understand the need for gate drivers in switching power devices by observing its output waveform on oscilloscope and present result as a team. (P.I.2.1.2) (P.I.8.3.1)* *LO 1.3: Determine specifications of the components for dc-dc converters depending on required input-output voltages and verify output voltage with theoretically calculated value. (P.I. 2.2.3) (P.I. 3.1.6)* *LO 1.4: Select appropriate components, meters, follow standard prescribed procedure and verify output of single phase bridge inverter with R load.(P.I. 4.1.3)*	
02.	**Analog and Digital Circuits:** ***Learning Objective:*** ***To Analyze and interpret different OP-AMP and digital logic circuits.***	**10**
	Content: Analog and Digital Circuits: Analog circuits: Operational amplifier circuits, Ideal and Practical Op-Amp, common OPAMP ICs; Basic OPAMP circuits- Inverting amplifier, Non-inverting amplifier, adder, subtractor, comparator. Digital circuits: Comparison of Analog and digital circuits, Review of Logic gates, Boolean algebra, universal gates, Flip flops: Set Reset (SR), Analog to digital converter. **Experiments** **7. Implementation of OPAMP as Inverting and Non-inverting amplifier.** **8. Implementation of OPAMP as comparator.** **9. Realization of basic gates using universal gates.** **10. Implementation of Analog to Digital converter.**	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Identify IC, study its pin diagram and use in inverting-non inverting amplifier and comparator. Observe output on oscilloscope to verify with theoretical results. (P.I. 2.1.2)(P.I. 2.2.2) (P.I.4.1.3)* *LO 2.2: Validate truth table of different logic gate after implementing standard norms of practice of effective team work. (P.I. 4.3.1) (P.I. 8.1.2)* *LO 2.3: Use Op-amp to convert analog signal into digital and digital signal into analog and compare results with theoretical concepts and present results as a team. (P.I.2.1.2)(P.I.8.3.1)*	
03.	**Microcontrollers and Motors:** ***Learning Objectives:*** *Use microcontroller to observe speed control of different types of motor.*	**12**

	Content: Introduction to Arduino Uno board, ATmega328P microcontroller for Arduino board, Communication between Arduino and Software, Interfacing of Arduino board with Potentiometer, thermistor and servomotor, PWM generation, ADC using Arduino. Servomotors: types, construction, principle of operation, characteristics and control, Stepper motor: Construction, Working Principle, and Applications, BLDC Motor: construction, working, electronic commutation, control of BLDC motor.	
	Experiments: **11. To generate PWM pulse using Arduino.** **12. Demonstrate construction of BLDC motor, Stepper motor and Servo motor.** **13. Stepper motor controller using Arduino.** **14. Servomotor controller using Arduino.** **15. Integration of Arduino with different sensors.**	
	Learning Outcomes: *A learner will be able to* *LO 3.1:Write a program to generate PWM pulse and validate results through skillful use of contemporary engineering tools.(P.I. 2.4.2)(P.I.4.3.1)(P.I.5.1.1)* *LO 3.2: Write a program compatible to Arduino Board to control speed of different types of motor and present result as a team. (P.I. 2.1.2) (P.I. 8.2.1)* *LO 3.3: Identify different sensors used in Engineering applications and integrate them with Arduino. (P.I. 4.1.4) (P.I. 8.3.1)* *LO 3.4: Demonstrate construction of BLDC motor, Stepper motor and Servo motor. (P.I. 2.2.2)*	
	Minimum 03 experiments from each module, and total at least 10 experiments	
	Total	**30**

Performance Indicators:

<u>**P.I. No.**</u>	<u>**P.I. Statement**</u>
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble and evaluate information and resources.
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.4.2	Identify engineering systems, variables, and parameters to solve the problems.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.

4.3.3 Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.

5.1.1 Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities.

8.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.

8.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes: Learner will be able to

1. Validate VI characteristics of different power electronic switches and performance of different dc-dc and dc-ac converters. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Analyze operation of op-amp and digital IC technologies in different applications. *(LO 2.1, LO 2.2, LO 2.3)*
3. Apply fundamental concepts of programming to develop a code for different applications of Arduino. *(LO 3.1, LO 3.2, LO 3.3)*
4. Demonstrate construction of BLDC motor, Stepper motor and Servo motor. (LO 3.4)

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC302.1	--	3	2	3	--	--	--	3	--	--	--
MELBC302.2	--	3	--	3	--	--	--	3	--	--	--
MELBC302.3	--	3	--	3	2	--	--	3	--	--	--
MELBC302.4	--	2	--	--	--	--	--	--	--	--	--
Average	--	**3**	**2**	**3**	**2**	--	--	**3**	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Power Electronics M.H. Rashid, Prentice-Hall of India
2. Electronic Devices and Circuits, Robert Boylestad and Louis Nashelsky, PrenticeHall
3. Modern Digitals Electronic, Jain R P, Tata McGraw Hill, 1984
4. Programming Arduino, Dr.Simon Monk, McGraw-Hill Education 2012
5. Electric Machinery, Bimbhra P.S., Khanna Publisher

Reference Books :

1. Power Electronics, Ned Mohan, Undeland, Robbins, John Wiley Publication
2. Special Electrical Machine, E. G. Janardanan, PHI publication

Other Resources :

1. NPTEL Course: Fundamentals of semiconductor devices, Prof. Digbijoy N. Nath, IISc Bangalore :-Web link- https://nptel.ac.in/courses/108/108/108108122/

2. NPTEL Course: Power Electronics Prof. D.Prasad, Prof. N.K. De, Dr. D.Kastha, Prof. Sabyasachi Sengupta, IIT Khragpur :-Web link- https://nptel.ac.in/courses/108/105/108105066/
3. NPTEL Course: Basic Electronics By Prof. Mahesh B. Patil, IIT Bombay :- Web link- https://nptel.ac.in/courses/108101091
4. NPTEL Course: Digital Electronics By Prof. N.J.Rao, IISc Bangalore:- https://nptel.ac.in/courses/106108099
5. NPTEL Course: Electrical Machines By Prof. G.Bhuvaneshwari, IIT Delhi :- https://nptel.ac.in/courses/108102146

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Lab experiments: 10 Marks
- Internal Assessment:10 Marks
  Evaluating proficiency in the field by assessing the candidate's capability to execute connection or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through analysis of the data during laboratory session.
- Regularity and active participation - 5 Marks

END SEMESTER ASSESSMENT (25 Marks)

Students will be assessed based on three parameters:

• Drawing circuit diagram, Observation Table, Relevant formula:	05 Marks
• Experiment conduction:	05 Marks
• Sample calculations and conclusion:	05 Marks
• Oral:	10 Marks

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table and write relevant formula. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.

  Then the student will be allowed to start with the performance of the experiment.

- Students will be allocated 1 hour to complete the circuit connections and take readings. The connections and output is then checked by both the examiners for its correctness. The weightage is 05 Marks

- Students will do sample calculations, draw graph if required and write conclusion of the experiment. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.

- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
SBL	MESBL301	PYTHON PROGRAMMING LABORATORY	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	50	--	2	100

Pre-requisite:

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Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering Tool Usage
4. PO9: Communication
5. PO11: Life-long Learning

Course Objectives:

1. To get acquainted with the basic concepts of Python programming language as well as common packages and libraries.
2. To generate an ability to design, analyze and perform experiments on real life problems in mechanical engineering using python.

Module	Details	Hrs.
	Course Introduction Python is a simple but powerful programming language which is widely employed in automation for its effectiveness in communication with machines, data science, image processing, machine learning, etc. The course is structured to reinforce learning and foster critical thinking skills for Python programming. The programming concepts that are built in the initial modules will be applied to solve mechanical engineering problems.	**01**
01.	**Introduction to Python Programming** ***Learning Objective:*** *To develop problem specific codes using the basics of Python Programming.*	**15**
	Contents: Overview of Python programming language, Introduction to Jupyter notebook and different IDE for python. Basic Syntax and Data Types - Variables and data types, Operators, Input and output functions, Manipulating data types.	

	Strings: String methods, indexing and slicing the string, Data Structures- list, tuple, set and dictionary. **Experiment/s:** 1. **Introduction to Python*:** To study the importance of python and compare its advantages and limitations over other programming languages. 2. **Calculating principal stress values***: Write a python program to calculate the maximum and minimum principal stresses along with maximum shear stress generated in the material. 3. **Conversion of Temperature:** Write a program where you take input of temperature in Celsius and print the temperature value in Kelvin and Fahrenheit. 4. **Handling strings*:** Write a python code for creating and manipulating strings using various string methods. 5. **Handling new Data Structure of Python***: Write a python code for creating and manipulating data structures like list, tuple, set and dictionary.	
	Self-Learning Topics: ---	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Demonstrate the use of mathematical operators to solve the engineering problems. (P.I.-1.3.1)* *LO 1.2: Demonstrate the use of fundamental concepts of python to solve mechanical engineering problems. (P.I.-1.4.1)* *LO 1.3: Demonstrate the use of methods related to the string, list, tuple and dictionaries. (P.I.-5.1.2)* *LO 1.4: Demonstrate proficiency in using slicing and indexing in datatypes. (P.I.-5.2.2)*	
02.	**Conditional Statements and OOPs** ***Learning Objective:*** *To apply appropriate logical tools along with the object-oriented programming to arrive at the solutions in the systematic manner.*	**16**
	Contents: To demonstrate the use of conditional statements, functions, OOPs concept and file handling. **Experiments:** 1. **Generate a number analyzer (Menu driven)***: Develop a Python program to analyze an input number, determining whether it is even or odd and checking for primality 2. **Generating different patterns*:** Write a python program to generate different types of patterns. 3. **Moment of Inertia calculator of standard sections (using functions)***: Write a python program to display the moment of inertia of the standard sections using functions. 4. **Classes and Objects***: Write a python code to solve the problems using the classes and objects. 5. **Reading & Writing files***: Write a python code to create, read, write and append a text file.	

	6. **Quiz Game (Object-Oriented Programming)**: Implement a quiz game where questions are objects of a class. Include features like scoring and multiple-choice questions.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Demonstrate the use of logical operators, loops and conditional statements to make the python program generic in nature. (P.I.-1.3.1)* *LO 2.2: Demonstrate use of coding to solve specific mechanical engineering problems in systematic manner. (P.I.-1.4.1)* *LO 2.3: Apply OPPs concept using classes and objects to optimize the code (P.I.-5.2.1)* *LO 2.4: Modify the concept of coding using conditional statements and loops. (P.I.-5.2.2)*	
03.	**Python Libraries** ***Learning Objective:*** *To apply the knowledge of mathematics and statistics for data analysis, numerical computations, and image processing by using libraries of python programming.*	**20**
	Contents: Python libraries such as Math, SymPy , Numpy , Matplotlib , Seaborn, Pandas , OpenCV and Tensorflow **Experiment/s:** 1. **Performing basic Numerical computations*** : Demonstrate the use of Math, SymPy and Numpy libraries for numerical computations. 2. **Data visualization Techniques*** : Demonstrate the use of bar graph , line graph , histogram etc. for data visualization. 3. **Performing Basic Data Exploration (Using NumPy, Pandas and Matplotlib)***: Analyze a dataset (CSV file) using NumPy and Pandas. Calculate statistics, visualize data using Matplotlib, and draw insights from the analysis. 4. **Object detection***: Demonstrate the use of OpenCV library to detect the object. 5. **Image Processing**: Demonstrate the use of Tensorflow library for image processing. 6. **Currency Converter (API Integration)**: Build a currency converter that fetches the latest exchange rates from an API. Use requests library for API integration. 7. **Password Generator (Random Module)**: Develop a password generator that creates strong, random passwords. Use the `random` module to generate different combinations.	
	Self-Learning Topics: ***Explore Python libraries***	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Install the pre-defined libraries in python programming and demonstrate the use of Math and Sympy libraries. (P.I.-1.1.1)*	

	LO 3.2: Demonstrate the use of Numpy and Matplotlib libraries to solve the problems in mechanical engineering field and to produce the results graphically. (P.I.-1.4.1, 5.2.2) *LO 3.3: Demonstrate the use of Pandas library to solve the problems related to data analysis. (P.I.-.5.2.2)* *LO 3.4: Demonstrate the use of OpenCV library for object detection. (P.I.-5.1.2)* *LO 3.5: Apply Image processing techniques using tensorflow library. (P.I.- 5.1.2)* *LO 3.6: Explore different types of libraries for resources available in python documentation. (P.I.-2.2.2)* *LO 3.7: Produce results for engineering problems using python libraries (P.I.-2.4.2)*	
04.	**Case Study** ***Learning Objectives:*** *To apply the concepts of python programming to solve mechanical engineering problems using IT tools collectively by working in a team*	**8**
	Contents: Application of Python programming libraries to solve Mechanical Engineering Problems. **Experiment/s:** 1. **Shear force and Bending moment diagram***: Write a python program to plot SFD and BMD of a simply supported beam. 2. **Data Analysis**: Demonstrate the use of python libraries to get the insights on the dataset. 3. **Object detection and Image processing:** Demonstrate the use of OpenCV and tensorflow library to detect the object or image.	
	Self-Learning Topics: ---	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Articulate programs for specific mechanical engineering applications. (P.I. -2.1.1)* *LO 4.2: Design the proper flowchart of the solution required for the real-life mechanical engineering problem. (P.I. -2.1.2)* *LO 4.3: Convert the conditions of the solution into Python code in a team. (P.I. -9.2.1)* *LO 4.4: Calculate the solution of the given problem based on human input and automate the entire process. (P.I. -5.1.2, 9.2.1,11.2.2)* *LO 4.5: present the results in a team (P.I. -5.2.2, 9.3.1)*	
The Laboratory Exercises marked with an asterisk (*) are mandatory in each module.		
	Total	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra and statistics to solve problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering
2.1.2	Identify engineering systems, variables, and parameters to solve the problems

2.2.2	Identify, assemble, and evaluate information and resources.
5.1.2	Adapt the tools and techniques to solve engineering problems
5.2.2	Demonstrate proficiency in using discipline specific tools.
9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field.

Course Outcomes: A learner will be able to -

1. Demonstrate the understanding of basic concepts of python programming. *(LO 1.1 , LO 1.2 , LO 1.3 , LO 1.4)*
2. Demonstrate the use of functions and OOP's to code in systematic and efficient way. (*LO 2.1, LO 2.2 , LO 2.3 , LO 2.4*)
3. Use different packages available in python to solve various problems.(*LO 3.1 , LO 3.2 , LO 3.3 , LO 3.4 , LO 3.5 , LO 3.6 , LO 3.7*)
4. Build python program for different applications. (*LO 4.1 , LO 4.2 , LO 4.3 , LO 4.4 , LO 4.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MESBL301.1	3	--	--	--	3	--	--	--	--	--	--
MESBL301.2	3	--	--	--	3	--	--	--	--	--	--
MESBL301.3	3	3	--	--	3	--	--	--	--	--	--
MESBL301.4	--	3	--	--	3	--	--	--	3	--	2
Average	**3**	**3**	--	--	**3**	--	--	--	**3**	--	**2**

Text Books :

1. Beginning Python: Using Python 2.6 and Python 3.1, James Payne,2010 Wiley Publishing, Inc.
2. Programming through Python, M. T. Savaliya, R. K. Maurya, Ganesh Magar, Revised Edition, 2020, SYBGEN Learning India Private Limited.

Reference Books :

1. Core Python Programming, Dr. R. Nageswara Rao,2nd Edition,2018, Dreamtech Press.
2. Programming for Computations - Python , Swein Linge - Hans Petter Langtangen , 2016, Springer Open.

Other Resources :

1. Python Documentation: Web Link： https://docs.python.org/3
2. NPTEL Course: Programming in Python by Prof. Rizwan Rehman, Department of Computer Science and Applications Engineering, Dibrugarh University.
   Web link: https://onlinecourses.swayam2.ac.in/cec22_cs20

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(30 Marks)

Laboratory Experiments: 15 Marks

Group Course Project on Mechanical Engineering problems: 10 marks

The group Size will be 2 to 4 students each. The problem definition will be selected based on the subjects studied in Mechanical Engineering. Students should complete the project using Python Programming language (Any IDE can be selected for coding purpose). The output of the program should match with their problem definition and the results should be presented in proper format. The program developed should be generic.

The presentation will be done to evaluate the project, challenges faced, and alternative solutions and modifications possible.

Attendance and Active participation: 5 marks

2. **Practical Test (20 Marks)**

Distribution of Marks :

The test will be conducted after 50 % of the syllabus.

Practical examination of 1 hour duration to be conducted by Internal Examiner.

Evaluation of practical examination to be done by examiner based on the printout of student work. For each program the evaluation will be done based on the correct output generation, compactness of the program, methodology used to achieve the output and the presentation of programs and the results.

END SEMESTER EXAMINATION (50 MARKS)

Section 1: Practical Examination (30 Marks)

The section one will have practical exam based on the laboratory exercises conducted during the term. For each program the evaluation will be done based on the correct output generation, compactness of the program, methodology used to achieve the output and the presentation of programs and the results.

Section 2: Debugging and Output Prediction Exercise (10 Marks)

The second section involves questions problems such as providing partial code segments with bugs and asking students to identify and correct the errors, predict the output of the corrected code, complete the code, identify the appropriate library etc. For each program the evaluation will be done based identifying the errors, completion of partial code and the correct output prediction.

Section 3: Oral (10 Marks)

Two examiners, one Internal and one External will do the evaluation.

Duration of Practical examination, debugging and output prediction exercise is 2 hours.

Practical Examination	: 30 Marks
Debugging and Output Prediction Exercise	: 10 Marks
Oral Examination	: 10 Marks

Course Type	Course Code	Course Name	Credits
MNP	MEMNP301	MINI PROJECT – 1A	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
50	--	50

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project Management and Finance
11. PO11: Life-Long Learning

Course Objectives :

1. To familiarize students about available infrastructure at Department/Institute level, online resources, plagiarism, expectations from MP 1A and 1B, etc.
2. To guide students in identifying societal or research needs and formulating them into problem statements.
3. To facilitate problem-solving in group settings.
4. To apply basic engineering principles to address identified problems.
5. To foster self-learning and research skills.

Course Outcomes :

At the end of the course, learners will be able to:

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
    - Research/white paper/article/blog writing/publication, etc.
    - Business plan for entrepreneurship product creation
    - Patent filing.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

At the beginning of semester-III, project guides are required to conduct around 4 hours' orientation sessions including following topics:

- Familiarizing students about infrastructure available at Department/Institute level and how to use it.
- How to identify societal problems and formulate project problem statement.
- How to carry out literature survey.
- What is plagiarism and what care needs to be taken while writing a report.
- What is project report template and how it should be used.
- What are expectations from mini-projects 1A and 1B.

Mini project may be carried out in one or more form of following:

- Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semesters III and IV and Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case-by-case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- **Continuous Assessment marks distribution in semester III (50 marks):**

- 10 marks for the Topic Approval Presentation in front of the progress monitoring committee
- 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
- 20 marks for the Final Report & Presentation
- 05 marks for Regularity and active participation

- **Continuous Assessment marks distribution in semester IV (50 marks):**
  - 15 marks for the In-Semester Two Presentations
  - 10 marks for the Participation in Project Competitions, TPP, etc.
  - 20 marks for the Final Report & Presentation
  - 05 marks for Regularity and active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester III:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
  - The first review will focus on finalizing the problem statement (topic approval).
  - The second review will focus on finalizing the proposed solution.

Semester IV:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
  - The first review will assess the readiness to build a working prototype.
  - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to the above-mentioned points, the following performance criteria shall be included during the in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester IV (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks.

Course Type	Course Code	Course Name	Credits
HSS	HSS301	PRODUCT DESIGN	02

Program Outcomes addressed:

1. PO2 Problem analysis
2. PO3 Design/Development of solutions
3. PO5 Engineering tool usage
4. PO6 The engineer and the world
5. PO7 Ethics
6. PO8 Individual and collaborative team work
7. PO10 Project management & finance
8. PO11 Life-long learning

Course Objectives:

1. Understand the product design process and its user-centered principles.
2. Apply fundamental design principles to create innovative product designs.
3. Demonstrate proficiency in generating and evaluating design concepts through ideation techniques.
4. Evaluate and synthesize sustainable and user-centric design practices in product development.

Module	Details	Hrs.
	Course Introduction – The course Product Design provides a thorough understanding of the principles, methods, and methodologies used in developing unique and functional products. Whether you want to be an industrial designer, a UX/UI specialist, or a creative problem solver, this course will provide you the necessary knowledge and abilities to envision, develop, and revise products that fulfill user needs and market demands. Students will investigate many areas of product design, such as aesthetics, usability, and sustainability, using both theory and hands-on practice. Design thinking, prototyping, and research will demonstrate to students how to turn ideas into concrete things that improve user experience and address real-world challenges.	**01**
01.	**Introduction to Product Design** ***Learning Objective:*** *Understand the fundamental principles and key elements that contribute to effective product design.*	**3-5**
	Contents: Overview of product design process, Importance of user-centered design, Design thinking methodologies, Case studies of successful product designs, Introduction to design tools and software (e.g., Sketch, Adobe XD)	

	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply design thinking methodologies to develop user-centered solutions.* (*P.I.- 2.1.1, 2.3.1, 3.2.1, 3.3.1*) *LO 1.2: Gain introductory experience with digital design tools.* (*P.I. – 5.1.1, 5.2.1*)	
02.	**Design Principles and Fundamentals** ***Learning Objective:*** *Understand and apply core design principles to create functional and aesthetically pleasing products.*	**5-7**
	Contents: Understanding design principles (e.g., balance, hierarchy, contrast), Human factors in design (ergonomics, anthropometrics), Material selection and properties, Basics of aesthetics and styling, Hands-on exercises in sketching and prototyping	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental design principles such as balance, contrast, proportion, and harmony to create aesthetically and functionally effective designs.* (*P.I. – 3.1.5, 3.2.3, 6.1.1*) *LO 2.2: Analyze and evaluate design elements to develop user-centered solutions that enhance usability, accessibility, and overall user experience.* (*P.I. – 3.1.1, 6.2.1*)	
03.	**Concept Generation and Ideation** ***Learning Objective:*** *Develop creative ideas and transform them into viable product concepts through structured ideation techniques.*	**5-7**
	Contents: Techniques for brainstorming and idea generation, Sketching and visualization techniques, Developing design briefs and specifications, Evaluating and selecting design concepts, Design for X, Rapid prototyping methods (e.g., 3D printing, CNC machining)	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply various ideation techniques such as brainstorming, mind mapping, and SCAMPER to generate innovative and creative product concepts*. (*P.I. – 2.4.4, 3.1.6, 3.2.1*) *LO 3.2: Develop and evaluate multiple design concepts based on user needs, feasibility, and functionality to refine ideas into viable solutions.* (*P.I. – 2.2.4, 3.1.1, 3.1.6*)	
04.	**Product Lifecycle** ***Learning Objectives:*** *Understand the stages of a product's lifecycle and how they influence design, development, and sustainability.*	**3-5**
	Contents: Detailed overview of the product development lifecycle, Cost estimation and budgeting, Marketing and Market research, Regulatory and compliance requirements (e.g., safety standards)	

	Learning Outcomes: *A learner will be able to* *LO 4.1: Understand and analyze the stages of the product lifecycle and their impact on design, marketing, and sustainability decisions.* (*P.I. – 3.1.1, 3.1.6, 6.3.2, 11.3.2*) *LO 4.2: Analyze the influence of lifecycle considerations such as material selection, manufacturing processes, and end-of-life disposal to develop sustainable and cost-effective product solutions.* (*P.I. – 3.1.5, 6.3.1, 6.4.1, 6.4.2, 11.1.1, 11.2.2*)	
05.	**User Experience (UX) Design** ***Learning Objective:*** *Design intuitive and user-friendly products by applying UX principles and usability testing.*	**3-5**
	Contents: Understanding user needs and behaviour, Usability testing and feedback gathering, Wire-framing and prototyping for digital products, Iterative design process, Accessibility and inclusive design principles	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply UX design principles such as usability, accessibility, and interaction design to create intuitive and user-friendly products.* (*P.I. – 3.1.6, 3.3.1, 5.2.2*) *LO 5.2: Conduct user research and usability testing to analyze user needs, gather feedback, and refine designs for an enhanced user experience.* (*P.I. – 3.1.1, 3.1.6, 5.1.2, 5.2.1, 10.3.1, 10.3.2*)	
06.	**Sustainability in Product Design** ***Learning Objective:*** *Incorporate sustainable practices and materials to create environmentally responsible product designs.*	**3-5**
	Contents: Environmental impact assessment in product design, Sustainable materials and manufacturing processes, Design for disassembly and recycling, Circular economy principles Case studies of eco-friendly product designs.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply sustainable design principles by selecting eco-friendly materials, optimizing manufacturing processes, and minimizing environmental impact throughout the product lifecycle.* (*P.I. – 3.1.5, 6.3.2, 7.1.1, 11.3.1*) *LO 6.2: Assess the lifecycle impact of products in terms of resource consumption, carbon footprint, and end-of-life disposal to develop eco-friendly and socially responsible design solutions.* (*P.I. – 3.4.1, 6.4.1, 7.2.2, 11.3.2*) *LO 6.3: Demonstrate good communication and collaboration with interdisciplinary teams by incorporating sustainable design concepts, explaining environmental and social implications, and enabling cross-disciplinary discussions to create new, eco-friendly product solutions.* (*P.I. – 8.2.1, 8.3.1*)	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.1	Articulate problem statements and identify objectives.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.1	Recognize that need analysis is key to good problem definition.
3.1.5	Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions.
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development.
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions.
3.4.1	Refine a conceptual design into a detailed design within the existing constraints (of the resources)
5.1.1	Identify modern engineering tools such as computer-aided drafting, 46 odelling and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) 46odelling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity.
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.
6.4.1	Describe management techniques for sustainable development.
6.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives.
7.2.2	Examine and apply moral & ethical principles to known case studies.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
10.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.
10.3.2	Use project management tools to schedule an engineering project, so it is completed on time and on budget.
11.1.1	Describe the rationale for the requirement for continuing professional development.
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field.
11.3.1	Source and comprehend technical literature and other credible sources of information.
11.3.2	Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to –

1. Apply design thinking methodologies effectively to solve design problems. (*LO 1.1, LO 2.1, LO 2.2, LO 3.1, LO 3.2*)
2. Demonstrate proficiency in utilizing design tools and techniques for product development. (*LO 1.2, LO 5.1*)
3. Communicate and collaborate effectively for interdisciplinary teamwork. (*LO 6.3*)
4. Create functional and aesthetically pleasing product designs. (*LO 5.2*)
5. Integrate sustainable and user-centric design principles into product development processes. (*LO 4.1, LO 4.2, LO 6.1, LO 6.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HSS301.1	--	3	3	--	--	3	--	--	--	--	--
HSS301.2	--	--	3	--	3	--	--	--	--	--	--
HSS301.3	--	--	--	--	--	--	--	3	--	--	--
HSS301.4	--	--	3	--	3	--	--	--	--	3	--
HSS301.5	--	--	3	--	--	3	3	--	--	--	3
Average	--	**3**	**3**	--	**3**	**3**	**3**	**3**	--	**3**	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. "Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger, published by McGraw-Hill Education; 7th edition (January 25, 2021).
2. "Engineering Design: A Project-Based Introduction" by Clive L. Dym and Patrick Little, published by Wiley; 4th edition (August 26, 2015).
3. "Universal Principles of Design" by William Lidwell, Kritina Holden, and Jill Butler, published by Rockport Publishers; Revised and updated edition (January 1, 2010).

Reference Books :

1. "Sketching: Drawing Techniques for Product Designers" by Koos Eissen and Roselien Steur, published by BIS Publishers; 2nd edition (March 1, 2011).
2. "Materials and Design: The Art and Science of Material Selection in Product Design" by Mike Ashby and Kara Johnson, published by Butterworth-Heinemann; 3rd edition (October 10, 2014).
3. "The Design of Everyday Things" by Don Norman, published by Basic Books; Revisedand expanded edition (November 5, 2013).

Other Resources :

1. NPTEL Course: Product Design and Development, Prof. Inderdeep Singh, IITRoorkee Weblink: https://onlinecourses.nptel.ac.in/noc21_me83/preview
2. NPTEL Course: Product Design and Innovation, By Prof. Supradip Das, Prof. Swati Pal, Prof. Debayan Dhar, IIT Guwahati, IIT Guwahati, Web link: https://onlinecourses.nptel.ac.in/noc21 de01/preview

Continuous Assessment – Theory - (50 Marks)

Suggested breakup of distribution

Multiple Choice Questions	10 Marks
Case Study	20 Marks
Group Project	15 Marks
Regularity and Active participation	05 Marks

Course Type	Course Code	Course Name	Credits
PCC	MEPCC405	ENGINEERING MATHEMATICS-IV	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)	MSE	ESE	
Continuous Assessment	Mid-Semester Exam (MSE)				
20+25*	30	50	1.5	2	125

Tutorial

Pre-requisite :

1. BSC101 Engineering Mathematics-I
2. BSC204 Engineering Mathematics-II
3. MEPCC301 Engineering Mathematics-III

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives :

1. To provide the Basic knowledge on the concepts of mathematics pertaining to the field of engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of mathematics in the field of Engineering

Module	Details	Hrs
	Course Introduction In Mechanical Engineering, mathematics serves as the indispensable language that unlocks the mysteries of physical world from the sleek designs of automotive engines to the towering structures of industrial machinery, every facet of mechanical engineering is underpinned by mathematical principles. For example- Application of probability and statistics in Engineering design and analysis. Application of Correlation and Regression for improved efficiency and reliability. Application of Complex Integration in Flow and transfer Function Analysis.	**02**
01	**Probability Theory and Random Variable**	**6-8**
	Learning Objective/s:	
	The learner will be able to analyze random variables using the basic theory of probability and will be able to apply various mathematical techniques in determining probability functions.	
	Contents:	

	Conditional Probability, Bayes Theorem, Total Probability Theorem, Definition of Random Variable, Types of Random Variable: Discrete and Continuous, Probability Mass and Density Function, Measures of Central Tendency and Dispersion.	
	Self-Learning Topics:	
	Cumulative Distribution and Density Function	
	Learning Outcomes :	
	A learner will be able to *LO 1.1 Identify independents sets and disjoint sets and use its knowledge in the context of conditional probability. (P.I.-2.1.3)* *LO 1.2 Apply mathematical techniques of union, intersection and addition of sets, numbers for finding probabilities of events using Bayes' Theorem and Total Probability Theorem. (P.I.-1.1.1)* *LO 1.3 Identify if a given Random variable is Discrete or continuous in nature using existing definitions and formulas from Probability. (P.I.-2.1.2)* *LO 1.4 Apply mathematical techniques for finding Expectation, Variance, Probability density function and Probability distribution function. (P.I.-1.1.2)*	
02	**Probability Distribution**	**6-8**
	Learning Objective/s:	
	Learner will be able to analyse and identify standard probability distribution functions and apply the knowledge of distribution for finding probabilities of various events.	
	Contents:	
	Binomial distribution, Poisson Distribution , Fitting of a Poisson Curve, Gaussian Distribution, Normal Distribution (Standard Normal distribution , Reverse problem of Normal distribution).	
	Self-Learning Topics:	
	Joint Probability Distribution	
	Learning Outcomes :	
	A learner will be able to *LO 2.1 Apply mathematical techniques of exponents, algebra and basic probability for finding the probabilities of various events using Binomial, Poisson and Normal Distribution. (P.I.-1.1.1)* *LO 2.2 Identify the area under a Standard Normal Curve (bounded or unbounded) and use its knowledge in the context of Normal Distribution. (P.I.-2.1.3)* *LO 2.3 Identify whether Poisson distribution or Normal Distribution is applicable to a given problem using basic definitions of distribution and the data inferred from the problem. (P.I.-2.1.2)* *LO 2.4 Apply the advanced mathematical techniques of statistics to find the distribution of probabilities when percentile of area under the curve is given. (P.I. -1.1.2)* *LO 2.5 Articulate the problems statements in way such that either normal distribution or reverse normal distribution is to applied. (P.I.-2.1.1)*	
03	**Sampling Theory**	**7-9**
	Learning Objective/s:	
	The learner will be able to analyze mathematical problems and apply parametric or non-parametric tests based on the hypothesis framed.	

	Contents:	
	Introduction to Sampling Theory, Testing of Hypothesis: Level of Significance, Critical Region, One and Two Tailed Tests, Test significance of large samples test: One sample. Students' t-distribution: One sample, two sample, Chi-square test, F-test.	
	Self-Learning Topics:	
	Test of significance of large sample: Two sample	
	Learning Outcomes:	
	A learner will be able to *LO 3.1 Identify whether z-test or t-test is to be applied depending on the sample size provided. (P.I.-2.2.2)* *LO 3.2 Identify the required Level of Significance necessary to contradict or accept the null hypothesis formulated for the given mathematical problem. (P.I.-2.3.2)* *LO 3.3 Apply basic mathematical techniques such as summation and square root for finding the test statistic in t-test, chi-square and F tests. (P.I.-1.1.1)* *LO 3.4 Identify the critical value of t-test, chi-square and F tests from the distribution tables provided and use this knowledge to come up with a decision for the hypothesis stated. (P.I.-2.1.3)* *LO 3.5 Apply advanced techniques of Mean(average) and Exponents for finding the expected frequency and use this knowledge in testing the Goodness of Fit (P.I.-1.1.2)*	
04	**Correlation and Regression**	**7-9**
	Learning Objective/s:	
	Learner will be able to analyze the mathematical dataset given and apply techniques of correlation and regression to identify the relationships between variables from the dataset.	
	Contents:	
	Correlation, Karl Pearson's coefficients of correlation(r), Spearman's Rank correlation coefficient (R): Repeated Rank, Non-repeated rank, Regression, Line of regression, Curve fitting: Linear and Second-Degree Curves.	
	Self-Learning Topics:	
	Fitting of an exponential Curve	
	Learning Outcomes :	
	A learner will be able to *LO 4.1 Identify whether Karl Pearson's or Spearman's coefficient of correlation is to be used in establishing relationship between two variables depending on the dataset given. (P.I.- 2.1.3)* *LO 4.2 Apply basic mathematical techniques from algebra in finding the lines of regression and regression coefficients. (P.I.-1.1.1)* *LO 4.3 Identify whether a linear degree curve or a quadratic degree curve is to be fit for the given data set based on the knowledge of Curve Fitting (P.I.-2.2.2)* *LO 4.4 Apply fundamental concepts of simultaneous equations and use for curve fitting.(.I.-1.3.1)*	
05	**Complex Integration-I**	**5-7**

	Learning Objective/s:	
	Learner will be able to analyze complex power series and determine the value of complex integration using Cauchy's theorem and Cauchy's formula.	
	Contents:	
	Line Integral, Cauchy's Integral theorem: Simple connected, multiply connected regions. Cauchy Integral formula (without proof). Taylor's and Laurent's series (without proof).	
	Self-Learning Topics:	
	Winding Numbers	
	Learning Outcomes :	
	A learner will be able to *LO 5.1 Apply mathematical techniques from calculus to evaluate line and contour integrals. (P.I.-1.1.1)* *LO 5.2 Apply advanced mathematical techniques of analytical functions to rewrite the complex functions in a way that Cauchy Integral formula can be used. (P.I.-1.1.2)* *LO 5.3 Identify whether Cauchy Integral Theorem or Cauchy Integral Formula is to be used depending on the points where the function does not exist. (P.I.-2.1.3)* *LO 5.4 Identify the terms with negative powers in the power series expansion of complex functions and use this knowledge in understanding Taylor and Laurent Series. (P.I.-2.1.2)*	
06	**Complex Integration-II**	**5-7**
	Learning Objective/s:	
	Learner will be able to analyze various types of singularities and apply its knowledge in finding contour integrals.	
	Contents:	
	Definition of Singularity, Definition of Zeroes and Poles of f(z). Residues, Cauchy's Residue Theorem (without proof), Application of Residue Theorem to evaluate real integrals.	
	Self-Learning Topics:	
	Application of Residue Theorem to evaluate improper real integrals.	
	Learning Outcomes :	
	A learner will be able to *LO 6.1 Identify the existence of limits near the point of singularity and use this knowledge in classifying the types of singularities. (P.I.-2.1.2)* *LO 6.2 Apply mathematical techniques of calculus to evaluate contour integrals using the knowledge of residues. (P.I.-1.1.1)* *LO 6.3 Identify the order of poles and apply this knowledge for finding residues of complex function. (P.I.-2.1.3)* *LO 6.4 Apply fundamentals of distance in checking whether the singularities lie inside or outside the contour. (P.I.-1.3.1)*	
	Course Conclusion	**01**
	Engineering Mathematics plays an important role in analysing uncertainties and making informed decisions in engineering design and	

	analysis and in identifying the most influential factors and fine-tune designs for improved efficiency, reliability, or cost-effectiveness.	
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.1.2	Apply advanced mathematical techniques to model and solve engineering problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.2	Identify, assemble and evaluate information and resources.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required

Course Outcomes :

1. Analyse random variables and apply the concepts of probability for getting the spread of data.*(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Analyse the mathematical problem given and apply the concepts of distribution in finding probabilities. .*(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5)*
3. Analyse and apply the concept of Sampling Theory to frame and make decisions on the hypothesis. .*(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5)*
4. Analyse and interpret the data using Correlation and Regression. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4)*
5. Apply the concepts of Complex Integration for identifying and evaluating integrals, computing residues and evaluating various contour integrals. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4. LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC405.1	3	2	--	--	--	--	--	--	--	--	--
MEPCC405.2	3	2	--	--	--	--	--	--	--	--	--
MEPCC405.3	3	2	--	--	--	--	--	--	--	--	--
MEPCC405.4	3	2	--	--	--	--	--	--	--	--	--
MEPCC405.5	3	2	--	--	--	--	--	--	--	--	--
Average	**3**	**2**	--	--	--	--	--	--	--	--	--

Text Books :

1. Advanced Engineering Mathematics, H. K. Dass, Twenty-first Revised Edition, 2013, S.Chand and Company Ltd.

Reference Books :

1. Probability, Statistics and Random Processes, T Veerarajan, Second Edition, 2004, Tata McGraw-Hill Publishing Company Ltd.
2. Advanced Engineering Mathematics, Erwin Kreyszig, Eight Edition, 2010, Wiley Eastern Limited.
3. Complex Variables and Applications, S. Ponnusamy and Herb Silverman, First, 2006, Birkhauser Boston.
4. Higher Engineering Mathematics, Dr. B. S. Grewal, Forty Second Edition, 2017, Khanna Publication.

Other Resources :

1. NPTEL Course: Probability and Statistics By Dr. Somesh Kumar, Department of Mathematics, IIT Kharagpur :-Web link: https://youtu.be/VVYLpmKRfQ8?si=Gh3EtQrLSrEFZMNo
2. NPTEL Course: Complex Analysis by Prof. P. A. S. Sree Krishna, Department of Mathematics, IIT Guwahati :-Web link: https://youtu.be/Mwpz1zjPlzI?si=JU090YU2-MxJOXJD

IN-SEMESTER ASSESSMENT (75 MARKS)

1. Continuous Assessment of Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per Gate exam pattern/ level	:	05 Marks
One Class test	:	05 Marks
One Team-pair- Solo	:	05 Marks
Regularity and attentiveness	:	05 Marks

2. Continuous Assessment of Tutorial (25 Marks)

Suggested breakup of distribution

Students must be encouraged to write at least 6 class tutorials. At least 6 Class tests will be conducted based on class tutorials on entire syllabus. Each class tests carries 20 Marks. Average will be taken of all class tests.

Minimum six Tutorials	:	20 Marks
Regularity and active participation	:	05 Marks

3. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% of the syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End semester examination will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% -30% weightage, and the syllabus covered from MSE to ESE carrying 70% - 80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC406	THEORY OF MACHINES	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)	MSE	ESE	
Continuous Assessment	Mid-Semester Exam (MSE)				
20	30	50	1.5	2	100

Pre-requisite :

1. ESC101- Engineering Mechanics
2. MEPCC302- Mechanics of Solids

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives :

1. To impart the knowledge of basic kinematics and mechanisms, including the classification of mechanisms and types of motion.
2. To perform kinematic analysis of mechanisms, including the determination of displacement, velocity, and acceleration
3. Using fundamental principles of mechanical analysis, to analyze static and dynamic forces within a single slider mechanism.
4. Understand transmission system mechanisms and kinematic parameters controlling machine devices.

Module	Details	Hrs
	Course Introduction This course deals with mechanism and their analysis as a part of machines. It also deals with forces acting on the machine component. This is a core course which facilitates in understanding design requirements and design of new machines.	**01**
01	**Basic Kinematics and Inversions of mechanism.** ***Learning Objective/s:*** *To apply the knowledge of engineering fundamentals in basic kinematics to analyze the inversion of various mechanisms.*	**5-7**
	Contents:	
	1.1 Basic Kinematics Difference between Structure, Machine and Mechanism, Kinematic link & its types, Kinematic pairs its types, Types of constrained motions, Types of joints, Definition of the kinematic chain, Degree of freedom (mobility), Kutzbach and Grűbler's mobility criterion.	

	1.2 Mechanism and its inversions: Four bar chain mechanism and its inversions, Grashoff's law of four bar mechanism, single slider crank chain and its inversions, Double slider crank chain, and its inversions.	
	Self-Learning Topics: -- *limitations of Grubler's criterion and Inversions of the double slider mechanism.* ***Learning Outcomes :*** *A learner will be able to* *LO 1.1: Apply the fundamental engineering concept to differentiate between machine and mechanism (P.I.-1.3.1)* *LO 1.2: Apply the mechanical engineering concept to determine the degrees of freedom of the given mechanism. (P.I.-1.4.1)* *LO 1.3 Identify the quick return mechanism in the shaping machine, used to save the idle time of the machine. (P.I.-2.1.1)* *LO 1.4 Identify the link to be constrained in a four-bar chain to provide a beam engine mechanism. (P.I.-2.1.2)*	
02	**Straight line generating mechanism and Special Mechanisms.** ***Learning Objective/s:*** *Analyze the various mechanisms for delivering constrained motion using principles of kinematics.*	**4-6**
	Contents: 2.1 Straight line generating mechanisms: Introduction to Exact straight line generating mechanisms (Peaucillier's and Hart's Mechanisms), Introduction to Approximate Straight line generating mechanisms (Watt's, Grasshopper mechanism and Tchebicheff's mechanism.) Special Mechanisms (No problems on this topic) 2.2 Offset slider crank mechanisms- Working principle of Pantograph, Relationship between input-output angular displacement in single Hook’s Joint. 2.3 Steering Gear Mechanism- Condition of correct steering, working principle of Ackerman and Davis steering gears.	
	Self-Learning Topics:	
	Derivation on Tchebicheff's mechanism for proportionate links.	
	Learning Outcomes : *A learner will be able to* *LO 2.1: Identify a straight-line mechanism with 8 numbers of links. (P.I.-2.1.1)* *LO 2.2: Identify the condition of minimum and maximum output speed for a single Hook’s Joint (P.I.-2.1.1)* *LO 2.3: Use the principle of instantaneous center to obtain the correct steering equation for the Davis steering mechanism (P.I.-2.3.1)* *LO 2.4: Combine the principles of basic kinematics to produce a mechanism with definite output motion. (P.I.-2.3.1)*	

<table>
<tr><td rowspan="4">03</td><td>Velocity and Acceleration analysis</td><td rowspan="4">7-9</td></tr>
<tr><td>Learning Objective/s:
To apply basic concepts of the relative velocity and acceleration method to analyze the Coriolis component in the mechanism. (Graphical method)</td></tr>
<tr><td>Contents:
3.1 Velocity Analysis of Mechanisms (mechanisms up to 6 links)
Velocity analysis by relative velocity method (Graphical approach)
3.2 Acceleration Analysis of Mechanisms (mechanisms up to 6 links)
Acceleration analysis by relative method including pairs involving Coriolis acceleration (Graphical approach)</td></tr>
<tr><td>Self-Learning Topics:
Velocity analysis of quick return mechanism.

Learning Outcomes :
A learner will be able to
LO 3.1: Apply the fundamental engineering concepts to determine centripetal and tangential components of acceleration for an arbitrary rotating point. (P.I.-1.3.1)
LO 3.2: Apply Mechanical engineering concepts to determine the angular velocities of different links within the mechanism using the Relative velocity method. (P.I.-1.4.1)
LO 3.3: Identify the Coriolis component in the mechanism and analyze its effects on the mechanism. (P.I.-2.1.2)
LO 3.4: Draw velocity and acceleration polygon to analyze the mechanism for angular acceleration of links. (P.I.-2.1.4)</td></tr>
<tr><td rowspan="4">04</td><td>Static and dynamic force analysis of the Slider crank mechanism</td><td rowspan="4">8-10</td></tr>
<tr><td>Learning Objective/s:
To analyze static and dynamic forces of a single slider mechanism using basic concepts of mechanism.</td></tr>
<tr><td>Contents:
Static force analysis of Slider crank mechanism: Piston effort, piston side thrust, force along the connecting rod, the tangential force acting on the crank pin, the radial force acting along the crankshaft, and Torque on the crankshaft. (neglecting the mass of connecting rod and crank),
Dynamic force analysis of Slider crank mechanism:
The radius of gyration of rigid bodies, analysis of compound pendulum, Conditions of developing two mass statically and dynamically equivalent system correction couple, the torque exerted on the crankshaft due to Inertia force, the torque exerted on the crankshaft due to correction couple, and The torque exerted on the crankshaft due to mass at the big end of connecting rod.</td></tr>
<tr><td>Self-Learning Topics:
Theory and analysis of compound pendulum.

Learning Outcomes :</td></tr>
</table>

	A learner will be able to *LO 4.1: Identify the static forces acting on a single slider mechanism used in IC engine to analyse static equivalent condition. (P.I.-2.1.3)* *LO 4.2: Formulate a dynamically equivalent system/ model of the connecting rod comprising two masses using principles of dynamic equivalent conditions (P.I.-2.3.1)* *LO 4.3: Identify the assumptions and significance of correction couple in the fulfilling condition of dynamic equivalence for a single slider mechanism used in IC engine. (P.I.-2.3.2)*	
05	**Transmission System** ***Learning Objective/s:*** *To select a suitable drive system for a given application using basic concepts of belt and gear drive.*	**7-9**
	Contents: 5.1 Belts drive Types of belt drive, Types of the belt, velocity ratio of belt and compound belt drive, Length of open and cross belt drive, Power transmitted by belt, Ratio of driving tensions for flat belt drive, Determination of angle of contact, Centrifugal tension in the belt, initial tension in the belt, maximum tension in belt and condition of maximum power transmission. 5.2 Gears- Types of gear, Law of gearing, Forms of teeth, Details of gear terminology, Determination of Path of contact, Arc of contact and Contact ratio, Interference in involutes gears, Minimum number of teeth for interference-free motion, Methods to control interference in involutes gears.	
	Self-Learning Topics: *Slip of belt, the crowning of pulley, and the difference between involute and cycloidal tooth profile.* ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to identify various types of transmission systems used in real life (P.I.-1.3.1)* *LO 5.2: Apply Mechanical engineering concepts to analyze belt drive for maximum power output with safe working tension in belt. (P.I.-1.4.1)* *LO 5.3: Differentiate between belt drive and gear drive, and use this knowledge to identify a suitable system for real-life applications. (P.I.-2.1.1)* *LO 5.4: Analyze the involute gear drive to determine the minimum number of teeth on the pinion to avoid interference. (P.I.-2.1.2)*	
06	**Gyroscope and Governor** ***Learning Objective/s:*** *Analyze the gyroscope and governor to improve performance characteristics.*	**5-7**
	Contents:	

	6.1 Gyroscope: Gyroscopic couple and its effect on general spinning bodies, Gyroscopic couple and its effect on naval during steering, pitching and rolling. 6.2 Governor: Terminologies used in governor, determination of the height of Porter governor with and without friction, Effect, and Power of Porter governor, determination of the height of Hartnell governor with and without friction. Performance characteristics of the governor (stability, isochronous, sensitivity, and hunting).	
	Self-Learning Topics: *Gyroscopic effect on airplanes and effect, and Power of Porter governor*	
	Learning Outcomes : *A learner will be able to* *LO 6.1: Mechanical engineering concepts to determine the gyroscopic effect on the ship during pitching, steering and rolling. (P.I.-1.4.1)* *LO 6.2: Apply fundamental engineering concepts to analyze stability and hunting characteristics of the governor. (P.I.-1.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.4 (new PI)	Desired inferences need to be drawn from graphical tools/representations of engineering quantities of mechanism.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.

Course Outcomes: A learner will be able to -

1. Construct a mechanism for constrained motion using proportionate links.(*LO 1.1*, *LO 1.2 , LO 1.3 L.O 1.4, LO 2.1, LO 2.2 and LO 2.4*)
2. Determine motion parameters through kinematic analysis of mechanisms. (*LO 3.1, LO 3.2 , LO 3.3 and LO 3.4*)
3. Evaluate forces and moments by conducting dynamic analysis of single slider mechanisms (*LO 4.1, LO 4.2 and LO 4.3*)
4. Select transmission systems and machine components based on requirements. (*LO 5.1, LO 5.2 , LO 5.3 and LO 5.4*)

5. Demonstrate Gyroscopic effects on the mechanical systems and performance characteristics of a Hartnell Governor. (*LO 6.1 and LO 6.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC406.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC406.2	3	3	--	--	--	--	--	--	--	--	--
MEPCC406.3	--	3	--	--	--	--	--	--	--	--	--
MEPCC406.4	3	3	--	--	--	--	--	--	--	--	--
MEPCC406.5	3	--	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	--	--	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Theory of Machines, S.S. Ratan,, 5th edition, 2021, Tata McGraw Hill.
2. Theory of Mechanisms and Machines, Ghosh and A.K. Mallik, 3rd edition, 2009, East-West Press
3. Theory of Machines, Sandhu Singh, 3rd edition, 2011, Pearson Publishers
4. Theory of Machines, R.S. Khurmi and J .K.Gupta , 21th edition, 2022, S Chand Publisher
5. Theory of Machines , P.L. Ballaney, 25th edition, 2021, Khanna Publishers

Reference Books :

1. Theory of Machines and Mechanism, J.J. Uicker, G.R. Pennock, and J.E. Shigley , 3rd edition, 2009, Oxford Higher Education.
2. Theory of Machines, Thomas Bevan , 3rd edition, 2009, CSB Publishers & Distributors
3. Kinematics and Dynamics of Machinery, 2017, R.L. Norton, McGraw Hill

Other Resources :

1. NPTEL Course: Kinematics of Machines by Prof. Ashok Kumar.Malik, Department of Mechanical Engineering at IIT Kanpur :-Web link- https://nptel.ac.in/courses/112104121
2. NPTEL Course: Dynamics of Machines by Prof. C. Amarnath, Prof. K. Kurien Issac, and Prof. P. SeshuDepartment of Mechanical Engineering at IIT Bombay :-Web lnk- https://nptel.ac.in/courses/112/101/112101096/:

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

- Numerical Assignment/s (min 20 problems) — 05 Marks
- Class test based on above numerical assignment — 05 Marks
- Working model development to demonstrate concept — 05 Marks
- Regularity and Active Participation — 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC407	THERMAL ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESC101 Engineering Mechanics
2. MEPCC304 Thermodynamics

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO6: The Engineer and The World

Course Objectives:

1. To apply and analyze the heat transfer concepts applicable for steady state and transient conditions.
2. To apply concepts of steam turbines to analyze its performance.
3. To apply concepts of compressors and gas turbine to analyze its performance.
4. To perceive operations of an I. C. Engines and it's environmental aspects.

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Conduction** ***Learning Objective:*** *To apply and analyze the heat transfer concepts applicable for steady state and transient conditions.* **Contents:** **Introduction:** Modes of Heat Transfer: Generalized heat conduction equation in rectangular, Steady state heat conduction through plane wall, composite wall. Thermal contact resistance. Critical radius of insulation in cylinder and sphere. Heat transfer from Extended Surfaces: Types of extended surfaces and its significance. Governing differential equation for fin (Finite, Infinite, and Insulated tips) and its solution. Fin efficiency and effectiveness.	**6-8**

	Self-Learning Topics: *Generalized heat conduction equation in cylindrical and spherical coordinates.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply mathematical techniques to solve basic problem of heat transfer. (P.I.-1.1.1)* *LO 1.2: Apply heat transfer concepts to understand fundamentals of composite walls, critical thickness of insulation and extended surfaces. (P.I.-1.4.1)* *LO 1.3: Identify composite wall, extended surfaces and its technical parameters to solve problems on it. (P.I.-2.1.2)* *LO 1.4: Combine scientific principles and engineering concepts to formulate mathematical models of an extended surfaces. (P.I.-2.3.1)*	
02.	**Convection** ***Learning Objective:*** *To apply and analyze the heat transfer concepts applicable for steady state and transient conditions.*	**6-8**
	Contents: Free and Forced convection. Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate and in pipe. General thermal analysis: Constant heat flux and constant surface temperature, boundary layer parameters. Separation of boundary layer and its methods of control.	
	Self-Learning Topics: ***Fundamentals of Convection in real-time applications like Aeroplane, boiler, boiling of fluid etc.***	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to understand free and forced convection. (P.I.-1.3.1)* *LO 2.2: Apply heat transfer concepts to understand fundamentals of Boundary layer and flow separation over a flat plate and pipe. (P.I.-1.4.1)* *LO 2.3: Identify specific empirical relations and its significance to solve problems on convection, boundary layer over a flat plate and pipe. (P.I.2.1.3)* *LO 2.4: Apply engineering mathematics and computations to solve problems on heat exchangers. (P.I.-2.4.1)*	
03.	**Heat Exchangers and Transient Heat Transfer** ***Learning Objective:*** *To apply and analyze the heat transfer concepts applicable for steady state and transient conditions.*	**6-8**
	Contents: **Heat Exchanger:** Types of heat exchangers, Overall heat transfer coefficient, LMTD, Effectiveness, Effectiveness – Number of Transfer Unit (ε- NTU) method, Correction factor for multi pass (up to 2 passes on shell and tube side) and cross flow heat exchanger.	

	Unsteady state heat transfer: Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant.	
	Self-Learning Topics: *Critical/specific application Heat exchangers in mechanical/Medical industry*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to understand types of heat exchangers. (P.I.-1.3.1)* *LO 3.2: Apply fundamentals of heat transfer to understand basics of heat exchangers and transient heat transfer. (P.I.-1.4.1)* *LO 3.3: Identify heat exchangers and its technical parameters to solve problems on it. (P.I.-2.1.2)* *LO 3.4: Combine scientific principles and engineering concepts to formulate mathematical models in design of heat exchangers. (P.I.-2.3.1)* *LO 3.5: Apply engineering mathematics and computations to solve problems on heat exchangers. (P.I.-2.4.1)*	
04.	**Steam Turbine** ***Learning Objectives:*** ***To Apply concepts of steam turbines to analyze its performance.***	**6-8**
	Contents: Energy sources for power plants, Solar thermal energy, nuclear energy, bioenergy, geothermal. **Steam Turbine:** Basic of steam turbine, Classification, compounding of turbine, Impulse turbine –velocity diagram, Condition for max efficiency Reaction turbine, Degree of reaction, Parson's turbine, Condition for maximum efficiency, Numerical on Parson's turbine only.	
	Self-Learning Topics: *Basic accessories required in steam Turbine, General layout of Power plant.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply mathematical techniques to solve problems on steam turbine. (P.I.-1.1.1)* *LO 4.2: Apply mechanical engineering concepts to understand energy transfer across all components of steam turbine. (P.I.-1.4.1)* *LO 4.3: Identify type of steam turbine, concepts of velocity triangles to solve problems on impulse and reaction turbine. (P.I- 2.1.3)* *LO 4.4: Apply engineering mathematics and computations to solve problems on steam turbine. (P.I.-2.4.1)*	
05.	**Air compressor and Gas Turbine** ***Learning Objective/s:*** *To apply concepts of compressors and gas turbine to analyze its performance.*	**7-9**
	Contents: **Air compressor:** Introduction and general classification of reciprocating compressor positive displacement, Multi Staging of reciprocating compressor. Centrifugal compressor, surging and choking of compressor.	

	Gas Turbine: Classification and application, Reheating, Regeneration and Intercooling. Jet Propulsion-Principle- Working-Turbo - jet engine - Turbo - prop engine, Prop-jet engine- Rocket propulsion- Principles - Advantages -disadvantages- Applications.	
	Self-Learning Topics: *Applications of Air compressor in real life and Gas Turbine application*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to understand types of compressors and gas turbine. (P.I.-1.3.1)* *LO 5.2: Apply mechanical engineering concepts to understand energy transfer across all components of compressor and gas turbine. (P.I.-1.4.1)* *LO 5.3: Identify type of compressor and gas turbine, to solve problems on compressors and gas turbine. (P.I.- 2.1.3)* *LO 5.4: Apply engineering mathematics and computations to solve problems on compressors and gas turbine. (P.I.-2.4.1)*	
06.	**Internal Combustion Engine** ***Learning Objective/s:*** *To perceive operations of an I. C. Engines and it's environmental aspects.*	**5-7**
	Contents: **I.C. Engines:** Introduction to I. C. Engine and its Classification. Working of Four stroke and Two-stroke engines. Combustion in SI and CI engine, Knocking detonation. **Engine Emission and Control:** Sources of Engine Emissions, Constituents of S.I. and C.I. Engine exhaust and their effects on environment and health. Study of emission (Euro & Bharat stage) norms, Control methods for S.I and C I engine emissions.	
	Self-Learning Topics: *Modern trends/technologies in automobiles.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply fundamental engineering concepts to understand operations of an I. C. Engines. (P.I.-1.3.1)* *LO 6.2: Apply mechanical engineering concepts to understand fundamentals of an I. C. Engine. (P.I.-1.4.1)* *LO 6.3: Identify risk and impacts of an I. C. Engine emissions. (P.I.-6.1.1)* *LO 6.4: Describe methods/techniques to control engine emissions (P.I.-6.2.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
6.1.1	Identify risks/impacts in the life-cycle of an engineering product or activity.
6.2.1	Describe management techniques for sustainable development.

Course Outcomes: A learner will be able to -

1. Apply the fundamentals of heat transfer to real life problems for steady and unsteady state. *(LO LO 1.1, LO 1.2, LO 2.1, LO 2.2)*
2. Formulate mathematical model for different modes of heat transfer. *(LO 1.3, LO 1.4, LO 2.3, LO 2.4)*
3. Analyse performance of heat exchanger and extended surface. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5)*
4. Apply engineering fundamentals of steam turbine, gas turbine and air compressor for selection of it in specific applications. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
5. Apply engineering fundamentals of an I. C. engine and it's emission impact on environment. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC407.1	3	--	--	--	--	--	--	--	--	--	--
MEPCC407.2	--	3	--	--	--	--	--	--	--	--	--
MEPCC407.3	3	3	--	--	--	--	--	--	--	--	--
MEPCC407.4	3	3	--	--	--	--	--	--	--	--	--
MEPCC407.5	3	--	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	--	--	--	**3**	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Heat and Mass Transfer by R. K. Rajput, Revised edition, 2019, S. Chand

2. Thermal Engineering by R. K. Rajput, Eleventh edition, 2020, Rainbow Book Distributor

Reference Books :

1. Fundamentals of Heat and mass Transfer by Frank P. Incropera, Devid P. Dewitt, Fifth edition, 2007, Wiley India Pvt Ltd.
2. Heat and Mass Transfer: Fundamentals and Applications by Yunus A. Çengel and Afshin J. Ghajar, Sixth edition, 2020, Tata McGraw Hill.
3. Thermal Engineering-I by Mahesh M. Rathore, First edition, 2018, Tata McGraw Hill

4. Internal Combustion Engines by V Ganeshan, third edition, 2007, Tata McGraw Hill

Other Resources :

1. NPTEL Course: Introduction to Heat Transfer By Prof .Dr.C. Balaji, IIT Madras :-Web link- https://nptel.ac.in/courses/108/101/108101037/
2. NPTEL Course: Heat Exchangers: Fundamentals and Design Analysis By Prof. Prasanta Kr Das, Prof. Indranil Ghosh, , IIT Kharagpur :-Web link- https://nptel.ac.in/courses/112105248
3. NPTEL Course: I.C. Engine and Gas Turbine By By Prof. Pranab K. Mondal, Prof. Vinayak N. Kulkarni, IIT Guwahati :-Web link- https://nptel.ac.in/courses/112103262

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level:	05 marks
One Class test:	05 marks
Open Book test:	05 Marks
Regularity and active participation:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC408	MANUFACTURING TECHNOLOGY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC101 Engineering Mathematics I
2. BSC204 Engineering Mathematics II
3. MEPCC302 Mechanics of Solids
4. MEPCC303 Materials Science and Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions

Course Objectives:

1. To apply fundamental and Mechanical engineering concepts to solve problems related to Production Processes.
2. To understand and apply the various steps in casting process and select appropriate casting method for given application.
3. To identify appropriate joining and forming process for a given application.
4. To compare various Traditional and Non Traditional Machining processes used in manufacturing of a component.
5. To understand the various methods of polymer processing and powder metallurgy.

Module	Details	Hrs.
	Course Introduction Mechanical engineering helps realize ideas and scientific concepts into reality and Manufacturing technology assists in achieving this goal by efficiently and economically creating products. In this course the students will know about the manufacturing processes and technologies, used to create everyday objects, industrial machines, transport vehicles, etc. at a mass manufacturing scale. This will give them an insight into the current and upcoming production technologies used by the Mechanical industry in creating sustainable and economically feasible products in an efficient manner.	**01**

01.	**Introduction to Production Processes and Metal Casting** ***Learning Objective:*** *The learner is expected to apply, analyze and design the parameters for the various methods and equipment used in Metal Casting Processes.*	**9-11**
	Contents: • Classification of Production Processes and applications areas • Pattern making materials, Types of pattern and allowances. • Sand moulding and Machine moulding • Gating system: Types of riser, types of gates, solidification • Special casting processes: Shell moulding, Investment casting, Die casting, Vacuum casting, • Inspection & casting defects and remedies	
	Self-Learning Topics: *Advanced Casting Processes like Investment casting and Die casting*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Identify the important tools and equipment required for casting methods. (P.I.-1.3.1)* *LO 1.2: Identify and apply the appropriate method of casting for a specific application. (P.I.-1.4.1)* *LO 1.3: Analyze the various parameters for designing a specific mould for it, while ensuring defects are not generated. (P.I.-2.2.4)* *LO 1.4: Interpret the application data and analyze the applicable casting model to select the most suitable system. (P.I.-2.3.1)* *LO 1.5: Analyze and select the most appropriate a casting method for particular component. (P.I.-10.2.2)* *LO 1.6: To identify and modify the design parameters of casting mould riser to improve the mould efficiency and decrease the defects produced. (P.I. 10.2.3)*	
02.	**Joining Processes** ***Learning Objective:*** *The learner is expected to apply and analyze the various methods and equipment used in Joining Processes.*	**5-7**
	Contents: • Classification of various joining processes; Applicability, advantages and limitations of Adhesive bonding, Mechanical Fastening; • Welding and allied processes, Hybrid joining processes. • Classification and Working of various welding methods: Gas, Arc, Chemical, Radiant, Solid State etc. • Welding Joints, Welding Positions, Welding defects and their remedies.	
	Self-Learning Topics: *Advanced Welding Processes*	
	Learning Outcomes:	

	A learner will be able to *LO 2.1: Identify the important tools and equipment required for joining methods. (P.I.-1.3.1)* *LO 2.2: Identify and apply the appropriate method of joining for a specific application. (P.I.-1.4.1)* *LO 2.3: Analyze the selection of appropriate equipment required for joining, while ensuring defects are not generated during the joining process. (P.I.-2.2.4)* *LO 2.4: Interpret the application data and analyze the applicable joining model to select the most suitable system. (P.I.-2.3.1)* *LO 2.5: Apply sustainable development principles to the selection and analysis of joining equipment and processes, while ensuring the sustainability of products formed by joining processes. (P.I.-6.2.3)* *LO 2.6: Identify risks and their impacts due to defects produced in the life-cycle of an assembled product made by joining processes. (P.I.-6.2.4)*	
03.	**Forming processes** ***Learning Objective:*** *The learner is expected to apply and analyze the different forming processes and their applications.*	**5-7**
	Contents: • Introduction and classification of metalworking processes, hot and cold working processes • Introduction, classification and analysis of forging and rolling operations, Defects in rolled and forged components, • Extrusion process, Classification and analysis of wire and tube drawing processes.	
	Self-Learning Topics: *Wire and Tube drawing processes*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Identify the important tools and equipment required for forming methods. (P.I.-1.3.1)* *LO 3.2: Identify and apply the appropriate method of forming for a specific application. (P.I.-1.4.1)* *LO 3.3: Analyze and specify the appropriate equipment required for forming a particular component, while ensuring defects are not generated. (P.I.-2.2.4)* *LO 3.4: Interpret the application data and analyze the applicable forming model to select the most suitable system. (P.I.-2.3.1)* *LO 3.5: Analyze the benefits and select the most appropriate forming process for a particular component. (P.I.-10.2.4)* *LO 3.6: Compare the benefits and select the most appropriate wire drawing process for a particular application. (P.I. – 10.2.5)*	
04.	**Machine Tools, Machining Processes and Tool Engineering** ***Learning Objectives:*** *The learner is expected to apply, analyze and design the parameters for the machines and tools used for subtractive manufacturing.*	**9-11**
	Contents: **Machine Tools and Machining Processes:** • Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines and selection of grinding wheel (Dressing	

	and Truing), Broaching machines, Lapping/Honing machines (Super Finishing Operations) and shaping/slotting/planning Machines. • Gear Manufacturing: Gear milling, standard cutters and limitations, Gear Hobbing, Gear Shaping, Gear Shaving and Gear Grinding processes **Tool Engineering** • Geometry and nomenclature of single point cutting tool, Speed, feed, depth of cut, Cutting forces and • Taylor's tool life equation, • Concept of chip formation and types of chips.	
	Self-Learning Topics: *Gear Finishing operations: Gear Shaving and Gear Grinding processes*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Identify the important tools and equipment required for machining processes. (P.I.-1.3.1)* *LO 4.2: Identify and apply the appropriate method of machining for a specific application. (P.I.-1.4.1)* *LO 4.3: Analyze and specify the appropriate tool and equipment required for machining processes. (P.I.-2.2.4)* *LO 4.4: Identify the assumptions of the machining requirements of the given application and, to analyze and derive the necessary process parameters. (P.I.-2.3.2)* *LO 4.5: To interpret the important standard related to design specifications of a cutting tool required for specific machining operation. (P.I.-6.2.5)* *LO 4.6: To refine and modify the design parameters of a cutting tool to improve its cutting tool life and enhance its sustainability. (P.I. 6.4.6)*	
05.	**Non Traditional Machining Processes, Sheet metal Working Processes and Jigs & Fixtures** ***Learning Objective/s:*** *The learner is expected to apply and analyze the different non-traditional manufacturing processes and devices, that are used for finishing and holding operations of components in production activities.*	**5-7**
	Contents: **Non Traditional Machining Processes:** • Electro-chemical machining (ECM) • Electric-discharge machining (EDM) • Ultrasonic machining (USM) • Laser Beam Machining (LBM) **Sheet metal working processes** • Classification of Sheet metal operations, • Types of Presses used in sheet metal operations, • Types of Press Tool dies. **Introduction to Jigs and Fixtures and types.** • Classification and types of Jigs and Fixtures	
	Self-Learning Topics: *Types of Press Tool dies.*	

	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify the important tools and equipment required for non-traditional machining processes. (P.I.-1.3.1)* *LO 5.2: Identify and apply the appropriate method of non-traditional machining for a specific application (P.I.-1.4.1)* *LO 5.3: Analyze and specify the appropriate equipment required for non-traditional machining. (P.I.-2.2.4)* *LO 5.4: Identify the assumptions of the for non-traditional machining requirements of the given application and, to analyze and derive the necessary process parameters. (P.I.-2.3.2)* *LO 5.5: Select the optimized economic sheet metal production process for specific sheet metal application (P.I.-6.3.3)* *LO 5.6: Identify and select the appropriate jig or fixture design for improvement reduction of environmental waste during production processes. (P.I.-6.3.4)*	
06.	**Polymer Processing, Powder Metallurgy and Intelligent Manufacturing** ***Learning Objective/s:*** *The learner is expected to apply and analyze the manufacturing processes and equipment, that are used for creating plastic and sintered powder engineering components.* *The learner is also expected to understand the concepts related to Industry 4.0 in the context of Manufacturing Technology.*	**4-6**
	Contents: **Polymer Processing:** • Polymer Moulding Techniques for thermoplastic and thermosetting plastics. • Applications of Plastics in engineering field. **Powder Metallurgy (PM):** • Introduction to PM, Powder making processes, Steps in PM. • Compaction and Sintering processes. • Secondary and finishing operations in PM. **Intelligent manufacturing in the context of Industry 4.0,** • Cyber-physical systems (CPS) • Internet of Things (IoT) enabled manufacturing • Cloud Manufacturing	
	Self-Learning Topics: *Applications of Plastics in engineering field.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify the important tools and equipment required for creating plastic and sintered powder engineering components. (P.I.-1.3.1)* *LO 6.2: Apply and analyze the appropriate method for creating plastic and sintered powder engineering components, for a specific application. (P.I.-1.4.1)* *LO 6.3: Analyze the selection of appropriate equipment required for Polymer processing. (P.I.-2.2.4)* *LO 6.4: Interpret the application data and analyze the applicable Powder Metallurgy model to select the most suitable system. (P.I.-2.3.1)*	

	LO 6.5: Understand the use of Industry 4.0 in the context of improvement of industrial practices(P.I.-6.3.5) *LO 6.6: Understand the use of IoT in the improvement of economic context of production processes. (P.I.-6.3.6)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.2.4	Compare and contrast alternative solution processes to select the best process
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
6.2.3	Apply sustainable development principles to the selection and analysis of joining equipment and processes, while ensuring the sustainability of products formed by joining processes.
6.2.4	Identify risks and their impacts due to defects produced in the life-cycle of an assembled product made by joining processes.
6.2.5	To interpret the important standard related to design specifications of a cutting tool required for specific machining operation.
6.2.6	To refine and modify the design parameters of a cutting tool to improve its cutting tool life and enhance its sustainability.
6.3.5	Understand the use of Industry 4.0 in the context of improvement of industrial practices.
6.3.6	Understand the use of IoT in the improvement of economic context of production processes.
10.2.2	Analyze and select the most appropriate a casting method for particular component.
10.2.3	To identify and modify the design parameters of casting mould riser to improve the mould efficiency and decrease the defects produced.
10.2.4	Analyze the benefits and select the most appropriate forming process for a particular component.
10.2.5	Compare the benefits and select the most appropriate wire drawing process for a particular application.

Course Outcomes: A learner will be able to -

1. To apply fundamental and Mechanical engineering concepts to solve problems related to Production Processes. *(LO 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, 5.2 & 6.1)*
2. To understand and apply the various steps in casting process and select appropriate casting method for given application. *(LO 1.1 – 1.6)*

3. To identify appropriate joining and forming process for a given application. *(LO 2.1 – 2.6 & LO 3.1 – 3.6)*
4. To compare various Traditional and Non Traditional Machining processes used in manufacturing of a component. *(LO 4.1 – 4.6 & LO 5.1 – 5.6)*
5. To understand the various methods of polymer processing and powder metallurgy. *(LO 6.1 – 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC408.1	3	3	--	--	--	--	--	--	--	3	--
MEPCC408.2	3	3	--	--	--	3	--	--	--	--	--
MEPCC408.3	3	3	--	--	--	--	--	--	--	3	--
MEPCC408.4	3	3	--	--	--	3	--	--	--	--	--
MEPCC408.5	3	3	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	**--**	**--**	**--**	**3**	**--**	**--**	**--**	**3**	**--**

Text Books :

1. A Textbook of Production Technology, P. C. Sharma, 2022, S Chand Publication
2. Production Technology, R. K. Jain, 2022, Dnyaandeep Publication
3. Production Technology by W.A.J. Chapman Vol I, II, III, 2001, CBS Publishers & Distributors
4. Manufacturing Science, A. Ghosh and A. K. Malik, Second edition, 2010, Affiliated East-West Press
5. Tool Design, Donaldson, 5th Edition, 2017, McGraw Hill Education

Reference Books :

1. Elements of workshop technology. Vol. 1 & II, S K Hajra Choudhury, 2008, Media Promoters
2. Foundry technology, O. P. Khanna, 2011, Dhanpat Rai Publications
3. Welding technology, O. P. Khanna, 2015, Dhanpat Rai Publications
4. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2016, Apress.

Other Resources :

1. NPTEL Course: Manufacturing Process Technology I & II by By Prof. Shantanu Bhattacharya, IIT Kanpur, Web Link - https://onlinecourses.nptel.ac.in/noc22_me28/preview
2. NPTEL Course: Introduction to Industry 4.0 And Industrial Internet of Things by Prof. Sudip Misra, IIT Kharagpur:- Web link-https://onlinecourses.nptel.ac.in/noc24_cs34/preview
3. NPTEL Course: Mechanics of Sheet Metal Forming by Prof. R Ganesh Narayanan, IIT Guwahati:- Web link- https://onlinecourses.nptel.ac.in/noc24_me51/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

- Assignment on live problems/ case studies : 10 marks
- Open book test/ Open notes test : 05 Marks
- Regularity and active participation : 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	MELBC403	VIRTUAL INSTRUMENTATIONAL LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite:

1. ESCLC206 Basic Electronics Engineering Laboratory
2. MELBC302 Industrial Electronics Laboratory

Program Outcomes addressed:

1. PO3: Design/Development of Solutions
2. PO4: Conduct investigations of complex problems
3. PO5: Engineering tool usage
4. PO6: The engineer and the World
5. PO9: Communication

Course Objectives:

1. To familiarize with the LabVIEW software.
2. To impart knowledge on sensor characteristics for integration with LabVIEW software.
3. To acquaint with calibration of different sensors.
4. To acquaint with Data Acquisition Systems.

Module	Details	Hrs.
	Course Introduction The course introduces the usage of various functionalities of LabVIEW software and how the software can be integrated with hardware modules for interfacing various sensors and actuators for building real life working modules for specific applications.	**01**
01	***Learning Objective:*** *Learner will be able to demonstrate the skill to effectively use various functionalities of LabVIEW software.*	**04**
	Experiment: Introduction to LabVIEW software, construction of LabVIEW block diagram and front panel for selecting input and output DAQ modules	
	Self-Learning Topics: Identify measuring instruments come across in our day life	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Demonstrate the skill in using LabVIEW software. (P.I.-5.1.1).* *LO 1.2: Demonstrate the skill in using various functions of LabVIEW software. (P.I.-5.2.2).*	

02	***Learning Objective:*** *Learner will be able to demonstrate the skill to use different functions/ modules of LabVIEW software.*	**04**
	Experiment: Perform simulation using LabVIEW with signal generator.	
	Self-Learning Topics: *Range and span of the pressure measuring devices*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Demonstrate proficiency in using LabVIEW software for simulation. (P.I.-5.1.1).* *LO 2.2: Demonstrate the skill in using LabVIEW software for simulation with signal generator. (P.I.-5.2.2).*	
03	***Learning Objective:*** *Learner will be able to apply knowledge in analyzing and interpretation of experimental from interfacing of different sensors with LabVIEW software.*	**04**
	Contents: Interfacing of pressure sensor, load cell, strain gauge, flow sensor and float sensor.	
	Self-Learning Topics: *Working principles of pressure sensor, load cell, strain gauge, flow sensor and flat sensor*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply skills in using appropriate tolls and procedures for interfacing different sensors with LabVIEW software (P.I.-4.3.1).* *LO 3.2: Analyze the signals from the sensors for the measurement of different physical quantities (P.I.-4.3.2).* *LO 3.3 : demonstrate the skill in interfacing sensors with DAQs using LabVIEW software (P.I.-5.2.2).*	
04	***Learning Objectives:*** *Learner will be able to demonstrate the ability to find solutions in engineering terms for calibration of different sensors..*	**04**
	Experiment: Calibration of sensors (Temperature sensor, pressure sensor, Load Cell, flow sensor).	
	Self-Learning Topics: *Input output relationship of different signals from sensors.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Explore the engineering procedures for calibration of sensors (P.I.-3.1.5).* *LO 4.2: Demonstrate the skill for calibrating sensors and arrive at proper conclusions (P.I.-3.1.6).* *LO 4.3: Demonstrate the ability to identify and explore the techniques for calibration of sensors using LabVIEW software. (P.I.-6.1.1).*	

05	***Learning Objective/s:*** *Learner will be able to demonstrate skill in using different techniques and resources to interface microcontrollers with LabVIEW software.*	**04**
	Experiment: Interfacing of microcontrollers with LabVIEW software	
	Self-Learning Topics: .	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply skill in using appropriate software for interfacing microcontroller with LabVIEW software (P.I.-4.1.3).* *LO 5.2: Use appropriate tools and procedures for interfacing sensors with microcontroller using LabVIEW software (P.I.-4.3.1).* *LO 5.3 : demonstrate the skill in selecting extended tolls for interfacing microcontrollers with LabVIEW software (P.I.-5.1.2).*	
06	***Learning Objective/s:*** *Learner will be able to demonstrate the skill for development of engineering design solutions for designing and executing control modules using LabVIEW software.*	**06**
	Experiment: Perform simulation for developing control module using LabVIEW software	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Determine design objectives for developing control module using LabVIEW software. (P.I.-3.1.6).* *LO 6.2: Apply appropriate tools and techniques for integrating hardware modules with LabVIEW software (P.I.-3.2.1).* *LO 6.3: Demonstrate the skill in using LabVIEW software by integrating hardware components to develop control module for specific applications. (P.I.-5.2.2).*	
07	***Learning Objective/s:*** *Learner will be able to demonstrate the ability to effectively work as a team for solving open ended problems in the domain of automation.*	**04**
	Experiment: Development of real life working model with NI DAQ system with interfacing of sensors and actuators using LabVIEW software	
	Learning Outcomes: *A learner will be able to* *LO 7.1: Identify appropriate modern tools and its functionalities for developing real life working model with use of LabVIEW software (P.I.-5.1.1).* *LO 7.2: Demonstrate the skill in developing real life working model by interfacing sensors and actuators (P.I.-5.3.2).* *LO 7.3: Present the results more effectively by integrating microcontrollers, sensors and actuators with LabVIEW software for developing a system as a whole. (P.I.-9.3.1)*	
	Course Conclusion	

	Learner is able to apply skill in using various functionalities of LabVIEW software and interfacing techniques for building various control modules.	**01**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
3.1.5	Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.2	Analyse data for trends and correlations, stating possible errors and limitations.
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.1.2	Adapt the tools and techniques to solve engineering problems.
5.2.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level.
9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes: A learner will be able to

1. Apply skill in interfacing of different sensors with DAQ devices using LabVIEW software (*LO 1.1, LO 1.2, LO 2.1, LO 2.2, LO 3.1, LO 3.2, LO 3.3).*
2. Develop skill in calibration of different sensors using LabVIEW software (*LO 4.1, LO 4.2*, *LO 4.3).*
3. Develop skill in interfacing microcontrollers with LabVIEW software (*LO 5.1, LO 5.2, LO 5.3, LO 6.1, LO 6.2*, *LO 6.3).*
4. Develop Real Life Working Model with NI DAQ System with Interfacing of Sensors and Actuators using LabVIEW software(*LO 7.1, LO 7.2*, *LO.7.3).*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC403.1	--	--	--	3	3	--	--	--	--	--	--
MELBC403.2	--	--	3	--	--	2	--	--	--	--	--
MELBC403.3	--	--	3	3	3	--	--	--	--	--	--

MELBC403.4	--	--	--	--	3	--	--	--	2	--	--
Average	--	--	**3**	**3**	--	**2**	--	--	**2**	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Books :

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
2. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi

Reference Books :

1. Control systems by Dhanesh Manik, Cengage Learning , John Wiley & Sons
2. Mechanical Measurements by S P Venkateshan, John Wiley & Sons

Other Resources :

1. https://www.ni.com/en.html

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment - (25 Marks)

Suggested breakup of distribution

Practical performance based on all the experiments mentioned in the syllabus with proper understanding	:	10 Marks
Working model development to demonstrate concepts	:	05 Marks
Oral conducted during the practical performance	:	05 Marks
Regularity and active participation	:	05 Marks

END SEMESTER EXAMINATION (25 MARKS)

A pair of Internal and External examiners will do the evaluation.

Students will be assessed based on the following parameters:

- Any one of the experiment based on the syllabus will be given to the students.
- Students are required to write a brief procedure for conducting the experiment including the circuit diagram and observation table, if any. The procedure is checked by both internal and external examiners for correctness. Evaluated out of 10 marks.
- Students are required to perform the given experiments, write the inference of the result and conclusion. The result is checked by both internal and external examiners for correctness. Evaluated out of 10 marks.
- Oral will be conducted by pair of Internal and External examiners. Evaluated out of 05 marks.

Course Type	Course Code	Course Name	Credits
LBC	MELBC404	THERMAL ENGINEERING LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite:

1. MEPCC301 Engineering Mathematics-III
2. MEPCC304 Thermodynamics

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO7: Ethics

Course Objectives:

1. To equip students to apply the concept of various modes of heat transfer through experimental approaches.
2. To instil comprehensive understanding of heat transfer principles applied to diverse engineering applications.
3. Analysing engine performance and emissions using diverse engine testing methods, presenting findings visually and numerically.
4. To orient students with contemporary engineering tools through the simulation of heat transfer processes.

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Measurement of Thermo-physical properties** ***Learning Objective:*** *To apply the knowledge and analyse various modes of heat transfer through experimental approaches.* **Contents:** To ascertain the appropriate mode of heat transfer utilizing basic knowledge for a given experimental system and calculate the thermal conductivity, heat transfer coefficient, and emissivity. (Any 3 Experiments) 1. Determine Thermal conductivity of metal rod. 2. Determine the thermal conductivity of composite wall. 3. Measurement of emissivity of grey surface. 4. Measurement of heat transfer coefficient for flow through tubes in	**6-8**

	free convection. 5. Measurement of heat transfer coefficient for flow through tubes in forced convection.	
	Self-Learning Topics: *Determination of thermal conductivity and heat transfer coefficient.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply mathematical concepts of differentiation to solve heat transfer equations. (P.I.-1.1.1)* *LO 1.2: Apply the concepts of conduction, convection, and radiation to evaluate performance parameters (P.I.-1.4.1)* *LO 1.3: Identify the mode of heat transfer, variables and parameters involved in the given system to perform analysis (P.I.-2.1.2)* *LO 1.4: Identify the sources of errors in evaluated parameters and make valid conclusions consistent with the objectives. (P.I.-2.4.3, 2.4.4)*	
02.	**Extended Surfaces and compressor** ***Learning Objective:*** *To apply understanding of heat transfer mechanisms and carry out performance analysis of variety of engineering applications.*	**4-6**
	Contents: To carry out performance analysis of extended surfaces and heat exchanger. (Any 2 Experiments) 1. Performance analysis of extended surfaces under free and force convection. 2. Estimation of overall heat transfer coefficient and effectiveness of heat exchanger. 3. Trial on reciprocating air compressor.	
	Self-Learning Topics: *Determination of performance of modern extended surfaces and compressors.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Identify extended surfaces and various types of heat exchanges to adopt the existing procedure to solve the problem (P.I.-2.2.3)* *LO 2.2: Apply the knowledge of calculus to solve mathematical models associated with fins and heat exchangers (P.I.-2.4.1)* *LO 2.3: Use appropriate instrumentations and procedures to make measurement of physical quantities. (P.I.-4.1.3, 4.3.1)* *LO 2.4: Analyze experimentally collected data for trends and correlations to make conclusions consistent with objectives. (P.I.-4.3.2)*	
03.	**Internal Combustion Engine and its performance** ***Learning Objective:*** *To be able to measure and analyse engine performance and emission parameters using various engine testing methods.*	**8-10**
	Contents: To conduct a load test and heat balance test on petrol/diesel engine and assess impact of emissions through a case study. (Any 3 Experiments)	

	1. Conduct a load test on petrol engine. 2. Conduct Heat Balance Test on petrol engines. 3. Case study on Exhaust gas analysis on engine. 4. Conduct a Morse test on petrol engine. Conduct a Load test on diesel engine. 5. Conduct Heat Balance Test on diesel engines.	
	Self-Learning Topics: *Modern trends in I. C. Engine*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Use appropriate experimental procedure to conduct load test and heat balance test and collect the data (P.I.-4.3.1)* *LO 3.2: Represent collected experimented data in tabular and graphical form to perform analysis and draw valid conclusions. (P.I.-4.3.3)* *LO 3.3: Understand the impact/risks involved due to engine emissions through practical case study (P.I.-7.1.1)* *LO 3.4: Understand the relation between automobile vehicles and its relationship with environment. (P.I.-7.1.2)*	
04.	**CFD simulation of 1D and 2D problem** ***Learning Objectives:*** *To orient students with contemporary engineering tools through the simulation of heat transfer processes.*	**6-8**
	Contents: Thermal simulation analysis of 1D/2D problems with conduction and convection boundary conditions. (Any 2 Experiments) 1. Thermal Analysis using CFD– 1D problems with conduction and convection boundary conditions. 2. Thermal Analysis using CFD – 2D problems with conduction and convection boundary conditions.	
	Self-Learning Topics: *CFD simulation Tools*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply knowledge of basic heat conduction, convection principles to identify appropriate boundary conditions (P.I.-1.4.1)* *LO 4.2: Apply the knowledge of mathematics to solve heat conduction/convection problem analytically (P.I.-1.3.1)* *LO 4.3: Adapt modern engineering tool for heat transfer analysis of a system (P.I.- 5.1.2)* *LO 4.4: Verify and validate the results through analytical calculations to verify the accuracy, limitations and assumptions in tool. (P.I.-5.3.2)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.3	Identify sources of error in the solution process, and limitations of solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
4.1.3	Apply appropriate instrumentations and/or software tools to make measurement of physical quantities.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
5.1.2	Adapt the tools and techniques to solve engineering problems
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
7.1.1	Identify risks/impacts in the life-cycle of an engineering product or activity
7.1.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.

Course Outcomes: A learner will be able to -

1. Estimate thermal conductivity of engineering materials and evaluate performance parameters of various heat transfer applications. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
2. Analyze engine performance and emission parameters at different operating conditions. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
3. Apply modern engineering simulation tool to solve practical problems. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC404.1	3	3	--	3	--	--	--	--	--	--	--
MELBC404.2	--	--	--	3	--	--	3	--	--	--	--
MELBC404.3	3	--	--	--	3	--	--	--	--	--	--
Average	**3**	**3**	**--**	**3**	**3**	**--**	**3**	**--**	**--**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Heat and Mass Transfer, R K Rajput, 7th Edition, S. CHAND.
2. Heat and Mass Transfer, P K Nag, 3rd Edition, McGraw Hill.
3. IC Engine, Mathur and Sharma, 2018, Dhanpat Rai Publications.

Reference Books :

1. Internal Combustion Engines, V Ganeshan, 4th Edition, McGraw Hill.
2. Heat and Mass transfer: Fundamentals and Applications, Yunus A. Cengel, 6th Edition, McGraw Hill.

Other Resources :

1. Virtual Lab: Fluid and Thermal Sciences Lab, IIT Guwahati: Web link: https://vlab.amrita.edu/index.php?sub=1&brch=194
2. Heat & Thermodynamics Virtual Lab, Amrita Vishwa Vidyapeetham: Web link: https://nptel.ac.in/courses/108/106/108106098/
3. Virtual Lab on Automotive Systems:

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(25 Marks)

Suggested breakup of distribution

- Practical performance based on the experiments
- mentioned/performed with the proper understanding: 15 Marks
- Development of CFD solution for real time application: 05 marks
- Regularity and active participation: 05 Marks

2. END SEMESTER EXAMINATION (25 MARKS)

Students will be assessed based on three parameters:

- Thermal Engineering concepts/understanding
- Practical performance
- Oral

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to write brief procedure for conducting the experiment including the diagram and observation table, if any. The experimental procedure is checked by the examiners (Internal and External) and evaluated out of 5 Marks.
- Then the student will be allowed to conduct the experiment.
- Students will be allocated 1 hour to complete performance. The results and calculation is then checked by both the examiners for its correctness. The weightage of the same is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	MELBC405	MACHINE SHOP PRACTICE	01

Examination Scheme		
Continuous Assessment	End Semester Exam (ESE)	Total
25	25	50

Pre-requisite :

1. SEC101- Basic Workshop Practice I
2. SEC202- Basic Workshop Practice II

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering tool usage
4. PO6: The engineer and the world
5. PO8: Individual and collaborative team work
6. PO11: Life-long learning

Course Objectives :

1. To familiarize with basic machining processes.
2. To familiarize various machining operations and machine protocols.

Module	Contents	Hrs
	Course Introduction Machine shop practice is concerned with the fundamental concepts and practices of machining, an essential part of manufacturing and engineering processes. The course will give students a solid basis for working effectively in a machine shop environment that includes operations such as lathe, shaping, milling, grinding, and welding.	**01**
01.	***Learning Objectives:*** *1. To acquire the ability to interpret part specifications, dimensions, tolerances, and geometric tolerance symbols from engineering drawings.* *2. To acquire knowledge of different cutting tools, machine tools, tool holders, and tool geometries used in machining operations.* *3. To learn to use precision measuring tools to verify part dimensions and ensure quality control.*	**17**

	Content: Lathe, Shaping, Milling, Grinding • One composite job consisting minimum four parts employing operations performed of various machine tools (Lathe operation, Shaping, Milling, Grinding). • Tool Grinding – To know basic tool Nomenclature.	
	Learning Outcomes : *A learner will be able to* *LO1.1: Interpret technical drawings, recognize critical dimensions, tolerances, and geometric elements required for machining processes. (P.I. – 1.3.1, 1.4.1, 11.3.1)* *LO1.2: Select the appropriate cutting tools, machine tools, tool holders, and fixtures for specific machining tasks, and demonstrate proper usage safely and effectively. (P.I. – 5.1.2, 5.2.2, 6.1.1, 6.2.1, 8.3.1)* *LO1.3: Competent in the effective use of precision measuring tools to examine work pieces, confirm dimensions, and ensure adherence to quality requirements and standards. (P.I. – 5.2.1, 6.1.1, 8.1.1, 11.3.2)*	
02.	***Learning Objectives:*** *1. To understand and adhere to safety protocols for welding, including proper handling of equipment, use of personal protective equipment (PPE), and precautions for preventing accidents and injuries.* *2. To gain proficiency in operating various welding equipment and tools, including welding machines, welding torches, electrodes, filler materials, and auxiliary equipment.* *3. To learn the fundamentals of different welding processes like Tungsten Inert Gas (TIG) welding and Metal Inert Gas (MIG) welding.*	**12**
	Content: Advanced Welding • Application of TIG / MIG Welding on Mild Steel, Stainless Steel, and Aluminum. • Overview of Robotic Welding.	
	Learning Outcomes : *A learner will be able to* *LO2.1: Adhere to safety protocols and practices when operating welding equipment. (P.I. – 6.1.1, 6.2.1, 8.1.1)* *LO2.2: Follow welding procedure specifications and relevant industry standards to ensure weld quality, integrity, and compliance with regulatory requirements. (P.I. – 2.3.1, 2.4.2, 2.4.4, 11.2.1, 11.3.2)* *LO2.3: Perform different welding processes like Tungsten Inert Gas (TIG) welding and Metal Inert Gas (MIG) welding. (P.I. – 8.3.1, 11.2.1, 11.3.2)*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.

2.4.2 Produce and validate results through skilful use of contemporary engineering tools and models.
2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2 Demonstrate proficiency in using discipline-specific tools.
6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.
6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts.
11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.
11.3.1 Source and comprehend technical literature and other credible sources of information.
11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes:

A learner will be able to

1. Know the specifications, controls and safety measures related to machines and machining operations. (*LO 1.1, LO 1.2, LO 1.3, LO 2.1*)
2. Perform various machining operations for making engineering jobs. (*LO 1.2, LO 1.3, LO 2.2, LO 2.3*)
3. Perform Tool Grinding. (*LO 1.2, LO 1.3*)
4. Perform welding operations. (*LO 2.1, LO 2.2, LO 2.3*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC405.1	3	3	--	--	3	3	--	3	--	--	3
MELBC405.2	3	3	--	--	3	3	--	3	--	--	3
MELBC405.3	3	--	--	--	3	3	--	3	--	--	3
MELBC405.4	--	3	--	--		3	--	3	--	--	3
Average	**3**	**3**	--	--	**3**	**3**	--	**3**	--	--	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment

Tool to be used	Marks
1) Job work of a composite job consisting of lathe, shaping, milling and grinding operations.	10
2) Job work consisting of welding operation.	10
3) Attendance and Active Participation	05
Total	**25**

End Semester Examination (25 Marks)

A pair of Internal and External examiners will do the evaluation.

Tool to be used	Marks
Each student will be given a practical assignment on any one operation of lathe, shaping, milling, grinding or welding which will be completed within a given time and assessed by examiners during the oral examination.	
1) Practical Assignment	15
2) Oral	10
Total	**25**

Course Type	Course Code	Course Name	Credits
SBL	MESBL402	CAD MODELING LABORATORY	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	50	–	02	100

Pre-requisite:

1. ESL204 Engineering Graphics Laboratory

Program Outcomes addressed:

1. PO3: Design/Development of Solutions
2. PO5: Engineering tool usage
3. PO9: Communication
4. PO11: Life-long learning

Course Objectives:

1. To impart the 3D Solid Modelling skills for development of 3D models of engineering components.
2. To impart the 3D surface modelling skills for development of 3D models of basic engineering components.
3. To impart the 3D modelling skills for assembling different parts made in 3D modelling software.
4. To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc.
5. To introduce Product data exchange among CAD systems.

Module	Detailed Contents	Hrs
	Course Introduction This Computer Aided Modelling course enables design and development of products within the digital manufacturing landscape. CAD models can be utilized to generate CAM programming codes for machine applications. CAD tools are indispensable in modern engineering that allows user to develop 3D solid and surface models and their assemblies and converting them to drawings.	**02**
01.	**Sketch Techniques and Basic Modelling Techniques** ***Learning Objective/s:*** *To apply beginner level modelling techniques for creating parametric sketches used in part modeling and for creating a 3D parametric part of basic engineering components.* **Content:**	**16-18**

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Introduction Sketch Techniques:

Set up options and settings for the sketch environment, create a sketch from a part file template, Use sketch constraints to control sketch geometry, Master general sketch tools, Create sketches from AutoCAD geometry, Use 3D sketch tools

Introduction Basic Modelling Techniques:

Configure options and settings for part modeling, Create basic part features, Use the Extrude tool, Create revolved parts and thread features, Create work features, Use the Fillet tool, Create intelligent hole features, bend parts

Experiments
1. Identify the appropriate sketching plane to sketch basic geometric shapes, apply constraints and dimensions, and build a model utilizing essential drawing tools such as the line tool, polygon tool, offset, rectangle tools etc., and effectively translate 2D sketches into 3D models. And generate detailed drawing of the models created. (Minimum 2)
2. Explore Document-Specific Settings (e.g., materials, units, bill of materials etc.), utilize modification tools (e.g., extrusion, revolve, fillet, thread, hole, bend parts etc.), work feature tools (e.g., work planes, work axis etc.), and pattern tools (e.g., rectangular, circular etc.) to efficiently create 3D solid CAD models for given components. And generate detailed drawing of the models created. (Minimum 2)
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<tr><td></td><td>
Self-Learning Topics:
Create solid models of any machine components using the tools which is not covered in experiments.
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Learning Outcomes :
A learner will be able to
LO 1.1: Identify appropriate drawing tools of modelling software to build 3D models from 2D sketches in 3D space. (P.I.- 5.1.1)
LO 1.2: Create detail drawing of engineering components, (P.I.-5.1.2)
LO 1.3: Create and modify 3D CAD Solid models of various machine components using combinations of features basic features in a CAD tool. (P.I.- 3.2.2)
LO 1.4: Identify alternative approach for CAD Modeling of same components by using various create tool, modify tools, in CAD software. (P.I.- 3.2.3)
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<tr><td>02.</td><td>
Advanced Modelling Techniques

Learning Objective/s:
To apply advance level modelling techniques to explore some of the more complex and curvy modeling techniques used to create/develop 3D CAD models of engineering component.
</td><td>11-13</td></tr>
<tr><td></td><td>
Content:
Create complex sweeps and lofts, Work with multi-body and derived parts, Utilize part tolerances, Understand and use parameters and iProperties, Troubleshoot modeling failures, Use of transformations commands and manipulation commands to modify the created CAD models.
</td><td></td></tr>
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Experiments
1. Build a model of engineering components utilizing multiple work planes, sketches, and 3D sketch geometry with the advanced features
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	of modelling (e.g., sweep, loft, rib etc.) and pattern tools (e.g., coil, spiral, curves etc.). And generate detailed drawing of the models created. (Minimum 2) **2. Create multi-body, derived parts and assemblies to facilitate precise matching between components and efficiently manage part files. Manage part tolerances and utilize parameters & iProperties for enhanced modeling control and documentation. And generate detailed drawing of the models created. (Minimum 2)**	
	Self-Learning Topics: *Create solid models of any machine components using the tools which is not covered in experiments.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Identify appropriate feature-based modelling tools of modelling software to build 3D models. (P.I.- 5.1.1)* *LO 2.2: Create detail drawing of engineering components, (P.I.-5.1.2)* *LO 2.3: Create and modify 3D CAD Solid models of various machine components using advanced features in a CAD tool. (P.I.- 3.2.2)* *LO 2.4: Identify alternative approach for CAD Modeling of same components by using various create tool, modify tools, in CAD software. (P.I.- 3.2.3)*	
03.	**Surface Modelling Techniques** ***Learning Objective/s:*** *To apply 3D Surface modelling skills for development of 3D CAD models of basic engineering components.*	**11-13**
	Content: Generating Surfaces from open profiles using create tools, Path & Guide surface option commands like stitch, ruled surface, patch, sculpt, extend, trim, shell etc. **Experiment** **1. Build a surface model for duct using surface tools present in the modelling software.** **2. Students will assume shape and size of the surface model based on their creative idea and develop a 3D model.**	
	Self-Learning Topics: *Create surface models of any component which is not covered in experiments.*	
	Learning Outcomes : *A learner will be able to* *LO 3.1: Adapt the use of sweep, loft, patch stitch tool etc. to create and modify Surface models of engineering components (P.I.- 5.1.2)* *LO 3.2: Identify the limitations of solid modeling CAD features available in a software for surface modeling approach. (P.I.-5.2.1)*	
04.	**Assembly, Drafting and GD & T** ***Learning Objective/s:*** *To impart the 3D modelling skills for assembling different parts made in 3D modelling software and to generate production drawings with important features like GD &T, surface finish, heat treatments etc.*	**11-13**

	Content: Create parametric assembly of engineering components and production drawings. **Experiment/s** 1. **Apply the CAD modelling techniques to model the parts and assembly of engineering components like, crosshead, square tool post, drill jig, etc.** 2. **Create the assembly drawing and detail drawing sheet for the same, including GD & T, surface finish.**	
	Self-Learning Topics: *Create assembly/sub-assembly of the parts of any component/machine which is not covered in experiments* ***Learning Outcomes :*** *A learner will be able to* *LO 4.1: Create assembly models of given objects using assembly tools of a modelling software. (P.I.-5.1.2)* *LO 4.2: Demonstrate use of assembly specific tools to check fit, interference, cross sections etc., of an assembled CAD Model. (P.I.-5.2.2)* *LO 4.3: Create assembly and detailed drawing using different features like GD & T, surface finish etc., of the modelled assembly. (P.I.-10.3.1)* *LO 4.4: Use different tools to animate and present the assembled model. (P.I.-10.3.2)*	
05.	**Data Exchange** ***Learning Objective/s:*** *To introduce Product data exchange among CAD systems.*	**5-7**
	Content: Introduction to types of formats used for different softwares and their applications. To develop CAD compatibility between different softwares using data exchange formats. **Experiment/s** 1. **Apply the CAD modelling techniques to convert solid/ surface model from the parts created so far, in IGES, STEP and stl. file format respectively. (Minimum 2)**	
	Self-Learning Topics: ---	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify commands in CAD tools, for product data exchange among CAD systems. (P.I.-5.1.1)* *LO 5.2: Create IGES, STEP and stl files from the existing CAD models using CAD tools. (P.I.- 5.1.2)* *LO 5.3: Identify the reasons to use CAD data exchange formats for different types of projects and in different fields. (P.I.- 12.1.1)* *LO 5.4: Identify the problems associated with compatibility among CAD tools and how product data exchange helps in resolving the same (P.I.- 12.1.2)*	

	Minimum 9, Maximum 11 experiments	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
3.2.2	Build models/prototypes to develop a diverse set of design solutions
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline-specific tools
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation
11.1.1.	Describe the rationale for the requirement for continuing professional development
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

Course Outcomes: A learner will be able to -

1. Use CAD tools for creating Solid models. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4*)
2. Use CAD Tools for creating Surface models. (*LO 3.1, LO 3.2*)
3. Build assembly models and generate production drawing of the same. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
4. Apply the concept of product data exchange for making a model compatible among different CAD systems. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4*)

CO-PO Mapping Table with Correlation Level

CO ID	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
MESBL402.1	--	--	3	--	3	--	--	--	--	--	--
MESBL402.2	--	--	--	--	3	--	--	--	--	--	--
MESBL402.3	--	--	--	--	3	--	--	--	3	--	--
MESBL402.4	--	--	--	--	3	--	--	--	--	--	3
Average	--	--	**3**	--	**3**	--	--	--	**3**	--	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. A textbook of Machine Drawing, Laxminarayan and M.L.Mathur, 3rd Edition , 2017, Jain Brothers Delhi
2. A text book of Machine Drawing by R.B.Gupta, Satyaprakashan, 10th Edition, 2019, Tech. Publication
3. Machine Drawing by K.I. Narayana, P. Kannaiah and K. Venkata Reddy, 5th Edition, 2016, New Age International (P) Limited, Publishers

Reference Books :

1. Machine Drawing, N.D. Bhatt, 51st Edition, 2022, Charotar Publishing Home Pvt. Ltd.
2. Machine Drawing, R. K. Dhawan, 2006, S. Chand Publication
3. Machine Drawing by M. B. Shah, 2nd Edition, 2009, Pearson Education India

Other Resources :

1. Tutorial links of various CAD Software.
2. NPTEL Course on Introduction to CAD (Theory):- https://nptel.ac.in/courses/112102101

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - (30 Marks)

Suggested breakup of distribution

- Practical performance based on all the experiments mentioned in the syllabus with proper understanding: 15 marks
- A reverse engineering group project (max 4 students) to demonstrate concepts: 10 marks
- Regularity and active participation: 05 marks

2. Practical Test (20 Marks)

- The test will be conducted after 40 % of the syllabus.
- Practical test of 1-hour duration to be conducted by Internal Examiner, based on creation, modification and detail drawing generation of CAD Parts, from given
- sketches.
- Evaluation of practical examination to be done by examiner, based on the printout of student′s work.

END SEMESTER EXAMINATION (50 MARKS)

Students will be assessed based on three parameters:

- Machine Drawing Concept/ CAD knowledge
- CAD Skills
- Oral
- Students will be randomly allocated with a detail/assembly drawing of mechanical system/structure having minimum 5 to maximum 7 components (excluding standard components).
- Students will be asked to create CAD models of the parts, build CAD assembly and
- generate production drawing for the same using CAD tools.

Students will be getting 2 Hours to complete the task. Additional 10 minutes will be allocated for printouts.

Two examiners, one Internal and one External will do the evaluation, based on printout and oral exam. The evaluation breakup is given below:

• Creation of CAD Models	:	10 Marks
• Building CAD Assembly	:	10 Marks
• Generation of a Production Drawing	:	10 Marks
• Oral Examination	:	20 Marks

Course Type	Course Code	Course Name	Credits
MNP	MEMNP402	MINI PROJECT – 1B	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project Management and Finance
11. PO11: Life-Long Learning

Course Objectives :

1. To familiarize students about available infrastructure at Department/Institute level, online resources, plagiarism, expectations from MP 1A and 1B, etc.
2. To guide students in identifying societal or research needs and formulating them into problem statements.
3. To facilitate problem-solving in group settings.
4. To apply basic engineering principles to address identified problems.
5. To foster self-learning and research skills.

Course Outcomes :

At the end of the course, learners will be able to:

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
    - Research/white paper/article/blog writing/publication, etc.
    - Business plan for entrepreneurship product creation
    - Patent filing.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

At the beginning of semester-III, project guides are required to conduct around 4 hours' orientation sessions including following topics:

- Familiarizing students about infrastructure available at Department/Institute level and how to use it.
- How to identify societal problems and formulate project problem statement.
- How to carry out literature survey.
- What is plagiarism and what care needs to be taken while writing a report.
- What is project report template and how it should be used.
- What are expectations from mini-projects 1A and 1B.

Mini project may be carried out in one or more form of following:

- Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semesters III and IV and Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- **Continuous Assessment marks distribution in semester III (50 marks):**
    - 10 marks for the Topic Approval Presentation in front of the progress monitoring committee
    - 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee

- 20 marks for the Final Report & Presentation
- 05 marks for Regularity and active participation

- **Continuous Assessment marks distribution in semester IV (50 marks):**
  - 15 marks for the In-Semester Two Presentations
  - 10 marks for the Participation in Project Competitions, TPP, etc.
  - 20 marks for the Final Report & Presentation
  - 05 marks for Regularity and active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester III:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
  - The first review will focus on finalizing the problem statement (topic approval).
  - The second review will focus on finalizing the proposed solution.

Semester IV:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
  - The first review will assess the readiness to build a working prototype.
  - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to the above-mentioned points, the following performance criteria shall be included during the in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester IV (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks.

Course Type	Course Code	Course Name	Credits
VEC	VEC402	ENVIRONMENT & SUSTAINABILITY	02

Program Outcomes addressed:

1. PO2: Problem Analysis
2. PO6: The Engineer and The World
3. PO7: Ethics
4. PO11: Life-long learning

Course Objectives :

1. To provide students with foundational knowledge and understanding of environmental science principles and concepts.
2. To explore the principles of sustainability and their applications in various domains of engineering and technology.
3. To familiarize students with the legal and ethical considerations associated with environmental management and sustainability practices.
4. To equip students with practical skills and strategies for promoting renewable energy, energy efficiency, waste management, and environmental impact assessment.

Module	Details
01	**Foundations of Environmental Sciences** Introduction to Environmental Science, Earth's Systems: Atmosphere, Hydrosphere, Lithosphere, Biosphere, Ecological Principles: Energy flow, Nutrient cycling, Biodiversity, Environmental Degradation: Pollution, Deforestation, Habitat loss, Environmental Monitoring and Data Analysis.
02	**Sustainability Basics** Concepts of Sustainability and Sustainable Development, Sustainable Resource Management: Water, Air, Land, Sustainable Agriculture and Food Systems, Sustainable Transportation and Urban Planning, Sustainable Business Practices and Corporate Social Responsibility
03	**Legal & Ethical Considerations** Environmental Laws and Regulations: National and International Perspectives, Environmental Policies and Governance Frameworks, Ethical Issues in Environmental Decision Making, Environmental Justice and Equity, Corporate Ethics and Environmental Responsibility
04	**Renewable energy & Energy efficiency** Introduction to Renewable Energy Sources: Solar, Wind, Hydro, Biomass, Geothermal, Energy Conversion Technologies and Systems Energy Efficiency Measures and Strategies, Policy Support for Renewable Energy Deployment, Economic and Environmental Impacts of Renewable Energy
05	**Waste management & recycling**

	Solid Waste Management: Collection, Treatment, Disposal, Recycling Processes and Technologies, E-waste Management and Hazardous Waste Handling, Circular Economy Principles, Waste Reduction Strategies: Source Reduction, Reuse, Repair
06	**Environmental Impact Assessment** Introduction to Environmental Impact Assessment (EIA), EIA Process: Screening, Scoping, Impact Assessment, Mitigation, Monitoring, Methods and Tools for Impact Assessment: GIS, LCA, Risk Assessment, Case Studies of EIA in Various Sectors: Infrastructure, Energy, Mining, Construction, Role of Stakeholders in EIA Process
Total no. of hours: **30**	

Course Outcomes :

1. Gain a comprehensive understanding of key environmental science principles and their relevance to engineering disciplines.
2. Apply principles of sustainability to analyze and address environmental challenges in engineering projects and processes.
3. Demonstrate awareness of legal and ethical considerations in environmental decision-making and management practices.
4. Develop proficiency in implementing renewable energy technologies and energy-efficient practices in engineering designs and operations.
5. Acquire knowledge and skills in waste management, recycling, and circular economy principles for sustainable resource utilization.
6. Apply environmental impact assessment methods to evaluate and mitigate the environmental impacts of engineering projects and activities.

Text Books :

1. Environmental Science: Toward a Sustainable Future by Richard T. Wright and Dorothy F. Boorse (Publisher: Pearson Education).
2. Introduction to Environmental Engineering and Science by Gilbert M. Masters and Wendell P. Ela (Publisher: Pearson Education).
3. Renewable and Efficient Electric Power Systems by Gilbert M. Masters (Publisher: Wiley).

Reference Books :

1. Environmental Law Handbook by Thomas F. P. Sullivan, David R. Buente Jr., and Sally Fairfax, Bernan Press.
2. Sustainability Science by Bert J. M. de Vries, Springer.
3. Environmental Impact Assessment: Theory and Practice by Peter Wathern, Routledge.

Other Resources:

1. NPTEL Course: Introduction to Environmental Engineering & Science- Fundamental & Sustainability Concepts, Prof. Brajesh Kumar Dubey, Department of Multidisciplinary IIT Kharagpur : Web link: https://archive.nptel.ac.in/courses/127/105/127105018/
2. NPTEL Course: Environment And Development, By Prof. Ngamjahao Kipgen, IIT Guwahati, Web link: https://onlinecourses.nptel.ac.in/noc23_hs133/preview

Course Type	Course Code	Course Name	Credits
PCC	MEPCC509	MECHANICAL VIBRATION	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite :

1. ESC101 Engineering Mechanics
2. MEPCC302 Mechanics of Solids

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct investigations of complex problems
5. PO8: Individual and team work
6. PO9: Communication

Course Objectives:

1. To introduce fundamental concepts of vibrations, their causes, effects, and applications while developing competency in formulating and solving vibration problems using mathematical models.
2. To familiarise with the various damping mechanisms and their effects on vibratory systems.
3. To make aware of the response of single and multi-degree of freedom systems under free/forced conditions.
4. To acquaint with the principles of vibration measuring instruments and condition monitoring.

Module	Details	Hrs
	Course Introduction The Mechanical Vibrations course is crucial for ensuring the safety, efficiency, and reliability of mechanical systems. It helps engineers analyze, control, and minimize unwanted oscillations in applications like automotive, aerospace, and robotics. The subject supports predictive maintenance, reduces downtime, and enhances system performance. Emphasizing practical applications, it equips students with skills to effectively enhance system reliability and solve engineering vibration problems.	**01**
01.	**Basic Concepts of Vibration and Free Undamped Single Degree of Freedom (SDOF) Vibration System** ***Learning Objective:*** *To introduce the fundamental principles of vibrations, mathematical modeling, and analytical methods for solving free undamped single-degree-of-freedom systems.*	**6-7**

	Contents: Basic concepts of vibration: Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method	
	Self-Learning Topics: *Vibrations impact on structures, machines, and human health.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Draw a free-body diagram of given system using Newton's laws. (PI 1.2.1)* *LO 1.2 Apply the fundamental engineering concepts to identify the causes and effects of vibrations on mechanical systems. (PI 1.3.1)* *LO 1.3: Identify the nature of motion of the system to differentiate between deterministic and non-deterministic vibration (PI 2.1.1)* *LO 1.4: formulate mathematical model of an undamped SDOF system using appropriate mass-spring-damper parameters and gravitational law to govern the behavior of undamped SDOF system. (PI 2.3.1)* *LO 1.5: Determine the kinetic and potential energy in given mechanical system to use in Energy, Lagrangian, and Rayleigh's methods for vibration analysis. (PI 2.2.1)* *LO 1.6: Calculate natural frequencies of mechanical systems through mathematical modelling for vibration analyses. (PI 2.4.1)*	
02.	**Free Damped Single Degree of Freedom Vibration System and Equivalent Single Degree of Freedom Vibration System** ***Learning Objective:*** *To get accustomed to the effects of damping in vibration systems with viscous and colomb damping and simplify complex systems into equivalent single-degree-of-freedom models.*	**5-6**

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Contents:

Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, effects of damping. types of damping, Free vibration response of single degree of freedom system with viscous damping: Critical damping, over damping and under damping, logarithmic decrement method, Free vibration response of single degree of freedom system with Colomb damping: Reduction of amplitude in one cycle due to coloumb damping.

Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, and multi-dampers into a single spring and damper with linear or rotational coordinate system.

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Self-Learning Topics:
Effect of critical damping on automotive suspension systems and other devices.

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Learning Outcomes:

A learner will be able to

LO 2.1: Draw a free-body diagram of given system using Newton's laws. (PI 1.2.1)
LO 2.2: Apply fundamental engineering concepts to study the effects of damping (PI 1.3.1)
LO 2.3: Use the logarithmic decrement method to calculate the amplitude decay in damped systems. (PI 2.1.1)
LO 2.4: Identify key parameters and variables in engineering systems to compare viscous and Coulomb damping behaviour. (PI 2.1.2)
LO 2.5: Convert complex multi-spring, multi-mass, and multi-damper systems into equivalent single-degree-of-freedom systems using free body digram and Newton's law/ Energy principle. (PI 2.2.1)
LO 2.6: Identify the critical damping constant to determine, whether a system returns to equilibrium without oscillating (PI 2.1.2)
LO 2.7: formulate a mathematical model of a damped SDOF system using mass-spring-damper parameters and Newton's law/ Energy principle to govern the damped SDOF system. (PI 2.3.1)

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03.

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Forced Single Degree of Freedom Vibratory System and Vibration Isolation and Transmissibility

Learning Objective:
To study the response of damped forced vibration systems under different excitation conditions.

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9-10

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	Contents: Response of a damped forced vibration under harmonic force excitation: Equation of motion, force polygon (inertia force, damping force, spring force excitation force and displacement, Magnification factor plot, and Phase angle plot Response of a damped forced vibration under rotating and reciprocating masses: Equation of motion, Amplitude plot, and Phase angle plot. Response of a damped forced vibration under the harmonic motion of the base or support: Equation of motion (absolute and relative method), Amplitude plot, and Phase angle plot Vibration Isolation and Transmissibility: Equation of motion, Force/Motion Transmissibility plot, Phase angle plot, and materials used for vibration isolation.	
	Self-Learning Topics: *Derivation of finding relative displacement due to support excitation and materials used for effective vibration isolation*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to identify the forces acting on a vibrating system (PI 1.2.1)* *LO 3.2: Identify an appropriate material for effective vibration isolation based on system requirements. (PI 1.3.1)* *LO 3.3: Calculate the amplitude response of systems under different excitation types through mathematical modelling for vibration analyses. (PI 2.4.1)* *LO 3.4: Draw force polygons to illustrate the contributions of inertia, damping, spring, and excitation forces in a vibrating system. (PI 2.1.4)* *LO 3.5: Apply a relation between force/motion transmissibility and frequency ratio to identify the mass, spring, and damper-controlled region (PI 2.2.2)* *LO 3.6: Develop the mathematical model and equation of motion for a system subjected to harmonic base motion using either the absolute or relative method, demonstrating a diverse set of solutions. (PI 2.2.3)* *LO 3.7: Formulate a mathematical model of the SDOF system using mass-spring-damper parameters and Newton's law to govern the SDOF system under forced excitation. (PI 2.3.1)*	
04.	**Two Degree of Freedom System.** ***Learning Objective:*** *To study the response of two degrees of freedom system under various conditions.*	**9-10**

	Contents: System with Two Degrees of Freedom: principle mode of vibration, Normal mode, co-ordinate coupling (displacement coupling, elastic coupling velocity coupling and inertia coupling), generalized and principle co-ordinates. Natural frequency of undamped systems: Simple spring-mass systems, mass on tightly stretched strings, double pendulum, torsional systems, combined rectilinear and angular system, geared systems. The ratio of amplitude of motion, modal vector, modal shape, and location of node, Undamped forced vibrations of two degrees of freedom system with harmonic excitation, Undamped dynamic vibration absorber: Working principle, Amplitude ratio, frequency ratio, frequency ration curves	
	Self-Learning Topics: *Use of dynamic absorbers in engineering systems.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Draw a free-body diagram of given system using Newton's laws. (PI 1.2.1)* *LO 4.2: Apply the concept of generalized coordinates in vibration analysis to obtain an uncoupled equation. (PI 1.3.1)* *LO 4.3: Apply mechanical engineering concepts to solve forced vibration problems in two-degree-of-freedom systems subjected to harmonic excitation. (PI 1.4.1)* *LO 4.4: Draw the mode shape diagram and locate node points of the system to analyze relative displacement of all parts of a system for that particular mode. (PI 2.1.4)* *LO 4.5: Formulate a mathematical model of the two degrees of freedom system using mass-spring-damper parameters and Newton’s law to govern the system's various conditions. (PI 2.3.1)* *LO 4.6: Calculate natural frequencies of mechanical systems through mathematical modelling for vibration analyses. (PI 2.4.1)*	
05.	**Vibration measuring instruments, Data Acquisition & Signal Processing.** ***Learning Objective:*** *To educate on working principle of vibration measuring instruments, data acquisition, signal processing techniques and ISO standards used in vibration measurement for vibration analysis.*	**06-07**

Contents:

Vibration Measuring Instruments:
Eddy current probes, Capacitive and Inductive sensors, Seismic velocity transducers (Moving coil and Moving magnet), Laser vibrometer Piezoelectric accelerometers, MEMS accelerometers

Selection criteria of vibration measuring instrument: Frequency, Amplitude, Application Type, and Fault Detection Accuracy.

Sensor Location for Vibration Measurement: Identification of Critical Measurement Points (Bearings, Rotors, Shafts, and Machine Casings), Mode Shapes, and Node Points Consideration. Effects of Structural Rigidity and Resonance on Placement.

Sensor Mounting Techniques: Direct vs. Indirect Mounting, Mounting Methods: Stud Mounting, Adhesive Mounting, Magnetic Mounting, Handheld Probes. Effects of Mounting Stiffness on Measurement Accuracy, Preloading and Torque Considerations for Stud Mounting, and Damping Effects of Adhesive and Soft Mounting Materials.

Classification of signals: Signal analysis, Fast Fourier Transform (FFT), Essential Settings in Data Acquisition System (Plot Formats, Frequency Span and Frequency Resolution, Average Types and Number of Averages, Windowing, Spectrum Scaling), Signal conditioning.

ISO 2954:2012 -Vibration Monitoring – Characteristics of Vibration Meters,
ISO 5348:1998 – Mechanical Vibration and Shock – Mechanical Mounting of Accelerometers,
ISO 18431 Series – Signal Processing for Vibration and Shock Data,
ISO 16063 Series – Methods for the Calibration of Vibration and Shock Transducers and
ISO 5349-1 & ISO 5349-2 – Measurement and Evaluation of Human Exposure to Hand-Transmitted Vibration

Self-Learning Topics:
Introduction to ISO standards.

Learning Outcomes:
A learner will be able to

LO 5.1: Apply fundamental engineering concepts to explain the operation of vibrometer and acclerometer. (PI 1.3.1)

LO 5.2: Apply laser-based measurement techniques to determine vibration characteristics using a laser vibrometer. (PI 1.4.1)

LO 5.3: Identify key factors influencing sensor selection for vibration analysis. (PI 2.1.2)

LO 5.4: Identify suitable sensor and mounting techniques for vibration measurement based on system requirements. (PI 2.2.4)

	LO 5..5 Extract engineering requirements from ISO 16063 for transducer calibration and ISO 5349 for human vibration exposure assessment.(3.1.4) *LO 5.6: Demonstrate teamwork and technical communication skills by conducting literature reviews, analysing case studies, and presenting findings on vibration measurement techniques through well-structured reports and presentations. (P.I. 1.4.1,2.1.2,2.2.2,3.1.1, 4.1.1,4.1.2, 8.2.1, and 9.1.1)* *Each group (maximum of 4 students) will conduct a structured study on advanced vibration measurement techniques, analyzing instrument selection, sensor placement, and signal processing techniques. The task involves literature review, case study analysis, and presentation, covering the following aspects:* 1. *Instrument Identification, Comparison and Selection* 2. *Sensor Placement* 3. *Mounting Techniques* 4. *Data collection and analysis* 5. *Measurement Accuracy Evaluation* 6. *Advanced Vibration Measurement technique: Machine learning and IoT & AI-Based Vibration Monitoring System. ISO-Based Standards and Compliance in Vibration Monitoring System.*	
06.	**Introduction to Condition Monitoring and Fault detection:** ***Learning Objective:*** *To equip with knowledge of vibration based condition monitoring, fault detection, and ISO standards for machine condition assessment.*	**6-7**
	Contents: Condition monitoring, Condition monitoring techniques: Monitoring of machine and process parameters, Temperature monitoring, Lubricant monitoring, Leak detection monitoring, Noise monitoring, Acoustic emission monitoring, and Vibration monitoring Different stages of Vibration measurement and monitoring: Machine installation and commissioning, machine operation, and Aged machine. Vibration-based detection of different faults in machines: Types of faults (Rotor faults, Bearing, Gear-box faults and Motor faults. Rotor fault detection: mass unbalance, shaft bent or bow, misalignment, crack, shaft rub, etc Other fault detection: Mechanical Looseness, Blade Passing Frequency, Blade variation and Blade Health Monitoring and Electric motor defects (General electric problem, stator winding defects and rotor defects.) Bearing fault detection: Inner race, outer race, Ball and Cage defects Applications of Condition Monitoring Case studies related Balancing Problems in Turbines, Condition Monitoring in Sugar mills, Health Monitoring of Journal Bearing, Condition Monitoring of Industrial Pumps. (Aspects to be covered: Selection of sensors, recommended	

	location of sensor, direction of measurement, selection of plot type, Data validation, and Identification of Faults) Introduction to Vibration severity charts, ISO standards; ISO 13373 Series-Covers vibration-based condition monitoring and fault diagnosis. ISO 20816 -Bearing and Shaft Vibration (merge of ISO 7919 and ISO 10816)	
	Self-Learning Topics: *ISO standards.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply the principles and applications of vibration monitoring techniques in condition monitoring. (PI 1.3.1)* *LO 6.2: Identify system parameters and fault indicators for vibration-based fault detection in machines, including rotor, bearing, gearbox, and motor faults, ensuring accurate assessment and problem-solving. (P.I. 2.1.2)* *LO 6.3: Identify and analyze temperature, lubricant properties, acoustic emissions, and vibration data to select appropriate condition monitoring techniques for vibration analysis. (PI 2.2.2)* *LO 6.3: Extract engineering requirements from ISO standard 20186 guidelines to monitor vibration severity levels in rotating machinery. (PI 3.1.4)* *LO 6.5: Demonstrate teamwork and effective communication by conducting literature reviews and case study analyses on condition monitoring techniques, ensuring structured problem-solving and well-documented findings. (P.I. 1.4.1,2.1.2,2.2.2,3.1.1, 4.1.1,4.1.2, 8.2.1, and 9.1.1)* *Each group (maximum of 4 students) will conduct a structured study on vibration-based condition monitoring, analyzing fault detection techniques, machine health assessment, and compliance with ISO standards. The task involves literature review, case study analysis, and presentation, covering the following aspects:* 1. *Condition Monitoring Techniques: Identification, Comparison, and Selection* 2. *Sensor Selection and Placement for Condition Monitoring* 3. *Fault Detection and Diagnosis Techniques* 4. *Data Collection, Processing, and Validation* 5. *Measurement Accuracy Evaluation in Fault Diagnosis* 6. *Advanced Vibration Monitoring Techniques: IoT & AI-Based Fault Detection* 7. *ISO-Based Standards and Compliance in Condition Monitoring*	
	Course Conclusion:	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply fundamental engineering concepts to solve engineering problems
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.4 (new PI)	Desired inferences need to be drawn from graphical tools/representations of engineering quantities of mechanisms.
2.2.1	Reframe complex problems into interconnected sub-problems
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy
2.4.1	Apply engineering mathematics and computations to solve mathematical models
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.1	Recognize that need analysis is key to good problem definition
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE.
4.1.1	Define a problem, its scope and importance for purposes of investigation
4.1.2	Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
9.1.1	Read, understand and interpret technical and non-technical information

Course Outcomes: A learner will be able to

1. Formulate and analyze single-degree-of-freedom vibration systems for engineering applications. (*LO 1.1, LO 1.2, LO 1.4, LO 1.5, LO 1.6, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5 LO 2.6 and LO 2.7)*
2. Evaluate the dynamic response of forced vibration systems under different excitation conditions. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6 and LO 3.7)*
3. Apply the principles of two-degree-of-freedom systems to solve engineering vibration problems. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5 and LO 4.7)*

4. Use appropriate vibration measurement techniques for accurate assessment of dynamic systems. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, and LO 5.6)*
5. Apply vibration monitoring and fault detection techniques to detect early-stage faults in machines *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, and LO 6.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC509.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC509.2	3	3	--	--	--	--	--	--	--	--	--
MEPCC509.3	2	3	--	--	--	--	--	--	--	--	--
MEPCC509.4	3	3	--	--	--	--	--	--	--	--	--
MEPCC509.5	3	3	3	3	--	--	--	2	2	--	--
MEPCC509.6	3	3	3	3	--	--	--	2	2	--	--
Average	**3**	**3**	**3**	**3**	**--**	**--**	**--**	**2**	**2**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Mechanical Vibrations, V.P. Singh, 3rd edition, 2014, Dhanpat Rai & Co.
2. Mechanical Vibrations, S.S. Rao, 6th edition, 2017, Pearson Education.
3. Theory of vibrations with applications, William T. Thomson, Marie Dillon Dahleh,and Chandramouli P. ,5th edition, 2020, Pearson Education.
4. Mechanical Vibrations, J.B. K. Das, 2nd edition, 2012, Cengage Learning.
5. Fundamentals of Vibrations, Leonard Meirovitch, 1st edition, 2001, McGraw Hill
6. B.K.N. Rao, "Handbook of Condition Monitoring", Elsevier
7. A.R. Mohanty, "Machine Condition Monitoring: Principles and Practices", CRC Press 2017, ISBN:9781138748255

Reference Books :

1. Mechanical Vibrations- Schaum's outline series, William W.Seto, McGraw Hill
2. Fundamentals of Mechanical Vibration by S.Graham Kelly, Tata McGraw Hll
3. Theory and Practice of Mechanical Vibrations by J.S.Rao, K. Gupta, New Age International Publications
4. R.A. Collacott, "Mechanical Fault Diagnosis and Condition Monitoring",1st Edition, Chapman and Hall, ISBN: 978-94-009-5723-7

Other Resources :

1. NPTEL Course: Vibration Analysis and Control by Prof. R. R. Rajput, Department of Mechanical Engineering at IIT Delhi:
Web Link: https://nptel.ac.in/courses/112106039

2.	NPTEL Course: Dynamics of Machines by Prof. C. Amarnath, Prof. K. Kurien Issac, and Prof. P. SeshuDepartment of Mechanical Engineering at IIT Bombay: Web lnk- https://nptel.ac.in/courses/112/101/112101096/:
3.	ttps://nptel.ac.in/courses/112105232 – Machinery Fault Diagnosis and Signal Processing, IIT, Kharagpur

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

Tool to be used	Marks
• Numerical Assignment/s (min 20 problems)	05
• Class test based on above numerical assignment	05
• Article reading	05
• Regularity and Active Participation	05

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	MEPCC510	FLUID MECHANICS AND MACHINERY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESC101 Engineering Mechanics
2. MEPCC301 Engineering Mathematics-III
3. MEPCC407 Thermal Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering Tool Usage
4. PO8: Individual and Collaborative Team work
5. PO9: Communication

Course Objectives:

1. To acquire knowledge of core fluid mechanics principles, including viscosity, fluid statics, and Archimedes principle, showcasing adept application proficiency.
2. To develop skills for applying fluid kinematics and dynamics, analysing viscous flow, and solving practical problems in hydraulic turbines, pumps, and pumping systems.
3. To apply theoretical knowledge practically, showcasing expertise in using Bernoulli's equation for devices like orifice meters and Venturi meters, and analysing thrust in pipe bends.
4. To develop problem-solving skills for real-world engineering challenges, emphasizing practical application.
5. To understand and quantify different types of losses in pipes and turbomachinery.

Module	Details	Hrs.
	Course Introduction This course introduces the principles of fluid mechanics and their application to fluid machinery. It covers fluid behavior, including flow dynamics, energy transformation, and key concepts like Bernoulli's and continuity equations. Students will also learn about the design, operation, and performance of fluid machinery such as pumps, turbines, and compressors. The course combines theoretical understanding with	**01**

<table>
<tr><td></td><td>practical problem-solving, preparing students to analyze and optimize fluid systems in real-world engineering applications.</td><td></td></tr>
<tr><td>01.</td><td>Introduction

Learning Objective:
To utilize the knowledge of fluid statics and its properties to quantify hydrostatic forces acting over submerged surfaces.

Contents:
Newton’s law of viscosity, Newtonian and non-Newtonian Fluid, Fluid Statics: Pascal’s law, Hydrostatic law, hydrostatic force on submerged surfaces (horizontal, vertical, inclined & curved), Archimedes principle, Buoyancy and Floatation.

Self-Learning Topics:
Different types of fluids, Fluid properties

Learning Outcomes:
A learner will be able to
LO 1.1: Apply Newton's law of viscosity to characterize the behavior of Newtonian and non-Newtonian fluids, understanding the relationship between shear stress and shear rate. (P.I.-1.3.1)
LO 1.2: Apply fluid statics principles to analyze and calculate hydrostatic forces on Pascal’s submerged surfaces. (P.I.-1.4.1)
LO 1.3: Employ Archimedes' Principle to determine buoyancy and flotation forces acting on submerged or floating bodies. (P.I.-2.1.2)
LO 1.4: Derive and apply the concepts of buoyancy and flotation in practical engineering problems, including the calculation of forces and equilibrium conditions. (P.I.-2.3.1)</td><td>7-9</td></tr>
<tr><td>02.</td><td>Fluid Kinematics

Learning Objective:
To leverage the differential equation of continuity to analyze fluid kinematics and evaluate mathematical models to understand various fluid patterns.

Contents:
Classification of fluid flow, streamline, path line, streak line, acceleration of fluid particle, local and convective acceleration, differential equation of continuity, concept of circulation, rotational flow and vortices, stream function and potential function. Methods of dimensional analysis - Buckingham π Theorem and Rayleigh’s Method.

Self-Learning Topics:
Cauchy Riemann Equation

Learning Outcomes:
A learner will be able to
LO 2.1: Apply mechanical engineering concepts to classify fluid flow into different types (steady, unsteady, laminar, turbulent) and distinguish between streamlines, path lines, and streaklines. (PI-1.4.1)
LO 2.2: Apply fundamental engineering concepts to distinguishing between acceleration of fluid flow, local and convective acceleration. (PI-1.3.1)</td><td>7-9</td></tr>
</table>

	LO 2.3: Derive and apply the differential equation of continuity to fluid flow problems (PI-2.1.3) *LO 2.4: Apply dimensional analysis techniques such as Buckingham π Theorem and Rayleigh's Method to derive dimensionless groups and empirical relationships for fluid flow problems. (PI- 2.3.1)*	
03.	**Dynamics of Fluid Flow**	**7-9**
	Learning Objective: *To employ Bernoulli's principle to practical fluid flow problems and analyze flow with control volume approach using RTT.*	
	Contents: Concept of control volume and control surface, Importance of Reynolds Transport theorem (RTT) and its derivation (No numerical), Forces acting on fluid in motion, Euler's equation in Cartesian coordinates, Expression of Bernoulli's equation from principle of energy conservation and by integration of Euler's equation. Application of Bernoulli's equation in Orifice meter, Venturi meter and Pitot tube. Momentum of fluid in motion: impulse momentum relationship and its applications for determination of thrust for pipe bend.	
	Self-Learning Topics: *Working principle of rotameter.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Discuss the importance of the Reynolds Transport Theorem (RTT) and describe its role in converting a system description to a control volume description. (PI-1.3.1)* *LO 3.2: Conceptually define control volume and control surface and explain their significance in fluid mechanics. (PI- 1.4.1)* *LO 3.3: Analyze and explain the forces acting on a fluid in motion using Euler's equation in Cartesian coordinates. (PI- 2.1.2)* *LO 3.4: Apply the impulse-momentum relationship **to** determine the momentum change of a fluid in motion and calculate the resulting thrust in systems like pipe bends. (PI-2.3.1)* *LO 3.5: Apply fundamental and mechanical engineering knowledge to set up, run, and analyze Computational Fluid Dynamics (CFD) simulations to model fluid flow through a pipe, interpret key flow characteristics such as velocity, pressure, and turbulence, and compare the results with theoretical predictions and real-world data to assess the accuracy and performance of the model. (PI:.1.3.1, PI:.1.4.1, PI:.2.2.4, PI:.2.4.2, PI:.5.1.1, PI:.5.2.1, PI: 9.1.2, PI: 9.1.3)*	
04.	**Flows in Conduits**	**6-8**
	Learning Objectives: *1. To harness the knowledge of Bernoulli's and Darcy-Weisbach equation to calculate head losses in fluid flow systems.* *2. To categories different flow regime and analyse forces acting on fluid for different geometries.*	
	Contents: Head loss in pipes due to friction (Darcy-Weisbach equation), Loss of energy in pipe (major and minor). Relationship between shear stress and pressure gradient in laminar flow, Laminar flow between parallel plates (Plane	

	Poiseuille & Couette flow), Laminar flow in circular pipe (Hagen-Poiseuille flow).	
	Self-Learning Topics: *Relationship between shear stress and pressure gradient in laminar flow*	
	Learning Outcomes:	
	A learner will be able to *LO 4.1: Apply fundamental engineering knowledge to determine head losses in pipes using the Darcy-Weisbach equation. (PI-1.3.1)* *LO 4.2: Identify and evaluate major and minor energy losses within piping system and apply this knowledge to assess fluid system performance. (PI-2.1.2)* *LO 4.3: Compare various geometries in laminar flow, illustrate velocity profiles for fluid flows. (PI-1.4.1)* *LO 4.4: Employ the concepts of shear stress and pressure gradient in laminar flow to analyze and address engineering challenges efficiently. (PI-2.4.1)*	
05.	**Hydraulic Turbine** ***Learning Objective/s:*** *To utilise the knowledge of hydraulic turbines to estimate it's performance.*	**5-7**
	Contents: Hydraulic Turbine: Basic theory, Classification of turbines, Theory of impulse and reaction turbines, Characteristics of turbines, Specific speed of turbine, Types of pumps: Pelton turbine, Francis turbine, Kaplan turbine.	
	Self-Learning Topics: *Classification of modern turbines.*	
	Learning Outcomes :	
	A learner will be able to *LO 5.1: Apply mechanical engineering concepts to describe the characteristics of turbines in terms of efficiency, flow rates, and power output. (PI-1.4.1)* *LO 5.2: Apply fundamental engineering concepts to Describe the basic theory of hydraulic turbines, including the principles of energy conversion from fluid flow to mechanical energy. (PI-1.3.1)* *LO 5.3: Demonstrate understanding of impulse and reaction turbine principles and recognize their respective characteristics. (PI-2.1.3)* *LO 5.4: Analyze hydraulic turbine systems, for optimal performance based on construction and operational factors. (PI-2.4.1)*	
06.	**Hydraulic Pumps**	**5-7**
	Learning Objective/s: *To utilise the knowledge of hydraulic pumps to estimate it's performance.*	
	Contents: Classification of pumps, Definition of pumping systems and system characteristics, Specific speed of pumps, Centrifugal pumps: Construction, characteristics, determination of operating point, cavitation and NPSH. Reciprocating pumps: Construction, Types, Discharge, head, efficiency of pump and Use of Air vessel.	

	Self-Learning Topics: *Classification of modern pumps*	
	Learning Outcomes:	
	A learner will be able to *LO 6.1: Apply mechanical engineering concepts to describe the characteristics of pumps in terms of efficiency, flow rates, and power output. (PI-1.4.1)* *LO 6.2: Apply fundamental engineering concepts to describe the basic theory of hydraulic pumps, including the principles of energy conversion from mechanical energy to fluid flow (PI- 1.3.1)* *LO 6.3: Analyze hydraulic pump systems, including centrifugal pump and reciprocating pump, for optimal performance based on construction and operational factors. (PI-2.4.1)* *LO 6.4: Select the appropriate pump size, apply problem-solving techniques, collaborate with the team, present outcomes confidently, and create clear, professional engineering drawings. (PI-2.1.2, PI-8.2.1, PI-8.2.2, PI-9.1.2, PI-9.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.
8.2.2	Treat other team members respectfully.
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents.
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear.
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations.

Course Outcomes: A learner will be able to -

1. Apply the basic concepts of fluid mechanics to determine viscous effects of fluid and hydrostatic forces. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Apply the concepts of fluid kinematics and visualize the fluid flow using mathematical models. (*LO 2.1, LO 2.2, LO 2.3, LO2.4)*
3. Apply laws of mass, momentum and energy conservation in fluid dynamics. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
4. Apply engineering knowledge to analyze CFD simulations for real-time applications and select the appropriate pump size for the given problem, while collaborating with the team and presenting results clearly with professional drawings. *(LO 3.5, LO 6.4)*
5. Apply knowledge to determine losses in pipe, shear stress and pressure gradient in laminar flow. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4)*
6. Apply knowledge to determine performance parameters of hydraulic machines. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 6.1, LO 6.2, LO 6.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC510.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC510.2	3	3	--	--	--	--	--	--	--	--	--
MEPCC510.3	3	3	--	--	--	--	--	--	--	--	--
MEPCC510.4	3	3	--	--	3	--	--	3	3	--	--
MEPCC510.5	3	3	--	--	--	--	--	--	--	--	--
MEPCC510.6	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	--	--	**3**	--	--	**3**	**3**	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. A textbook of Fluid Mechanics by R K Bansal, 1st Edition, 2015, Laxmi Publication
2. Engineering Fluid Mechanics by K. L. Kumar: 1st Edition, and reprint 2016, Eurasia Publishing house (P) Ltd.
3. Fluid Mechanics and Machinery by C S P Ojha, Chandramaouli, and R Berndtson, 1st Edition, 2010, Oxford University Press India
4. A Textbook of Fluid Mechanics and Hydraulic Machines by R K Rajput, 6th Edition, 2016, S. Chand.

Reference Books :

1. Fluid Mechanics by Yunus A Cengel and John A Cimbala, 3rh Editiion, 2014, Tata McGraw-Hill

2. Fluid Mechanics by Frank M. White, by, 7th edition, 2011, McGraw-Hill Education

3. Fluid Mechanics by Kundu and Cohen, , by, 6th Edition, 2016, Elsevier Inc.

4. Hydraulics and Fluid Mechanics by Dr. Mody and Seth, 21st Edition, 2017, Standard book house.

Other Resources :

1. NPTEL Course: Introduction to Fluid Mechanics By Prof. Suman Chakraborty, Department of Mechanical Engineering at IIT Kharagpur:
Web link- https://nptel.ac.in/courses/112/105/112105269
2. NPTEL Course: Fluid Mechanics by Prof. Subashisa Datta, Department of Mechanical Engineering, IIT Guwahati: Web link: http://swayam.gov.in/nd1_noc20_ce59/preview
3. NPTEL Course: Introduction to Turbo Machines by Prof. Babu Viswanathan, Department of Mechanical Engineering at IIT Madras: Web link: https://nptel.ac.in/courses/112/106/112106303/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

MCQ test as per GATE pattern/level	:	05 marks
Class test	:	05 marks
Think Pair Share worksheet	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC5011	FINITE ELEMENT ANALYSIS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite :

1. BSC101 - Engineering Mathematics-I
2. BSC204 - Engineering Mathematics-II
3. MEPCC301 - Engineering Mathematics-III
4. MEPCC302 - Mechanics of Solids

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO8: Individual and Team Work
7. PO9: Communication

Course Objectives :

1. Enable students to comprehend foundational FEA concepts, software workflows, and geometry preparation techniques for effective pre-processing.
2. Equip students with the ability to perform static structural analyses, interpret stress/strain results, and validate findings against theoretical solutions.
3. Instruct students in analysing dynamic systems through modal, harmonic, and transient analyses to identify natural frequencies and resonance risks.
4. Guide students in simulating heat transfer mechanisms and evaluating coupled thermo-mechanical effects, such as thermal expansion and stress.
5. Train students to model non-linear behaviours, including material plasticity and contact interactions, using advanced FEA software tools.
6. Prepare students to apply fatigue analysis, fracture mechanics and multi-physics simulations to refine designs and solve complex engineering problems.

<table>
<tr><th>Module</th><th>Details</th><th>Hrs</th></tr>
<tr><td></td><td>Course Introduction

This course equips students with the fundamental principles and practical skills of FEA, covering topics like static structural analysis, dynamic and modal analysis, thermal and thermo-mechanical analysis, and non-linear analysis. Through hands-on learning with commercial software package, students will apply FEA in real-world mechanical engineering problems. Advanced topics like design optimization and multi-physics simulations will also be explored. This comprehensive approach ensures students develop critical problem-solving skills, making them competitive and versatile in the engineering industry.</td><td>01</td></tr>
<tr><td rowspan="4">01.</td><td>Introduction to FEA
Learning Objective/s:
To get acquainted to the history, applications, and limitations of Finite Element Analysis (FEA) and apply its workflow using industry-standard software for geometry preparation, material assignment, and meshing.</td><td rowspan="4">4-6</td></tr>
<tr><td>Contents:

History, applications, and limitations.
Types of analysis: Structural, thermal, modal, fluid, etc.
Overview of FEA workflow: Pre-processing, solving, and post-processing,
Introduction to FEA software, Geometry preparation, Importing CAD models and simplifying geometry, Material properties and meshing: Element types, mesh quality, and convergence.

Tool-Based Learning:
• Create a simple 3D model and mesh it using commercial software package
• Assign materials and boundary conditions to a cantilever beam</td></tr>
<tr><td>Self-Learning Topics:
Advanced Meshing Options and Mesh refinement</td></tr>
<tr><td>Learning Outcomes :
A learner will be able to
LO 1.1 Identify the history, applications, and limitations of Finite Element Analysis (FEA) in engineering and scientific fields. (PI 2.1.2, PI 2.3.2, PI 2.4.4)
LO 1.2 Demonstrate an understanding of the FEA process, including pre-processing, solving, and post-processing, to conduct accurate simulations. (PI 2.2.2, PI 2.3.2, PI 2.4.3)
LO 1.3 Perform geometry preparation, import CAD models, and simplify geometry for efficient FEA simulations. (PI 5.2.1, PI 5.1.1, PI 4.3.4)
LO 1.4 Assign appropriate material properties and implement meshing techniques while ensuring mesh quality and convergence. (PI 2.2.4, PI 2.3.1)</td></tr>
</table>

02.	**Structural Analysis (Static and Linear)** ***Learning Objective/s:*** *To apply elasticity theory, solve linear static problems with FEA software, and optimize simulations through parametric studies and mesh refinement.*	**8-10**
	Contents: ***Theory of elasticity and stress-strain relationships*** ***Boundary Conditions and Loads:*** Forces, Pressures, and Displacements ***Element Types:*** Solid Elements, Shell Elements, Beam Elements, Tetrahedral Elements *(Different types of elements and element selection to be covered from FEA perspective.)* ***Boundary Condition Types:*** Fixed Support, Displacement Support, Frictionless Support, Cylindrical Support, Compression Only Support ***Solver Selection:*** Direct Solver, Iterative Solver *(Background theoretical knowledge related to types of solver to be discussed from FEA perspective)* ***Solver Settings:*** Damping, Large Deflection, Pivot Checking, Inertia Relief *(Basic background of solver settings to be discussed from FEA perspective)* ***Post-Processing Types***: Stress Contours, Deformation Plots, Safety Factors **Tool-Based Learning:** • Analyze a bracket or beam under static loading using commercial software package. • Conduct a parametric study by varying loads/materials in the software and evaluate their impact on stress/deformation. • Perform a mesh convergence analysis to assess how mesh density influences simulation accuracy.	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 2.1 Apply principles of elasticity theory and stress-strain relationships to define boundary conditions (force, pressure, displacement) and analyze their impact on mechanical systems. (PI 1.3.1, PI 2.3.1, PI 4.1.4, PI 5.1.2)* *LO 2.2 Apply commercial software to solve linear static problems, interpret results, and evaluate stress contours, deformation plots, and safety factors. (PI 1.1.1, PI 2.1.2, PI 5.2.1, PI 5.3.2, PI 8.1.2, PI 9.3.1)* *LO 2.3 Conduct parametric studies and mesh convergence analysis to assess the impact of load/material variations and mesh density on simulation accuracy. (PI 2.4.3, PI 5.3.2)*	
03.	**Dynamic and Modal Analysis** ***Learning Objective/s:*** *To analyze dynamic systems by determining natural frequencies and mode shapes through modal analysis and simulating transient responses and damping effects using commercial FEA software.*	**11-12**

	Contents: **Modal Analysis: Natural Frequencies and Mode Shapes** ***Element Types:*** Solid, Shell, Beam ***Boundary Conditions:*** Fixed Support, Displacement Support ***Solver***: Eigenvalue ***Solver Settings:*** Number of Modes, Frequency Range ***Post-Processing:*** Mode Shapes, Natural Frequencies **Harmonic and Transient Analysis** ***Element Types:*** Solid, Shell, Beam ***Boundary Conditions:*** Harmonic Loads, Transient Loads ***Solver:*** Harmonic Response Solver, Transient Dynamic Solver ***Solver Settings:*** Damping, Time Step, Load Frequency ***Post-Processing:*** Frequency Response Plots, Time History Plots, Stress and Deformation Contours **Damping Effects and Resonance** ***Element Types:*** Solid, Shell, Beam ***Boundary Conditions:*** Damping Support ***Solver:*** Modal Damping Analysis ***Solver Settings:*** Damping Ratios, Material Damping ***Post-Processing:*** Damped Natural Frequencies, Mode Shapes with Damping ***Tool-Based Learning:*** • Perform modal analysis on a simple structure (e.g., a cantilever beam) using commercial software package. • Simulate a transient response for a structure under impact loading.	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 3.1 Quantify natural frequencies, mode shapes, damping effects, and resonance in dynamic systems. (PI 1.4.1, PI 2.1.2, PI 4.1.3, PI 5.1.1)* *LO 3.2 Compute mode shapes and simulate harmonic and transient responses using commercial software. (PI 1.4.1, PI 2.1.2, PI 5.1.1, PI 5.2.2, PI 5.3.2)* *LO 3.3 Apply a commercial software package to perform modal and transient simulations for structures subjected to impact loading. (PI 5.1.1, PI 5.2.2, PI 8.1.2, PI 9.3.1)*	
04.	**Thermal and Thermo-Mechanical Analysis** ***Learning Objective/s:*** *To analyze heat transfer modes and coupled thermo-mechanical problems using steady-state and transient thermal analysis techniques.*	**6-8**
	Contents: ***Heat Transfer Modes:*** Conduction, Convection, and Radiation ***Steady-State and Transient Thermal Analysis:*** ***Elements:*** Solid, Shell, Line ***Boundary Conditions:*** Convection, Radiation, Temperature, Heat Flux, Adiabatic ***Solver Selection:*** Steady-State, Transient Thermal	

	Solver Settings: Initial Conditions, Time Step (for Transient), Convergence Criteria ***Post-Processing:*** Temperature Contours, Heat Flux Vectors, Thermal Gradients ***Thermo-Mechanical Coupling: Thermal Stresses and Expansion*** ***Elements:*** Solid, Shell ***Boundary Conditions:*** Thermal Loads, Mechanical Loads ***Solver:*** Thermo-Mechanical ***Settings***: Temperature-Dependent Material Properties, Thermal Expansion Coefficients, Coupled Field Analysis ***Post-Processing:*** Thermal Stress Contours, Displacement Plots, Thermal Strain ***Tool-Based Learning***: • Simulate heat transfer in a heat sink using a commercial software package. • Analyze thermal stresses in a pipe under temperature gradients.	
	Self-Learning Topics: **--**	
	Learning Outcomes : *A learner will be able to* *LO 4.1 Quantify conduction, convection, and radiation in steady-state and transient conditions. (PI 1.1.1, PI 1.4.1, PI 4.1.4)* *LO 4.2 Evaluate thermal stresses through heat transfer simulations using commercial software. (PI 1.4.1, PI 5.2.2, PI 5.3.1)* *LO 4.3 Apply **c**omputational tools to model heat dissipation in a heat sink and analyze thermal stresses in a pipe under temperature gradients. (PI 5.1.1, PI 8.1.2, PI 9.3.1)*	
05.	**Non-Linear Analysis** ***Learning Objectives:*** *To analyze nonlinearities (geometric, material, contact) and simulate material models and contact mechanics using commercial software.*	**5-7**
	Contents:	
	Geometric Non-Linearity ***Elements:*** Shell, Solid, Beam ***Meshing:*** Coarse and Fine mesh, quadratic elements. ***Solver Selection:*** Newton-Raphson (implicit), Arc-Length (post-buckling), Explicit (severe deformation). ***Solver Settings:*** Automatic time stepping, adaptive convergence. ***Post-Processing:*** Deformation plots, buckling modes, energy curves. **Material Non-Linearity** ***Plasticity Models:*** Bilinear, kinematic hardening (von Mises, Drucker-Prager). ***Hyperelasticity:*** Mooney-Rivlin, Neo-Hookean, Ogden. ***Creep:*** Norton's Law, Prandtl-Reuss. ***Elements:*** Solid (plasticity, creep). ***Meshing:*** Quadratic elements, refined mesh in stress zones. ***Solver Selection:*** Static (plasticity, creep), Explicit (hyper elasticity).	

	Solver Settings: Nonlinear stabilization, time integration for creep. ***Post-Processing:*** Plastic strain contours, stress-strain curves, creep strain vs. time. **Contact Non-Linearity** ***Types:*** Frictionless, frictional (Coulomb), bonded, rough. ***Elements:*** 3D 8-node surface-to-surface contact element, 3D target segment element, 20-node brick element, 10-node tetrahedral element ***Meshing:*** Refined contact zones, matching mesh for accuracy. ***Solver Selection:*** Penalty method, Augmented Lagrange, Lagrange multipliers ***Solver Settings:*** Frictional sliding, contact stiffness adjustment, stabilization damping. ***Post-Processing:*** Contact pressure, frictional stress, slip visualization, reaction forces. ***Tool-Based Learning:*** • Simulate a rubber component under large deformation using commercial software package. • Analyze contact between two metal parts under load.	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 5.1 Identify geometric, material, and contact nonlinearities in structural systems. (PI 2.1.2, PI 2.3.1, PI 5.2.1, PI 5.3.1)* *LO 5.2 Perform nonlinear simulations covering plasticity, hyper elasticity, and creep in materials using commercial software. (PI 2.4.1, PI 2.4.2, PI 5.1.2, PI 5.2.2)* *LO 5.3 Simulate large deformations in rubber components. (PI 2.2.3, PI 2.4.2, PI 5.2.1, PI 5.3.2)* *LO 5.4 Analyze contact mechanics in metal parts under load.(PI 2.3.1, PI 2.4.4, PI 4.1.3, PI 5.2.2, PI 9.3.1)*	
06.	**Fatigue Analysis, Fracture Mechanics and Multi-Physics Simulations** ***Learning Objective/s:*** *To comprehend and apply advanced finite element techniques in ANSYS for fatigue analysis, fracture mechanics, and multi-physics simulations, including appropriate element selection, meshing strategies, solver configurations, and post-processing methods to ensure accurate and efficient simulations.*	**5-7**
	Contents:	
	Fatigue Analysis ***Element Types:*** Quadratic elements, Surface-coating elements. ***Meshing:*** High-density meshes at stress concentrators (notches, holes), Cyclic symmetry meshing for rotational components. **Solver Selection**: Implicit solvers for low-cycle fatigue, Explicit solvers with cycle-jumping for high-cycle fatigue. **Solver Settings**: Rainflow counting integration, SN/EN curves with Goodman correction. **Post-Processing**: Fatigue life contour plots (Miner's rule), Critical node	

	tracking for crack initiation. ***Fracture Mechanics*** ***Element Types***: Quarter-point elements, Cohesive zone elements ***Meshing:*** Spider-web meshing, XFEM (eXtended Finite Element Method) ***Solver Selection:*** Static implicit, Explicit dynamic ***Solver Settings:*** Contour integral settings ***Post-Processing:*** Crack path visualization, Stress intensity factor (SIF) history plots. **Multi-Physics Simulations (Fluid-Structure Interaction)** ***Element Types:*** Lagrangian shells/solids for structures; Eulerian tetrahedral/hexahedral for fluids**,** Interface for coupling. ***Meshing:*** Non-conformal meshes, Arbitrary Lagrangian-Eulerian (ALE). ***Solver Selection:*** Partitioned coupling, Monolithic solvers ***Solver Settings:*** Under-relaxation factors, Time-step sub-cycling ***Post-Processing:*** Fluid pressure/stress overlays on deformed structures, Streamlines with displacement animations. ***Tool-Based Learning:*** • Perform the fatigue analysis of a metallic plate with a central hole subjected to cyclic loading, leading to potential fatigue failure. • Conduct fracture mechanics analysis for a pre-cracked structural component subjected to external loading, raising concerns about crack growth and structural integrity. • Perform a fluid-structure interaction (FSI) simulation of a flexible plate subjected to fluid flow, leading to structural deformation due to fluid forces in order to ensure structural stability.	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 6.1 To perform fatigue analysis and interpret fatigue life contour plots in order to identify critical regions for failure prevention. (PI 2.4.2, PI 5.1.1, PI 5.2.1)* *LO 6.2 To analyze fracture mechanics to assess structural durability. (PI 2.4.3, PI 4.1.3, PI 4.3.1, PI 5.2.2)* *LO 6.3 To perform multi-physics simulations and validate FEA results using industry software. (PI 2.3.1, PI PI 2.4.2, PI 5.1.2, PI 5.3.1, PI 5.3.2, PI 8.1.2, PI 9.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble, and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate models (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.2	Produce and validate results through skillful use of contemporary engineering tools and models.
2.4.3	Identify sources of error in the solution process and limitations of the solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data.
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling, and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
5.3.1	Discuss limitations and validate tools, techniques, and resources.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
8.1.2	Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective teamwork to accomplish a goal.
9.3.1	Create engineering-standard figures, reports, and drawings to complement writing and presentations

Course Outcomes :

1. Apply fundamental FEA concepts, including pre-processing, solving, and post-

processing, to model and analyse mechanical systems. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*

2. Utilize commercial software to solve linear static problems, conduct parametric studies, and assess stress-strain relationships for accurate simulations. *(LO 2.1, LO 2.2, LO 2.3)*

3. Perform dynamic and thermal analyses by computing mode shapes, transient responses, and thermal stresses using industry-standard tools. *(LO 3.1, LO 3.2, LO 3.3, LO 4.1, LO 4.2, LO 4.3)*

4. Analyse nonlinear structural behaviour, including plasticity, hyper elasticity, creep, and contact mechanics, using advanced FEA techniques. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*

5. Apply FEA techniques for fatigue, fracture, and multi-physics simulations, ensuring accurate analysis through proper meshing, solvers, and post-processing. *(LO 6.1, LO 6.2, LO 6.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC5011.1	--	3	--	2	3	--	--	--	--	--	--
MEPEC5011.2	3	3	--	2	3	--	--	2	2	--	--
MEPEC5011.3	3	3	--	2	3	--	--	2	2	--	--
MEPEC5011.4	3	--	--	2	3	--	--	2	2	--	--
MEPEC5011.5	--	3	--	2	3	--	--	--	2	--	--
Average	**3**	**3**	**--**	**2**	**3**	**--**	**--**	**2**	**2**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. P. N. Godbole & Dhananjay R. Dolas , *Finite Element Method and Computational Structural Dynamics with ANSYS,* (CRC Press)
2. Kenneth G. Budinski , *Engineering Materials: Properties and Selection with ANSYS Applications,* (Prentice Hall)
3. Ram K. Jha, *ANSYS Workbench Tutorial: Structural & Thermal Analysis Using the Finite Element Method,* (CRC Press)
4. Buch A. & Hadi M., *Practical Finite Element Simulations with ANSYS Workbench 2023,* (Springer)
5. Saeed Moaveni, *Finite Element Analysis: Theory and Application with ANSYS,* (Pearson)
6. Esam M. Alawadhi, *Topology Optimization in Engineering Design with ANSYS* (Elsevier)

Reference Books :

1. Zhi-Hua Zhong, *Finite Element Procedures for Structural Analysis with ANSYS*, (Springer)
2. John Matsson , *An Introduction to ANSYS Fluent 2023*, (SDC Publications)
3. Xin-She Yang, *Introduction to Computational Heat Transfer with MATLAB and ANSYS*, (Elsevier)
4. Karthik Selvam, *Introduction to ANSYS Workbench 2023*, (Springer)
5. Khalid Saeed & M. M. Rashid**,** *Heat Transfer and Thermal Stress Analysis in ANSYS*, (Springer)
6. Andrew Buchanan, *Fatigue and Fracture Mechanics in ANSYS Workbench*, (CRC Press)

Other Resources :

1. **Basics of Finite Element Analysis – I,** Prof. S. K. Bhattacharyya, IIT Kanpur
   Link: https://archive.nptel.ac.in/courses/112/104/112104193/
2. **Finite Element Method,** Prof. Biswanath Banerjee and Prof. Amit Shaw, IIT Kharagpur
   Link: https://onlinecourses.nptel.ac.in/noc22_me43/preview
3. **Finite Element Analysis,** Prof. A. K. Dasgupta, IIT Kharagpur
   Link: https://archive.nptel.ac.in/courses/105/105/105105041/
4. **Finite Element Method,** Prof. S. K. Bhattacharyya, IIT Kanpur
   Link: https://archive.nptel.ac.in/courses/112/105/112105308/
5. **Basics of Finite Element Analysis – II,** Prof. S. K. Bhattacharyya, IIT Kanpur
   Link: https://archive.nptel.ac.in/courses/112/104/112104205/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
Class Test	:	05 Marks
Open book test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC5012	COMPUTER AIDED ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC101: Engineering Mathematics-I
2. BSC102: Engineering Physics-I
3. BSC204: Engineering Mathematics-II
4. BSC205: Engineering Physics-II
5. MEPCC301: Engineering Mathematics-III
6. MEPCC302: Mechanics of Solids
7. MEPCC304: Thermodynamics
8. MEPCC407: Thermal Engineering
9. MEPCC510: Fluid Mechanics and Machinery

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO5: Engineering Tool Usage
4. PO6: The Engineer and The World
5. PO8: Individual and Collaborative Team work
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. Introduce students to the fundamentals of CAE and FEA for structural, thermal, CFD, and electromagnetic analysis.
2. Guide students in creating 1D, 2D, and 3D meshes and selecting appropriate elements for accuracy.
3. Train students to assess mesh quality and apply adaptive meshing for better simulations.
4. Familiarize students to the direct and iterative solvers, convergence criteria, and HPC techniques for efficient analysis.

5. Enhance Post-Processing Interpretation through the analysis of stress, strain, deformation, and fatigue life results in structural simulations.

6. Familiarize students to the visualization of velocity, pressure, turbulence, and force analysis in fluid and thermal simulations.

Module	Details	Hrs.
	Course Introduction Computer-Aided Engineering (CAE) is a critical aspect of modern engineering design and analysis. It integrates Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) to evaluate structural, thermal, and fluid behavior in engineering applications. This course covers fundamental and advanced topics, including meshing techniques, solver settings, and post-processing methodologies. Students will gain hands-on experience with industry-standard CAE tools, enhancing their ability to solve complex engineering problems efficiently.	**01**
01.	**Introduction to CAE, Types of Elements and Mesh Generation**	**6-8**
	Learning Objective: *To get familiar to the basics of CAE, different types of analysis, and apply mesh quality metrics and adaptive meshing techniques.*	
	Contents: ***Introduction to Computer-Aided Engineering (CAE)***, Overview of different types of analysis like Structural Analysis (e.g., stress, strain, fatigue), Thermal Analysis (e.g., heat transfer, conduction), Fluid Dynamics (CFD) (e.g., airflow, turbulence) ***Geometry:*** 1D, 2D & 3D elements**,** Geometry creation/import & simplification ***Material properties:*** Modulus of Elasticity, Modulus of Rigidity, Poisson's Ratio ***Meshing:*** Element types, mesh quality, and convergence ***Mesh Quality Metrics:*** Aspect Ratio, Jacobian Ratio, Skewness, warping, Adaptive Meshing ***Use of Symmetry***, Planar Symmetry, Axial Symmetry, Cyclic Symmetry	
	Self-Learning Topics: *Advanced Mesh Quality Improvement Techniques*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply the fundamental principles of Computer-Aided Engineering (CAE) to evaluate their application in engineering design. (PI 1.4.1)* *LO 1.2: Compare the role of CAE in structural, thermal, and fluid dynamics simulations. (PI 2.2.4)* *LO 1.3: Apply different methods of geometry creation, import, and simplification in CAE for effectiveness and efficiency. (PI 1.3.1)* *LO 1.4: Apply knowledge of material properties to improve the accuracy of simulation results. (PI 1.2.1)*	

	LO 1.5: Identify the limitations of meshing in the accuracy and efficiency of numerical simulations. (PI 2.4.3) *LO 1.6: Apply the concepts of planar, axial, and cyclic symmetry in CAE modeling, and justify their effectiveness in reducing computational complexity. (PI 2.4.1)*	
02.	**Structural Analysis (Static and Linear)**	**7-9**
	Learning Objective/s: *To select element types, mesh refinement methods, and solvers to ensure convergence and optimize computational performance in FEA.*	
	Contents: ***Introduction*** Basics of static and linear analysis, Theory of elasticity and stress-strain relationships ***Types of elements:*** Solid Elements, Shell Elements, Beam Elements, Tetrahedral Elements *(Different types of elements and element selection to be covered from FEA perspective.)* ***Boundary Conditions:*** Forces, Pressures, Fixed Support, Displacement Support, Frictionless Support, Cylindrical Support, Compression Only Support ***Solver Selection:*** Direct Solver, Iterative Solver *(Background theoretical knowledge related to types of solver to be discussed from FEA perspective)* ***Solver Settings:*** Damping, Large Deflection, Pivot Checking, Inertia Relief *(Basic background of solver settings to be discussed from FEA perspective)* ***Post-Processing***: Stress Contours, Deformation Plots, Safety Factors	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply the fundamental principles of static and linear analysis in structures using the theory of elasticity. (PI 1.1.2)* *LO 2.2: Identify various boundary conditions and load types in accurately simulating real-world engineering constraints. (PI 2.1.3)* *LO 2.3: Distinguish the element type (solid, shell, beam, and tetrahedral elements) for the structure, justifying selection based on geometry and loading in FEA models. (PI 2.2.4)* *LO 2.4: Articulate the use of direct and iterative solvers, along with solver settings such as damping, large deflection, pivot checking, and inertia relief. (PI 2.1.1)* *LO 2.5: Validate common post-processing outputs like stress contours, deformation plots, and safety factors. (PI 2.4.2)* *LO 2.6: A Task-Based Group Activity Before MSE (Part I) (PI 1.3.1, PI 2.1.2, PI 2.2.4, PI 2.3.1, PI 5.2.2, PI 6.4.2, PI 8.1.2, PI 9.1.2, PI 11.3.1)*	

<table>
<tr><td></td><td>Each group (max 4 students) will analyze the stress distribution, deformation, and factor of safety of a structure subjected to different loading conditions using a commercial Finite Element Analysis (FEA) software package.

Following aspects are to be addressed:

A. Design and Model Creation:
• Create a 3D CAD model of the structure with assigned material properties (e.g., steel, aluminum).
• Import the model into the commercial software package for analysis.

B. Meshing and Preprocessing:
• Perform mesh refinement and evaluate mesh quality metrics like aspect ratio and skewness.
• Apply appropriate boundary conditions (fixed support at one end).

C. Load Application:
• Apply different types of loads (point loads, distributed loads, moment loads) at various locations.
• Vary magnitudes of force to observe the beam's response under different conditions.

D. Analysis and Simulation:
• Conduct static structural analysis to determine stress, strain, and deformation distribution.
• Compare results across different load cases and mesh densities.

E. Results Interpretation:
• Identify failure points and factor of safety.
• Optimize the beam's design by modifying cross-sectional dimensions or material properties.
• Validate the FEA results with theoretical calculations.</td><td></td></tr>
<tr><td rowspan="4">03.</td><td>Dynamic and Modal Analysis</td><td rowspan="4">6-8</td></tr>
<tr><td>Learning Objective:
Apply post processing tools to analyze displacement, stress, and strain contours, evaluate design reliability, assess convergence, and visualize modal analysis to identify resonance risks and estimate fatigue life.</td></tr>
<tr><td>Contents:</td></tr>
<tr><td>Introduction
Significance and basics of Modal, Harmonic and Transient Analysis, Natural Frequencies and Mode Shapes

Modal Analysis
Element Types: Solid, Shell, Beam
Boundary Conditions: Fixed Support, Displacement Support
Solver Selection: Subspace Iteration Method, Block Lanczos Method
Solver Settings: Number of Modes, Frequency Range
Post-Processing: Mode Shapes, Natural Frequencies

Harmonic and Transient Analysis
Element Types: Solid, Shell, Beam
Boundary Conditions: Harmonic Loads, Transient Loads
Solver: Full Method, Reduced Method (CMS), Mode Superposition
Solver Settings: Damping, Time Step, Load Frequency</td></tr>
</table>

	Post-Processing: Frequency Response Plots, Time History Plots, Stress and Deformation Contours	
	Self-Learning Topics --	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply the significance and fundamental concepts of Modal, Harmonic, and Transient analysis, including natural frequencies and mode shapes in dynamic systems. (PI 1.4.1)* *LO 3.2: Differentiate between solid, shell, and beam elements, and justify their use in dynamic analyses. (PI 2.2.4)* *LO 3.3: Identify appropriate boundary and loading conditions in modal, harmonic, and transient analyses, and recognize key system variables and parameters that influence dynamic behavior. (PI 2.1.2)* *LO 3.4: Validate outputs like mode shapes, frequency response, and time history plots, and evaluate their importance. (PI 2.4.2)* *LO 3.5: A Task-Based Group Activity Before MSE (Part II) (PI 1.3.1, PI 2.1.2, PI 2.2.4, PI 2.3.1, PI 5.2.2, PI 6.4.2, PI 8.1.2, PI 9.1.2, PI 11.3.1)* *Each group (max 4 students) will perform modal, harmonic, and transient analysis on a structure using a commercial Finite Element Analysis (FEA) software package, investigating its natural frequencies, mode shapes, harmonic response, and transient behavior.* *Following aspects are to be addressed:* *A. Design and Model Creation:* • *Create a 3D CAD model of the structure with assigned material properties (e.g., steel, aluminum).* • *Import the model into the commercial software package for analysis.* *B. Modal Analysis:* • *Apply fixed boundary conditions at appropriate point.* • *Solve for natural frequencies and mode shapes using the Eigenvalue solver with multiple modes.* • *Interpret mode shapes to understand vibration characteristics.* *C. Harmonic Analysis:* • *Apply harmonic loads with varying frequencies.* • *Use a harmonic response solver to examine resonance effects and frequency response plots.* • *Study the effects of damping.* *D. Transient Analysis:* • *Introduce transient loads to observe time-dependent deformation.* • *Use a transient dynamic solver to analyze stress variations over time.* *E. Results Interpretation* • *Generate time history plots to visualize dynamic behavior.*	
04.	**Introduction to Computational Fluid Dynamics**	**6-8**
	Learning Objectives: *To comprehend the basics of CFD, including flow equations, numerical methods, element types, mesh generation, and boundary conditions using simulation tools.*	
	Contents: ***Introduction*** History, significance and applications of CFD, Governing Equations of Fluid Flow: Navier-Stokes Equations, Numerical Methods in CFD (Finite Volume Method)	

	Computational tools Introduction to CAD modelling, Types of Elements (1D, 2D, 3D and surface), Selection of elements according to specific application ***Material:*** Properties of materials, selection of materials ***Grid Generation and Mesh Types*** Structured, Unstructured, Hybrid, Mesh Quality Metrics and Refinement Techniques ***Boundary Conditions and Initial Conditions*** Velocity Inlet, Pressure Inlet, Pressure Outlet, Outflow, Wall, Symmetry /Axis, Periodic, Standard Initialization, Hybrid Initialization, Patch Initialization	
	Self-Learning Topics: *CFD Mesh Generation and Refinement Techniques*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the significance and applications of Computational Fluid Dynamics (CFD). (PI 1.4.1)* *LO 4.2: Apply governing fluid flow equations and numerical method like the Finite Volume Method to solve practical engineering problems using Computational Fluid Dynamics (CFD). (PI 1.1.2)* *LO 4.3: Identify relevant material properties and selection criteria within a CFD tool to define system parameters influencing fluid-structure interaction and thermal behaviour. (PI 2.1.2)* *LO 4.3: Classify element types (1D, 2D, 3D, surface) and justify element selection based on geometry and application. (PI 2.2.4)* *LO 4.4: Extract key differences among mesh types (structured, unstructured, hybrid) and interpret mesh quality metrics to draw conclusions consistent with analysis objectives and limitations. (PI 2.4.4).* *LO 4.5: Apply appropriate boundary and initial conditions in CFD simulations, including various inlet, outlet, wall, and initialization types, to ensure accurate solution setup. (PI 2.4.1)*	
05.	**Fluid Analysis** ***Learning Objective/s:*** *To apply pressure-based and density-based solvers, select turbulence models, and set convergence criteria for flow simulations.*	**6-8**
	Contents:	
	Pressure-Based Solver for Incompressible Flows, Density-Based Solver for High-Speed Compressible Flows, Time Stepping (Steady vs. Transient), Turbulence Modelling Settings, RANS Models, k-ε, k-ω (Standard, SST), LES (Large Eddy Simulation) & DES (Detached Eddy Simulation), Convergence Criteria & Residual Controls, Residual Convergence Criteria.	

Post Processing: Visualization Tools: Contours, Streamlines, and Vectors, ISO-Surface and Cut Plane Visualization, Quantitative Analysis: Force, Drag, Lift, Data Export.

Self-Learning Topics:

Pressure Velocity Coupled Scheme

Learning Outcomes :

A learner will be able to

LO 5.1: Distinguish between pressure-based and density-based solvers and evaluate their applications in incompressible and compressible flow simulations. (PI 2.2.4)

LO 5.2: Combine fluid dynamics principles and engineering concepts to formulate suitable steady or transient time-stepping models and select turbulence approaches like RANS, LES, or DES based on applicability and accuracy. (PI 2.3.1)

LO 5.3: Identify convergence criteria and residual control parameters within engineering simulations to solve problems related to simulation accuracy. (PI 2.1.2)

LO 5.4: Validate CFD results through skilful use of visualization tools like contours, streamlines, and cut planes, and interpretation of quantitative data such as force, drag, and lift. (PI 2.4.4)

LO 5.5: A Task-Based Group Activity After MSE (Part III) (PI 1.3.1, PI 1.4.1, PI 2.1.2, PI 2.2.4, PI 2.3.1, PI 5.2.2, PI 6.4.2, PI 8.1.2, PI 9.1.2, PI 11.3.1)

Each group (max 4 students) will simulate and analyze fluid flow behavior over a 2D or 3D geometry using appropriate solvers and turbulence models. Students will apply pressure-based and/or density-based solvers, select steady or transient analysis, and evaluate aerodynamic quantities like drag and lift using post-processing tools.

Following aspects are to be addressed:

A. Problem Definition & Geometry Selection:
- *Choose a 2D airfoil (e.g., NACA 0012) or a 3D bluff body (e.g., cylinder, sphere).*
- *Define the objective: e.g., analyze drag at various flow speeds or investigate vortex shedding.*

B. Pre-Processing:
- *Create/import geometry in appropriate software module.*
- *Generate mesh (structured/unstructured) and perform mesh refinement study.*
- *Identify suitable boundary and initial conditions.*

C. Solver Setup:
- *Select pressure-based solver for subsonic flows or density-based for high-speed compressible flow.*
- *Use steady or transient time-stepping as appropriate.*
- *Choose and justify a turbulence model:*
- *(e.g., k-ε for general flow, k-ω SST for wall-bounded flows, LES/DES for unsteady separations).*

D. Solver Setup:
- *Select pressure-based solver for subsonic flows or density-based for high-speed compressible flow.*
- *Use steady or transient time-stepping as appropriate.*
- *Choose and justify a turbulence model:*
- *(e.g., k-ε for general flow, k-ω SST for wall-bounded flows, LES/DES for unsteady separations).*

E. Post-Processing:
- *Use contours, streamlines, vectors, ISO-surfaces, and cut planes for flow visualization.*
- *Extract quantitative data: lift, drag, pressure forces.*

	• *Export data for plotting and comparison.* F. *Post-Processing:* • *Use contours, streamlines, vectors, ISO-surfaces, and cut planes for flow visualization.* • *Extract quantitative data: lift, drag, pressure forces.* • *Export data for plotting and comparison.*	
06.	**Thermal Analysis**	**6-8**
	Learning Objective/s: *Demonstrate the ability to set up, solve, and analyze heat transfer and thermo-mechanical problems using appropriate numerical methods, solver settings, boundary conditions, and post-processing techniques*	
	Contents: ***Different modes of heat transfer:*** Conduction, Convection, and Radiation ***Steady-State and Transient Thermal Analysis:*** ***Elements:*** Solid, Shell, Line ***Material Properties:*** Thermal Conductivity, Specific Heat Capacity, Density, Emissivity ***Boundary Conditions:*** Convection, Radiation, Temperature, Heat Flux, Adiabatic ***Solver Selection:*** Steady-State, Transient Thermal ***Solver Settings:*** Initial Conditions, Time Step (for Transient), Convergence Criteria ***Post-Processing:*** Temperature Contours, Heat Flux Vectors, Thermal Gradients ***Thermo-Mechanical Coupling: Thermal Stresses and Expansion*** ***Elements:*** Solid, Shell ***Material Properties:*** Modulus of Elasticity, Modulus of Rigidity, Poisson's Ratio, Thermal Conductivity, Specific Heat Capacity, Density, Thermal Expansion Coefficient, Emissivity ***Boundary Conditions:*** Thermal Loads, Mechanical Loads ***Solver:*** Thermo-Mechanical ***Settings***: Temperature Dependent, Coupled Field Analysis, Convergence Criteria ***Post-Processing:*** Thermal Stress Contours, Displacement Plots, Thermal Strain	
	Self-Learning Topics: --	
	Learning Outcomes:	
	A learner will be able to *LO 6.1: Apply the fundamental modes of heat transfer-conduction, convection, and radiation-and evaluate their relevance in engineering applications. (PI 1.4.1)* *LO 6.2: Identify key material properties and parameters that influence thermal and thermos-mechanical behavior in engineering applications. (PI 2.1.2)*	

	LO 6.3: Differentiate between steady-state and transient thermal analyses, and identify appropriate boundary conditions, solver types, and settings for various thermal problems. (PI 2.3.1) *LO 6.4: Validate post-processing results such as temperature contours, heat flux vectors, and thermal gradients in thermal simulations. (PI 2.4.2)* *LO 6.5: Identify the mathematical, engineering, and relevant knowledge involved in thermo-mechanical coupling, including thermal loads and expansion, necessary for modeling thermal stress and strain using coupled field simulations. (PI 2.1.3)* *LO 6.6: A Task-Based Group Activity After MSE (Part IV) (PI 1.3.1, PI 2.1.2, PI 2.2.4, PI 2.3.1, PI 5.2.2, PI 6.4.2, PI 8.1.2, PI 9.1.2, PI 11.3.1)* *Each group (max 4 students) will simulate heat transfer and thermo-mechanical behavior of an engineering component under thermal loads using steady-state and transient analysis. Students will identify suitable boundary conditions, solver settings, and evaluate post-processing results to predict performance, deformation, and potential failure.* *Following aspects are to be addressed:* *A. Component Selection and Problem Definition:* • *Choose a real-world component (e.g., electronic chip, brake disc, exhaust manifold, turbine blade).* • *Define the operating environment, heat sources, and mechanical constraints.* *B. Pre-Processing:* • *Model or import geometry in appropriate software module.* • *Choose appropriate element type (solid or shell) and generate mesh.* • *Assign material properties, including temperature-dependent behavior.* *C. Thermal Analysis (Phase 1):* • *Apply steady-state and transient thermal boundary conditions: convection, radiation, heat flux, etc.* • *Select the correct thermal solver and configure time steps and convergence criteria.* • *Simulate and post-process: generate temperature contours, heat flux vectors, and thermal gradients.* *D. Thermo-Mechanical Analysis (Phase 2):* • *Use temperature results as input for coupled field analysis.* • *Apply mechanical boundary conditions (fixed supports, pressure loads).* • *Define thermal expansion coefficients and temperature-dependent material properties.* • *Run the simulation and post-process: obtain thermal stress contours, displacement plots, and thermal strain.* *E. Report and Presentation:* • *Document the problem, methodology, simulation settings, results, and conclusions in a formal report.* • *Create a presentation summarizing key results, visualizations, and insights.*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.2.1	Apply laws of natural science to an engineering problem.

1.3.1 Apply fundamental engineering concepts to solve engineering problems.

1.4.1 Apply Mechanical engineering concepts to solve engineering problems.

2.1.1 Articulate problem statements and identify objectives

2.1.2 Identify engineering systems, variables, and parameters to solve the problems.

2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem

2.2.4 Compare and contrast alternative solution processes to select the best process.

2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.

2.4.1 Apply engineering mathematics and computations to solve mathematical models.

2.4.2 Produce and validate results through skilful use of contemporary engineering tools and models.

2.4.3 Identify sources of error in the solution process, and limitations of the solution.

2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.

5.2.2 Demonstrate proficiency in using discipline-specific tools.

6.4.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.

8.1.2 Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.

9.1.2 Produce clear, well-constructed, and well-supported written engineering documents.

11.3.1 Source and comprehend technical literature and other credible sources of information.

Course Outcomes: A learner will be able to -

1. Analyse the fundamental principles and applications of Computer-Aided Engineering (CAE) tools across structural, thermal, and fluid domains. *(LO 1.1, LO 1.2, LO 1.4, LO 4.1, LO 6.1)*

2. Apply appropriate modelling techniques, material properties, and symmetry concepts to improve simulation accuracy and computational efficiency in CAE. *(LO 1.3, LO 1.5, LO 1.6, LO 4.3, LO 6.2)*

3. Evaluate and implement boundary conditions, solver settings, and element types in structural, dynamic, thermal, and CFD analyses. *(LO 2.2, LO 2.3, LO 2.4, LO 3.2, LO 3.3, LO 4.5, LO 5.1, LO 5.2, LO 6.3)*

4. Analyse solver methodologies such as static, dynamic, and thermal solvers, and assess time-stepping, turbulence modelling, and convergence strategies for accurate simulations. *(LO 2.1, LO 3.1, LO 5.2, LO 5.3, LO 6.3, LO 6.5)*

5. Interpret and analyse post-processing results from structural, CFD, and thermal simulations to support engineering decisions. *(LO 2.5, LO 3.4, LO 5.4, LO 6.4)*

6. Collaborate in task-based activities to solve multidisciplinary engineering problems using CAE tools, demonstrating teamwork, communication, and technical skills. *(LO 2.6, LO 3.5, LO 5.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPE5012.1	3	3	--	--	--	--	--	--	--	--	--
MEPE5012.2	3	3	--	--	2	2	--	2	2	--	2
MEPE5012.3	3	3	--	--	2	2	--	2	2	--	2
MEPE5012.4	3	3	--	--	--	--	--	--	--	--	--
MEPE5012.5	3	3	--	--	2	2	--	2	2	--	2
MEPE5012.6	3	3	--	--	2	2	--	2	2	--	2
Average	**3**	**3**	--	--	**2**	**2**	--	**2**	**2**	--	**2**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. S. S. Rao, The Finite Element Method in Engineering, 6th Edition, Butterworth-Heinemann, 2018.
2. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
3. R. K. Mittal, Computational Fluid Dynamics, 1st Edition, Cengage Learning India, 2015.
4. M. D. Raisinghani, Computational Fluid Dynamics, 1st Edition, Narosa Publishing House, 2007.
5. John D. Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, 1st Edition, McGraw-Hill, 1995.
6. Rainald Löhner, Applied Computational Fluid Dynamics Techniques, 1st Edition, Springer, 2008.
7. Olek C. Zienkiewicz, Robert L. Taylor, Jianzhong Zhu, The Finite Element Method: Its Basis and Fundamentals, 7th Edition, Butterworth-Heinemann, 2013.
8. J. N. Reddy, An Introduction to the Finite Element Method, 4th Edition, McGraw-Hill Education, 2019.

Reference Books :

1. O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method: Its Basis and Fundamentals, 7th Edition, Elsevier, 2013.
2. Klaus-Jürgen Bathe, Finite Element Procedures, 2nd Edition, Prentice Hall, 2014.
3. David Hutton, Fundamentals of Finite Element Analysis, 1st Edition, McGraw-Hill, 2004.

4. H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson, 2007.
5. S. S. Rao, The Finite Element Method in Engineering, 6th Edition, Butterworth-Heinemann, 2018.
6. Joel H. Ferziger, Milovan Perić, Robert L. Street, Computational Methods for Fluid Dynamics, 4th Edition, Springer, 2020.
7. Daryl L. Logan, A First Course in the Finite Element Method, 6th Edition, Cengage Learning, 2016.

Other Resources :

1. NPTEL Course: Finite Element Analysis
   Web link: https://nptel.ac.in/courses/112/101/112101115/
2. NPTEL Course: Introduction to Computational Fluid Dynamics
   Web link: https://nptel.ac.in/courses/101/104/101104013/
3. NPTEL Course: Computer Methods in Mechanics
   Web link: https://nptel.ac.in/courses/112/106/112106317/
4. NPTEL Course: Computational Fluid Dynamics
   Web link: https://nptel.ac.in/courses/112/106/112106142/
5. NPTEL Course: Numerical Methods and Computational Techniques
   Web link: https://nptel.ac.in/courses/111/105/111105071/
6. NPTEL Course: Structural Analysis
   Web link: https://nptel.ac.in/courses/105/105/105105071/
7. NPTEL Course: Product Design & Manufacturing using CAE
   Web link: https://nptel.ac.in/courses/112/103/112103174/
8. NPTEL Course: Finite Element Analysis
   Web link: https://nptel.ac.in/courses/112/101/112101022/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
A task based group activity, before MSE. (Part I)	:	05 Marks
A task based group activity, after MSE. (Part II)	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC5013	COMPUTATIONAL FLUID DYNAMICS	03

<table>
<tr><th colspan="6">Examination Scheme</th></tr>
<tr><th colspan="3">Distribution of Marks</th><th colspan="2" rowspan="2">Exam Duration (Hrs.)</th><th rowspan="3">Total Marks</th></tr>
<tr><th colspan="2">In-semester Assessment</th><th rowspan="2">End Semester Examination (ESE)</th></tr>
<tr><th>Continuous Assessment</th><th>Mid-Semester Exam (MSE)</th><th>MSE</th><th>ESE</th></tr>
<tr><td>20</td><td>30</td><td>50</td><td>1.5</td><td>2</td><td>100</td></tr>
</table>

Pre-requisite:

1. BSC102- Engineering Physics-I
2. BSC205- Engineering Physics-II
3. MEPCC304-Thermodynamics
4. MEPCC407 – Thermal Engineering
5. MEPCC510 – Fluid Mechanics and Machinery

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and the World
7. PO11: Life-Long Learning

Course Objectives:

1. To acquaint with the fundamentals and applications of Computational Fluid Dynamics (CFD) in engineering.
2. To inculcate the significance of governing equations like the Navier-Stokes equations and numerical methods (FVM, FDM, FEM).
3. To impart skills in pre-processing, solver setup, and post-processing within the CFD workflow.
4. To inculcate the usage of CFD tools like ANSYS Fluent/CFX for practical and research-oriented applications.

Module	Details	Hrs.
	Course Introduction This course covers the basics of Computational Fluid Dynamics (CFD), including Navier-Stokes equations and numerical methods like Finite Volume and Finite Element. Students will learn grid generation, mesh quality, and element selection using tools like Design Modeller. Key topics include turbulence modeling, multiphase flow, and combustion. By the end, students will be able to simulate and analyze fluid dynamics in engineering applications.	**01**
01.	**Introduction to Computational Fluid Dynamics**	**5-7**
	Contents: Basics of CFD and its Applications, Governing Equations of Fluid Flow: Navier-Stokes Equations, Numerical Methods in CFD (Finite Volume,	

	Finite Difference, Finite Element Methods), Role of Pre-processing, Solvers, and Post-processing in CFD Workflow	
	Self-Learning Topics: *Different tools/software available for CFD simulations.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply numerical methods to solve fluid dynamics problems related to various engineering field. (P.I.-1.1.1)* *LO 1.2: Apply advanced mathematical techniques to model and solve mechanical engineering problems. (P.I.-1.1.2)* *LO 1.3: Identify the various numerical model and its relevance with respect to engineering problem. (P.I.-2.1.3)* *LO 1.4: Compare various numerical model based on real life application. (P.I.-2.2.4)*	
02.	**Essentials of CFD Tools** ***Learning Objective:*** *To comprehend the features and workflow, and Design Modeller/SpaceClaim.*	**5-7**
	Contents: Introduction to Computational tools and Design Modeller/Space Claim, Types of Elements (1D, 2D, 3D and surface), Selection of elements according to specific application, Grid Generation and Mesh Types (Structured, Unstructured, Hybrid), Mesh Quality Metrics and Refinement Techniques, Introduction to Boundary Conditions and Initial Conditions.	
	Self-Learning Topics: *Comparative simulation analysis between different software.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply the concepts of boundary and initial conditions in numerical simulations. (1.2.1)* *LO 2.2: Identify and differentiate between various types of elements (1D, 2D, 3D, and surface) and their applications in simulations. (P.I.-2.1.3)* *LO 2.3: Analyze grid generation, mesh quality assessment, and refinement techniques. (5.2.2)* *LO 2.4: Analyze the features of ANSYS Fluent, CFX, and Design Modeller/Space Claim and their relevance in engineering design. (P.I.-5.2.2)*	
03.	**Solver Setup and Solution Techniques** ***Learning Objective:*** *To inculcate the process of setting up solvers for computational simulations, including the selection of appropriate physical and turbulence models.*	**5-7**
	Contents: Selection of Physical Models (Single-phase, Multiphase, Heat Transfer, etc.), Turbulence Models (k-epsilon, k-omega, SST) and Their Applications, Pressure and Velocity Coupling Schemes (SIMPLE, PISO), Convergence Criteria and Residual Monitoring.	

	Self-Learning Topics: *solver efficiency across different CFD platforms like ANSYS Fluent, OpenFOAM, and COMSOL*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Identify turbulence models (k-epsilon, k-omega, SST) and their application in solving practical fluid dynamics problems. (P.I.-2.1.3)* *LO 3.2: Identify and select appropriate physical models for various types of fluid flow simulations. (P.I.-2.2.2)* *LO 3.3: Identify convergence criteria and residuals to ensure the accuracy and reliability of simulation results. (P.I.-3.2.3)* *LO 3.4: Apply pressure and velocity coupling schemes effectively to achieve stable and accurate solutions. (P.I.-3.3.1)*	
04.	**Post-Processing Techniques** ***Learning Objectives:*** *To acquaint with visualization tools in analyzing simulation results, including contours, streamlines, and vectors.*	**5-7**
	Contents: Visualization Tools: Contours, Streamlines, and Vectors, ISO-Surface and Cut Plane Visualization, Quantitative Analysis: Force, Drag, Lift, and Heat Transfer Coefficients, Data Export and Comparison with Experimental Results.	
	Self-Learning Topics: ***Case studies demonstrating the use of visualization tools in*** *aerospace, automotive, and biomedical engineering*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Identify visualization tools like contours, streamlines, and vectors to interpret fluid flow behavior effectively. (P.I.-2.2.2)* *LO 4.2: Identify various techniques for ISO-surface and cut-plane visualization to study complex fluid flows. (P.I.-2.2.3)* *LO 4.3: Visualize tools like contours and streamlines help identify inefficiencies and potential risks in fluid flow and thermal systems, aiding in sustainable design improvements. (P.I.-6.3.1)* *LO 4.4: Understand quantitative analysis results, including force, drag, lift, and heat transfer coefficients, to determine the sustainability and practicality of engineering designs. (P.I.-6.3.2)*	
05.	**Multiphase and Transient Analysis in ANSYS Fluent** ***Learning Objective/s:*** *To inculcate the fundamental approaches to simulating multiphase flows using Volume of Fluid (VOF) and Eulerian models.*	**4-6**
	Contents: Multiphase Flow Simulation: Volume of Fluid (VOF) and Eulerian Models, Transient Analysis for Unsteady Flow Problems, Free Surface Flow and Phase Change Simulations, Applications: Bubble Dynamics, Sloshing, and Phase Change	
	Self-Learning Topics: *Case study on multiphase and transient flow.*	

	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply multiphase and transient simulation techniques to solve practical engineering problems. (P.I.-1.2.1)* *LO 5.2: Identify free surface flows and phase change phenomena for applications such as sloshing and bubble dynamics. (P.I.-2.2.2)* *LO 5.3: Compare Volume of Fluid (VOF) and Eulerian models to simulate multiphase flows in engineering applications. (P.I.-2.2.4)*	
06.	**Combustion and Optimization in Computational Tool** ***Learning Objective/s:*** *To impart the principles of combustion modelling, including premixed, non-premixed, and partially premixed models.*	**4-6**
	Contents: Combustion Modelling: Premixed, Non-Premixed, and Partially Premixed Models, Chemical Reaction Mechanisms and Species Transport, Parametric Studies and Optimization using Design-Xplorer in ANSYS, Automation of CFD Workflows with User-Defined Functions (UDFs)	
	Self-Learning Topics: *Combustion and optimization in CFD using different solver.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify the effectiveness and applications of various numerical methods for solving fluid motion equations. (P.I.-3.2.3)* *LO 6.2: Apply grid generation techniques, such as algebraic and elliptic methods, to solve fluid dynamics problems. (P.I.-3.3.1)* *LO 6.3: Understanding different combustion modeling approaches (premixed, non-premixed, partially premixed) ensures engineers stay updated on advanced simulation techniques, reinforcing the need for continuous professional development. (P.I.-11.1.1)* *LO 6.4: Identify chemical reaction mechanisms and species transport which allows engineers to recognize gaps in combustion modeling and use credible sources to improve simulation accuracy. (P.I.-11.1.2)*	
	Course Conclusion Students will gain understanding of CFD principles and practical applications. They will be skilled in numerical methods, CFD workflows, and using software tools for simulations. The course covers advanced topics like multiphase flows and combustion modeling. Graduates will be prepared to solve complex fluid flow problems and optimize designs.	**01**
	Total	**45**

Performance Indicators:

P.I. No. **P.I. Statement**

1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.

1.1.2 Apply advanced mathematical techniques to model and solve mechanical engineering problems.

1.2.1 Apply laws of natural science to an engineering problem.

2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem

2.2.2 Identify, assemble and evaluate information and resources

2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.

2.2.4 Compare and contrast alternative solution processes to select the best process.

2.4.3 Identify sources of error in the solution process, and limitations of the solution.

3.2.3 Identify suitable criteria for the evaluation of alternate design solutions

3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development.

5.2.2 Demonstrate proficiency in using discipline-specific tools.

6.3.1 Identify risks/impacts in the life-cycle of an engineering product or activity

6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability

11.1.1 Describe the rationale for the requirement for continuing professional development

11.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

Course Outcomes: A learner will be able to -

1. Apply fundamental principles of Computational Fluid Dynamics (CFD) and numerical methods (FVM, FDM, FEM) to solve fluid flow problems. (*LO 1.1, LO 1.2,LO 1.3, LO1.4*)
2. Analyse mesh quality and assess mesh refinement techniques to improve simulation accuracy. (*LO 2.1, LO 2.2,LO 2.3, LO 2.4*)
3. Identify various numerical model and its application in simulation. (*LO 1.3, LO 1.4, LO 3.1, LO 3.2, LO 3.3, LO 3.4*)
4. Analyze CFD simulation results using post-processing techniques such as contour and streamlines to evaluate the thermal performance. (*LO 3.3, LO 3.4, LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
5. Analyze transient multiphase flow problem and combustion modelling. (*LO 5.1, LO 5.2, LO 5.3, LO 6.1, LO 6.2, LO 6.3, LO 6.4*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC5013.1	3	3	--	--	--	--	--	--	--	--	--
MEPEC5013.2	2	2	--	--	2	--	--	--	--	--	--
MEPEC5013.3	--	3	3	--	--	--	--	--	--	--	--
MEPEC5013.4	--	3	3	--	--	3	--	--	--	--	--

MEPEC5013.5	2	3	3	--	--	--	--	--	--	--	3
Average	**2**	**3**	**3**	**--**	**2**	**3**	**--**	**--**	**--**	**--**	**3**

Text Books :

1. Introduction to Computational Fluid Dynamics by H.K. Versteeg and W. Malalasekera.
2. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, Hemisphere Publishing Company.
3. Computational Fluid Dynamics by T.J. Chung, Cambridge University Press 2003
4. Computational fluid flow and heat transfer by K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.
5. An Introduction to Computational Fluid Dynamics by Versteeg, H.K. and Malalasekara, W., , Pearson Education, 2010.

Reference Books :

1. Computational fluid dynamics by J.A. Anderson, McGraw-Hill Publications 1995
2. Computational fluid mechanics and heat transfer by D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications 2002
3. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H. Versteeg and W. Malalasekera
4. Computational Fluid Dynamics by T.J. Chung. 2002

Other Resources :

1. NPTEL Managed by IITs and IISC
2. OpenCourseWare (MIT, TUDelft, Yale University, edX, Coursera etc.)
3. Research papers and Discussion forums (researchgate, academia.edu)

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

Numerical Assignments (Minimum 20 problems): 5 marks

Class test based on above Numerical assignment: 5 marks

A task based on group activity: 5 marks

Regularity and active participation: 5 marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	MELBC506	MECHANICAL VIBRATIONS LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite:

1. MEPCC302: Mechanics of Solids
2. MEPCC406: Theory of Machines

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO8: Individual and collaborative team work
6. PO9: Communication

Course Objectives:

1. To familiarize students with the measurement and analysis of vibrational characteristics in mechanical systems.
2. To impart practical skills in using vibration analysis tools and techniques.
3. To enable students to validate theoretical concepts through experimental work.
4. To familiarize students with the measurement and analysis of vibrational characteristics in mechanical systems.

Module	**Details**	Hrs.
	Course Introduction The Mechanical Vibrations Laboratory is a practical course designed to complement the theoretical concepts of mechanical vibrations. It aims to provide hands-on experience in analyzing and interpreting the vibrational behavior of mechanical systems. Students will perform experiments to measure natural frequencies, damping ratios, and resonance conditions in various systems, including spring-mass setups, beams, and torsional shafts.	
01.	**Free Vibration Analysis** ***Learning Objective:*** *To impart fundamental concepts of free vibrations and analyze the dynamic behavior of mechanical systems for practical engineering applications.*	**08**

	Self-Learning Topics: *Fundamentals and basic concepts of vibrations.*	
	Theme for conducting Experiment: 1. Determination of the radius of gyration using a bi-filar and trifilar system. ***Learning Outcome:*** *A learner will be able to* *LO 1.1: Model and analyze bifilar and trifilar suspension systems to determine the moment of inertia of mechanical components, perform team-based experimentation, and communicate results effectively using technical documentation. (P.I. 2.3.1, 4.3.1, 8.1.2, 9.1.2)*	
	Theme for conducting Experiment: 2. Determination of natural frequency in a longitudinal vibrating system ***Learning Outcome:*** *A learner will be able to* *LO 1.2: Apply Newton's law to mathematically model longitudinal vibrations in single and multiple spring systems, determine equivalent stiffness and natural frequency analytically and experimentally, while working collaboratively to conduct tests, interpret results, and present technical findings through well-structured reports and presentations.(PI 1.1.2, PI 2.3.1, PI 4.1.4, PI 8.1.2, PI 9.1.2)*	
	Theme for conducting Experiment: 3. Determination of natural frequency of undamped torsional vibration of a single and two rotor shaft system. ***Learning Outcome:*** *A learner will be able to* *LO 1.3: Use analytical techniques and experimental procedures to evaluate the natural frequency of undamped torsional vibrations in single and dual-rotor systems, while functioning as a team to document and present results effectively.(PI 1.4.1, PI 2.1.3, PI 4.3.1, PI 8.1.2, PI 9.1.2)*	
02.	**Forced Vibration Analysis** ***Learning Objective:*** *To introduce fundamental concepts of vibration analysis and dynamics to investigate the dynamic behavior of forced vibration systems using appropriate experimental approaches and tools.*	**06**

	Self-Learning Topics: *Fundamentals of forced vibration and computational method*	
	Theme for conducting Experiment: 1. To study the forced vibration of the beam with different boundary conditions. ***Learning Outcome:*** *A learner will be able to* *LO 2.1: Apply Newton's law and vibration theory to model and analyze forced vibration responses of beams under varying boundary conditions, determine damping behavior using analytical and experimental methods, while working collaboratively to interpret data and communicate results through technical documentation and presentations.(PI 1.1.2, PI 2.3.1, PI 4.3.1, PI 8.1.2, PI 9.1.2)*	
	Theme for conducting Experiment: 2. Determination of force transmissibility ratio in a forced vibration system. ***Learning Outcome:*** *A learner will be able to* *LO 2.2: Use appropriate vibration analysis techniques to determine the force transmissibility ratio in a forced vibration system, interpret system behavior across varying excitation frequencies, and validate theoretical predictions with experimental observations.(PI 1.1.2, PI 2.1.3,PI 2.4.4, PI 4.3.1)*	
03.	**Damped Vibration Analysis** ***Learning Objective:*** *To get acquainted with theoretical and experimental techniques to analyse damped vibrations and estimate the damping coefficient in mechanical systems.*	**06**
	Self-Learning Topics: *Fundamentals and basic concepts of vibrations and damping methods.*	
	Theme for conducting Experiment: 1. Analysis of damped torsional vibration in a single rotor system for damping coefficient estimation. ***Learning Outcome:*** *A learner will be able to* *LO 3.1: Analyze damped torsional vibration in single rotor systems using theoretical models and experimental techniques to estimate damping coefficients, validate dynamic behavior through time-*	

	response data, and collaboratively present accurate conclusions through effective documentation and presentations. (PI 1.1.2, PI 2.3.1, PI 4.1.4, PI 8.1.2, PI 9.1.2)	
04.	**Modern Tools & Computational Analysis** ***Learning Objective:*** *Apply experimental and simulation-based techniques to analyse vibration characteristics of beams under various boundary conditions.*	**06**
	Self-Learning Topics: *Fundamentals and basic concepts of vibrations and basic knowledge of computation methods.*	
	Theme for conducting Experiment: 1. Experimental investigation of free vibration characteristics of a beam using modal testing with an impact hammer. ***Learning Outcome:*** *A learner will be able to* *LO 4.1:Use experimental modal analysis techniques with modern instrumentation (e.g., impact hammer and data acquisition systems) to determine natural frequencies and mode shapes of beams under various boundary conditions, and collaborate effectively to analyze results and document findings through technical reports.(PI 2.4.1, PI 4.1.3,PI 4.3.1, PI 5.2.2, PI 8.1.2, PI 9.1.2)*	
	Theme for conducting Experiment: 2. Simulation-based vibration Analysis of Beams with Various Boundary Conditions using a computational method. ***Learning Outcome:*** *A learner will be able to* *LO 4.2: Apply computational tools to simulate free vibration behavior of beams with different boundary conditions, interpret simulation results to extract mode shapes and natural frequencies, and document outcomes through collaborative reporting and technical presentations.(PI 2.3.1, PI 4.1.3, PI 4.3.1, PI 5.2.2, PI 8.1.2, PI 9.2.2)*	
05.	**Static and Dynamic balancing** ***Learning Objective:*** *To get acquainted with theoretical and experimental principles of static and dynamic balancing and determine the optimal position and magnitude of counterweights in rotating systems.*	**04**
	Self-Learning Topics: *Length diagram, force polyfon and couple polygon*	

	Theme for conducting Experiment: 1. Experimental determination of counterweight position for static and dynamic balancing of rotating masses ***Learning Outcome:*** *A learner will be able to* *LO 5.1:Analyze static and dynamic balancing of rotating masses using theoretical and experimental approaches, compute the magnitude and angular position of counterweights, and work collaboratively to conduct tests and communicate findings through structured technical documentation.* *(PI 1.1.2, PI 1.4.1, PI 2.1.2, PI 2.1.4, PI 4.1.3, PI 4.3.1, PI 8.1.2, PI 9.1.2)*	
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.4 (new PI)	Desired inferences need to be drawn from graphical tools/representations of engineering quantities of mechanism.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
5.2.2	Demonstrate proficiency in using discipline-specific tools.

8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents

Course Outcomes: A learner will be able to -

1. Evaluate the dynamic response of undamped vibration systems under different excitation conditions. *(LO 1.1, LO 1.2, LO 1.3, LO 2.1, and LO 2.2)*
2. Analyse the response of mechanical systems with damping technique. *(LO 3.1)*
3. Use modern engineering tools to capture and analyse vibration data of the mechanical system. (*LO 4.1 and LO 4.2)*
4. Determine counterweight positions for effective static and dynamic balancing of rotating systems. *(LO 5.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC506.1	3	3	--	3	--	--	--	2	2	--	--
MELBC506.2	2	2	--	2	--	--	--	2	2	--	--
MELBC506.3	--	3	--	3	2	--	--	2	2	--	--
MELBC506.4	3	3	--	3	3	--	--	2	2	--	--
Average	**3**	**3**	--	**3**	**3**	--	--	**2**	**2**	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Engineering Vibrations, Daniel J. Inman., 3rd Edition, 2009 Pearson Education.
2. Mechanical Vibrations, G. K. Groover , 8th Edition, 2009 Nem Chand & Bros.
3. Mechanical Vibrations, Singiresu S. Rao, 6th Edition, 2018 Pearson Education.

Reference Books :

1. Introductory Course on Theory and Practice of Mechanical Vibration, Rao, J.S. and Gupta, K., 2004, New Age International Pvt. Ltd.
2. Theory of Vibration with Applications, Thomson, W.T., 1990, CBS Publishers, New Delhi

Other Resources :

1. [NPTEL :: Mechanical Engineering - Mechanical Vibrations](https://archive.nptel.ac.in/courses/112/103/112103111/)
   https://archive.nptel.ac.in/courses/112/103/112103111/

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment (25 Marks)

Performance based on experiment (Marks will be awarded to students based on experiment performance with proper understanding)	:	15 Marks
An oral will be conducted based on each experiment	:	05 Marks
Regularity and Active Participation	:	05 Marks

END SEMESTER EXAMINATION (25 MARKS)

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to write appropriate procedure, observation and observation table if required for the same. The experiment procedure is checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- The students will be allocated 1 hour to complete the execution. The students are required to perform the given experiment complete calculation and draw graph if required. Then students required to write conclusion and inferences drawn from results. The experimental performance will be checked by both the examiners for its correctness. The weightage is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

  Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	MELBC507	FLUID MECHANICS & MACHINERY LABORATORY	02

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite:

1. ESC101 Engineering Mechanics
2. PCC301 Engineering Mathematics-III

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO6: The Engineer and The World
5 PO8: Individual and Collaborative teamwork.

Course Objectives:

1. To analyze fluid properties, dynamics, and flow phenomena for effective engineering design and analysis.
2. To acquaint with the implementation of the continuity equation, discharge flow calculations, major and minor losses in pipes, and the concept of hydraulic gradient energy.
3. To familiarize with the performance characteristics of pumps and turbines through theoretical understanding and practical applications.

Module	Details	Hrs.
	Course Introduction This course aims to develop a strong foundation in fluid mechanics and hydraulic machinery, essential for analyzing and designing mechanical engineering systems. Students will comprehend fluid behavior, differentiate flow patterns, and evaluate forces acting on moving fluids. The course will also examine hydraulic turbines, pumps, and pumping systems, analyze their characteristics, and assess cavitation effects and pipe losses. By the end of this course, students will be able to apply these concepts to optimize fluid transport systems in various engineering applications.	**01**
01.	**Fluid Mechanics** ***Learning Objective:*** - *To demonstrate Bernoulli equation and its application to measurement of flow using different equipment.* - *To introduce various types of pipe losses and guide the analysis of velocity profiles in a pipe.*	**09**

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Contents:

Experiment:

1. Verification of Bernoulli's Equation
2. Determination the friction factor in Pipes
3. Determination of major and minor losses in Pipe systems

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Self-Learning Topics:

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Learning Outcomes:

A learner will be able to

LO 1.1: Apply mathematical and scientific principles to analyze and validate Bernoulli's equation, interpreting its practical implications in fluid flow systems. (PI 1.1.1, 1.2.1, 2.1.1, 2.3.1, 4.1.1, 6.1.1)

LO 1.2: Apply fluid mechanics principles to evaluate and compare Bernoulli's equation in different pipe flow conditions, considering energy loss and system efficiency. (PI 1.3.1, 1.4.1, 2.2.3, 2.3.2, 4.1.3, 6.1.2)

LO 1.3: Identify and analyze the factors influencing friction factor and flow losses in pipe systems, and compare different approaches for loss minimization. (PI 2.1.2, 2.2.4, 4.3.1, 6.2.1)

LO 1.4: Conduct investigations to determine major and minor losses in pipe systems, validate results through experimental data, and compare with theoretical models. (PI 1.3.1, 2.3.1, 4.1.1, 4.3.2, 6.2.3)

LO 1.5: Assess the impact of fluid flow efficiency on energy conservation and sustainable pipeline design, incorporating ethical and environmental considerations. (PI 4.3.4, 6.1.3, 8.1.1, 8.2.1)

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02.

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Hydraulic Machinery

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20

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Learning Objectives:

- *Apply various techniques to enhance the performance of turbo machines and analyze their practical applications.*
- *Describe the characteristics, components, and working principles of pumps and hydraulic turbines, and differentiate between various types of turbines.*

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Contents:

Experiments:

1. Trial on centrifugal pump
2. Trial on reciprocating pump.
3. Trial on Impulse turbine (Pelton Wheel Turbine)
4. Trial on Reaction turbine (Francis Turbine)

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Self-Learning Topics:

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Learning Outcomes:

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A learner will be able to.

LO 2.1: Apply fluid mechanics and thermodynamic principles to evaluate the performance of centrifugal and reciprocating pumps, and turbines. (PI 1.3.1, 1.4.1, 2.1.1, 2.3.1, 4.1.1, 6.1.1)

LO 2.2: Identify and analyze factors influencing the efficiency and performance of pumps and turbines under varying operating conditions. (PI 2.1.2, 2.2.4, 4.3.1, 6.2.1)

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</table>

	LO 2.3: Conduct experiments to measure and validate the performance of impulse and reaction turbines, and interpret results for optimization. (PI 1.3.1, 2.3.1, 4.1.1, 4.3.2, 6.2.3) *LO 2.4: Investigate the energy transfer process in an impulse turbine and assess its efficiency through experimental trials. (PI 4.3.4, 6.1.3, 8.1.1, 8.2.1)* *LO 2.5: Evaluate the impact of efficient pump and turbine designs in minimizing energy consumption and promoting sustainable water management. (PI 4.3.4, 6.1.3, 8.1.1, 8.2.1)* *LO 2.6: Analyze the sustainability and energy efficiency of reaction turbines in hydraulic power generation applications. (PI 6.1.3, 6.2.3, 8.1.1, 8.2.1)*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.2.1	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
4.1.1	Define a problem, its scope and importance for purposes of investigation.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations.
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.

6.1.2	Identify risks/impacts in the life-cycle of an engineering product or activity.
6.1.3	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.2.3	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.

Course Outcomes: A learner will be able to -

1. Apply fundamental fluid mechanics and thermodynamic principles to analyze Bernoulli's equation, flow patterns, and energy losses in pipe networks for practical engineering applications. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5*)
2. Identify, calculate, and evaluate major and minor losses in piping systems by conducting experiments and validating results with theoretical models to optimize fluid transport efficiency. *(LO1.2, LO 1.3, LO 1.4, LO 1.5)*
3. Analyze and assess the performance of pumps under varying operating conditions by investigating efficiency factors, energy losses, and sustainability considerations in fluid flow systems. *(LO 2.1, LO 2.2, LO 2.5)*
4. Investigate, evaluate, and optimize the performance of impulse and reaction turbines by conducting experiments, analyzing energy transfer processes, and assessing sustainability in hydraulic power generation. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC507.1	3	3	--	3	--	3	--	3	--	--	--
MELBC507.2	3	3	--	3	--	3	--	3	--	--	--
MELBC507.3	3	3	--	3	--	3	--	3	--	--	--
MELBC507.4	3	3	--	3	--	3	--	3	--	--	--
Average	**3**	**3**	--	**3**	--	**3**	--	**3**	--	--	--

Text Books :

1. Introduction to Fluid Mechanics & Fluid Machines – Som Biswas, Chakraborty, TMH.
2. Fluid Mechanics & Machinery – R. K. Bansal, Luxmi Publications.
3. Fluid Mechanics & Machinery – C.S.P Ojha, R. Berndtsson, P.N. Chandramouli

Reference Books :

1. Introduction to Fluid Mechanics – Fox & Macdonald, Wiley
2. Fluid Mechanics – Fundamentals & Applications – Cengel & Cimbala, TMH.
3. Fluid Mechanics and Fluid Power Engineering by D S Kumar, S K Kataria & Sons

Other Resources :

1. Virtual Labs: https://eerc03-iiith.vlabs.ac.in/List%20of%20experiments.html

IN-SEMESTER ASSESSMENT (50 MARKS)

Continuous Assessment (25 Marks)

Performance based on experiment (Marks will be awarded to students based on experiment performance with proper understanding)	:	15 Marks
An oral will be conducted based on each experiment	:	05 Marks
Regularity and Active Participation	:	05 Marks

END SEMESTER EXAMINATION (25 MARKS)

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to write appropriate procedure, observation and observation table if required for the same. The experiment procedure is checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- The students will be allocated 1 hour to complete the execution. The students are required to perform the given experiment complete calculation and draw graph if required. Then students required to write conclusion and inferences drawn from results. The experimental performance will be checked by both the examiners for its correctness. The weightage is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	MELBC508	COMPUTATIONAL LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite :

1. MEPCC301 - Engineering Mathematics-III
2. MEPCC302 - Mechanics of Solids
3. MEPCC407 - Thermal Engineering

Program Outcomes addressed :

1. PO2: Problem analysis
2. PO3: Design/development of solutions
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO8: Individual and Collaborative Team work
6. PO9: Communication

Course Objectives:

1. Equip students with a solid understanding of FEA and CFD principles, focusing on geometry creation, meshing, boundary conditions, and solver settings.
2. Guide students through the application of meshing techniques to ensure accurate and reliable simulation results.
3. Provide hands-on experience with industry standard tools for various analyses, including static, modal, thermal, transient, and fluid flow.
4. Familiarize students to the post-processing techniques in order to analyse and validate simulation results and further optimize designs.

Module	Detailed Contents	Hrs
	Course Introduction This course introduces students to the fundamentals of Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) using industry standard software. Students will learn to create geometry, generate meshes, set boundary conditions, and configure solvers. Through practical tasks, they will perform static, modal, thermal, and fluid flow analyses for various engineering problems. The course emphasizes understanding mesh quality, analysing simulation results, and applying post-processing techniques to evaluate stress, deformation, and flow performance. By the end, students will be equipped to use software based tools to solve real-world problems and optimize engineering designs.	**01**

<table>
<tr><td rowspan="5">01.</td><td>Learning Objective/s:
To utilize appropriate software for geometry creation, meshing, and boundary conditions, while ensuring suitable element selection and mesh quality for static structural analysis.</td><td rowspan="5">07</td></tr>
<tr><td>To get acquainted to Essentials of FEA covering the following topics:
Introduction to FEA Software Interface and Geometry Modelling Tools
Types of Elements in FEA (1D, 2D, 3D, Difference between surface elements and solid elements)
Selection of Element Types
Understanding Mesh Quality Metrics
Defining Boundary Conditions (Supports, Loads) and Material Properties</td></tr>
<tr><td>Tasks:
i. 2D/3D geometry creation using industry standard geometry modelling tool.
ii. Generation of solid and surface elements.
iii. Generation of structured and unstructured mesh for a 1D and 2D element.
iv. Meshing and element size refinement for a 2D/3D solid object (e.g., bracket or plate).
v. Setting up boundary conditions and loads for a static structural analysis.</td></tr>
<tr><td>Self-Learning Topics:
Advanced Mesh Refinement and Optimization in ANSYS for accurate Structural Analysis.</td></tr>
<tr><td>Learning Outcomes :
A learner will be able to
LO 1.1: Apply suitable industry standard modelling tool for geometry creation and model setup. (PI 3.1.1, PI 5.1.1, PI 5.2.1, PI 9.3.1)
LO 1.2: Identify and select appropriate FEA element types for various analysis scenarios. (PI 2.3.1, PI 4.1.4, PI 5.2.1, PI 8.2.1)
LO 1.3: Create mesh and validate mesh quality metrics for accurate simulations. (PI 2.4.2, PI 4.3.3, PI 5.3.2, PI 9.1.1)
LO 1.4: Apply boundary conditions and material properties to engineering models to solve structural analysis problems. (PI 2.3.1, PI 2.4.4, PI 3.3.1, PI 8.3.1)</td></tr>
<tr><td rowspan="2">02.</td><td>Learning Objective/s:
To explore solver settings for static, modal, thermal, and transient analyses, and perform post-processing to interpret stress, deformation, and safety factors.</td><td rowspan="2">08</td></tr>
<tr><td>To apply the FEA based commercial software package in order to solve problems covering the following topics:
Types of Solvers and Solver Settings
Analysis Types: Static, Modal, Thermal, and Transient
Convergence criteria
Post-Processing: Stress Distribution, Deformation, Factor of Safety, Iso-surface and Contour Visualization</td></tr>
</table>

	Tasks: i. Static structural analysis of a stepped bar. ii. Modal analysis to determine the natural frequencies of a simple structure (e.g., a bridge or plate). iii. Structural buckling analysis of a slender column under axial compression. iv. Stress analysis of a pressure vessel with internal pressure.	
	Self-Learning Topics: *Understanding Failure Modes through structural analysis in ANSYS*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Identify and apply the appropriate solver and solver settings for static, modal and transient analyses. (PI 3.3.1, PI 4.1.2, PI 5.2.1)* *LO 2.2: Apply convergence criteria to ensure the accuracy and stability of finite element analysis (FEA) simulations across various analysis types. (PI 2.4.2, PI 4.3.2, PI 5.3.2)* *LO 2.3: Interpret and evaluate post-processing results, including stress distribution, deformation, and factor of safety, to assess the structural integrity of engineering models. (PI 2.4.4, PI 4.3.1, PI 8.3.1)* *LO 2.4: Utilize visualization techniques such as iso-surfaces and contour plots to analyze simulation outputs and extract meaningful engineering insights. (PI 4.3.3, PI 5.1.1, PI 9.3.1)*	
03.	***Learning Objective/s:*** *To use industry standard software tool to create geometries, generate grids with appropriate element types, and evaluate mesh quality and connectivity for accurate simulations.*	**06**
	To get acquainted to Essentials of CFD covering the following topics: *Introduction to CFD Software Interface and Geometry Modelling Tools* *Types of Elements and Grid generation* *Types of Mesh* *Mesh Quality Metrics* *Mesh Connectivity Metrics* *Boundary Conditions and Solvers*	
	Tasks : i. 2D/3D geometry creation using Design Modeler and/or Space Claim ii. Unstructured mesh generation for a Y-section iii. Structured mesh generation for the study of external flow over a NACA aerofoil iv. Grid generation for 3D domain using Fluent meshing. v. Apply different types of boundary conditions like velocity, mass flow rate, pressure, pressure far field, temperature, heat flux, stationary wall, rotating wall, periodic and symmetry to suitable fluid and thermal problem.	
	Self-Learning Topics: *Optimizing Mesh Quality for accurate CFD Simulations*	

	Learning Outcomes : *A learner will be able to* *LO 3.1: Construct 2D and 3D geometries using industry standard software for engineering simulations. (PI 3.1.1, PI 5.1.1, PI 5.2.1, PI 9.3.1)* *LO 3.2: Identify and select appropriate fluid and thermal element types for various analysis scenarios. (PI 2.3.1, PI 4.1.4, PI 5.2.1, PI 8.2.1)* *LO 3.3: Develop an unstructured and structured mesh using appropriate meshing techniques and validate mesh quality metrics for accurate simulations. (PI 2.4.2, PI 4.3.3, PI 5.3.2, PI 9.1.1)* *LO 3.4: Apply boundary conditions and material properties to engineering models to solve fluid and thermal analysis problems. (PI 2.3.1, PI 2.4.4, PI 3.3.1, PI 8.3.1)*	
04.	***Learning Objective/s:*** *To set up solver settings, initialization, and turbulence models, and apply post-processing techniques to export data in different formats for analysis.*	**08**
	To apply the CFD based commercial software package in order to solve problems covering the following topics: *Solver settings, Initialization, Residue, Report monitors* *Types of Turbulence Models* *Post Processing, Iso-surface Visualization, Cut Plane Visualization, 3D Field Visualization, Data Export in CSV format*	
	Tasks: i. Laminar and turbulent flow over an aerofoil at different angles of attack ii. Computational analysis of Jet surface interaction iii. Computational analysis of shell and tube heat exchanger iv. Transient study of phase change characteristics of an ice block.	
	Self-Learning Topics: *Simulation of Complex Fluid-Structure Interactions*	
	Learning Outcomes : *A learner will be able to* *LO 4.1: Configure solver settings, initialization, and report monitors to optimize fluid flow simulations. (PI 2.2.4, PI 4.1.2, PI 5.2.1)* *LO 4.2: Apply different turbulence models to simulate laminar and turbulent flow conditions accurately. (PI 2.4.2, PI 4.1.4, PI 5.3.2)* *LO 4.3: Visualize simulation results using iso-surface, cut-plane, and 3D field visualization techniques. (PI 4.3.2, PI 5.2.1, PI 9.3.1)* *LO 4.4: Export simulation data in CSV format for further analysis and reporting. (PI 4.3.3, PI 8.3.1, PI 9.1.1)*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.1	Recognize that need analysis is key to good problem definition.
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development.
4.1.2	Examine the relevant methods, tools, and techniques of experiment design, system calibration, data acquisition, analysis, and presentation.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data.
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data and drawing of conclusions.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling, and analysis; techniques and resources for engineering activities.
5.2.1	Identify the strengths and limitations of tools for acquiring information, modeling and simulating, monitoring system performance, and creating engineering designs.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
8.2.1	Identify tenets of the ASME professional code of ethics.
8.3.1	Examine and apply moral & ethical principles to known case studies.
9.1.1	Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective teamwork to accomplish a goal.
9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes: A learner will be able …….

1. To create accurate engineering models and develop high-quality meshes for simulation. *(LO 1.1, LO 1.3, LO 3.1, LO 3.3)*
2. To select and assign appropriate materials, boundary conditions, and element types to solve various analysis problems. *(LO 1.2, LO 1.4, LO 3.2, LO 3.4)*
3. To set up and optimize solver configurations and convergence criteria for both structural and fluid flow simulations. *(LO 2.1, LO 2.2, LO 4.1, LO 4.2)*
4. To interpret simulation outputs using advanced visualization techniques and generate reports for engineering decision-making. *(LO 2.3, LO 2.4, LO 4.3, LO 4.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC508.1	--	2	3	--	3	--	--	--	3	--	--
MELBC508.2	--	3	2	2	2	--	--	3	--	--	--
MELBC508.3	--	3	2	3	3	--	--	--	--	--	--
MELBC508.4	--	2	--	3	3	--	--	2	3	--	--
Average	--	**3**	**2**	**3**	**3**	--	--	**3**	**3**	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Books :

1. S. Moaveni, *Introduction to Finite Element Analysis Using ANSYS*. Boston, MA: Pearson, 2015.
2. N. S. Gokhale and S. S. Deshpande, *Practical Finite Element Analysis*. Finite to Infinite, 2008.
3. D. L. Logan, *A First Course in the Finite Element Method*, 6th ed. Boston, MA: Cengage Learning, 2016.
4. H. K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd ed. Harlow, UK: Pearson, 2007.
5. J. Blazek, Computational Fluid Dynamics: Principles and Applications, 3rd ed. Amsterdam, Netherlands: Elsevier, 2015.
6. J. D. Anderson, CFD Fundamentals with Applications. New York, NY: McGraw-Hill, 1995.

Reference Books :

1. J. N. Reddy, *An Introduction to the Finite Element Method*, 4th ed. New York, NY: McGraw-Hill, 2019.
2. C. S. Krishnamoorthy, *Finite Element Analysis: Theory and Programming*. New Delhi, India: Tata McGraw-Hill, 1994.
3. B. S. Gupta, *Introduction to Finite Elements in Engineering.* New Delhi, India: Oxford and IBH Publishing, 1991.
4. A. W. Date, *Introduction to Computational Fluid Dynamics.* Cambridge, UK: Cambridge University Press, 2005.
5. K. Muralidhar and T. Sundararajan, *Computational Fluid Flow and Heat Transfer,* 2nd ed. Alpha Science International, 2014.
6. P. Roache, *Verification and Validation in Computational Science and Engineering*. Albuquerque, NM: Hermosa Publishers, 1998.

Other Resources :

1. Basics of Finite Element Analysis - I (IIT Kanpur), Prof. Nachiketa Tiwari

   Link: https://nptel.ac.in/courses/112104193
2. Ansys Training: Introduction to Ansys DesignModeler

   Link:https://www.ansys.com/training-center/course-catalog/structures/introduction-to-ansys-designmodeler

3. Basics of Finite Element Analysis – II, Prof. Nachiketa Tiwari
   Link: https://nptel.ac.in/courses/112104205
4. edX - A Hands-on Introduction to Engineering Simulations (Cornell University)
   Link: https://www.edx.org/learn/engineering/cornell-university-a-hands-on-introduction-to-engineering-simulations
5. NPTEL - Computational Fluid Dynamics (IIT Kharagpur), Prof. S. K. Som
   Link: https://nptel.ac.in/courses/112105254
6. ANSYS Training - DesignModeler (CFD)
   Link: https://www.ansys.com/training-center/course-catalog/fluids/introduction-to-ansys-designmodeler-cfd
7. Udemy - Mastering ANSYS CFD
   Link: https://www.udemy.com/course/mastering-ansys-cfd/

IN-SEMESTER ASSESSMENT (25 MARKS)

1. Continuous Assessment (25 Marks)

Suggested breakup of distribution

- Performance based on completion of task (Marks will be awarded to students based on task performance with proper understanding) : 15
- Course Project (max 4 students) to demonstrate concept : 05
  1. Finite element analysis of any structural system
  2. CFD analysis of any fluid or thermal system
- Regularity and Active Participation : 05

END SEMESTER EXAMINATION (25 MARKS)

Students will be assessed based on three parameters:

- Finite Element Analysis and Computational Fluid Dynamics concepts / understanding
- Practical performance
- Oral

- Students will be randomly allocated a task from the list of tasks performed during the semester (or any other similar task) and will be asked to write brief procedure related to the execution of the task including the diagram and/or calculation if any. The procedure and/or calculation is checked by the examiners (Internal and External) and evaluated out of 5 Marks.
- Then the student will be allowed to complete the task.
- The students will be allocated 1 hour to complete the execution. The students are required to complete the given task and write conclusion for the simulation result and compare it with mathematical calculation, if any. The completed task will be checked by both the examiners for its correctness. The weightage is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
AEC	AEC502	PROFESSIONAL COMMUNICATION & ETHICS-2	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	--	--	--	50

Pre-requisite:

1. Satisfactory completion of AEC201 course work/ a similar level of course in Semester 2/ previous semesters

Program Outcomes addressed:

1. PO7 : Ethics
2. PO8 : Individual and Teamwork
3. PO9 : Communication
4. PO11: Life-long learning

Course Objectives:

1. To inculcate in students professional and ethical attitude, effective communication skills, team work, multidisciplinary approach and an ability to understand engineers' social responsibility.
2. To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career.
3. To create awareness about professional ethics and codes of professional practice and leadership.
4. To prepare students for a successful career that meets the global industrial and corporate requirement, provide students to work on multidisciplinary projects as part of different teams to enhance their team building capabilities like leadership, motivation, teamwork, etc.

Module	Details	Hrs.
	Course Introduction The curriculum of Professional Communication and Ethics-2 is designed to build up a proficient and ethical approach among the students in the professional engineering environment. Their capacity and skills of effective oral and written communication will be enhanced with the various practical activities that have been designed within the course. Through practical sessions will supplement the learner's interactive competence and confidence to respond appropriately and creatively to the implied challenges of the global industrial and corporate	**01**

<table>
<tr><td></td><td>requirements. It will further inculcate within the budding engineer the social commitment of as responsible technical citizens.</td><td></td></tr>
<tr><td rowspan="4">01.</td><td>ADVANCED TECHNICAL WRITING:PROJECT/PROBLEM BASED LEARNING

Learning Objective:
To discern and develop an effective style of writing important technical/business documents.
To understand the dynamics of professional communication and to develop creative and efficient presentation skills.
To understand the importance of integrity and personal and professional code of ethics</td><td rowspan="4">04</td></tr>
<tr><td>Contents:
Contents:
1.1 Writing Reports
o Classification of reports on the basis of: Subject Matter, Time Interval, Function, Physical Factors.
o Parts of a long formal report: Front Matter, Main Body and Back Matter.
o Language and style of Reports: Grammar, Tone, Style, Vocabulary, Format of the report from title page to appendices.
1.1 Definition, purpose and types of proposals : Parts of a Proposal: Elements, Scope and Limitations, Conclusion
o Technical Proposal.
o Business Plan.
1.3 Technical paper writing. (APA/IEEE)
Parts of a Research paper:
o Title Page
o Abstract,
o Introduction
o Problem Statement/Hypothesis
o Research methods,
o Data Search (Primary/Secondary)
o Quantitative/ Qualitative Analysis
o Discussion,
o Delimitations,
o future scope and
o References.
o Appendix
o Acknowledgement
1.4 Presenting and Publishing a Research Paper (Significance as a professional)</td></tr>
<tr><td>Self-Learning Topics:
Read and summarise a business plan by any industry expert.
Read an academic research paper and look for gaps in the research area.</td></tr>
<tr><td>Learning Outcomes:
The learner will be able to
LO 1.1: Objectively state the purpose of research, research methodology and apply the knowledge while writing an academic paper in IEEE format.(9.1.1,9.1.3,,11.1.1,11.1.2,11.3.1)</td></tr>
</table>

	LO 1.2: Present research paper effectively in a time bound manner to everyone's understanding (8.3.1, 9.1.3, 9.2.2, 9.2.3) *LO 1.3: Demonstrate the ability use critical thinking to find gaps in research and present it. (8.2.1, 11.1.2, 11.3.1)* *LO 1.4: Apply gained knowledge for continuous improvement for professional growth.(11.1.1)*	
02.	**EMPLOYABILITY SKILLS** ***Learning Objective:*** *To increase the ability to write constructive documents such as the SOP* *To instil productive and efficient skills for the workplace.* *To facilitate fluent and precise presentation skills, in professional situations with and without the use of ICT tools*	**02**
	Contents: **2.1 Statement of Purpose** o Purpose o Elements of SOP o Structure o Tips for writing effective SOP. **2.2 Verbal Aptitude Tests** modeled on CAT,GRE,GMAT,IELTS **2.3 Group Discussions** :Purpose, parameters of evaluating, Types of GDs (Traditional, Case-based & Role Plays), GD Etiquettes **2.4 Personal Interviews:** Preparation, Types of questions, Types of interviews and modes of interviews. Types: Structured, Stress, Behavioural, Problem Solving & Case-based, Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
	Self-Learning Topics: ***Watch recordings of professional interviews from online resources.(ex:Civil Service interviews), IIM and UPSC GDs***	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply knowledge for continuous improvement and professional growth. (11.1.1.)* *LO 2.2: Demonstrate effective communication and arrive at decisions through strong leadership skills and teamwork. (7.1.1,8.1.2,8.2.1,8.2.3, 8.2.4, 8.3.1,9.2.2)* *LO 2.3: Effectively prepare for competitive exams through mock tests (8.2.1,11.1.1)* .	
03.	**TECHNICAL/BUSINESS PESENTATIONS**	**02**
	Learning Objective: *To prepare academic and technical presentation slides and to present it to the audience.* *To be able to engage the audience during a presentation.*	

	To comprehend the presentation skills and etiquette. *To gain teamwork skills and problem solving skills*	
	Contents: **3.1 Effective Presentation Strategies:** o Purpose of a presentation, o Understanding the audience, location and the event, o Arranging the material, structuring the presentation, o Making effective slides and platform skills. **3.2 Group Presentations:** o Sharing responsibility in a team (Delegation) o Creating the content together (Uniformity) o Transition phases and Coordination. **3.3 Individual Presentations:** o Introduction of Self and Topic o Understanding the audience, building rapport o Time Management o End with Q n A, Feedback	
	Self-Learning Topics: *Watch YouTube videos of presentations like TED TALKS on motivational topics*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply oral and written communication skills effectively and ethically during group discussions. (7.1.1, 7.2.2, 8.2.1, 9.2.1, 9.2.2.)* *LO 3.2: Demonstrate presentation skills and leadership skills through team work and management (8.1.2, 8.2.1,8.3.1, 9.3.2)* *LO 3.3: Exhibit impressive presentation etiquette with appropriate ethical standards. (7.1.1,7.3.1,9.2.2)*	
04.	**INTERPERSONAL SKILLS** ***Learning Objectives:*** *1. To help budding engineers understand the importance of interpersonal skills for personal and professional growth.* *2. To aid the learner in understanding the significance of employment generation and the need for it.*	**03**
	Contents: **4.1. Interpersonal Skills:** o Emotional intelligence, o Leadership o Conflict Management, o Negotiation & Conflict Resolution o Time management, o Assertiveness o Decision making. **4.2. Start- Up Skills:** o Financial Literacy o Risk Assessment o Data Analysis.	

	Self-Learning Topics: Collect information on some failed startups. Assess and analyse the reasons for their failure.	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the learned interpersonal skills in presenting posters, business plans and proposals. (7.1.1, 7.2.2, 7.3.1,8.1.2,8.3.1,9.3.2, 11.1.1)* *LO 4.2: Participate in a well-organized and constructive GD. (7.2.2, 7.3.1,8.2.1, 8.3.1)* *LO 4.3: Generate a business plan for a startup. (8.2.1,11.1.1,11.1.2)*	
05.	**CORPORATE ETHICS** ***Learning Objective/s:*** *1. To aid the learner to differentiate between various codes of conduct and ethics in the social and professional world.* *2. To enforce the significance of ethical citizenry.* *3. To generate awareness on the importance of IPR and its consequences*	**02**
	Contents: **5.1. Intellectual Property Rights : Significance, Duration, Laws** o Copyrights o Trademarks o Patents o Geographical Indication o Industrial Designs o Trade Secrets **5.2 Gender Equity & Inclusivity at the Work Place** o Study on Cases related to Gender Equity in India & Global o Corporate Social Responsibility o Inclusivity at the work place	
	Self-Learning Topics: Read a biography on a Business Leader/Philanthropist	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Utilise moral and ethical principles in their professional and social life (7.1.1, 7.2.2, 7.3.1)* *LO 5.2: Critically evaluate various socioeconomic, gender issues of discriminatory nature (7.1.1, 7.2.2,7.3.1, 8.1.1, 8.1.2)* *LO 5.3: Employ the awareness of IPR to avoid unethical practices in their professional life (7.1.1,7.2.2, 8.2.1, 8.2.2, 11.1.1)*	
06.	**Activities for Ability Enhancement (Practical Sessions):**	**30**
	Contents: *1. Prepare a TRIFOLD POSTER on any one Technical problem with solutions for the same and present it. (Team of 4/ Trifold (10 M)+ Presentation + Group Dynamics (5M)* *2. Write a research paper on the given topic in IEEE format (5M)* *3. Prepare an SOP for admission procedure in a reputed university.(5M)*	

	4. Participate in GDs on given topic followed by Mock Interview((5M) *5.Attempt Verbal Aptitude Tests(5M)* *6. Assess and analyse a Case Study on the topic on Gender Equity & Inclusivity; Generate a solution based article and present before an audience (10M)*	
	Activities will start in the inverted pyramid, viz., with group activities first so as to build confidence and ending with solo presentations in the form of research paper presentation or Gender Equity presentation. *Group Discussion, Interview Skills, Presentation skills will have at least three mock drills before the final assessment of the same.* *Rigorous development of the English language, social and professional etiquette will be the praxis*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
7.2.2	Examine and apply moral & ethical principles to known case studies
7.3.1	Apply and exhibit universal human values and a diverse and inclusive mind-set, free of discrimination
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution andleadership skills
8.2.2	Treat other team members respectfully
8.2.3	Listen to other members
8.2.4	Maintain composure in difficult situations
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1	Read, understand and interpret technical and non-technical information
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that themain point is clear
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others
9.2.2	Deliver effective oral presentations to technical and non-technical audiences
9.2.3	Apply efficient and effective communication, keeping in mind the diversity and uniqueness in the team.
9.3.2	Use a variety of media effectively to convey a message in a document or a

presentation

11.1.1 State the rationale for the requirement for continuing professional development

11.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

11.3.1 Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Communicate effectively and ethically in both oral and written forms which will in turn provide a solid foundation for their future managerial roles. (*LOs 1.1, 1.2, 1.4, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1)*
2. Possess the skill set required for successful employability and exhibit leadership skills. (*LOs 2.1, 2.2, 3.2, 4.2, 4.3)*
3. Develop an acumen to prepare for and give various competitive exams and emerge successful in group discussions and conduct healthy debates. (*LOs 2.1, 2.2, 2.3, 4.2)*
4. Develop creative thinking and demonstrate knowledge of professional and personal etiquettes & ethics, such as diversity and inclusivity, in the global environment. (*LOs 1.3, 3.2, 3.3, 4.3, 5.1, 5.2, 5.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
AEC502.1	--	--	--	--	--	--	3	3	3	--	3
AEC502.2	--	--	--	--	--	--	3	3	3	--	2
AEC502.3	--	--	--	--	--	--	2	3	2	--	2
AEC502.4	--	--	--	--	--	--	3	3	3	--	3
Average	**--**	**--**	**--**	**--**	**--**	**--**	**3**	**3**	**3**	**--**	**3**

Reference Books:

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin:*

2. *Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021).

3. *Business communication today*. Upper Saddle River, NJ: Pearson.
4. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
5. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).*Personal development for life and work*. Mason: South Western Cengage Learning.
6. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow, England: Pearson.
7. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
8. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
9. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Other Resources :

1. NPTEL Course: https://archive.nptel.ac.in/courses/109/104/109104030
   Dept. of Humanities and Social Sciences, IIT Kanpur, A Course on Communication Skills

CONTINUOUS INTERNAL ASSESSMENT (50 Marks)

1. Prepare a TRIFOLD POSTER on any one socio-technical problem with solutions for the same and present it. (Team of 4/ Trifold) (10 M) + Presentation & Group Dynamics. (5M)
2. Write a TECHNICAL research paper on a designated topic in IEEE format. (5M)
3. Prepare an SOP for admission procedure in a reputed university. (5M)
4. Participation in Final GD on concrete/abstract topic followed by Mock Interview. (5M)
5. Verbal Aptitude Tests (5M)
6. Analyse a Case Study on the topic of Gender Equity & Inclusivity (10M)
7. Regularity and Active participation (5M)

Course Type	Course Code	Course Name	Credits
MNP	MEMNP503	MINI PROJECT- 2A	01

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project Management and Finance
11. PO11: Life-Long Learning

Course Objectives:

1. To guide students in identifying societal or research needs and formulating them into problem statements.
2. To facilitate problem-solving in group settings.
3. To apply basic engineering principles to address identified problems.
4. To foster self-learning and research skills.

Course Outcomes:

At the end of the course, students will be able to:

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project
Mini project may be carried out in one or more form of following: Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc. • Students must form groups of 3 to 4 members either from the same or from different departments.

- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- Continuous Assessment marks distribution in semester V (50 marks):
    - 05 marks for the Topic Approval Presentation in front of the progress monitoring committee
    - 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
    - 25 marks for the Final Report & Presentation
    - 05 marks for Regularity and Active participation
- Continuous Assessment marks distribution in semester VI (50 marks):
    - 15 marks for the In-Semester Two Presentations
    - 05 marks for Participation in Project Competitions, TPP, etc.
    - 25 marks for the Final Report & Presentation
    - 05 marks for Regularity and Active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester V:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
    - The first review will focus on finalizing the problem statement (topic approval).
    - The second review will centre on finalizing the proposed solution.

Semester VI:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
  - The first review will assess the readiness to build a working prototype.
  - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to above mentioned points, the following performance criteria shall be included during in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester VI (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks.

Course Type	Course Code	Course Name	Credits
HSS	**HSS502**	**Entrepreneurship**	**02**

<table>
<tr><th colspan="7">Examination Scheme</th></tr>
<tr><th colspan="3">Distribution of Marks</th><th colspan="2" rowspan="2">Exam Duration (Hrs.)</th><th rowspan="3">Total Marks</th></tr>
<tr><th colspan="2">In-semester Assessment</th><th rowspan="2">End Semester Exam (ESE)</th></tr>
<tr><th>Continuous Assessment</th><th>Mid-Semester Exam (MSE)</th><th>MSE</th><th>ESE</th></tr>
<tr><td>50</td><td>--</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
</table>

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solutions
4. PO6: The Engineer & The World.
5. PO7: Ethics
6. PO10: Project Management & Finance
7. PO11: Life-long learning

Course Objectives:

1. To develop Entrepreneurial mindset amongst the learners.
2. To promote Entrepreneurship as life-skills to improve quality of life, skills of creation and management of entrepreneurial pursuits.
3. To explore paths of the innovation through the creative problem-solving skills
4. To familiarize with the steps involved in ‘idea to product’ development.
5. To get acquainted with the preparation of pitch at ideation, business idea presentation and funding stages

Module	Details	Hrs
00	**Course Introduction:** This course aims to equip individuals with the knowledge, skills, and mindset needed to identify and pursue new business opportunities. It aims to foster an entrepreneurial culture and mindset to help develop the next generation of entrepreneurs who can create jobs, drive economic growth, and contribute to the society. Entrepreneurship is a life skill that will help an individual succeed in a variety of scenarios, both personal and professional. By its very nature, entrepreneurship is an interdisciplinary field that draws from a range of disciplines, including business, economics, engineering, and social sciences. Some of the key topics covered in Entrepreneurship Course include opportunity recognition, market research, business planning, financing, marketing, and management while emphasizing the development of critical thinking, creativity, risk-taking, and problem- solving skills.	**1**

<table>
<tr><td>1</td><td>Fundamentals of Entrepreneurship</td><td>5-6</td></tr>
<tr><td></td><td>Learning Objectives:
• To gain knowledge about the concepts and principles of entrepreneurship, including opportunity recognition and value creation.
• To develop an entrepreneurial mindset and skills that will enable them to identify, evaluate, and pursue viable business opportunities with confidence.</td><td></td></tr>
<tr><td></td><td>Contents:
Introduction to Entrepreneurship, Entrepreneurial Mindset, Opportunity Identification, Market Analysis & Customer Research, Business Models & Go-to-Market, Funding and Financial Management, Marketing Aspects, Scaling the Venture and Growth Strategies:
Note: A real life case study covering key elements of the module shall be covered.</td><td></td></tr>
<tr><td></td><td>Learning Outcome:
The learner would be able to
• Understand the concept of Entrepreneurship
• State the myths, advantages and limitations of Entrepreneurship
• Interpret and analyze market research data and customer analysis to make informed business decisions.
• Discuss the steps in the process of Entrepreneurship</td><td></td></tr>
<tr><td>2</td><td>Technological Innovation and Entrepreneurship</td><td>4-5</td></tr>
<tr><td></td><td>Learning Objectives:
• To enhance creative problem-solving skills and to examine the importance of innovation in business success.
• To identify the types of Innovation
• To gain knowledge for taking an idea to product development stage while protecting the idea with IPR.</td><td></td></tr>
<tr><td></td><td>Content:
Foundations of Creativity and Innovations, Creative thinking process, Types of Innovation: Incremental, Disruptive, and Radical, Innovation Process: from idea to execution; Protecting ideas - Patents and IPR. Exploring Technological Innovation through Case Studies.</td><td></td></tr>
<tr><td></td><td>Learning Outcome:
The learner would be able to
• Use their understanding of the role Technological innovation plays in driving business success.
• To formulate steps for taking an idea to product stage with necessary patents</td><td></td></tr>
<tr><td>3</td><td>Ideation, Prototyping, Testing, Validation and Commercialisation</td><td>5-6</td></tr>
<tr><td></td><td>Learning Objectives:
• Experiment to test Minimum Viable Products (MVPs) and validate business ideas.
• To formulate a Build-Measure-Learn feedback loop for continuous improvement.</td><td></td></tr>
</table>

	Contents: Identifying customer needs and problems to solve, Ideation, Concept Development, Design Thinking, Prototyping, Minimum Viable Product (MVP), Testing, and Iterations. Understanding the Market, customer feedback and refinement of business idea based on feedback. *Note:* A real life case study covering key elements of the module shall be covered.	
	Learning Outcome: *The learner would be able to* • *Select specific measures to design, test, and validate Minimum Viable Products (MVPs) to assess business ideas.* • *Interpret the learnings from the build-measure-learn feedback loop to facilitate continuous improvement and learning.*	
4	**Financial Resources**	3-4
	Learning Objectives: • *Describe the key concepts, and strategies related to fundraising for entrepreneurial ventures.* • *Compare various funding sources, including angel investors, venture capitalists, grants, and crowdfunding platforms.* • *Devise and create compelling investor pitches, develop financial projections.*	
	Contents: Funding new ventures – bootstrapping, crowd sourcing, Angel investors, VCs, debt financing, and due diligence; Raising fund during life-cycle of a new ventures. *Note:* A real life case study covering key elements of the module shall be covered.	
	Learning Outcome: *The learner would be able to* • *Recognize various fundraising strategies and techniques, enabling s to choose the most appropriate funding sources for their entrepreneurial ventures.* • *Sketch effective pitches and fundraising campaigns tailored to different types of investors and funding sources, ensuring successful capital-raising efforts.*	
5	**National Entrepreneurial Culture**	4-5
	Learning Objectives: • *To gain knowledge of legal and regulatory requirements for startups, including compliance with relevant regulations.* • *To identify the various government initiatives to develop the start-up ecosystem.*	
	Contents: Entrepreneurial Ecosystem in India, Key regulations and legal aspects, Forms of Business Ownership, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments,	

	banks etc. Government incentives for entrepreneurship, Incubation, & Acceleration.	
	Learning Outcome: *The learner would be able to* • *Describe the current scenario of Entrepreneurial activity in India.* • *To state legal and regulatory requirements and compliances for start-ups.* • *To state the various government initiatives to support the entrepreneurs.*	
6	**Start-up Case Studies**	3-4
	Learning Objectives: *To relate the real life case studies and analyse them for acquiring the clarity on various aspects of entrepreneurship covered in the first 5 modules*	
	Contents: Case Studies of various start-ups (with Indian Context): Start-ups from Tech, Edtech, Fintech, and Agriculture domain; Study of successful start-ups and failed start-ups.	
	Learning Outcome: • *To evaluate the real-world examples and case studies that will help them understand the practical aspects of idea to product, fundraising and financial management in the context of entrepreneurship.*	
7	***Course Conclusion***	1

In-semester Assessment - Continuous Assessment: Suggested

1 Teams of 3-4 students shall present a One-Minute business idea pitch– ideation phase-10 marks
2 Teams of 3-4 students shall present a Three-Minute Business Pitch –Validation phase-10 marks
3 Teams of 3-4 students shall present a Five-Minute Business Pitch for Funding- 15 marks
4 Teams of 3-4 students shall present analysis of one case study of successful or failed start-up- (15 Marks)

Course Outcome: Learner will be able to

CO1: State the concept of Entrepreneurship and Indian Start-up ecosystem
CO2: Identify the business ideas and to analyse the environment for potential business opportunity.
CO3: Identify the specific measures to design, test, and validate Minimum Viable Product.
CO4: State the key concepts, and strategies related to fundraising for entrepreneurial ventures.
CO4: Identify the legal and regulatory framework for entrepreneurs in Indian context.
CO5: Analyse and correlate the reasons for the success or the failure of entrepreneurial firms.

Text Books:

1. Poornima Charantimath, Entrepreneurship Development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Vasant Desai, Entrepreneurial Development and Management, Himalaya Publishing House
5. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books

6. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
7. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.

Reference Books:

1. Zero to One: Notes on Startups, or How the Build the Future by Peter Thiel
2. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries
3. India as Global Start-up Hub: Mission with Passion by C B Rao
4. Innovation and Entrepreneurship: Practice and Principles by Peter F Drucker
5. Effective Entrepreneurial Management: Strategy, Planning, Risk Management, and Organization - Robert D. Hisrich, Veland Ramadani, Springer (2017)
6. Entrepreneurship- Theory, Process Practice –by Kuratko &Hodgetts, Thompson South-Western Publication

Relevant Websites:

1. www.msme.gov.in
2. www.dcmesme.gov.in
3. www.msmetraining.gov.in

Other Resources:

1. NPTEL Course: Entrepreneurship By Prof. C Bhaktavatsala Rao, IIT Madrao
   Weblink https://onlinecourses.nptel.ac.in/noc20_mg35/preview
2. NPTEL Course: Entrepreneurship Essentials By Prof. Manoj Kumar Mondal, IIT Kharagpur
   Weblink https://onlinecourses.nptel.ac.in/noc21_ge06/preview

Course Type	Course Code	Course Name	Credits
PCC	MEPCC611	MACHINE DESIGN	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite :

1. ESE 101 Engineering Mechanics
2. MEPCC302 Mechanics of Solid
3. MEPCC303 Material Science and Engineering
4. MEPCC406 Theory of Machine
5. MEPCC408 Manufacturing Technology

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO6: The Engineer and the World
6. PO8: Individual and Collaborative Team work
7. PO9: Communication
8. PO10: Project Management and Finance

Course Objectives:

1. Familiarize students with the basic principles of machine design and with various design considerations.
2. Acquaint students with functional and strength design principles of important machine elements.
3. Guide students through the design calculation, preparation of working drawings based on designs.
4. Familiarize students to the use of design data books & various codes of practice for the design/selection of standard machine elements.

Module	Details	Hrs
	Course Introduction Machine Design equips students with the principles, methods, and tools essential for designing mechanical systems. It bridges theory and practice,	**01**

	fostering innovation and performance improvement. Students gain a solid foundation in stress analysis, material selection, and failure criteria—key concepts vital for real-world applications	
01.	**Design Fundamentals** ***Learning Objective/s:*** *To understand the fundamental principles of machine design*	**5-7**
	Contents:	
	Design methods, Basic principle of Machine Design, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Modes of failures, Factor of safety, Design stresses, Theories of failures, Standards, Preferred Series and Numbers. Variables stresses, reversed, repeated, fluctuating stresses	
	Self-Learning Topics: ***Learning Outcomes :*** *A learner will be able to* *LO 1.1: Select the factor of safety and design stresses for the component design (P.I.- 1.3.1, 2.4.1)* *LO 1.2: Identify the modes of failure. (P.I.- 1.3.1, 2.1.3, 2.4.1)* *LO 1.3: Use the theory of failure as per requirement. (P.I.- 1.2.1, 2.4.4)* *LO 1.4: Use the Standards, I.S. Codes, Preferred Series and Numbers (P.I.- 1.3.1, 2.4.4)* *LO 1.5: Differentiate the reversed, repeated and fluctuating stresses. (P.I.- 1.3.1, 2.1.2)*	
02.	**Basics Principles of Design** ***Learning Objective/s:*** *Design components under different loading conditions using stress analysis, fatigue concepts, and failure criteria.*	**5-7**
	Contents: Design for tensile, compressive, shear, bending and torsional loads. Static and fatigue stress concentration factors, Methods of stress concentrations, Endurance limit - estimation of endurance limit, Soderberg and Goodman criteria	
	Self-Learning Topics:	
	Learning Outcomes :	
	A learner will be able to *LO 2.1: Identify and determine the resisting area for different failure in components. (P.I.-1.4.1, 2.4.1)* *LO 2.2: Use the static and fatigue stress concentration factors and SN Curve for design. (P.I.- 2.1.2, 2.3.1)* *LO 2.3: Estimate the endurance limit. (P.I.- 1.3.1, 2.4.1)*	

	LO 2.4: Apply the Soderberg and Goodman design criteria for the components design. (P.I.- 2.1.3, 2.4.1)	
03.	**Design against static loads:** ***Learning Objective/s:*** *Design the machine elements like knuckle joints, eccentrically loaded bolted joints, power screws, and helical springs subjected to static load conditions for the given specification.* **Contents:** Knuckle joint, Bolted joints under eccentric loading; Power Screw- Screw Jack. Helical Coil Springs under static load. ***Self-Learning Topics:*** *Socket and Spigot Cotter joint, Leaf Spring.* ***Learning Outcomes :*** *A learner will be able to* *LO 3.1: Design knuckle joints for given specification, (P.I. -2.4.1, 3.1.6)* *LO 3.2: Check the fork, eye and pin for different mode of failure by identifying the correct resisting area. (P.I.- 1.4.1, 2.2.1, 2.4.1,3.2.3)* *LO 3.3: Select the standard bolt from the catalogue for the Eccentric load in the plane of the bolts. (P.I-. 2.3.1, 3.1.4)* *LO 3.4: Design a screw Jack for given specification. (P.I.- 1.4.1,2.4.1, 3.1.6)* *LO 3.5: Design a helical spring for the given specification under static loads. (P.I.- 1.3.1, 2.1.3, 3.1.6)*	**9-11**
04.	**Design of Power transmitting elements:** ***Learning Objective/s:*** *Design the shafts, keys and couplings considering load conditions, fatigue criteria, and functional requirements for given specifications.* **Contents:** Shafts: Design under static and fatigue criteria. Keys: Types of keys and their selection based on shafting condition. Couplings: Classification of couplings. Design of flange couplings, bush pin flexible coupling. ***Self-Learning Topics:*** ***Learning Outcomes :*** *A learner will be able to* *LO 4.1: Design a power transmitting shaft subjected to static and fatigue criteria (P.I.-1.3.1, 2.1.2, 2.3.1, 3.1.6, 4.3.1)* *LO 4.2: Select key for the given shaft and check for the shear and crushing failure (P.I. - 1.3.1,2.1.2, 2.3.1, 3.1.4,3.1.6)* *LO 4.3: Design a coupling and checking various coupling elements under different failure criteria. (P.I.- 2.1.2, 2.3.1, 2.4.4,3.3.1, 4.3.1)*	**9-11**
	Selection of Rolling Element Bearings:	

05.	***Learning Objective/s:*** *Select the suitable rolling contact bearing based on constant and variable loads and speed.*	**5-7**
	Contents: Types of bearing and designation, selection of rolling contact bearings based on constant / variable load & speed conditions.	
	Self-Learning Topics:	
	Learning Outcomes :	
	A learner will be able to *LO 5.1: Know the function and components and the terminology of the rolling contact bearing. (P.I.-1.3.1. P.I.-1.4.1)* *LO 5.2: Determine the rated life of the bearing for required reliability. (P.I.-2.1.2, P.I.-2.4.1, PI 4.3.1)* *LO 5.3: Select the suitable rolling contact bearing based on given specifications (P.I.-3.1.4, PI 3.1.6, PI 4.3.2)*	
06.	**Design for Manufacturing and Assembly** ***Learning Objectives:*** *Understand the importance of DFM and DFA in product development, distinguish them from traditional design approaches, and apply design considerations for casting, forging, and machining*	**4-6**
	Contents: Importance of DFM and DFA in product development, Differences between traditional design and DFM/DFA approaches, Benefits of integrating DFM and DFA in design, Design consideration for Casting, Forging and Machining.	
	Self-Learning Topics: ***Learning Outcomes :***	
	A learner will be able to *LO 6.1: Differentiate between traditional design and DFMA approach. (P.I.-1.3.1,2.1.3)* *LO 6.2: State the various DFMA consideration in design. (P.I.-1.2.1, 1.4.1)* *LO 6.3: Analyze the benefits of integrating DFM and DFA in the design process. (P.I.-1.3.1, 2.2.3)* *LO 6.4: Apply design considerations for casting, forging, and machining in product development. (P.I.-1.4.1, 2.2.2, 6.2.1)* *LO 6.5: A Task-Based Group Activity on DFM and DFA Applications (PI 6.1.1, PI 6.3.1 PI-8.2.1, PI 8.2.2, PI 9.1.1, PI 9.1.2, PI 9.2.2, PI 10.1.1, 10.3.1)* *Each group (max 4 students) will participate in a Manufacturing-Oriented Redesign Task with the following deliverables:* *A. Product Selection: Choose an existing mechanical component (e.g., engine bracket, gearbox casing, or machine tool holder) currently produced using conventional design methods.*	

	B. Design Evaluation: Analyze the product's manufacturing and assembly process using criteria like complexity, material usage, tolerances, and cost. Identify drawbacks in manufacturability or assembly. *C. Redesign Phase: Apply DFM and DFA principles to improve design for one of the following processes: casting, forging, or machining. Propose simplifications, process optimizations, and part consolidation. Emphasize cost reduction and manufacturability.* *D. Planning and Presentation: Prepare a concise report (max 5 pages) and a visual presentation that includes:* *Redesign rationale* *Before-after comparison (features, cost, assembly steps)* *A Gantt chart or task plan outlining team contributions* *Justification based on manufacturability, cost, and efficiency*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Articulate problem statements and identify objectives
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub-problems
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHR
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions

3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data.
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
8.2.2	Treat other team members respectfully
9.1.1	Read, understand and interpret technical and non-technical information
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
10.1.1	Describe various economic and financial costs/benefits of an engineering activity
10.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.

Course Outcomes: A learner will be able to -

1. To demonstrate the understanding of various design consideration. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5)*
2. To design machine elements under various conditions by selecting suitable materials, design stresses on the basis of strength concept. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5)*
3. To design power transmitting machine elements subjected to static and fluctuating loads. (*LO 4.1, LO 4.2, LO 4.3, LO 5.1, LO 5.2, LO 5.3*)
4. To select bearings for a given application from the manufacturers catalogue. *LO 5.4, LO 5.5)*
5. Apply DFMA principles to various design processes *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC601.1	3	3	--	--	--	--	--	--	--	--	--
MEPCC601.2	3	3	3	--	--	--	--	--	--	--	--
MEPCC601.3	3	3	3	3	--	--	--	--	--	--	--
MEPCC601.4	3	3	3	3	--	--	--	--	--	--	--
MEPCC601.5	3	3	3	3	--	3	--	3	3	3	--
Average	**3**	**3**	**3**	**3**	**--**	**3**	**--**	**3**	**3**	**3**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Design of Machine Elements - V.B. Bhandari, Second edition, 2007, Tata McGraw Hill Publication
2. Design of Machine Elements – C.S. Sharma and Kamlesh Purohit. 2009, Prentice Hall India Publication
3. Machine Design by N. C. Pandya and C. S. Shah, 2006, Charotar Publishing House Pvt. Limited.
4. Machine Design by R. S. Khurmi and J.K. Gupta, 2007, S. Chand and company Ltd.

Reference Books :

1. Machine Design -An Integrated Approach - Robert L. Norton, Second edition, 2006, Pearson Education
2. Mechanical Engineering Design by Joseph Edward Shigley, Charles R. Mischke and Richard Gordon Budynas, 2004, McGraw Hill Publication
3. Design Data: Data Book of Engineers by PSG College,2020, Kalaikathir, Achchagam-Coimbatore

Other Resources :

1. https://nptel.ac.in/courses/112/105/112105124/ - Design of Machine Elements, IIT Kharagpur
2. https://nptel.ac.in/courses/112/106/112106137/ - Machine Design-II, IIT Madras

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Assignments on live problems/ case studies	:	10 Marks
Open book test/ Open notes test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination carrying 20% weightage, and the syllabus covered from MSE to ESE carrying 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC6021	REFRIGERATION AND AIR CONDITIONING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. MEPCC304: Thermodynamics
2. MEPCC407: Thermal Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO6: The Engineer and the World
5. PO9: Communication

Course Objectives:

1. To impart a basic understanding of principles of Heat Pump, refrigeration and air conditioning.
2. To study various conventional and non-conventional refrigeration cycles and evaluate the performance of each cycle.
3. To understand the construction and working of different controls of refrigeration and air-conditioning systems with their applications.

Module	Details	Hrs.
	Course Introduction This course offers a basic understanding of Refrigeration and Air Conditioning. Different refrigeration cycles and a grasp of psychrometry and psychrometric processes utilized for air conditioning are also covered. Additionally, it contains cooling load estimation and various controls as well as their applications.	**01**
01.	**Introduction to Refrigeration and Refrigerants** ***Learning Objectives:*** *1. To impart the knowledge of engineering fundamentals in basic working principles of refrigerator and heat pump.* *2. To get acquaint with designation of the refrigerants and selection of an appropriate refrigerant as per the application.*	**3-5**

	Contents: 1.1 Introduction to Refrigeration: Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance 1.2 Refrigerants: Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties, Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants	
	Self-Learning Topics: *Carnot refrigerator, Carnot heat pump*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Define Refrigeration, Ton of Refrigeration and Coefficient of Performance. (PI:1.2.1)* *LO 1.2: Calculate the Coefficient of Performance (COP) of Carnot refrigerator and heat pump. (PI:1.4.1)* *LO 1.3: Apply the ASHRAE designation system to designate a refrigerant using chemical formula. (PI:1.4.1)* *LO 1.4: Compare different refrigerants based on their thermodynamic, chemical, and physical properties and select the appropriate one as per the application. (PI: 2.2.4)* *LO 1.5: Identify the environmental impact of refrigerants considering protocols by understanding Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). (PI:2.2.2, 6.2.1, 6.3.2, 9.3.1)* *LO 1.6: Recommend alternative refrigerants base*d on their environmental impact *and sustainability in modern refrigeration systems. (PI:2.2.2, 6.3.1, 9.3.2)*	
02.	**Vapour Compression Refrigeration, Vapour Absorption Refrigeration and Heat Pump** ***Learning Objective:*** *To get familiarized with the various refrigeration systems and heat pump for analyzing their coefficient of performance.*	**6-8**
	2.1 Vapour Compression Refrigeration System: Simple vapour compression cycle, Effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of subcooling, use of P-h charts, Actual VCR cycle, Use of P-h Charts, Comparison between air-cooled and water-cooled condenser based air conditioning systems, Types of condensers, evaporators, expansion devices and Compressors. 2.2 Heat Pump: Performance, Primary energy ratio, Energy efficiency, Coefficient of ratio.	
	Self-Learning Topics: *Heat pump*	
	Learning Outcomes: *A learner will be able to*	

	LO 2.1: Utilize P-h charts to analyze vapour compression refrigeration cycles considering the effect of the effects of liquid subcooling, superheating, evaporator, and condenser pressures (PI: 2.4.1) *LO 2.2: Classify and choose different types of Heat pumps, condensers, evaporators, expansion devices, and compressors based on applications. (PI: 2.2.4)* *LO 2.3: Define Performance factor, Energy Efficiency Ratio for heat pump. (PI:1.2.1)* *LO 2.4: Calculate the COP of vapour compression heat pump. (PI: 1.4.1)*	
03.	**Other and Non-Conventional Refrigeration Systems** ***Learning Objective/s:*** *Analyze the various refrigeration systems including non-conventional to determine their coefficient of performance.*	**6-8**
	Contents: 3.1 Other Refrigeration Systems: Vapour Absorption Refrigeration, Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system (Single and double effect), Electrolux refrigeration system. 3.2 Non-Conventional Refrigeration Systems: Thermoelectric Refrigeration, Thermo-acoustic Refrigeration, Vortex Tube Refrigeration.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Analyze the Coefficient of Performance (COP) for an ideal VAR system using established thermodynamic relationships. (PI: 2.1.2, 2.4.1)* *LO 3.2: Evaluate the working principle of thermoelectric, thermoacoustic and vortex tube refrigeration and discuss their potential applications. (PI: 6.3.1, 6.3.2)*	
04.	**Human Comfort and Psychrometry** ***Learning Objective/s:*** *To apply basic concepts psychrometry to analyze different human comfort conditions.*	**6-8**
	Contents: 4.1 Human Comfort: Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone, Indoor Air Quality, Green Buildings 4.2 Psychrometry: Need for air conditioning, Principle of psychromerty, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, Adiabatic air mixing, Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor process, Numerical based on psychrometric chart and Apparatus dew point .	

	Learning Outcomes: *A learner will be able to* *LO 4.1: Define effective temperature, interpret comfort charts, and delineate comfort zones for indoor environments. (PI: 1.2.1, 9.1.1, 9.3.2)* *LO 4.2: Evaluate green building concepts and their role in enhancing human comfort. (PI: 2.2.2, 6.3.2)* *LO 4.3: Identify various psychrometric processes, properties using psychometric charts. (PI: 2.2.3)* *LO 4.4: Calculate sensible heat factor and bypass factor for a given process. (PI: 1.4.1)* *LO 4.5: Analyze air conditioning parameters as per the application. (PI:2.4.1, 6.3.1)*	
05.	**Design of Air Conditioning Systems** ***Learning Objectives:*** *To analyze the cooling load for various air conditioning systems.*	**9-11**
	Contents: Different Heat sources, Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation, Introduction to Unitary Products viz; Room/Split and Packaged Air Conditioners, Introduction to recent developments viz. Variable Refrigerant Flow systems, VAV control systems, Inverter Units..	
	Self-Learning Topics: *Summer and winter air conditioning.*	
	Learning Outcomes: *A learner will be able to* *LO:5.1: Define Air Conditioning. (PI:1.2.1)* *LO 5.2: Identify the required information about heat sources and cooling load required. (PI:* 2.2.2*)* *LO 5.3: Calculate the sensible and latent heat load for given application. (PI:1.4.1)* *LO 5.4: Extract the required parameters for cooling load estimation from ASHRAE handbook. (PI 3.1.4)* *LO 5.5: Apply different load estimation techniques to analyze the cooling requirements of a building. (PI:* 2.4.1, 6.3.1*)* *LO 5.6: Integrate survey data and economic considerations into the design process of an air conditioning system. (PI: 3.1.6, 6.2.1)*	
06.	**Air Distribution System** ***Learning Objective/s:*** *To select a suitable duct system and air handling system for a given application.*	**8-10**
	Contents: 6.1 Duct Design: Friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design, Factors considered in air distribution system, Air distribution systems for cooling and heating.	

	6.2 Controls: LP/HP cutoff, Thermostats, Humidistats, Interlocking control, Electronic Controllers. 6.3 Applications: Refrigeration & A/C Ice plant: food storage plants – diary and food processing plants, Food preservation, Freeze Drying, A/c in textile, printing pharmaceutical industry and Hospitals, Liquefaction of LNG, Liquefaction of gases (cryogenics), Deep sea water air-conditioning	
	Self-Learning Topics: *Various pressure losses in ducts*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Define duct and air handling unit. (PI: 1.2.1)* *LO 6.2: Calculate pressure losses, airflow through ducts, for determination of equivalent diameters. (PI:1.4.1)* *LO 6.3: Apply design methodologies for duct systems to analyze air flow to minimize pressure losses. (PI:2.4.1, 6.3.4)* *LO 6.4: Identify and choose appropriate components such as filters, supply and return grills, controls and sensors as per application and significance of supplementary (PI: 2.1.2, 6.3.1)*	
	Course Conclusion At the end of the course, students would be expected to be able to 1. Demonstrate the working principle of refrigerators and heat pumps. 2. Determine COP of various Refrigeration systems. 3. Use psychrometric processes to get the required comfort conditions 4. Conduct a heat load analysis to calculate the cooling load for a given application and select an appropriate air distribution system. Understand the working principle of different controls and their applications.	**01**
	Total	**45**

Performance Indicators:

PI No.	**PI Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble, and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards.
3.1.6	Determine design objectives, functional requirements, and arrive at specifications.

6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.3.1	Identify risks/impacts in the life cycle of an engineering product or activity.
6.3.2	Understand the relationship between the technical, socio-economic, and environmental dimensions of sustainability.
6.3.4	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
9.1.1	Read, understand, and interpret technical and non-technical information.
9.3.1	Create engineering-standard figures, reports, and drawings to complement writing and presentations.
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation.

Course Outcomes: A learner will be able to -

1 Demonstrate an understanding of refrigerants designation and ODP, GWP, regulations and Protocols. *(LO 1.3, LO 1.4, LO 1.5, LO 1.6)*

2 Analyse Vapour Compression Refrigeration Systems and heat pump. (*LO1.1, LO 1.2, LO 2.1, LO 2.3, LO 2.4)*

3 Analyze Vapour absorption system and Evaluate the working principal of Non-Conventional Refrigeration Systems. (*LO 3.1, LO 3.2)*

4 Interpret psychometric information and perform numerical analysis as per the comfort conditions required.(*LO 4.1, LO 4.2, LO 4.3 , LO 4.4, LO 4.5)*

5 Conduct a comprehensive cooling load analysis to design an air conditioning systems integrating building survey and component selection. (*LO 2.2, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*

6 Design a sustainable air distribution system and select appropriate control systems as per their industrial applications considering the risk /impact on the life cycle of the system (*LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC6021.1	2	3	--	--	--	3	--	--	3	--	--
MEPEC6021.2	3	2	--	--	--	--	--	--	--	--	--
MEPEC6021.3	--	3	--	--	--	3	--	--	--	--	--
MEPEC6021.4	3	3	--	--	--	3	--	--	3	--	--
MEPEC6021.5	3	3	3	--	--	3	--	--	--	--	--

MEPEC6021.6	3	3	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	**3**	**--**	**--**	**3**	**--**	**--**	**3**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. Refrigeration and air-conditioning – C P Arora, TMH
2. Refrigeration and Air-conditioning – R. K. Rajput
3. Refrigeration and air-conditioning – W F Stoeker and J W Jones, TMH
4. Modern Air-conditioning practice – C P Arora, TMH
5. Basic Refrigeration and air-conditioning- P. Ananthanarayana, TMH

Reference Books:

1. Principles of refrigeration – R J Dossat, Willey Eastern Publication
2. Introduction to Refrigeration and Air-Conditioning Systems - Allen T. Kirpatrick
3. ASHRAE Handbook of Systems
4. ASHRAE Handbook of Equipments
5. ISHRAE Air Conditioning Handbook

Other Resources:

1. NPTEL Course: Refrigeration and Air Conditioning by Prof. M. Ramgopal
   Prof. R.C. Arora, Department of Mechanical Engineering at IIT Kharagpur :-Web link- NPTEL :: Mechanical Engineering - Refrigeration and Air Conditioning

2. NPTEL Course: Refrigeration and Air Conditioning by Prof. Ravi Kumar
   Prof. R.C. Arora, Department of Mechanical Engineering at IIT Roorkee :-Web link- NPTEL :: Mechanical Engineering - NOC:Refrigeration and air-conditioning

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
One Class test	:	05 Marks
Flip classroom	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC6022	HEATING, VENTILATION AND AIR CONDITIONING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. MEPCC304: Thermodynamics
2. MEPCC407: Thermal Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO6: The Engineer and the World
5. PO9: Communication

Course Objectives:

1. To impart the basic understanding of fundamental principles of refrigeration and air conditioning and evaluate the environmental impact of different refrigerants and explore eco-friendly alternatives.
2. To recognise different components of refrigeration and air conditioning systems and their functions.
3. To utilize psychometric chart for air property analysis and perform cooling load calculations for designing HVAC systems following industry standards.

Module	Details	Hrs.
	Course Introduction This course provides a foundational understanding of Heating, Ventilation, Air Conditioning, and Refrigeration (HVAC&R) systems, integrating modern advancements in energy efficiency and sustainable practices. Emphasizing recent trends, it covers the latest refrigeration cycles, eco-friendly refrigerants, and smart HVAC controls which can be integrated with IoT and AI. The course also explores psychrometry for human comfort, cooling load estimation, and energy-efficient air distribution systems. With a focus on green building concepts and evolving global environmental protocols, students will gain insights into designing sustainable and high-performance HVAC&R systems.	**01**
01.	**Introduction to Refrigeration and Refrigerants** ***Learning Objectives:*** *1. To impart the knowledge of engineering fundamentals in basic working principles of refrigerator and heat pump.*	**3-5**

	2. To get acquaint with designation of the refrigerants and selection of an appropriate refrigerant as per the application.	
	Contents: 1.1 Introduction to Refrigeration: Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance 1.2 Refrigerants: Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties, Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants	
	Self-Learning Topics: *Carnot refrigerator, Carnot heat pump*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Define Refrigeration, Ton of Refrigeration and Coefficient of Performance. (PI:1.2.1)* *LO 1.2: Calculate the Coefficient of Performance (COP) of Carnot refrigerator and heat pump. (PI:1.4.1)* *LO 1.3: Apply the ASHRAE designation system to designate a refrigerant using chemical formula. (PI:1.4.1)* *LO 1.4: Compare different refrigerants based on their thermodynamic, chemical, and physical properties and select the appropriate one as per the application. (PI: 2.2.4)* *LO 1.5: Identify the environmental impact of refrigerants considering protocols by understanding Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). (PI:2.2.2, 6.2.1, 6.3.2, 9.3.1)* *LO 1.6: Recommend alternative refrigerants based on their environmental impact and sustainability in modern refrigeration systems. (PI:2.2.2, 6.3.1, 9.3.2)*	
02.	**Vapour Compression Refrigeration, Vapour Absorption Refrigeration and Heat Pump**	**8-10**
	Learning Objective: *To get familiarized with the various refrigeration systems for analyzing their coefficient of performance.*	
	Contents: 2.1 Vapour Compression Refrigeration System: Simple vapour compression cycle, Effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of subcooling, use of P-h charts, Actual VCR cycle, Use of P-h Charts, Comparison between air-cooled and water-cooled condenser-based air conditioning systems, Types of condensers, evaporators, expansion devices and Compressors. 2.2 Vapour Absorption Refrigeration System: Simple and practical vapour absorption system, Refrigerant-	

	adsorbent properties, COP of ideal vapour absorption system, Domestic Electrolux refrigerator, Lithium bromide absorption system 2.3 Heat Pump: Performance, Primary energy ratio, Energy efficiency, Coefficient of ratio. Heating season performance factor, Seasonal energy efficiency ratio, Classification of heat pump, Vapour compression heat pump systems. Heat pump application in an industry	
	Self-Learning Topics: *Heat pump applications in an industry*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Utilize P-h charts to analyze vapour compression refrigeration cycles considering the effect of the effects of liquid subcooling, superheating, evaporator, and condenser pressures (PI: 2.4.1)* *LO 2.2: Classify and choose different types of Heat pumps, condensers, evaporators, expansion devices, and compressors based on applications. (PI: 2.2.4)* *LO 2.3: Analyze the COP of vapour absorption system. (PI: 2.4.1)* *LO 2.4: Define Performance factor, Energy Efficiency Ratio for heat pump. (PI:1.2.1)* *LO 2.5: Calculate the COP of vapour compression heat pump. (PI: 1.4.1)*	
03.	**Human Comfort and Psychrometry**	**7-9**
	Learning Objective/s: *To know the psychrometric processes for determining different human comfort conditions.*	
	Contents: 3.1 Human Comfort: Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone, Indoor Air Quality, Green Buildings 3.2 Psychrometry: Need for air conditioning, Principle of psychromerty, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, Adiabatic air mixing, Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor, Numerical based on psychrometric chart and Apparatus dew point .	
	***Learning Outcomes**:* *A learner will be able to* *LO 3.1: Define effective temperature, interpret comfort charts, and delineate comfort zones for indoor environments. (PI: 1.2.1, 9.1.1, 9.3.2)* *LO 3.2: Evaluate green building concepts and their role in enhancing human comfort. (PI: 2.2.2, 6.3.2)* *LO 3.3: Identify various psychrometric processes, properties using psychometric charts. (PI: 2.2.3)*	

	LO 3.4: Calculate sensible heat factor and bypass factor for a given process. (PI: 1.4.1) *LO 3.5: Analyze air conditioning parameters as per the application. (PI:2.4.1, 6.3.1)*	
04.	**Cooling Load Calculations**	**7-9**
	Learning Objective: *To get acquaint with various air conditioning systems for determining the cooling load.*	
	Contents: 4.1 Introduction to air conditioning: Classification of air conditioning system, relations summer and Winter Air conditioning 4.2 Cooling Load Estimation: Introduction, Components of cooling load, Different heat sources, Various load Estimation, Design of air conditioning system, building survey and economic aspect used in design.	
	Self-Learning Topics: *Summer and winter air conditioning.*	
	Learning Outcomes: *A learner will be able to* *LO:4.1: Define Air Conditioning. (PI:1.2.1)* *LO 4.2: Identify the required information about heat sources and cooling load required. (PI:* 2.2.2*)* *LO 4.3: Calculate the sensible and latent heat load for given application. (PI:1.4.1)* *LO 4.4: Extract the required parameters for cooling load estimation from ASHRAE handbook. (PI 3.1.4)* *LO 4.5: Apply different load estimation techniques to analyze the cooling requirements of a building. (PI:* 2.4.1, 6.3.1*)* *LO 4.6: Integrate building survey data and economic considerations into the design process of an air conditioning system. (PI: 3.1.6, 6.2.1)*	
05.	**Air Distribution System** ***Learning Objective/s:*** *To select a suitable duct system and air handling system for a given application.*	**6-8**
	Contents: 5.1 Duct: Classification of ducts, duct material, pressure in ducts, Flow through duct, pressure losses in duct, Air flow through simple duct system, Equivalent diameter, Methods of duct system design 5.2 Air Handling Unit: Fan coil unit, Types of fans used air conditioning Introduction applications, Fan laws ,Filters, supply and return grills, Sensors.	
	Self-Learning Topics:	

	Various pressure losses in ducts	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Define duct and air handling unit. (PI: 1.2.1)* *LO 5.2: Calculate pressure losses, airflow through ducts, for determination of equivalent diameters. (PI:1.4.1)* *LO 5.3: Apply design methodologies for duct systems to analyze air flow to minimize pressure losses. (PI:2.4.1, 6.3.4)* *LO 5.4: Identify and choose appropriate components such as filters, supply and return grills, and sensors as per function and significance of supplementary (PI: 2.1.2, 6.3.1)*	
06.	**Controls and applications**	**7-9**
	Learning Objective/s: *To get familiarized with the working principle and applications of different controls.*	
	Contents: 6.1 Controls: LP/HP cutoff, Thermostats, Humidistats, Interlocking control, Electronic Controllers 6.2 Applications: Refrigeration & A/C Ice plant – food storage plants – diary and food processing plants, Food preservation, Freeze Drying, A/c in textile, printing pharmaceutical industry and Hospitals, Liquefaction of LNG, Liquefaction of gases (cryogenics), Deep sea water air-conditioning.	
	Self-Learning Topics: *Liquefaction of LNG, Liquefaction of gases (cryogenics)*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify the requirements of A/C system for different applications. (PI: 2.2.2, 6.2.1)* *LO 6.2: Compare the diverse applications of refrigeration and air conditioning and select appropriate control as per the application.(PI: 2.2.4, 6.3.1)*	
	Course Conclusion At the end of the course, students would be expected to be able to 1. Demonstrate the working principle of refrigerators and heat pumps. 2. Determine COP of various Refrigeration systems. 3. Use psychrometric processes to get the required comfort conditions 4. Conduct a heat load analysis to calculate the cooling load for a given application and select an appropriate air distribution system. 5. Understand the working principle of different controls and their applications.	
	Total	**45**

Performance Indicators:

PI No.	PI Statement
1.2.1	Apply laws of natural science to an engineering problem.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble, and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards.
3.1.6	Determine design objectives, functional requirements, and arrive at specifications.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.3.1	Identify risks/impacts in the life cycle of an engineering product or activity.
6.3.2	Understand the relationship between the technical, socio-economic, and environmental dimensions of sustainability.
6.3.4	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
9.1.1	Read, understand, and interpret technical and non-technical information.
9.3.1	Create engineering-standard figures, reports, and drawings to complement writing and presentations.
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation.

Course Outcomes: A learner will be able to -

1 Demonstrate an understanding of refrigerants designation and ODP, GWP, regulations and Protocols. *(LO 1.3, LO 1.4, LO 1.5, LO 1.6)*

2 Analyse various refrigeration systems and heat pump. (*LO1.1, LO 1.2, LO 2.1, LO 2.3, LO 2.4, LO 2.5)*

3 Interpret psychometric information and perform numerical analysis as per the comfort conditions required.(*LO 3.1, LO 3.2, LO 3.3 , LO 3.4, LO 3.5)*

4 Conduct a comprehensive cooling load analysis and design air conditioning systems integrating building survey. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*

5 Design a sustainable air distribution system for minimum pressure loss and vibration. (*LO 5.1, LO 5.2, LO 5.3)*

6 Select appropriate control systems as per their industrial applications in refrigeration and air conditioning considering the risk /impact on the life cycle of the system.(*LO 2.2, LO 5.4, LO 6.1, LO 6.2)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC6022.1	2	3	--	--	--	3	--	--	3	--	--
MEPEC6022.2	3	2	--	--	--	--	--	--	--	--	--
MEPEC6022.3	3	3	--	--	--	3	--	--	3	--	--
MEPEC6022.4	3	3	3	--	--	3	--	--	--	--	--
MEPEC6022.5	3	2	--	--	--	2	--	--	--	--	--
MEPEC6022.6	--	3	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	**3**	**--**	**--**	**3**	**--**	**--**	**3**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. Refrigeration and air-conditioning – C P Arora, TMH
2. Refrigeration and Air-conditioning – R. K. Rajput
3. Refrigeration and air-conditioning – W F Stoeker and J W Jones, TMH
4. Modern Air-conditioning practice – C P Arora, TMH
5. Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH

Reference Books:

1. Principles of refrigeration – R J Dossat, Willey Eastern Publication
2. Introduction to Refrigeration and Air-Conditioning Systems - Allen T. Kirpatrick
3. ASHRAE Handbook of Systems
4. ASHRAE Handbook of Equipments
5. ISHRAE Air Conditioning Handbook

Other Resources:

1. NPTEL Course: Refrigeration and Air Conditioning by Prof. M. Ramgopal
   Prof. R.C. Arora, Department of Mechanical Engineering at IIT Kharagpur :-Web link- NPTEL :: Mechanical Engineering - Refrigeration and Air Conditioning

2. NPTEL Course: Refrigeration and Air Conditioning by Prof. Ravi Kumar
   Prof. R.C. Arora, Department of Mechanical Engineering at IIT Roorkee :-Web link- NPTEL :: Mechanical Engineering - NOC:Refrigeration and air-conditioning

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
One Class test	:	05 Marks
Flip classroom	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC6023	CRYOGENIC ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. MEPCC304 Thermodynamics
2. MEPCC407 Thermal Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5 PO6: The Engineer and The World

Course Objectives:

1. To familiarize with refrigeration principles, including vapor compression cycles, refrigerants, air-refrigeration, Psychrometry, and human comfort in air conditioning.
2. To acquaint with cryogenic systems, low-temperature properties, gas liquefaction for Neon, Hydrogen, and Helium, and specialized refrigeration techniques like magnetic cooling and cryo-coolers.
3. To develop an understanding of cryogenic fluid storage and transfer systems, along with their design, operation, and applications in low-temperature engineering.

Module	Details	Hrs.
	Course Introduction This course provides a strong foundation in cryogenic engineering, focusing on low-temperature science and technology while integrating theoretical knowledge with mathematical accuracy for in-depth analysis and application of key concepts. By combining theoretical principles with practical applications, students develop problem-solving skills essential for research and advanced studies.	**01**
01.	**Introduction to refrigeration and refrigerants** ***Learning Objective/s:*** *To acquaint with the fundamental properties of refrigerants*	**6-8**

	To analyze the working and operating principles of air refrigeration systems for effective mechanical system design.	
	Contents: **1.1 Introduction to Refrigeration:** Carnot refrigerator, Carnot heat pump, Reversed Carnot cycle, unit of refrigeration, Co- efficient of Performance **1.2 Refrigerants**: Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties, Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants. Nano-fluids and Phase Change Materials as refrigerant**.** **1.3 Air-refrigeration:** Bell Coleman cycle and its numerical.	
	Self-Learning Topics: *Selection of refrigerant*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Analyze the Carnot refrigerator and Carnot heat pump working principles to determine efficiency and performance, considering sustainability aspects. (PI 1.1.1, 6.2.3)* *LO 1.2: Apply thermodynamic principles to evaluate the Coefficient of Performance (COP) in refrigeration cycles, ensuring compliance with energy efficiency and environmental standards. (PI 1.2.1, 6.1.1)* *LO 1.3: Identify and classify different types of refrigerants based on thermodynamic, chemical, and physical properties, incorporating sustainability considerations. (PI 2.1.1, 6.1.3)* *LO 1.4: Compare the environmental impact of refrigerants using Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) criteria to determine sustainable alternatives. (PI 2.2.3, 6.2.3)* *LO 1.5: Assess the impact of refrigerant selection on sustainability and regulatory compliance under the Montreal Protocol, ensuring alignment with global environmental policies. (PI 6.1.1)* *LO 1.6: Evaluate the feasibility of air-refrigeration systems like the Bell Coleman cycle for different engineering applications, considering energy efficiency and sustainability aspects. (PI 6.2.3)*	
02.	**Refrigeration Systems** ***Learning Objective/s:*** *To acquaint with the concept of the vapor refrigeration system and analyze vapor compression cycles effectively using P-h charts.* *To inculcate the concepts of thermal comfort and Psychrometry while evaluating the effects of sub-cooling and superheating on refrigeration performance.*	**8-10**
	Contents: **Vapour Compression Refrigeration System:** Simple vapour compression cycle, Effect of liquid sub cooling& superheating, effect of evaporator and condenser pressures, methods of sub-cooling, use of P-h charts, Use of P-h Charts. **Human Comfort**: Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone, Indoor Air	

	Quality, Green Buildings **Psychrometry:** Need for air conditioning, Principle of Psychrometry, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, Adiabatic air mixing, Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor process, Numerical based on Psychrometric chart and Apparatus dew point.	
	Self-Learning Topics: *Heat pump*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply thermodynamic principles to analyze the performance of the vapour compression refrigeration cycle and its components, considering energy efficiency and sustainability aspects. (PI 1.4.1, 6.2.3)* *LO 2.2: Compare different psychrometric processes and their application in human comfort, indoor air quality, and energy efficiency, incorporating sustainability considerations. (PI 2.2.3, 6.1.3)* *LO 2.3: Evaluate the effects of subcooling, superheating, evaporator, and condenser pressures on refrigeration system efficiency, ensuring optimal energy utilization and environmental sustainability. (PI 2.3.1, 6.2.3)* *LO 2.4: Design air conditioning systems using psychrometric principles to achieve thermal comfort and optimize energy efficiency while considering environmental regulations. (PI 3.1.6, 6.2.1)* *LO 2.5: Develop selection criteria for air-conditioning system components based on design requirements and operating conditions, ensuring compliance with green building standards. (PI 3.2.3, 6.2.3)* *LO 2.6: Interpret and utilize P-h charts to assess refrigeration cycle performance and determine critical operating parameters, ensuring alignment with sustainable engineering practices. (PI 4.3.1, 6.2.1)* *LO 2.7: Analyze experimental data from refrigeration and psychrometric systems to validate performance and efficiency improvements, ensuring compliance with sustainability guidelines. (PI 4.3.2, 6.1.1)* *LO 2.8: Assess the environmental impact and sustainability of refrigeration and air-conditioning systems concerning energy consumption and green building standards. (PI 6.2.3)*	
03.	**Introduction to Cryogenic Systems & Low Temperature Properties** ***Learning Objective/s:*** *To explore cryogenic systems' historical development and multifaceted industrial applications.* *To analyze low-temperature properties of engineering materials and cryogenic fluids.*	**9-11**
	Contents: **Introduction to Cryogenic Systems**: Historical development, Applications of Cryogenics (Space, Food Processing, Super conductivity, Electrical Power, Biology, Medicine, Electronics and Cutting Tool Industry). **Low Temperature Properties**: Properties of Engineering Materials (Mechanical properties, Thermal properties, Electric and Magnetic properties), Properties of Cryogenic fluids.	
	Self-Learning Topics:	

	Fundamentals of Material Science and Thermo-Physical Properties at Low Temperatures.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply advanced mathematical techniques to model and analyze the thermal and mechanical behavior of materials under cryogenic conditions, considering engineering sustainability aspects. (PI 1.1.2, 6.2.3)* *LO 3.2: Evaluate the properties of cryogenic fluids and engineering materials at low temperatures using scientific principles and engineering concepts, incorporating environmental and sustainability considerations. (PI 1.2.1, 6.1.1)* *LO 3.3: Formulate a structured understanding of cryogenic system applications and relate them to real-world engineering challenges, ensuring alignment with sustainable engineering practices. (PI 2.2.3, 6.1.3)* *LO 3.4: Identify and compare different applications of cryogenic technology in space, medicine, electronics, and industrial sectors based on feasibility, efficiency, and sustainability. (PI 2.3.1, 6.2.3)* *LO 3.5: Design cryogenic systems for applications like space exploration by integrating material properties, cryogenic fluids, and safety considerations with societal and environmental impacts. (PI 3.1.6, 6.2.1)* *LO 3.6: Develop optimized cryogenic cooling techniques for energy efficiency and enhanced system performance in industrial applications, ensuring minimal environmental impact. (PI 3.4.1, 6.2.3)* *LO 3.7: Assess the sustainability and societal impact of cryogenic applications in medicine, energy, and superconductivity, ensuring compliance with environmental regulations. (PI 6.1.1)* *LO 3.8: Analyze environmental and ethical considerations in the development and implementation of cryogenic technology, ensuring alignment with industry and regulatory standards. (PI 6.2.3)*	
04.	**Gas liquefaction System** ***Learning Objective/s:*** *To understand the principles of ideal liquefaction systems and their components.* *To analyze gas liquefaction systems for Neon, Hydrogen, and Helium.* *To understand the principles and operation of gas liquefaction systems, including Joule Thomson, adiabatic expansion, and Linde Hampson cycles.*	**5-7**
	Contents: **Introduction to Liquefaction Systems**: Ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude & Cascaded System. **Gas Liquefaction Systems**: General liquefaction systems. Liquefaction systems for Neon, Hydrogen and Helium. Critical components of liquefaction systems.	
	Self-Learning Topics: *Different insulating materials for specific applications.*	
	Learning Outcomes:	
	A learner will be able to *LO 4.1: Apply thermodynamic principles to analyze the performance of ideal gas liquefaction cycles, including Joule-Thomson and adiabatic expansion processes, while considering energy efficiency and sustainability. (PI 1.4.1, 6.2.3)* *LO 4.2: Evaluate the working principles of Linde Hampson, Claude, and cascaded liquefaction cycles using mathematical and scientific models to ensure efficient and sustainable operations. (PI 1.2.1, 6.1.1)*	

	LO 4.3: Formulate an understanding of gas liquefaction systems and their applications in industries such as aerospace, medical, and energy sectors, incorporating sustainability aspects. (PI 2.2.3, 6.1.3) *LO 4.4: Identify and compare the efficiency of different gas liquefaction methods for Neon, Hydrogen, and Helium based on theoretical modeling and industrial feasibility. (PI 2.3.1, 4.3.2)* *LO 4.5: Design gas liquefaction systems considering energy efficiency, component selection, and feasibility for industrial applications, while addressing environmental concerns. (PI 3.1.6, 6.2.1)* *LO 4.6: Develop optimization strategies for improving liquefaction system performance while minimizing energy losses and promoting sustainable engineering practices. (PI 3.4.1, 6.2.3)* *LO 4.7: Conduct investigations using thermodynamic models to assess the performance of liquefaction cycles and their components, ensuring reliable and sustainable operations. (PI 4.3.1, 6.1.1)* *LO 4.8: Analyze experimental data and simulation results to validate improvements in gas liquefaction efficiency, considering technical and environmental impacts. (PI 4.3.2, 6.2.3)* *LO 4.9: Assess the environmental and societal impacts of gas liquefaction systems with respect to energy consumption, sustainability, and safety. (PI 6.1.1)* *LO 4.10: Evaluate the ethical and regulatory considerations in the operation and design of gas liquefaction systems, ensuring compliance with industry and environmental standards. (PI 6.2.3)*	
05.	**Cryogenic refrigeration systems** ***Learning Objectives:*** *To analyze advanced cryogenic refrigeration systems, including Magnetic Cooling, Stirling Cycle, and Cryo Coolers for diverse applications.*	**5-7**
	Contents: **Introduction to Cryogenic Refrigeration Systems**: Magnetic Cooling, Stirling Cycle, Cryo Coolers. **Cryogenic Refrigeration Systems**: Ideal refrigeration systems, Refrigeration using liquids and gases as refrigerant, Refrigerators using solids as working media.	
	Self-Learning Topics: *Basics of Thermodynamic Cycles for Refrigeration and Heat Engines*	
	Learning Outcomes :	
	A learner will be able to *LO 5.1: Apply engineering principles to analyze cryogenic refrigeration systems, including magnetic cooling, Stirling cycle, and cryo coolers, while considering sustainability and energy efficiency. (PI 1.1.1, 6.2.3)* *LO 5.2: Evaluate the suitability of various refrigerants, including liquids, gases, and solids, for cryogenic refrigeration systems under specific conditions, ensuring compliance with environmental regulations. (PI 1.2.1, 6.1.1)* *LO 5.3: Identify and compare different cryogenic refrigeration techniques based on efficiency, feasibility, and application requirements, incorporating sustainability considerations. (PI 2.2.3, 6.1.3)* *LO 5.4: Analyze the thermal behavior and efficiency of cryogenic refrigeration cycles through theoretical modeling and data interpretation, ensuring alignment with sustainable engineering principles. (PI 2.3.2, 4.3.2)*	

	LO 5.5: Design cryogenic refrigeration systems by selecting appropriate refrigerants and components to ensure safety, efficiency, and adherence to sustainability-focused engineering standards. (PI 3.1.6, 6.2.1) *LO 5.6: Develop optimized strategies for improving cryogenic refrigeration system performance while minimizing energy losses and promoting environmental sustainability. (PI 3.4.1, 6.2.3)*	
06.	**Cryogenic Fluid Storage and Transfer Systems** ***Learning Objective:*** *To evaluate the design and performance of cryogenic storage vessels, insulation types, and fluid transfer systems effectively.*	**4-6**
	Contents: **Cryogenic storage vessels and transportation:** Thermal insulation and their performance at cryogenic temperatures, Super insulations, Vacuum insulation, Powder insulation. Cryogenic fluid transfer systems.	
	Self-Learning Topics: *Heat Transfer Mechanisms and Insulation Techniques in Low-Temperature Applications.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply engineering principles to analyze the performance of thermal insulation systems for cryogenic storage and transportation, considering energy efficiency and sustainability. (PI 1.1.1, 6.2.3)* *LO 6.2: Identify and evaluate the factors affecting the efficiency of cryogenic storage vessels and fluid transfer systems under varying conditions, ensuring compliance with safety and environmental standards. (PI 1.2.1, 6.1.1)* *LO 6.3: Design cryogenic storage vessels and transfer systems with optimized insulation techniques to minimize thermal losses and enhance safety while addressing sustainability concerns. (PI 2.2.3, 6.1.3)* *LO 6.4: Analyze and compare the thermal performance of various insulation types for cryogenic applications based on theoretical principles and validated experimental data. (PI 2.3.2, 4.3.2)* *LO 6.5: Develop engineering strategies to enhance the efficiency of cryogenic insulation materials while ensuring compliance with industry standards and environmental considerations. (PI 3.1.6, 6.2.1)* *LO 6.6: Optimize the design of cryogenic storage and transfer systems to minimize energy loss, improve operational efficiency, and ensure sustainable engineering solutions. (PI 3.4.1, 6.2.3)*	
	Course Conclusion Upon completion, learner will be equipped to understand, design, and evaluate cryogenic systems, applying their knowledge to industrial sectors such as space technology, medical applications, and energy systems. This comprehensive understanding of cryogenics enables learners to contribute effectively to technological advancements and innovative engineering solutions.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.2.1	Apply laws of natural science to an engineering problem.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions.
3.4.1	Refine a conceptual design into a detailed design within the existing constraints of the resources.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations.
6.1.1	Identify and describe various engineering roles, particularly as pertains to protection of the public and public interest at the global, regional, and local levels.
6.1.3	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.2.3	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.

Course Outcomes: A learner will be able to -

1. Analyze refrigeration systems, including air-refrigeration, vapour compression, and absorption cycles, while selecting appropriate refrigerants and evaluating psychrometric properties for efficiency, environmental impact, and sustainability. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7, LO 2.8)*

2. Examine cryogenics, its historical development, material properties at low temperatures, and its applications in aerospace, medical, and industrial sectors while considering safety, efficiency, and environmental impact. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7, LO 3.8)*

3. Evaluate gas liquefaction cycles (Joule-Thomson, Linde-Hampson, Claude, and cascaded) and their thermodynamic performance, efficiency, and key components under various conditions. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6, LO 4.7, LO 4.8, LO 4.9, LO 4.10)*

4. Apply thermodynamic principles to optimize and design cryogenic refrigeration and liquefaction methods while ensuring efficiency, feasibility, safety, and sustainability. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*

5. Assess cryogenic fluid storage and transport by applying engineering principles, analyzing insulation techniques, safety, thermodynamic modeling, and sustainability to meet regulatory standards. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC6023.1	3	3	3	3	--	3	--	--	--	--	--
MEPEC6023.2	3	3	3	--	--	3	--	--	--	--	--
MEPEC6023.3	3	3	3	3	--	3	--	--	--	--	--
MEPEC6023.4	3	3	3	--	--	3	--	--	--	--	--
MEPEC6023.5	3	3	3	--	--	3	--	--	--	--	-
Average	**3**	**3**	**3**	**3**	**--**	**3**	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Randall F. Barron, “Cryogenics Systems”, Second Edition, Oxford University Press, New (1985).
2. Thomas M. Flynn, “Cryogenic Engineering”, second edition, CRC press, New York (2005)
3. R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1959

Reference Books :

1. Klaus D.Timmerhaus and Thomas M.Flynn, Cryogenic Process Engineering, Plenum Press,1989.
2. Tom Bradshaw, Beth Evans, John Vandore, Cryogenics –Fundamentals, Foundations and applications, IOP Publishing, Bristol, UK, 2022
3. Cryogenic technology & applications, A R Jha, Butterworth-Heinemann

Other Resources :

1. NPTEL Course: Cryogenic Engineering by IIT Bombay Web link- https://archive.nptel.ac.in/courses/112/101/112101004/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Active participation in Industrial Visit and Report	:	05 Marks
Case study/ Assignments	:	05 Marks
Class Tests	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	MELBC609	MACHINE DESIGN LABORATORY	02

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
25	25	50

Pre-requisite :

1. ESE 101 Engineering Mechanics
2. MEPCC302 Mechanics of Solid
3. MEPCC303 Material Science and Engineering
4. MEPCC406 Theory of Machine
5. MEPCC408 Manufacturing Technology

Program Outcomes addressed :

1. PO2: Problem analysis
2. PO3: Design/development of solutions
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO8: Individual and Collaborative Team work
6. PO9: Communication

Course Objectives:

1. Familiarize students to the use of design data books & various codes of practice for the design/selection of standard machine elements.
2. Guide students through the design calculation, preparation of working drawings of actual design model.
3. Equip students with the basic of modelling software, part design and assembly making.

Module	Detailed Contents	Hrs
	Course Introduction This lab course introduces students to the design of mechanical components such as shafts, keys, and couplings. Students will use modern engineering tools and computational methods to model and analyses the mechanical components/systems while adhering to industry standards. Through practical task and design projects, they will assess design parameters, stress, deformation, and performance characteristics, ensuring efficient and reliable solutions. This hands-on experience prepares students to effectively translate theoretical knowledge into practical engineering applications, equipping them for real-world challenges in mechanical system design.	**01**
	Learning Objective/s:	

01.	*To design machine elements with functional and strength design principle.* *To get acquainted to the design procedure of the Knuckle Joint / Cotter, Shaft, Screw Jack, Bush pin coupling.* *To select the materials and design stresses* *To identify the resisting areas for all possible modes of failure*	**15**
	Tasks: i. Design a Knuckle Joint / Cotter Joint to connect two rods of equal diameter subjected to an axial tensile force. ii. Design shaft under various conditions and to determine the shaft diameter using ASME code. iii. Design a screw jack for the given load carrying capacity and lifting height. iv. Design a bushed-pin type of flexible coupling for the given specification.	
	Self-Learning Topics:	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Design the knuckle joint / cotter joint using the empirical relations subjected to load condition (PI 2.1.3, PI 3.1.6, PI 5.1.1, PI 9.3.1)* *LO 1.2: Design a shaft subjected to static load condition and fatigue criteria. (PI 2.3.1, PI 3.1.6, PI 5.1.1, PI 9.1.2)* *LO 1.3: Design all the components of screw jack and check for the various failure criteria. (PI 2.4.1, PI 3.1.6, PI 5.3.2, PI 8.2.1, PI 9.1.1)* *LO 1.4: Design all the components of coupling and check for the various failure criteria. (PI 2.3.1, PI 2.4.4, PI 3.3.1, PI 5.2.1, PI 8.2.1, PI 9.3.1)*	
02.	***Learning Objective/s:***	**14**
	To prepare the working drawings of machine elements based on the design calculations and perform FEA analysis. *To get acquainted to the conversion of design dimensions into manufacturing / working drawing using modeling software.* *Perform the FEA analysis of the modelled components using simulation software.* *To perform design exercises in the form of design calculations.*	
	Tasks:	
	i. Convert design dimensions of knuckle joint/cotter joint into manufacturing / working drawing using modeling software. ii. Perform the FEA analysis of the modelled components using simulation software. iii. Design exercises in the form of design calculations with sketches and/ or drawings	

	on bolted joints, bearings and belt machine elements.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Convert design dimensions into manufacturing drawing and model the components and system using modeling software. (PI 3.3.1, PI 4.1.3, PI 5.1.2, PI 7.1.1, PI 7.2.1)* *LO 2.2: Analyze the modelled component/system using finite element analysis (FEA) simulations. (PI 3.1.4, PI 2.4.2, PI 2.4.4, PI 4.3.1, PI 5.3.2)* *LO 2.3: Interpret and evaluate post-processing results, including stress distribution, deformation to assess the structural integrity of machine element. (PI 2.4.4, PI 4.3.3, PI 5.2.1, PI 7.2.1)* *LO 2.4: Extract the data from a design data book like PSG and use it for the designing of the mechanical components. (PI 2.4.4, PI 3.1.4, PI 3.1.6)*	
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHR
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data and drawing of conclusions.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling, and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems

5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.

5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.

7.1.1 Identify situations of unethical professional conduct and propose ethical alternatives

7.2.1 Identify tenets of the ASME professional code of ethics

8.2.1 Identify tenets of the ASME professional code of ethics.

9.1.1 Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective teamwork to accomplish a goal.

9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.

9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes: A learner will be able …….

1. To design shaft, knuckle Joint, cotter joint under various conditions by selecting suitable materials, design stresses. *(LO 1.1, LO 1.2)*
2. To design screw jack and flexible flange couplings under various conditions by selecting suitable materials and design stresses. *(LO 1.3, LO 1.4)*
3. To convert design dimensions into working/manufacturing drawing of knuckle joint/cotter joints and flexible flange couplings. *(LO 2.1, LO 2.2, LO 2.3)*
4. To use the design data book/standard codes to standardise the designed dimensions. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC609.1	--	3	3	--	3	--	--	--	3	--	--
MELBC609.2	--	3	3	--	3	--	--	2	3	--	--
MELBC609.3	--	3	3	3	3	--	3	--	--	--	--
MELBC609.4	--	3	3	--	3	--	--	2	3	--	--
Average	--	**3**	**3**	**3**	**3**	--	**--**	**2**	**3**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Design of Machine Elements - V.B. Bhandari, Second edition, 2007, Tata McGraw Hill Publication
2. Design of Machine Elements – C.S. Sharma and Kamlesh Purohit. 2009, Prentice Hall India Publication
3. Machine Design by N. C. Pandya and C. S. Shah, 2006, Charotar Publishing House Pvt. Limited.
4. Machine Design by R. S. Khurmi and J.K. Gupta, 2007, S. Chand and company Ltd.

Reference Books :

1. Machine Design -An Integrated Approach - Robert L. Norton, Second edition, 2006, Pearson Education
2. Mechanical Engineering Design by Joseph Edward Shigley, Charles R. Mischke and Richard Gordon Budynas, 2004, McGraw Hill Publication
3. Design Data: Data Book of Engineers by PSG College,2020, Kalaikathir, Achchagam-Coimbatore

IN-SEMESTER ASSESSMENT (25 MARKS)

1. Continuous Assessment (25 Marks)

Suggested breakup of distribution

- Performance based on completion of task (Marks will be awarded to students based on task performance with proper understanding) : 15 Marks
- Course Project (max 4 students) : 05 Marks
  Design of any mechanical system consisting of four to five mechanical elements.
- Regularity and Active Participation : 05 Marks

END SEMESTER EXAMINATION (25 MARKS)

Students will be assessed based on

- Performance in the design task
- Oral

- Students will be randomly allocated a design task from the list of tasks performed during the semester (or any other similar task) and will be asked to write brief procedure related to the execution of the task including the diagram and/or calculation if any. The procedure and/or calculation is checked by the examiners (Internal and External) and evaluated out of 15 Marks.
- The students will be allocated 1 hour to complete the execution.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of oral examination which will be evaluated of 10 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
SBL	MESBL603	CNC AND 3D PRINTING LABORATORY	02

<table>
<tr><th colspan="6">Examination Scheme</th></tr>
<tr><th colspan="3">Distribution of Marks</th><th colspan="2" rowspan="2">Exam Duration (Hrs.)</th><th rowspan="3">Total Marks</th></tr>
<tr><th colspan="2">In-semester Assessment</th><th rowspan="2">End Semester Examination (ESE)</th></tr>
<tr><th>Continuous Assessment</th><th>Mid-Semester Exam (MSE)</th><th>MSE</th><th>ESE</th></tr>
<tr><td>50</td><td>--</td><td>50</td><td>--</td><td>02</td><td>100</td></tr>
</table>

Pre-requisite:

1. MESBL402 CAD Modeling
2. MEPCC408 Manufacturing Technology

Program Outcomes addressed:

1. PO3: Design/Development of Solutions
2. PO4: Conduct investigations of complex problems
3. PO5: Engineering tool usage
4. PO8: Individual and Collaborative Team work
5. PO9: Communication

Course Objectives:

1. To familiarize students with part programming for tool path generation for machining operations, using G-M codes.
2. To make students acquaint with developing tool path from CAD to CAM system, using computer aided tool.
3. To prepare students for developing a 3D printed part using, FDM technique from CAD data.
4. To enable students to know the process of interpreting and processing medical scan data.

Module	Details	Hrs.
	Course Introduction This lab course equips students with practical skills that are directly applicable to a wide range of industries, including automotive, aerospace, healthcare, and consumer products. This course is essential as it bridges the gap between traditional and modern manufacturing techniques, offering hands-on experience with both CNC programming and 3D printing technologies. By learning both CNC programming and 3D printing, students gain understanding of modern manufacturing, and prototyping cycles, in real-world applications.	**01**
01.	**Part A: - CNC part Programming** **Tool path generation for machining operations, using GM code part programming.** ***Learning Objective:***	**5-6**

<table>
<tr><td></td><td>To get acquainted with the basics of GM code part programming for developing tool paths for various machining operations.

Contents: Introduction to 2 and 3 axis CNC machines, importance of tool path generation for machining operations, coordinate system, setting of work zero and machine zero, basics of manual part programming for tool path generation using G-M codes, Canned cycles, manual part programming using G-M codes for developing a tool path for drilling, milling and similar machining operations.
Coordinate system and setting of work zero and machine zero for CNC lathe machines, manual part programming using G-M codes for developing a tool path for machining operations like, facing, turning, taper turning, radius turning, thread cutting, chamfer, etc.

Self-Learning Topics:
Constructional details of CNC machines.

Learning Outcomes:

Task: Develop the tool path for drilling, milling, and turning types of machining operations using GM codes, considering following points.
1. Set up coordinate system, prepare the part geometry diagram as per the coordinate system.
2. Select cutting tools required for given machining operations, refer standard machining data and calculate speed and feed for the same.
3. Use G-M codes, and various CANNED cycles to develop a required tool path.
(Total 3 experiments: - one of each on drilling, milling, and turning types of machining operations)
A learner will be able to
LO 1.1: Develop an appropriate tool path using GM codes, for given data. (PI 3.1.3, 3.1.4, 3.1.6, 4.3.1, 4.3.4, 9.1.1, 9.3.1)</td><td></td></tr>
<tr><td>02.</td><td>Tool path generation for machining operations, from CAD to CAM system, using computer aided tool.
Learning Objective:
To get familiarize with the use of computer aided tools like Autodesk Fusion 360 to create tool path for various machining operations, directly from CAD data.

Contents:
I. CAM Workspace
1. Introduction to CAM Workspace, workflow in the CAM environment, creating a new CAM project, stock material setup, coordinate systems and machine setup, setting of work piece orientation, home position.
2. Creating Basic and Advance level toolpaths, tool selection, creating basic level 2D toolpaths like 2D contour, 2D pocket, drilling, tapping, turning, facing, canned cycles, etc., use of advanced toolpath strategies like adaptive clearing, 3D Contour, etc.
3. Post-Processing and G-code Generation, selecting and configuring post-processors in CAM workspace, simulating toolpaths, generating G-code for CNC machining, steps to export G-code to machine controllers.
II. A case study or video demonstration on Part Programming Simulation: A case study or video demonstration on part programming</td><td>6-7</td></tr>
</table>

	simulation for any non-conventional machining process (electric discharge machining, laser cutting machining, plasma cutting machining etc.)	
	Self-Learning Topics: *Various computer aided tools available for assisting CAD data to CAM systems.*	
	Learning Outcomes: **Task: generate the tool path for drilling, milling, and turning types of machining operations using CAD to CAM systems, considering following points**. 1. Create CAD model of the required finished part, call the finished part in CAM environment, set up stock size, work piece orientation, coordinate systems and home position for the given part**.** 2. Generate, simulate, verify and post process the tool paths for machining operations, using Fusion 360. (Total 3 experiments: - one of each on drilling, milling, and turning types of machining operations) *A learner will be able to* *LO 2.1: Synthesize CAD to CAM data to simulate the tool path, and verify the same for the correctness (PI 3.1.3, 3.1.6, 4.3.1, 4.3.4, 5.1.1, 5.1.2, 5.2.2, 9.1.2, 9.1.3)* **Task: A task based group activity, After MSE-(max 4 students in one group), based on part programming simulation for any non-conventional machining process.** (Total 1 Task/experiment) *A learner will be able to* *LO 2.2: Identify, read and summarize one case study/ an article (from a quality journal/ conference/ research paper) or video demonstration, on a simulation approach, for any non-conventional machining process. (PI 3.1.1, 3.1.3, 8.3.1, 9.1.1, 9.3.2)*	
03.	**Part B: - Introduction to 3D printing** ***Learning Objective:*** *To get acquainted with 3D printing process sequence, pre-processing, actual printing and post processing using FDM technique.*	**9-10**
	Contents: **I. 3D printing process sequence** Overview of 3D printing process sequence, introduction to FDM printing method, steps in product development from CAD to FDM 3D printed structure. Software used in this process. FDM machine construction details. **II. Development of a 3D printed structure using FDM** Creating CAD parts, converting CAD file to file formats like. stl, .obj, etc., using product data exchange, refinement of. stl file, processing. stl file in 3D printing FDM software, part orientation and manipulation, Filament Setting, Slicing Setting, printing parameters settings. File transfer from software to machine, Part printing and post processing	
	Self-Learning Topics: *Various other 3D printing processes*	
	Learning Outcomes: **Task: To develop a 3D printed object by FDM approach, considering following points,** 1. Create a CAD model of a part/component to be 3D printed by FDM technique,	

	convert the CAD part to. stl file format, check and repair. stl file. 2. Perform preprocessing of .stl file using FDM based 3D printing software. 3. 3. set up alternative part orientation, and support structure settings, in a FDM based 3D printing software and select the most suitable orientation with respect to printing time and material consumption. 4. Develop G – Code output from preprocessing step, Print the 3D part using FDM method and perform post processing of the 3D printed part. (Total 2 experiments) *A learner will be able to* *LO 3.1: Create a 3D model in CAD environment and process the 3D model for printing the same object. (PI 3.1.3, 3.1.6, 3.2.2, 3.2.3, 4.3.1, 4.3.2, 4.3.4, 5.1.1, 5.1.2, 5.2.2, 9.1.2, 9.1.3, 9.3.1)*	
04.	**Part C: Introduction to Bio modeling** ***Learning Objectives:*** *To get acquainted with steps of medical modeling and scan data processing.*	**6-7**
	Contents: **I. Overview of bio modeling process** Introduction to biomedical scanning methods, reading and interpreting DICOM files using sample files in software. **II. Development of a 3D printed structure from DICOM files** Creation of 3D model from 2D images using any image processing software like, 3D Slicer (open source). Data Acquisition, Data Processing tools like, volume rendering, segmentation, thresholding, scissors, etc., generation of GM codes, file transfer to FDM machine, and 3D printing for a bio medical application.	
	Self-Learning Topics: *Methods of medical imaging.*	
	Learning Outcomes: **Task: Read and interpret any sample DICOM file (scan data). Process DICOM data, to develop a 3D printed object by FDM approach, considering following points,** 1. read and interpret the sample anatomical data from available DICOM files. 2. Process the DICOM file to extract a particular anatomical structure using data processing tools and prepare .stl file from the same. 3. Check and repair .stl files, preprocess the. stl file in a FDM based 3D printing software, 4. Develop G code output, and data transfer to FDM based 3D printer for actual printing, and post processing of printed part. (Minimum 1 experiment) *A learner will be able to* *LO 4.1: Create a 3D model using biomedical scan data and process the same for 3D printing. (PI 3.1.3, 3.1.6, 4.3.1, 4.3.2, 4.3.4, 5.1.2.5.2.2, 9.1.1, 9.1.2, 9.1.3, 9.3.1)*	
	Course Conclusion	**01**
	Total	**60**
Total Minimum 10 experiments		

Performance Indicators:

P.I. No.	P.I. Statement
3.1.3	Synthesize engineering requirements from a review of the state-of-the-art
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE.
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2.2	Build models/prototypes to develop a diverse set of design solutions
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.2	Demonstrate proficiency in using discipline-specific tools
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1	Read, understand and interpret technical and non-technical information
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation

Course Outcomes: A learner will be able to -

1. Develop a tool path for specific machining operations using part programming with G-M codes. *(LO 1.1)*
2. Generate CAM tool-path for specific machining operations from CAD Data. (*LO 2.1, LO 2.2)*
3. Create a 3D model of any real life object, in CAD environment and process the same for 3D printing. *(LO 3.1)*
4. Create a 3D model using biomedical scan data and process the same for 3D printing. *(LO 4.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MESBL603.1	--	--	3	3	--	--	--	--	3	--	--
MESBL603.2	--	--	3	3	3	--	--	2	3	--	--
MESBL603.3	--	--	3	3	3	--	--	--	3	--	--
MESBL603.4	--	--	3	3	3	--	--	--	3	--	--

Average	--	--	3	3	3	--	--	2	3	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications.
2. CAD / CAM and Automation, Farazdak Haideri , Nirali Prakashan.
3. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.

Reference Books :

1. Medical Modeling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
2. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication

Other Resources :

1. NPTEL Course: Computer numerical control (CNC) of machine tools and processes, IIT Kharagpur Prof. Asimava Roy Choudhury. Web link:- https://nptel.ac.in/courses/112105211
2. NPTEL Course: Fundamentals of Additive Manufacturing Technologies, IIT Guwahati, Prof. Sajan Kapil. Web link:- https://nptel.ac.in/courses/112103306

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - (30 Marks)

Suggested breakup of distribution

Practical performance based on all the experiments mentioned in the syllabus with proper understanding- 15 Marks
A task based group activity - Article reading and summarization: 10 Marks
Regularity and active participation: 5 marks

2. Practical Test (20 Marks)

- The test will be conducted after 40 % of the syllabus.
- Practical test of 1-hour duration to be conducted by Internal Examiner, based on developing tool paths for machining operations, from CAD to CAM systems.
- Evaluation of practical examination to be done by examiner, based on the printout of student's work.

END SEMESTER EXAMINATION (50 MARKS)

Students will be assessed based on three parameters:

- GM codes part programming knowledge,
- CAD to CAM Skills, Skills of 3D printing software, Skills of Slicer (open source) software,
- Oral

Students will be randomly allocated with two tasks based on experiments covered in syllabus during the semester.
Students will be getting 2 Hours to complete the task. Additional 10 minutes will be allocated for printouts.
Two examiners, one Internal and one External will do the evaluation, based on printout and oral exam.
The evaluation breakup is given below:

- Task 1: 20 Marks.
- Task 2: 20 Marks.
- Oral Examination: 10 Marks.

Course Type	Course Code	Course Name	Credits
MNP	MEMNP604	MINI PROJECT- 2B	01

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project Management and Finance
11. PO11: Life-Long Learning

Course Objectives:

1. To guide students in identifying societal or research needs and formulating them into problem statements.
2. To facilitate problem-solving in group settings.
3. To apply basic engineering principles to address identified problems.
4. To foster self-learning and research skills.

Course Outcomes:

At the end of the course, students will be able to:

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project
Mini project may be carried out in one or more form of following: Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of

software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
- However, based on the individual students or group capability, with the mentor’s recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- Continuous Assessment marks distribution in semester V (50 marks):
    - 05 marks for the Topic Approval Presentation in front of the progress monitoring committee
    - 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
    - 25 marks for the Final Report & Presentation
    - 05 marks for Regularity and Active participation
- Continuous Assessment marks distribution in semester VI (50 marks):
    - 15 marks for the In-Semester Two Presentations
    - 05 marks for Participation in Project Competitions, TPP, etc.
    - 25 marks for the Final Report & Presentation
    - 05 marks for Regularity and Active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester V:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:

- The first review will focus on finalizing the problem statement (topic approval).
- The second review will centre on finalizing the proposed solution.

Semester VI:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
  - The first review will assess the readiness to build a working prototype.
  - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to above mentioned points, the following performance criteria shall be included during in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester VI (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks.

Course Type	Course Code	Course Name	Credits
ELC	ELC601	Research Methodology	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	--	--	--	50

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer and The World.
4. PO7: Ethics
5. PO8: Individual and Collaborative Team Work
6. PO9: Communication
7. PO11: Life-long learning

Course Objectives:

1. To gain the knowledge of use research tools and techniques to design research projects and form the hypothesis.
2. To familiarize students about the literature review practice for identifying the research gap.
3. To gain the knowledge about collection of data and qualitative/ quantitative analysis of data and results
4. To understand the key practices in preparation of a research report / paper.
5. To foster ethical practices in research and publications

Module	Details	Hrs
00	**Course Introduction:** This course aims to introduce students to the important aspects of research. The course is intended to make students aware of formal research and to overcome common misconceptions in research that may be present in their minds. At the end of this course, students shall be able to take up research activities in a more systematic and formal manner right from the beginning. This course on Research Methodology learned through experiential learning mechanism can play a significant and holistic role in contributing to the personal and professional development of students.	1
1	**Fundamentals of Research Methodology**	4-5
	Content: Types of Research, Research approaches, Empirical research methods, Significance of research, Research design, Case study method,	

	Sampling technique, Sources of data, Selection of research problem, Research Ethics and Empiricism *Exercise: A group discussion on what is research and ethics in research with related case studies shall be conducted.*	
2	**Formulation of a Research Problem & Hypothesis formulation**	**4-5**
	Content: Selection and formulation of a research problem, Objectives of formulation, Criteria of a good research problem, Literature Review Process and Formulation of Research Questions Hypothesis-Characteristics and Hypothesis Testing –Logic and Importance *Exercise: Groups of students shall make Technical Presentations on Selection of a research problem and Hypothesis formulations based on topics given.*	
3	**Research Design**	**4-5**
	Content: The Research framework, Research design: Need, Characteristics & Components; Experimental and non-experimental designs, Experimental and non-experimental hypothesis testing. Classification schemes for research design, Principles of experimental designs, Writing rationale for a research *Exercise: Students shall prepare the framework of research methods and techniques to conduct a study on a given real life case study covering key elements of the module.*	
4	**Sampling Method**	**3-4**
	Content: Probability or random sampling, Cluster sampling, Area sampling, Multi-stage sub-sampling, Random sampling with probability proportional to size, Non-probability sampling. *Exercise: A real life case study shall be demonstrated to students covering key elements of the module shall be covered.*	
5	**Data Collection & Data Analysis**	**4-5**
	Content: Sources of data, Collection of data, Measurement and scaling technique, Collection of data from appropriate sources (primary and secondary), Correlation and causation, Classification of quantitative analysis. Selection and analysis of multi-variate methods, Performing data analysis and presentation of results, Case study method.	

	Exercise: Group of students shall carry out exercise of real life data collection on a given research problem and data analysis and submit the report	
6	**Report Writing and Journal Publication**	**3-4**
	Content: Preparation of a research report, Formats and Contents of report: Literature review, Presentation of research work, Research Design & Analysis, Results, Findings, and Contribution, Significance of research, and Conclusion. Mechanics of writing papers in Peer-reviewed Journals / Reputed Conferences. Ethics in Publication. *Exercise: Students shall prepare & submit a paper (4-5 pages) in a standard format (suitable universally accepted journal publication format) based on the exercises / research case study carried out in this course.*	
7	***Course Conclusion***	**1**

Course Outcome: Learner will be able to

CO1: Identify and demonstrate the importance of research process in science and technology domains
CO2: Perform literature reviews using print and online databases.
CO3: Analyse the data using qualitative and quantitative methods
CO4: Identify and prepare the key elements of a research report/ paper
CO5: Illustrate the rationale for research and publication ethics

Text Books:

1. C. R. Kothari and Gaurav Garg, Research Methodology: Methods and Techniques, New Age International Publisher, 2014.
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Sage Publication, 2018
3. R. Pannershelvam, Research Methodology, Prentice Hall, India, 2014

Reference Books:

1. John W. Creswel, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Ed., SAGE, 2018.Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2005.
2. Suresh C. Sinha and Anil K. Dhiman, Research Methodology (2 Vols-Set), Vedam Books, 2006.
3. Manfred Max Bergman, Mixed Methods Research, SAGE Books, 2006.
4. Paul S. Gray, John B. Williamson, David A. Karp, John R. Dalphin, The Research Imagination, Cambridge University press, 2007.
5. Cochrain & Cox, Experimental Designs, II Edn. Wiley Publishers, 2006

Other Resources:

NPTEL Course: Research Methodology By Prof. Edamana Prasad, Prof. Prathap Haridoss (IIT Madras) Weblink https://onlinecourses.nptel.ac.in/noc25_ge28/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6011	ART OF LIVING	02

Program Outcomes addressed:

1. PO6 : The Engineer & The World
2. PO7 : Ethics
3. PO8 : Individual and Team Work
4. PO9 : Communication
5. PO11: Life-long learning

Course Objectives :

1. To provide a comprehensive understanding of the principles of the Art of Living and their relevance to holistic well-being.
2. To equip participants with practical techniques like Sudarshan Kriya, yoga, and mindfulness for stress management and emotional balance
3. To enable participants to apply the Art of Living principles to enhance relationships, productivity, and life purpose.

Module	Details
01.	**Introduction to the Art of Living** Understanding the Mind and Stress, Breath and Life Energy, Basics of Yoga and Guided Meditation
02.	**Sudarshan Kriya and Breathing Techniques** Introduction to Sudarshan Kriya, Practicing Rhythmic Breathing Techniques
03.	**Emotional Well-being** Understanding and Balancing Emotions, Forgiveness and Gratitude Practices, Guided Meditation for Emotional Healing
04.	**Relationships and Social Connections** Compassion and Effective Communication, Stress-free Relationships, Group Activities for Trust and Collaboration
05.	**Living with Purpose and Awareness** Discovering Life Purpose, Mindfulness Practices, Time Management and Productivity
06.	**Sustaining the Practices** Developing a Daily Routine, Advanced Breathing Techniques, Reflections, and Closing Meditation
Total no. of hours: **30**	

Course Outcomes :

1. Gain insights into managing stress and emotions through breathwork and meditation

2. Develop skills for building harmonious relationships and enhancing emotional intelligence.
3. Cultivate mindfulness, compassion, and clarity in daily life.
4. Sustain the Art of Living practices for long-term well-being and self-discovery.

Text Books :

1. "Celebrating Silence" by Sri Sri Ravi Shankar (1999, Sri Sri Publications Trust)
2. "The Heart of Yoga: Developing a Personal Practice" by T.K.V. Desikachar (1995, Inner Traditions International)
3. "The Miracle of Mindfulness" by Thich Nhat Hanh (1975, Beacon Press)

Reference Books :

1. "Wisdom for the New Millennium" by Sri Sri Ravi Shankar (2000, Sri Sri Publications Trust)
2. "The Healing Power of the Breath" by Richard P. Brown and Patricia L. Gerbarg (2012, Shambhala Publications)

Course Type	Course Code	Course Name	Credits
LLC	LLC6012	Yoga and Meditation	02

Program Outcomes addressed:

1. PO6: The Engineer and The World
2. PO7: Ethics
3. PO11: Life-Long Learning

Course Objectives:

1. To raise awareness of the therapeutic and preventive benefits of Yoga and Meditation
2. To nurture Holistic wellness through the harmony of body, mind and self
3. To advocate for the application of Yogic science in the treatment and prevention of psychosomatic and Lifestyle disorders.
4. To inspire the practice of Yogic Science tools for fostering health and well-being in daily life.
5. To promote the art of purposeful and mindful living by cultivating a deep sense of oneness with the self, nature and the world.

MODULE	DETAILS
1.	**Introduction to Yoga and Meditation** Definition of Yoga, Importance of Yoga for Human life, Literature of Yoga: Yoga Sutra, Bhagavat Gita – Synthesis of Yoga, Hathapradipika etc. Challenges of health in students & youth - Studies, Yogic concept of Health and Meditation, Concept of Body and Disease in Yoga, Dimensions of Health- Physical, Mental, Social and Spiritual, Different types of yoga (Karma, Gyaan, Ashtanga, Bhakti), Eight limbs of ashtanga yoga.
2.	**Yoga and Wellness** Yoga and Medical perspectives – Health related fitness, Yoga for common ailments, Scientific Researches in Yoga, Yogic anatomy of Human body, Asanas – Definitions and classifications, Scientific reasoning behind the asanas, Yoga for Stress, Technostress and Lifestyle management. Mental Disturbances and Preventive, Curative Aspect of Yoga for Mental wellness.

3.	**Essentials of Yoga Practices** Difference between Yoga and Exercise, Obstacles in the path of Yogic Practices, Disciplines in Yogic practices – Prayers, Yama, Niyama, Place, Time, Diet, Schedule, Sequence for Yogic Practices. Yogasanas: Surya Namaskara, Standing asanas and Sitting asanas, Different groups of Yogasanas – Relaxation, Meditative, Digestive etc. Psycho-physiological effects and health benefits of Yogasana, Function and effect of Asanas - Digestive system, Respiratory system, Excretory system, Circulatory system, Nervous system etc.
4.	**Meditation – Role of Breath and Pranayama** Yogic anatomy, Wellness and Triguna system, Science of Pranayama – 'Prana', the vital principle, Prana and air element, Awareness - Breath Awareness, Different types of Breathing, Breath Control, Breath and Postures, Rhythmic Breathing, Pranic body in the five-fold body (Panchakosha), Power of breath, Difference between Pranayama and breathing, Prana and nervous system, Fivefold function of prana, Benefits of pranayama
5.	**Fundamental aspects of Meditation** Pranayama and deep breathing - Concept of Inhalation (Puraka), Retention (Kumbhaka), & Exhalation (Rechaka); Important Pranayamas; Pranayama and Meditation; Mind and Meditation; Inner Instrument – Mind, Constituents of Mind - Mana, Buddhi, Ahankar and Chitta(Consciousness), Magnitude of Mind, Buddhi – the determinative faculty; Body-Mind complex; Mind Cleansing; Yogic Meditation and Mindfulness meditations; Yogic Process and Outcome of Meditation – Pratyahara, Dharana and Dhyana; Scientific studies on Meditation and Healing.
6.	**Meditation Tools and Techniques** Why Meditate - States of Mind, Mind over Body – Processing Thoughts, Preparing for Meditation – Posture, Shanti prayers, Pranayama, Training the Mind: Practicing tools- Bhramari Pranayama, Sacred Pranav (Om) mantra, Mantra Japa/ajapa, Types of Mindfulness Meditations, Yoga Nidra, Body scan meditation, etc. Benefits of Meditation

Course Outcomes:

1. Gain comprehensive insights about the necessity of yoga for daily life.
2. Obtain a simplified understanding of the impact of mindful breathing on health wellbeing.
3. Acquire knowledge of 'practice and principles' of simple awareness meditation for Mental wellness
4. Gain required knowledge to improve overall health and immune system
5. Practice simple asanas and meditation techniques to improve concentration, self-confidence and inner peace

Text Books:

1. Light on the Yoga Sutras of Patanjali by B.K. Iyengar (Publisher: Orient Longman Pvt. Ltd. Mumbai)
2. Pranayama - The Art & Science by Dr. Nagendra H R (Publisher: Swami Vivekananda Yoga Prakashan, Bangalore)
3. Yog – Its Philosophy and Practice by Swami Ramdev (Publisher: Divya Prakashan, Haridwar)

Recommended Books

1. Pranayama-Science of Breath by Gharote, M. (Publisher: The Lonavla Yoga Institute, India)
2. Svatmarama's HathaYogaPradeepika by Gyan Shankar Sahay (Publisher: Yogic Heritage, India)
3. Yoga for Health and Peace by Padamshree Sadashiv Nimbalkar (Publisher: Yoga Vidya Niketan, Mumbai)

Other Resources:

1. NPTEL Course: Yoga and Positive Psychology for Managing career and life by Prof. Ashish Pandey, IIT Bombay.
Weblink https://archive.nptel.ac.in/courses/110/101/110101165/

2. SWAYAM Course: Yoga for Concentration by By Dr H R Nagendra, Dr Manjunath N K and Dr Apar Avinash Saoji from Swami Vivekananda Yoga Anusandhana Samsthana, Bangalore.
Weblink: https://onlinecourses.swayam2.ac.in/aic23_ge05/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6013	Health and Wellness	02

Program Outcomes addressed:

1. PO6: The Engineer and The World
2. PO7: Ethics
3. PO11: Life-Long Learning

Course Objectives:

1. To advocate for the significance of Holistic wellness
2. To enhance all dimensions of wellness through the lens of scientific temper.
3. To foster integrative medicine through mindful lifestyle choices and guided practices
4. To promote the integration of scientific research with ancient wellness practices & techniques.

MODULE	DETAILS
1.	**Foundations of Health Well-being** Defining Health and Wellness, Dimensions of wellness Determinants of Health behavior, Health in everyday life Constitution of your body, Medical Anatomy of physical body Layers of your Body: Physical, Physiological, Psyche Yogic anatomy of Physiological and Psyche layers, Triguna system
2.	**Physical Wellbeing** Management of Ailments: Common, Acute, chronic Integrative medicines: Ayurveda, Naturopathy, Yoga etc. Preventive care for illness, Lifestyle, Dietary habits, Repair and Rejuvenation
3.	**Emotional Wellness** Types of Emotions, Symptoms of emotional wellness Studies on challenges of emotional wellness: Sleep, Stress, Resilience, eating habits, attention deficit, Digital fatigue, Communications etc. Emotions and physical wellness Understanding the trinity of senses, sense objects and emotions, Studies on breath regulation, Role of breath in emotions, Yogic methods to emotional wellness

4.	**Mental Wellness** What is Mental Wellness, Dimensions of mental Wellness Scientific studies on Mental disorder issues: Depression, anxiety, behavioural disorder, addiction, self-disconnection, suicidal thoughts etc. Mind-Body issues: Mental Wellness, Mental illness and Physical illness, Constitution of Mind – Manas, Buddhi, ahankara, Chitta, Consciousness Intelligence and Mental Wellness, Modifications of Mind Paths to Mental Wellness: Regulating Thoughts, Meditation tools and process - Pranayama, Pratyahara, Dharna, Dhyana, Mindfulness meditation, Chakra meditation, Sabdh(mantra) Meditation, spiritual engagements
5.	**Intellectual Wellness** Mind, Intelligence and Intellectual Wellness Aspects of Intellect, incapacitate Intellect, Examining Intellectual Wellness, Nurturing Intellectual Wellness
6.	**Spiritual Wellness** Yogic understanding of term 'spiritual' Relationship: Physical, Physiological, Psyche, Consciousness (Spiritual) Symptoms of spiritual wellness Studies on Spiritual wellness and Body Healing Practices for spiritual wellness: Prayers, Yoga and Meditation, spiritual engagements

Course Outcome: Learner will be able to

1. Gain a comprehensive understanding of Holistic Health
2. Acquire essential knowledge to regulate thoughts and behavior.
3. Apply holistic health tools for emotional stability and healthy mind
4. Develop proficiency in applying cognitive faculty for intellectual pursuits
5. Acquire holistic wisdom for attaining inner peace in daily life

Text Books

1. Nature Cure for All: Natural Remedies for Health Disorders (Publisher: Nisargopachar Gramsudhar Trust, Pune)
2. Towards the Wellness of Body, Mind and Self – Conference Proceedings Editor - Dr. Jayanti Chavan (Publisher: Institute of Science and Religion, Navi Mumbai)

3. Ayurveda & Panchakarma – The Science of Healing and Rejuvenation by Dr. Sunil V. Joshi (Publisher: Motilal Banarsidass Publishing House, Delhi)

Reference books

1. Dr R Nagarathna and Dr H R Nagendra: Yoga for Promotion of Positive Health (Publisher: SVYP, Bangalore)

2. Text book of Kriya Yoga – The Cosmic Engineering of Life in the light of Medical Science by Yogacharyya Dr. Chanchal Roy Devsharmman
(Publisher: Motilal Banarsidass Publishing House, Delhi)

3. Yog – Its Philosophy and Practice by Swami Ramdev
(Publisher: Divya Prakashan, Haridwar)

Other Resources:

1. NPTEL Course: Adolescent Health And Well-Being: A Holistic Approach by Dr. Sumana Samanta, Dr. Parmeshwar Satpathy, IIT Kharagpur.
Weblink https://nptel.ac.in/courses/127105236

2. NPTEL Course: The Science of Happiness and Wellbeing by By Prof. Priyadarshi Patnaik, Prof. Manas K. Mandal from IIT Kharagpur.
Weblink https://onlinecourses.nptel.ac.in/noc23_hs06/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6014	DIET AND NUTRITION	02

Program Outcomes addressed:

1. PO6 : The Engineer & Society
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To provide students with a comprehensive understanding of nutrition principles and their application in promoting optimal health.
2. To develop critical thinking skills to evaluate nutritional information and make informed decisions.
3. To apply knowledge of nutrition education and counselling to promote healthy nutrition practices in individuals and group.
4. To demonstrate an understanding of role of nutrition in disease prevention and management.

Module	Details
01.	**Nutrition for wellness -1** Introduction to nutrition, food pyramid, Macros: Carbohydrates, Protein and fats, Micros: Vitamins A C E K and D, Minerals-Calcium, Iron and Zinc Importance of hydration, signs and symptoms, stages of dehydration.
02.	**Nutrition wellness -2** Introduction to mindful eating, plate concept, understanding physical and emotional hunger, eating disorder-Anorexia nervosa, bulimia nervosa and binge eating.
03.	**Exercise and fitness** Introduction to exercise and its importance, types of exercise its classification, side effects of over exercising, Impact of sedentary lifestyle on body composition.
04.	**Sleep and relaxation** Flow of circadian rhythm, sleep cycle, stages of sleep, sides effects, sleeping disorder- sleep apnea, insomnia, sleep hygiene routine and foods inducing sleep
05.	**Managing stress** Introduction to stress, causes, effects of stress, management of stress, foods and adaptogenic foods for stress management.
06.	**The lifestyle flow** Morning/ wake up rituals, meal flow i.e in which order to eat, post meal flow, bedtime rituals – how should your last hour of the day look like
Total no. of hours: **30**	

Course Outcomes :

1. Understand the fundamentals of nutrition and its role in promoting wellness.
2. Apply mindful eating practices to manage physical and emotional hunger.
3. Assess the importance of exercise and its impact on health and fitness
4. Gain insights into sleep hygiene and manage sleep-related disorders.
5. Develop strategies for stress management using nutrition and adaptogenic foods.
6. Assess the importance of exercise and its impact on health and fitness

Text Books :

1. Nutrition and dietetics by C.S. shah: covers various aspects of nutrition, including nutrient metabolism, dietary planning and diet therapy.
2. Dietetics by B. Srilakshmi- covers aspects of dietetics including nutrition, food science and diet therapy.

Reference Books :

1. Nutrition science by B. Shrilakshmi: provides an overview of nutrition, nutrient metabolism and dietary patterns
2. Food science by B. Shrilakshmi covers food, including food composition, food processing and food safety.

Course Type	Course Code	Course Name	Credits
LLC	LLC6015	PERSONALITY DEVELOPMENT	02

Program Outcomes addressed:

1. PO6 : The Engineer & Society
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To enhance self-awareness and self-confidence in the students.
2. To develop effective communication, leadership, and interpersonal skills.
3. To equip students with stress management and time management techniques.
4. To foster teamwork, problem-solving, and decision-making abilities.
5. To prepare students for professional life through resume building, interview skills, and networking.
6. To instill a growth mindset and adaptability in personal and professional contexts.

Module	Details
01.	**Self-Awareness and Emotional Intelligence** Understanding personality traits and self-assessment, Importance of emotional intelligence (EI) in personal and professional success, Strategies to enhance EI and self-awareness.
02.	**Communication Skills** Fundamentals of verbal and non-verbal communication, Public speaking, presentation skills, and storytelling, Listening skills and constructive feedback.
03.	**Leadership and Teamwork** Understanding importance of self-confidence, leadership styles, and their applications, Building effective teams and managing conflicts, Developing collaboration and networking skills.
04.	**Stress and Time Management** Recognizing stressors and managing stress effectively, Prioritization and goal-setting techniques, Tools for efficient time management and productivity.
05.	**Professional Development** Importance of presentation skills, resume writing, cover letter, and LinkedIn optimization, Interview preparation: Mock interviews and common questions, Networking skills and professional etiquette
06.	**Personal Growth and Adaptability** Developing a growth mindset and embracing lifelong learning, Cultivating resilience and adaptability to change, Setting long-term personal and professional goals
Total no. of hours: **30**	

Course Outcomes : By the end of this course, students will be able to:

1. demonstrate increased self-awareness and emotional intelligence.
2. communicate effectively in professional and personal contexts.
3. exhibit leadership and teamwork skills in various scenarios.
4. manage time and stress efficiently to enhance productivity.
5. prepare a professional resume, excel in interviews, and network effectively.
6. develop resilience, adaptability, and a growth-oriented mind-set.

Text Books :

1. Daniel Goleman, Emotional Intelligence: Why It Can Matter More Than IQ / What Makes a Leader: Why Emotional Intelligence Matters
2. Stephen R. Covey, The 7 Habits of Highly Effective People: Powerful Lessons in Personal Change

Reference Books :

1. Dale Carnegie, How to Win Friends and Influence People.
2. Anthony Robbins, Awaken the Giant Within: How to Take Immediate Control of Your Mental, Emotional, Physical, and Financial Destiny!
3. David J. Schwartz, The Magic of Thinking Big.
4. Robin Sharma, The Monk who sold his Ferrari.
5. Dorie Clark, Reinventing You: Define Your Brand, Imagine Your Future.
6. Gangadhar Joshi, Campus to Corporate: Your Roadmap to Employability.

Other Resources :

1. Videos and TED Talks by Simon Sinek, Brené Brown, Malcolm Gladwell and other motivational speakers
2. Online courses on communication and leadership (e.g., Coursera, LinkedIn Learning, EdX).