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

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Second Year Syllabus

Prepared by : Board of Studies for Mechanical Engineering

Approved By: Academic Council of Fr. C. Rodrigues Institute of Technology Effective from :2025-26

Revision: 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

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.

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**

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)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
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. .* **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)*	**6-8**
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.* **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:***	**7-9**

	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.* **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)*	**6-8**
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.* **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.	**6-8**

	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.*	**5-7**
	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)***	
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.*	**9-11**
	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.	

	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.* **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)*	**4-6**
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..* **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*	**6-8**

	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.*	**7-9**
	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)*	
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.*	**5-7**
	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)*	
	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:

P.I. No.	**P.I. Statement**
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, 46odelling 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)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
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)			
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

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)*	

03	**Velocity and Acceleration analysis**	**7-9**
	Learning Objective/s: *To apply basic concepts of the relative velocity and acceleration method to analyze the Coriolis component in the mechanism. (Graphical method)*	
	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)	
	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)*	
04	**Static and dynamic force analysis of the Slider crank mechanism**	**8-10**
	Learning Objective/s: *To analyze static and dynamic forces of a single slider mechanism using basic concepts of mechanism.*	
	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.	
	Self-Learning Topics: *Theory and analysis of compound pendulum.* ***Learning Outcomes :***	

	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.* **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)*	**5-7**
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.* **Contents:** **Machine Tools and Machining Processes:** • Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines and selection of grinding wheel (Dressing	**9-11**

	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.*	**6-8**
	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	

	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.*	**16-18**
	Content:	

	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)**	
	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 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)*	
02.	**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.*	**11-13**
	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.	
	Experiments **1. Build a model of engineering components utilizing multiple work planes, sketches, and 3D sketch geometry with the advanced features**	

	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