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

&

Final Year Syllabus

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

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 – B. Tech Semester-VII

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

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

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

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

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

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

Examination Scheme – B. Tech Semester-VII

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

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

Curriculum Structure – B. Tech Semester-VIII

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

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

Program Elective Course-V:

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

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

Open Elective Course-II:

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

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

Examination Scheme – B. Tech Semester-VIII

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	
MEPEC805Y	Program Elective-V	20	30	50	1.5	2	100
OEC802Y	Open Elective-II	20	30	50	1.5	2	100
MEMJP802	Major Project-B	50	--	50	--	--	100
INT801	Internship	50	--	50	--	--	100
	Total	**140**	**60**	**200**	--	--	**400**

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

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

Course Type	Course Code	Course Name	Credits
PCC	MEPCC712	ADVANCED MANUFACTURING TECHNOLOGY	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. MEPCC408 - Manufacturing Technology

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering Tool Usage
5. PO6: The Engineer and The World
6. PO11: Life-Long Learning

Course Objectives :

1. To introduce modern and emerging manufacturing processes beyond conventional machining and forming.
2. To understand advanced materials processing, automation, and digital manufacturing.
3. To study additive, micro, and hybrid manufacturing systems and their industrial applications.
4. To familiarize students with computer-integrated manufacturing, Industry 4.0 and sustainable production methods.

Module	Details	Hrs
	Course Introduction The course explores modern manufacturing paradigms that integrate innovative processes, smart systems, and digital technologies. It traces the evolution from conventional to advanced manufacturing, emphasizing precision, efficiency, sustainability, and flexibility. The course covers advanced machining, forming, and joining techniques; additive manufacturing; micro- and nano-fabrication; and the integration of Industry 4.0 technologies such as IoT, AI, and Digital Twins. Through case studies and industrial examples, the course develops the ability to analyze, select, and apply appropriate advanced manufacturing methods for diverse engineering applications, fostering expertise in intelligent and sustainable production systems	**01**

01.	**Introduction to Advanced Manufacturing** ***Learning Objective/s:*** *To get acquainted to the history, applications, and limitations of Finite Element Analysis (FEA) and apply its workflow using industry-standard software for geometry preparation, material assignment, and meshing.*	**7-9**
	Contents: • Evolution from conventional to advanced manufacturing including their comparison. • Classification of advanced processes (mechanical, thermal, chemical, hybrid) • Pillars of Industry 4.0: IoT, Big Data, Cloud, AI/ML, Cyber-Physical Systems • Smart factories, digital thread, and digital twin concepts • Comparison: Mass production vs. mass customization	
	Self-Learning Topics: *Smart factories, digital thread, and digital twin concepts*	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to explain the evolution from conventional manufacturing to advanced manufacturing and identify key differences between them. (PI 1.3.1)* *LO 1.2: Apply mechanical engineering principles to classify advanced manufacturing processes such as mechanical, thermal, chemical, and hybrid systems. (PI 1.4.1)* *LO 1.3: Identify the engineering and technological knowledge required to analyze Industry 4.0 pillars including IoT, AI/ML, Big Data, Cloud, and Cyber-Physical Systems. (PI 2.1.3)* *LO 1.4: Compare and contrast mass production and mass customization to evaluate the most suitable manufacturing approach for different industrial scenarios. (PI 2.2.4)*	
02.	**Additive Manufacturing (3D Printing) Technologies** ***Learning Objective/s:*** *The learner is expected to apply layer-by-layer fabrication principles and AM classifications to select materials, integrate DfAM techniques, evaluate post-processing operations, and optimize for aerospace, medical, and automotive applications*	**7-9**
	Contents: • Principles of layer-by-layer fabrication • Classification (ISO/ASTM 52900): VAT Polymerization, Material Extrusion, Powder Bed Fusion, Directed Energy Deposition, Binder Jetting, Sheet Lamination • Materials: polymers, metals, ceramics, composites, bio-materials • Processes: FDM, WAAM and Powder • Design for AM (DfAM): topology optimization, lattice structures, support generation • Post-processing: heat treatment, Hot Isostatic Pressing (HIP), surface finishing	

	• Applications: Aerospace (GE fuel nozzle), medical (implants), automotive, Process plant, etc.	
	Self-Learning Topics: *Post-processing: heat treatment, Hot Isostatic Pressing (HIP), surface finishing*	
	Learning Outcomes : *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to explain the principles of layer-by-layer fabrication used in additive manufacturing processes. (PI 1.3.1)* *LO 2.2: Apply mechanical and materials engineering knowledge to identify suitable polymers, metals, ceramics, composites, and biomaterials for various AM processes. (PI 1.4.1)* *LO 2.3: Identify key process variables and system parameters governing AM methods such as FDM, WAAM, and Powder Bed Fusion for different applications. (PI 2.1.2)* *LO 2.4: Compare and contrast alternative AM processes and post-processing techniques to select the most appropriate approach for aerospace, medical, and automotive components. (PI 2.2.4)*	
03.	**High-Performance Machining & Cutting** ***Learning Objective/s:*** *The learner is expected to apply high-performance machining techniques, Ultra-Precision, Hybrid, and Abrasive Waterjet/Laser/Plasma Cutting, while selecting tooling materials, coatings, and wear monitoring for enhanced efficiency..*	**7-9**
	Contents: • High-Speed Machining (HSM), Hard Machining, Cryogenic Machining • Machining Center: VMC, HMC • Hybrid manufacturing: Additive + Subtractive (e.g., DMG MORI LASERTEC) • Abrasive Waterjet, Laser, and Plasma Cutting • Tooling materials, coatings (TiAlN, DLC), and wear monitoring • Applications: Turbine Blades, Engine parts, Hip/knee joints, Dies and Molds	
	Self-Learning Topics: *Tooling materials*	
	Learning Outcomes : *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to explain the principles of high-speed machining, hard machining, cryogenic machining, and hybrid manufacturing processes. (PI 1.3.1)* *LO 3.2: Apply specialized mechanical engineering knowledge to analyze tooling materials, coating technologies (e.g., TiAlN, DLC), and their influence on cutting performance. (P.I – 1.4.1)* *LO 3.3: Identify machining and cutting process variables such as spindle speed, feed rate, coolant type, cutting forces, laser parameters, and abrasive pressure relevant to high-performance manufacturing. (PI 2.1.2)* *LO 3.4: Compare and contrast advanced cutting processes—abrasive waterjet, laser, and plasma cutting—to determine suitable applications for different materials and geometries. (PI 2.2.4)* *LO 3.5: Identify and select modern machining and monitoring tools, including CNC machining centers (VMC/HMC), wear monitoring systems, and hybrid additive–subtractive platforms. (P.I. – 5.1.1)*	

	LO 3.6: Verify the credibility of tool wear monitoring data and machining performance predictions by analyzing limitations and assumptions of tool condition monitoring systems and simulations. (P.I. – 5.3.2)	
04.	**Micro and Nano Manufacturing** ***Learning Objective/s:*** *The learner is expected to understand micro-machining fundamentals and challenges alongside nano-finishing processes to fabricate MEMS/micro-components, while implementing micro/nano-scale measurement for quality control.* **Contents:** • Micro-machining fundamentals and challenges • Micro-EDM, Micro-ECM, Micro-Laser Machining • Ultra-Precision Machining (diamond turning, micro-milling) • Nano finishing processes: Magnetic Abrasive Finishing, Chemical Mechanical Polishing (CMP) • Fabrication of MEMS and micro-components • Measurement and quality control at micro/nano scale • Applications: Transistors, Micro-gears, Micro-lenses and Nano-robots ***Self-Learning Topics:*** *Measurement and quality control at micro/nano-scale* ***Learning Outcomes :*** *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to analyze micro-machining principles and process behavior in micro-EDM, micro-ECM, and micro-laser machining. (PI 1.3.1)* *LO 4.2: Apply specialized mechanical and materials engineering knowledge to compare ultra-precision machining techniques such as diamond turning and micro-milling for micro-component fabrication. (PI 1.4.1)* *LO 4.3: Examine micro- and nano-scale measurement tools and inspection setups to determine their suitability for data acquisition and dimensional evaluation of MEMS and micro-components. (PI 4.1.2)* *LO 4.4: Analyze micro/nano measurement data to identify deviations, trends, or process-induced errors affecting machining accuracy and surface integrity. (PI 4.3.2)* *LO 4.5: Identify safety, environmental, and societal considerations associated with micro-EDM, micro-laser machining, CMP, and nano-finishing processes. (PI 6.1.1)* *LO 4.5: Evaluate the sustainability implications of micro/nano fabrication technologies with respect to energy consumption, hazardous by-products, and environmental impact. (PI 6.3.2)*	**5-7**
05.	**Advanced Forming and Joining Techniques** ***Learning Objectives:*** *The learner is expected to understand advanced forming and joining principles, classify high-energy and solid-state processes, analyze surface modification techniques, and evaluate their applicability for advanced alloys and composite materials.* **Contents:** • High-energy-rate forming: Explosive forming, Electrohydraulic forming, Magnetic pulse forming • Superplastic forming and hydroforming	**6-8**

	• Advanced joining: Friction Stir Welding (FSW), Laser Beam Welding (LBW), Electron Beam Welding (EBW) • PVD, CVD, Ion implantation, laser cladding • Solid-state joining and diffusion bonding • Comparison of joining and forming techniques for advanced alloys and composites • Applications: Aircraft fuselages, automotive frames stamping, Multi-material joints, Heat exchangers	
	Self-Learning Topics: *Solid-state joining and diffusion bonding*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to evaluate the principles of high-energy-rate forming, superplastic forming, and advanced joining processes. (PI 1.3.1)* *LO 5.2: Use specialized mechanical engineering knowledge to distinguish between solid-state, fusion, and surface-modification processes for advanced alloys and composites. (PI 1.4.1)* *LO 5.3: Identify engineering responsibilities related to safety, societal impact, and public protection in high-energy forming, laser/electron beam welding, and surface-engineering operations. (PI 6.1.1)* *LO 5.4: Interpret forming and joining standards, regulatory requirements, and safety codes relevant to explosive forming, laser systems, and vacuum-based joining technologies. (PI 6.2.1)* *LO 5.5: Identify knowledge gaps related to emerging forming and joining technologies and source credible information to address these gaps. (PI 11.1.2)* *LO 5.6: Interpret technical literature—including AWS, ASM, and current research—to assess the applicability of advanced forming and joining techniques for modern engineering applications. (PI 11.3.1)*	
06.	**Digital Manufacturing, AI & Emerging Trends**	**7-9**
	Learning Objective/s: *The learner is expected to understand digital manufacturing concepts and emerging technologies, analyze the role of AI/ML and simulation in process optimization, and evaluate applications of generative design, blockchain, and advanced fabrication trends through case studies.*	
	Contents: • Digital Twin & Simulation: process modeling, predictive maintenance • AI/ML in manufacturing: defect prediction, process optimization, demand forecasting • Generative design, cloud-based CAD/CAM • Autonomous Manufacturing • Blockchain in supply chain, augmented reality (AR) for assembly • Emerging: 4D printing, bio-fabrication, nanomaterial printing • Case studies: Tesla Gigafactory, Boeing 777X wing production, Rolls-Royce Trent engine	
	Self-Learning Topics: *Blockchain in supply chain, augmented reality (AR) for assembly*	

	Learning Outcomes : *A learner will be able to* *LO 6.1: Apply fundamental engineering concepts to describe the principles of digital manufacturing, including digital twins, simulation-driven modeling, and cloud-based CAD/CAM workflows. (PI 1.3.1)* *LO 6.2: Apply mechanical and computational engineering knowledge to classify emerging technologies such as 4D printing, bio-fabrication, and nanomaterial printing used in advanced manufacturing. (PI 1.4.1)* *LO 6.3: Identify safety, ethical, and societal responsibilities involved in deploying autonomous manufacturing, AI-based decision systems, and blockchain-enabled traceability. (PI 6.1.1)* *LO 6.4: Evaluate how emerging digital manufacturing technologies influence technical performance alongside socio-economic and environmental sustainability factors. (PI 6.3.2)* *LO 6.5: Identify gaps in knowledge related to rapidly evolving manufacturing technologies such as generative design, 4D printing, and bio-fabrication, and apply strategies to update technical competency. (PI 11.1.2)* *LO 6.6: Source and interpret credible digital manufacturing literature, industrial case studies, and emerging technology reports to support continuous professional development. (PI 11.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.4	Compare and contrast alternative solution processes to select the best process.
4.1.2	Examine relevant tools and techniques of experiment/inspection design
4.3.2	Analyze 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
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
11.1.2	Identify gaps in knowledge and apply strategies for independent learning.
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes : Learner will be able to

1. Apply engineering fundamentals and analytical skills to classify advanced manufacturing processes, interpret Industry 4.0 pillars, and evaluate smart manufacturing frameworks. *(LO 1.1, 1.2, 1.3, 1.4)*
2. Analyze additive manufacturing principles, material-process relationships, and DfAM strategies to select suitable AM techniques and post-processing operations for engineering applications. *(LO 2.1, 2.2, 2.3, 2.4)*
3. Apply advanced machining concepts, tooling science, and cutting-process parameters to compare high-performance machining and hybrid manufacturing approaches for precision components. *(LO 3.1, 3.2 ,3.3, 3.4, 3.5, 3.6)*
4. Investigate micro-/nano-scale fabrication methods and advanced forming/joining processes, examining their measurement systems, safety implications, and applicability to advanced alloys and composite structures. *(LO 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6)*
5. Evaluate digital manufacturing technologies, AI/ML-driven optimization tools, and emerging fabrication trends to assess their technical, societal, and sustainability impacts in modern industrial systems. *(LO 6.1, 6.2, 6.3, 6.4, 6.5, 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPCC712.1	3	3	-	-	-	-	-	-	-	-	-
MEPCC712.2	3	3	-	-	-	-	-	-	-	-	-
MEPCC712.3	3	3	-	-	3	-	-	-	-	-	-
MEPCC712.4	3	-	-	3	-	3	-	-	-	-	3
MEPCC712.5	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.

Text Books :

1. Kalpakjian, S., and Schmid, S.R., Manufacturing Processes for Engineering Materials, Pearson, 2020.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 2023.
3. Gibson, I., Rosen, D., and Stucker, B., Additive Manufacturing Technologies, Springer, 2021.

Reference Books :

1. Boothroyd, G., *Fundamentals of Machining and Machine Tools*, CRC Press, 2021
2. Rajiv Dutta, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2020.
3. Chryssolouris, G., Manufacturing Systems: Theory and Practice, Springer, 2013

Other Resources :

1. NPTEL course: Automation in Manufacturing, by Prof. Shrikrishna N. Joshi, IIT Guwahati, Weblink: https://onlinecourses.nptel.ac.in/noc25_me154/preview

2. NPTEL course: Manufacturing Systems Technology I & II, by Prof. Shantanu Bhattacharya, IIT Kanpur, Weblink: https://onlinecourses.nptel.ac.in/noc25_me156/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

2 Class Test (one before MSE and one after)	:	10 Marks
Article 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 carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7031	MECHANICAL SYSTEM DESIGN	03

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

Pre-requisite :

1. ESC101 - Engineering Mechanics
2. MEPCC302 - Mechanics of Solid
3. MEPCC303 - Material Science and Engineering
4. MEPCC406 - Theory of Machine
5. MEPCC408 - Manufacturing Technology
6. MEPCC611 - Machine Design

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: Modern tool usage
6. PO6: The Engineer and The World
7. PO8: Individual and team work
8. PO9: Communication
9. PO11: Life-long learning

Course Objectives :

1. Enable students to understand the concept of mechanical systems and the methodology of systematic design.
2. Enable students to analyse and design gearboxes, hoisting mechanisms of EOT cranes, belt conveyors and pumps as integrated mechanical systems.
3. Enable students to prepare clear working drawings and documentation based on the designed systems and components.
4. Enable students to use design data books and relevant codes of practice effectively during system design and validation.

Module	Details	Hrs
	Course Introduction Design of Mechanical System consist of System Design Concept, Introduction to material handling system, Hoisting Mechanism, Belt Conveyors, Gear Pump,	**01**

	Centrifugal Pump, Design of Machine Tool Gear Box and Transmission Gear Box. The systematic approach and fundamental understanding along with the technology availability help the designer to obtain the best design parameters.	
01.	**System Design Fundamentals** ***Learning Objective/s:*** *To understand the fundamental principles of mechanical system design, methodology and morphology of system design.*	**5-7**
	Contents: Methodology & Morphology of design, Optimum design, system concepts in design.	
	Self-Learning Topics: *Johnson's method of optimization.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1 Apply fundamental engineering concepts to explain the morphology of mechanical system design. (PI 1.3.1)* *LO 1.2 Apply mechanical engineering concepts to outline the idea of optimum design. (PI 1.4.1)* *LO 1.3 Combine basic science and engineering ideas to form list of specification for design of mechanical systems. (PI 2.3.1)*	
02.	**Material Handling System-A:** ***Learning Objective/s:*** *Design the hoisting mechanism for the given specifications.*	**6-8**
	Contents: Introduction to Material handling system, hoisting mechanism, snatch block assembly, Selection of hoisting Rope, sheave, hoisting hook, bearing for hook, design of cross piece, shackle plate and rope drum, selection motor with transmission system.	
	Self-Learning Topics: *Design of Trolley travel mechanism.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1 Apply fundamental engineering concepts to describe the different elements present in the hoisting system and explain their functions. (PI 1.3.1)* *LO 2.2 Apply mechanical engineering concepts to select the suitable wire rope and sheave for the given specification of hoisting mechanism. (PI 1.4.1)* *LO 2.3 Determine design objectives and specifications for a hoisting mechanism for a given material handling requirement. (PI 3.1.6)* *LO 2.4 Generate design solutions for various components of the hoisting snatch block for the given specification of hoisting mechanism. (PI 3.2.1)* *LO 2.5 Identify modern engineering tools (such as CAD and analysis software) to model and analyze hoisting components like rope drum, hook and snatch block assembly. (PI 5.1.1)* *LO 2.6 Demonstrate proficiency in using discipline-specific tools to validate stresses in selected hook for given specification. (PI 5.2.2)* *LO 2.7 Demonstrate effective communication, problem-solving and leadership skills while working in a team to design a hoisting mechanism and its transmission system. (PI 8.2.1)* *LO 2.8 Present results as a team with integrated contributions while justifying design decisions for the hoisting rope, hook, snatch block and rope drum. (PI 8.3.1)*	

	LO 2.9 Produce clear, well-constructed design documents for the hoisting mechanism, including calculations and specifications of rope, hook, snatch block and rope drum. (PI 9.1.2) *LO 2.10 Identify gaps in knowledge related to standards and recent practices in hoisting and material handling equipment and formulate a strategy to close these gaps. (PI 11.1.1)* *LO 2.11 Analyze the source and comprehend updated standards on wire ropes, hooks, sheaves and drums to improve design quality. (PI 11.3.1)*	
03.	**Material Handling System -B** ***Learning Objective/s:*** *Design the belt conveyor system for given specifications.*	**9-10**
	Contents: Introduction to Belt Conveyor system, Determination of belt width, power requirement, number of plies, troughing and straight idlers, pulley, shaft and bearing selection, design of take up unit.	
	Self-Learning Topics: *Design of bucket elevator*	
	Learning Outcomes : *A learner will be able to* *LO 3.1 Apply mechanical engineering fundamentals to determine belt width and power requirement, for a belt conveyor system. (PI 1.4.1)* *LO 3.2 Apply mathematical techniques to size troughing, returning idler and conveyor pulleys for given operating conditions. (PI 1.1.1)* *LO 3.3 Reframe belt conveyor design into sub-problems of belt width, power, plies, idlers, pulleys, shafts and take-up unit. (PI 2.2.1)* *LO 3.4 Identify and evaluate required design data and standards for selecting belt, idlers, pulleys, shafts, bearings and take-up arrangements. (PI 2.2.2)* *LO 3.5 Define belt conveyor design requirements in terms of capacity, belt width, power, and layout, considering practical constraints. (PI 3.1.6)* *LO 3.6 Generate and evaluate alternative selections of idlers, pulleys, shafts, and take-up arrangements to meet the specified conveyor duty. (PI 3.2.1)* *LO 3.7 Implement norms of practice and define roles for team members while executing belt conveyor design from requirements to component selection. (PI 8.1.2)* *LO 3.8 Demonstrate effective communication, problem-solving and collaboration within a team to finalize belt width, power rating. (PI 8.2.1)* *LO 3.9 Produce clear, well-constructed design documentation for a belt conveyor system including belt width, power calculations, idler, pulley, shaft and take-up unit details. (PI 9.1.2)* *LO 3.10 Deliver effective oral or visual presentations explaining the rationale for selected belt width, power rating, idler arrangement and take-up design. (PI 9.2.2)*	
04.	**Design of gear pump and Centrifugal Pump:** ***Learning Objectives:*** *Design a gear pump and centrifugal pump for the given specification.*	**4-6**
	Contents: Introduction to pump, classification of pump, Design of gear pump: standard motor selection, gear design, shaft design and bearing selection, casing and bolt design, sizing of design of suction and delivery pipe. Design of centrifugal pump: Standard motor selection, impeller design, impeller shaft design and bearing selection, blade profile, volute casing design.	
	Self-Learning Topics: *Internal Gear Pump*	

	Learning Outcomes: *A learner will be able to* *LO 4.1 Apply mechanical engineering concepts to classify pump and identify the components of gear and centrifugal pumps. (PI 1.4.1)* *LO 4.2 Apply mathematical techniques to estimate pump motor power requirement for the given specification of pump. (PI 1.1.1)* *LO 4.3 Reframe pump design problems into sub-problems such as motor selection, gear design, shaft and bearing design, and suction/delivery pipe sizing for gear pumps. (PI 2.2.1)* *LO 4.4 Identify the mathematical, engineering and other relevant knowledge required to analyze loading, stresses and failure modes in pump components like gears, shafts and casings. (PI 2.1.3)* *LO 4.5 Generate alternative pump design solutions by varying gear dimensions, materials and motor ratings to satisfy given duty requirements and constraints. (PI 3.2.1)* *LO 4.6 Design centrifugal pump system including impeller, blades, impeller shaft, bearing and casing for the centrifugal pump. (PI 3.1.6)* *LO 4.7 Identify and use modern engineering tools such as CAD and analysis software to model and analyze pump components including gears, impellers, shafts and casings. (PI 5.1.1)* *LO 4.8 Work in a small team to divide tasks for gear pump and centrifugal pump design and follow agreed norms for effective teamwork. (PI 8.1.2)* *LO 4.9 Present the completed pump design as a team, integrating motor selection and mechanical component design for given specification. (PI 8.3.1)* *LO 4.10 Identify gaps in knowledge related to modern pump design practices or standards and seek additional information to address these gaps. (PI 11.1.2)* *LO 4.11 Understand catalogues and standards for pumps, motors and piping to update design decisions. (PI 11.3.1)*	
05.	**Design of Multi Speed Gear Box**: ***Learning Objective/s:*** *Design a multi speed gear box for the given specifications.* **Contents:** Introduction, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, Determination of number of teeth, gearing diagram. ***Learning Outcomes:*** *A learner will be able to* *LO 5.1 Apply basic calculations to find the required variable speed range of a multi speed gearbox. (PI 1.4.1)* *LO 5.2 Articulate gearbox design problems by specifying required speed range, number of speeds and constraints before developing structure and ray diagrams. (PI 2.1.1)* *LO 5.3 Apply mathematical modelling techniques to construct speed charts and gearing diagrams for a given multi-speed gearbox specification. (PI 1.1.1)* *LO 5.4 Reframe multi-speed gearbox design problems into sub-problems of stage selection, gear ratio distribution and tooth number assignment using structure and ray diagrams. (PI 2.2.1)* *LO 5.5 Determine design objectives and functional requirements for a multi-speed gearbox and arrive at specifications for speed steps, gear ratios and shaft layout. (PI 3.1.6)* *LO 5.6 Generate alternative structure and ray diagrams for a required speed range and select an optimal scheme for detailed gearbox design. (PI 3.2.1)* *LO 5.7 Identify and use modern engineering tools such as CAD and spreadsheet-based calculators to construct speed charts and gearing diagrams for multi-speed gearbox design. (PI 5.1.1)*	**6-8**

	LO 5.8 Demonstrate proficiency in using discipline-specific analysis tools to evaluate gear tooth numbers, step ratios and feasibility of multi-speed gearbox layouts. (PI 5.2.2)	
06.	**Design of Transmission Gear Box:** ***Learning Objective/s:*** Design the transmission gear box for the given specification.	**9-11**
	Contents: Selection of gear type, spur, helical, bevel, worm and worm wheel gear pair, Single stage and two stage gear box with fixed ratio, determination of number of stages, assumptions, number of teeth on pinion and gear, selection of material for pinion and gear, determination of weaker element, design criteria, determination of module, checking for dynamic and wear load failure, determining proportion and construction details, thermal analysis for worm and worm wheel gear pair.	
	Self-Learning Topics: *Gear box housing layout and design.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1 Apply mechanical engineering principles to select appropriate gear types and fixed transmission ratios for single-stage and two-stage gearbox applications. (PI 1.4.1)* *LO 6.2 Apply mathematical and engineering fundamentals to determine number of stages, number of teeth on pinion and gear, for gearbox design. (PI 1.3.1)* *LO 6.3 Identify design requirements, assumptions, constraints, and governing parameters involved in the design of gear pair. (PI 2.1.2)* *LO 6.4 Reframe the design specifications of a two-stage gearbox into clear requirements for designing each individual gear pair, considering velocity ratio. (PI 2.2.1)* *LO 6.5 Design gear pair by selecting suitable materials for pinion and gear, and by determining module, proportions, and constructional details to meet functional requirements. (PI 3.4.1)* *LO 6.6 Apply engineering design principles to develop alternative gear system solutions and check dynamic and wear load safety for reliable and manufacturable designs. (PI 3.2.1)* *LO 6.7 Analyze dynamic load and wear load behavior in gear systems. (PI 4.1.4)* *LO 6.8 Investigate thermal performance of worm and worm wheel gear pairs by applying heat generation and heat dissipation principles. (PI 4.3.2)* *LO 6.9 Identify modern analytical and computational tools for gear design and their assumptions and limitations. (PI 5.1.1)* *LO 6.10 Use standard gear design data to perform gearbox design calculations, load checks for gear systems. (PI 5.2.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply mechanical engineering concepts to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub-problems

2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
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.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modelling and analysis; techniques and resources for engineering activities.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
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
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
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.
11.3.1	Source and comprehend technical literature and other credible sources of information.

Course Outcomes : Learner will be able to

1. Apply the concept of system design. *(LO 1.1, LO 1.2, LO 1.3)*
2. Design the hoisting mechanism of an EOT crane for given load, lift and duty conditions. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7, LO 2.8, LO 2.9, LO 2.10, LO 2.11)*
3. Design a belt conveyor system for specified material handling requirements, including belt selection and supporting components *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7, LO 3.8, LO 3.9, LO 3.10)*
4. Design pumps for the given applications. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6, LO 4.7, LO 4.8, LO 4.9, LO 4.10, LO 4.11)*
5. Design a multi-speed gearbox for a given speed range using structure and ray diagrams. *(LO5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 5.7, LO 5.8)*
6. Design gears for power transmission on the basis of given load and speed. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6, LO 6.7, LO 6.8, LO 6.9, LO 6.10)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC7031.1	3	2	--	--	--	--	--	--	--	--	--
MEPEC7031.2	3	--	3	--	3	--	--	3	2	--	3
MEPEC7031.3	3	3	3	--	--	--	--	3	3	--	--
MEPEC7031.4	3	3	3	--	2	--	--	3	--	--	3
MEPEC7031.5	3	3	3	--	3	--	--	3	--	--	3
MEPEC7031.6	3	3	3	3	3	--	--	--	--	--	--
Average	**3**	**2.8**	**3**	**3**	**2.75**	**3**	**--**	**3**	**2.5**	**--**	**3**

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

Text Books:

1. Design of Machine Elements - V.B. Bhandari, Fifth edition, 2020, Tata McGraw Hill Publication, ISBN: 978-9390177479
2. Mechanical System Design, S. P. Patil, second edition., JAICO Publishing House, ISBN: 978-8179923153
3. Gear Design Handbook, Gitin Maitra, second edition, McGraw Hill Education, ISBN: 978-0074602379
4. Material Handling Equipment, Rudenko, second edition, M.I.R. publishers, Moscow.
5. Pumps: Theory, Design and Applications", G. K. Sahu, New Age International, 2000 ISBN: 978-8122412246
6. Machine Tool design and Numerical Control, N. K. Mehta, 3rd edition, McGraw Hill Publication.
7. Engineering Design, Dieter G E, sixth edition, Tata McGraw Hill Publication , ISBN: 9781260113297

Reference Books :

1. Machine Design -An Integrated Approach, Robert L. Norton, Second edition, 2006, Pearson Education
2. Material Handling Equipment, Alexandrov,fifth edition, Mir Publication ISBN: 978-0714717456
3. Design Data: Data Book of Engineers by PSG College,2020, Kalaikathir, Achchagam-Coimbatore

Other Resources :

1. **Gear and Gear Unit Design: Theory and Practice,** IIT Kharagpur
   Link: https://onlinecourses.nptel.ac.in/noc22_me62
2. **Machine Design-II**, IIT Madras
   Link: https://nptel.ac.in/courses/112/106/112106137/ -

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Assignments on live problems/ case studies	:	10 Marks
Open book test/ Open notes test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7032	MACHINE TOOL DESIGN	03

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

Pre-requisite :

1. MEPCC611 - Machine Design

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO8: Individual and team work
6. PO9: Communication
7. PO10: Project Management and Finance
8. PO11: Life-long learning

Course Objectives:

1. To familiarize with the general principles of design of a machine tool.
2. To familiarize with procedure of design of speed and feed drives for a given machine tool.
3. To acquaint with the process of design of a machine tool structures
4. To impart the ability to design Guide ways and Power Screws
5. To impart the ability to design Spindles and Spindle Supports.

Module	Details	Hrs
	Course Introduction In the dynamic field of manufacturing, machine tool design is pivotal for keeping pace with current trends and fulfilling customer demands. The design of a machine tool influences its functionality, productivity, safety, durability, and environmental impact. Investing in a well-designed machine tool not only enhances operational efficiency and product quality but also contributes to the overall competitiveness and sustainability of manufacturing operations. With digitalization and sustainability at the forefront, machine tool designs must integrate advanced technologies to enhance efficiency, precision, and flexibility. Adapting to trends like additive manufacturing and modular setups ensures agility, while prioritizing user-centric design guarantees safety and usability. Ultimately, machine tool design serves as the cornerstone for driving innovation,	**01**

	competitiveness, and customer satisfaction in an ever-evolving industrial landscape. Quality of parts manufactured depends mostly on accuracy and reproducibility of a machine tool which finally depends on precise design and manufacture of a machine tool itself. As a manufacturer, the design criteria to be considered for getting this superior quality manufacture are covered in this subject.	
01.	**Machine Tool Drives and Mechanisms, General Principles of Machine Tool Design:** ***Learning Objective/s:*** *To familiarize with the general principles of design of a machine tool.*	**5-7**
	Contents: **Machine Tool Drives and Mechanisms** ***Introduction:*** Machine Tool Drives and Mechanisms, Working and auxiliary motions in machine tools, Parameters defining working motions of a machine tools, Calculation of machining time ***Machine Tool Drives:*** Selection of electric motor, Hydraulic and mechanical transmissions with their elements ***Technico-Economical Prerequisites for undertaking the design of new machine tool*** ***General Principles of Machine Tool Design:*** General Requirements of Machine Tool Design, Engineering Design Process Applied to Machine Tools, Kinematic layout of machine tool.	
	Self-Learning Topics: *Hydraulic and mechanical transmissions with their elements,*	
	Learning Outcomes: *A learner will be able to* *LO 1.1 Apply knowledge of machine tool elements and their motions to find suitable configurations for a given machining task. (P.I – 1.4.1)* *LO 1.2 Compare alternative kinematic layouts of machine-tool arrangements and select the most suitable configuration for the given application. (P.I – 2.2.4)* *LO 1.3 Apply techno-economic criteria to determine whether designing a new machine tool is feasible and justified. (P.I – 10.1.1)* *LO 1.4 Identify and apply the minimum machine-tool design requirements (rigidity, power, accuracy, kinematic structure, safety) to derive the essential specifications for a proposed new machine tool. (P.I – 3.1.1)* *LO 1.5 Select an appropriate drive system (mechanical / hydraulic / electrical) and motion scheme by analysing the working and auxiliary motions required for a given machine-tool operation. (P.I – 2.2.3)* *LO 1.6 Apply principles of kinematic layout to compare alternative machine-tool arrangements and select the most suitable configuration for a specified machining requirement. (P.I – 8.1.2, P.I – 8.2.1, P.I – 9.1.1, P.I – 10.3.1, P.I – 11.3.2)* *An activity to be carried out by a group of students and all groups need to submit a short report. The following points may be covered: -* *1. Identifying motions* *2. Arranging elements*	

	3. *Sequencing shafts & gears* 4. *Selecting power-flow* 5. *Comparing alternative layouts* 6. *Selecting the best layout* 7. *Comparing modern vs old layouts* 8. *Reviewing CNC vs conventional architectures* 9. *Exploring new kinematic chains*	
02.	**Regulation of Speed and Feed Rates** ***Learning Objective/s:*** *To familiarize with the ways and means to optimize of design of speed and feed drives for a given machine tool.*	**5-7**
	Contents: ***Aim of Speed and Feed Rate Regulation*** ***Stepped regulation of speed:*** Various laws of stepped regulations, Selection of suitable progression for machine tool drive, Selection of range ratio, Breakup of speed steps ***Classification of speed and feed boxes*** ***Other types of speed and feed drives:*** Quadrant change gear, Gear cone with sliding key, Norton Gear Box, Meander Drive, Gear boxes with clutched drive like the Ruppert Drive and Schopke drive ***Stepless Drives:*** Mechanical, Hydraulic, Electrical	
	Self-Learning Topics: *Stepless Drives: Mechanical, Hydraulic, Electrical*	
	Learning Outcomes : *A learner will be able to* *LO 2.1 Apply knowledge of working and auxiliary motions of machine tools to decide a suitable motion scheme for a given machining task. (P.I – 1.4.1.)* *LO 2.2 Apply principles of stepless speed-feed regulation to determine suitable speed, feed, and range-ratio values for achieving the required surface finish and material-removal rate. (P.I – 1.3.1)* *LO 2.3 Identify suitable speeds and feeds that reduce non-cutting motions and improve the performance of machine-tool drive systems. (P.I– 2.2.3)* *LO 2.4 Compare alternative speed-feed progression laws and drive mechanisms to select the most suitable configuration for a given machine-tool application. (P.I – 2.2.4)*	
03.	**Optimization of Speed and Feed boxes** ***Learning Objective/s:*** *To familiarize with process of speed regulation and procedure of design of speed and feed drives for a given machine tool.*	**5-7**
	Contents: **Design of speed box and Design of Feed Box** ***Structural diagrams and gearing diagram:*** Speed chart, Development of gearing diagram, general recommendations for developing gearing diagram, Determination of gear teeth, module, shaft sizes, center distances**,** ***Deviation diagram***	

	Machine tool drives using multiple speed motors, ***Kinematics of machine tools:*** gearing diagram for various machine tools.	
	Self-Learning Topics: ***------***	
	Learning Outcomes : *A learner will be able to* *LO 3.1 Develop the structural diagram and speed chart for a machine tool based on its specified operating requirements. (P.I – 2.3.1)* *LO 3.2 Apply mathematical relation related to speed or feed box to calculate various parameters of speed / feed boxes. (P.I – 1.1.1)* *LO 3.3 Determine specifications of speed / feed box using optimization concepts of machine tool gear boxes. (P.I – 3.1.6,)* *LO 3.4 Determine from the gearing diagram the gear trains needed to achieve the required speed–feed progression. (P.I – 3.4.1)* *LO 3.5 Verify whether the structural, speed, and gearing diagrams developed produce the required output speeds and feeds. (P.I –2.4.2,)* *LO 3.6 Apply mechanical engineering concepts to calculate gear-teeth numbers, module, shaft sizes, and centre distances needed for the machine-tool drive. (P.I – 1.4.1)*	
04.	**Design of Machine Tool Structures** ***Learning Objective/s:*** *To acquaint with the process of design of a machine tool structures.*	**9-11**
	Contents: ***Introduction to Machine Tool Structures:*** Functions of Machine Tool Structures and Their Requirements, Design criteria for Machine Tool Structures, Materials of Machine Tool Structures, Static and Dynamic Stiffness, Profiles of Machine Tool Structures ***Basic Design Procedure of Machine Tool Structures:*** Design for strength, Design for stiffness ***Design of various elements of structure:*** Design of Beds, Columns, housings Bases and Tables, Design of cross rails, arms, saddles and carriages, Design of rams ***Model technique in design of machine tool structures***	
	Self-Learning Topics: *Profiles of Machine Tool Structures*	
	Learning Outcomes: *A learner will be able to* *LO 4.1 Apply knowledge of machine-tool structural functions and force systems to determine the performance requirements of structural components for a given machining application. (P.I – 1.4.1)* *LO 4.2 Identify geometry profile of structural sections required to resist bending and torsional load. (P.I – 2.2.2)* *LO 4.3 Analyse for deflection of beds, columns, housings, bases, and tables using idealized structural model and its suitability under specified loading and boundary conditions (P.I – 2.4.4)* *LO 4.4 Formulate simplified load-transmission and rigidity models of cross-rails, arms, saddles, carriages, and rams to study their behaviour under machining loads. (P.I – 2.3.1)*	

	LO 4.5 Use model technique and similarity relations to interpret stiffness and natural-frequency behaviour of machine-tool structures. (P.I – 3.2.2) *LO 4.6 Apply fundamental engineering concepts to relate material properties and structural form to the static and dynamic stiffness of machine-tool structures. (P.I – 1.3.1)*	
05.	**Design of Guide ways and Power Screws** ***Learning Objective/s:*** *To impart the ability to design Guide ways and Power Screws*	**6-7**
	Contents: **Design of Guide ways** ***Design of slideways:*** Functions of guide ways, Shapes of slideways, Materials of slideways, Method of adjusting clearance in slideways, Design criteria, Design of slideways for wear resistance, Design of slideways for stiffness. ***Guide ways operating under liquid friction conditions:*** Design of hydrodynamic slideways, Design of hydrostatic slideways ***Guideway types:*** Design of aerostatic slideways, Design of antifriction guideways, Combination guideways: Slideways for hydraulic relief, slideways with rolling members ***Protecting devices for slideways*** **Design of Power Screws:** ***Design of sliding friction power screws:*** based on wear resistance, strength, stiffness and buckling ***Design of rolling friction power screws***: based on strength under static, cyclic loading and stiffness	
	Self-Learning Topics: *Combination guideways, Protecting devices for slideways*	
	Learning Outcomes: *A learner will be able to* *LO 5.1 Analyze strength, stiffness, and buckling of power screws under static and cyclic loading to verify safe operation. (P.I – 2.5.1)* *LO 5.2 Compare different guideway types based on friction, wear, load capacity, and stiffness for given operating conditions. (P.I – 2.2.4)* *LO 5.3 Determine preload, contact area, and alignment requirements for guideways based on functional and geometric considerations. (P.I – 3.1.6)* *LO 5.4 Calculate the critical load, torque required, and efficiency of a given power screw by identifying appropriate strength and buckling assumptions. (P.I – 2.5.2)* *LO 5.5 Evaluate guideway and power-screw options using engineering judgement based on strength, stiffness, wear, and manufacturability for a specified duty cycle. (P.I – 3.3.1)* *LO 5.6 Identify the functions and operating principles of different guideway types used in machine tools. (P.I – 2.2.2)*	
06.	**Design of Spindles and Spindle Supports:** ***Learning Objectives:*** *To impart the ability to design Spindles and Spindle Supports.*	**9-10**
	Contents: ***Introduction to spindles:*** Design of Spindles and Spindle Supports Functions of Spindle Unit and Requirements, Materials of Spindles, Effect of Machine Tool Compliance on Machining Accuracy	

	Design Calculations of Spindle**:* Deflection of spindle axis due to bending and compliance of spindle supports, Optimum spacing between spindle supports, Additional checks for strength ***Anti-friction bearings: Preloading of anti-friction bearings ***Sliding bearing**:* sleeve bearings, hydrodynamic journal bearings, hydrostatic journal bearings, Air lubricated bearings ***Bearing mountings***	
	Self-Learning Topics: *Additional checks for strength, hydrostatic journal bearings, Air lubricated bearings*	
	Learning Outcomes : *A learner will be able to* *LO 6.1 Identify functions and performance requirements of spindle units for a given machine tool application. (P.I – 2.2.2)* *LO 6.2 Analyze the effect of spindle and support compliance on machining accuracy under different loading conditions. (P.I – 2.5.2)* *LO 6.3 Find safe operating conditions for spindle bearings using thermal equilibrium and lubrication concepts during continuous operation. (P.I – 2.4.4)* *LO 6.4 Compare different types of spindle bearings and assess their suitability for given operating and thermal conditions. (P.I. – 2.2.4)* *LO 6.5 Identify suitable materials for spindle construction based on strength, stiffness, and operating requirements. (P.I – 1.4.1)* *LO 6.6 Apply fundamental engineering concepts to relate spindle speed, loading, and stiffness to overall spindle performance in machine tools. (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.
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify and evaluate speed–feed regulation schemes to determine ways of minimizing non-cutting motions and improving machine-tool drive performance.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Formulate mathematical or graphical model for analysis.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
2.4.4	Analyse stresses and deflection induced under various loading conditions.
2.5.1	Analyze normal stresses induced in the structural elements.
2.5.2	Analyze deflection induced in the structural elements under normal or tortional loading.
3.1.1	Identify the design problem, criteria, and constraints for machine-tool specification.

3.1.6 Determine design objectives, functional requirements and arrive at specifications.

3.2.2 Create simplified models of machine-tool structures and use similarity laws to understand stiffness and vibration behaviour.

3.2.3 Identify suitable criteria for the evaluation of alternate design solutions.

3.3.1 Evaluate systems and processes to meet desired needs.

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

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.

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

10.1.1 Describe various economic and financial costs/benefits of an engineering activity.

10.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.

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

Course Outcomes: Learner will be able to

1. Identify the general principles of design of a machine tool. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6)*
2. Apply laws of stepped and stepless speed-feed regulation to find suitable drive mechanisms and speed ranges for a given machine tool. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Design speed and feed drives for a given machine tool. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6)*
4. Analyse and validate design aspects of a machine tool structure. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*
5. Design the Guide ways and Power Screws. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*
6. Design Spindles and Spindle Supports of given machine tools. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPE6032.1	2	3	2	2	--	--	--	2	2	3	2
MEPE6032.2	3	3	--	--	--	--	--	--	--	--	--
MEPE6032.3	2	--	3	3	--	--	--	--	--	--	--
MEPE6032.4	3	2	2	3	- --	--	--	--	--	--	--
MEPE6032.5	2	2	3	2	--	--	--	--	--	--	--
MEPE6032.6	3	2	3	2	--	--	--	--	--	--	--
Average	**3**	**2**	**3**	**2**	**--**	--	--	**2**	**2**	3	2

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

Text Books :

1. N.K. Mehta, *Machine Tool Design,* Tata McGraw Hill, ISBN 0-07-451775-9
2. Bhattacharya and S. G. Sen., *Principles of Machine Tool*, New central book agency Calcutta, ISBN 81-7381-1555
3. D. K Pal, S. K. Basu, *Design of Machine Tool,* 4th Edition. Oxford IBH 2005, ISBN 81- 204-0968

Reference Books :

1. N. S. Acherkan, *Machine Tool*, Vol. I, II, III and IV, MIR publications
2. F. Koenigsberger, *Design Principles of Metal Cutting Machine Tools*, The Macmillan Company New York 1964
3. H.C.Town, *The Design and Construction of Machine Tools*, Central Machine Tool Research Institute, Bangalore, Machine Tool Design Handbook
4. PSG College of Engg. & Technology, *PSG Design Data Book*

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
A task-based group activity	:	05 Marks
Flip classroom	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7033	PROCESS EQUIPMENT DESIGN	03

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

Pre-requisite:

1. MEPCC302 - Mechanics of Solids
2. MEPCC407 - Thermal Engineering
3. MEPCC611 - Machine Design
4. MEPCC510 - Fluid Mechanics and Machinery

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO8: Individual and Collaborative Team work
5. PO9: Communication
6. PO11: Life-Long Learning

Course Objectives:

1. To provide an understanding of process equipment design parameters, applicable codes, and standards for industrial applications.
2. To employ fundamental principles of process equipment design for the sizing and design of pressure vessels and their supporting structures.
3. To utilize design fundamentals for developing storage tanks, heat exchangers, and agitators tailored to specific process requirements.
4. To implement appropriate testing and inspection techniques to ensure operational reliability and safety of process equipment.

Module	Details	Hrs
	Course Introduction This course focuses on the principles and practices of designing process equipment used in industries. It introduces design parameters, codes, and standards such as ASME and TEMA for safe and efficient operation. Students will learn methods for sizing and designing pressure vessels, storage tanks, heat	**01**

	exchangers, and agitators. The course emphasizes material selection, stress analysis, and integration of supports for structural stability. Practical aspects like testing and inspection techniques are included to ensure reliability.	
01.	**Fundamentals of Process equipment design** ***Learning Objective:*** *To provide an understanding of process equipment design parameters, applicable codes, and standards for industrial applications.* **Contents:** Basic considerations in process equipment design; general design procedure of process equipment design; Terminology used in pressure vessel design: Design pressures, Design temperatures, Design stresses, Design Loading such as wind load, temperature load, Dead load, Maximum allowable stress values, Minimum shell thickness, Welded joint efficiency and category, Corrosion allowance, Minimum design metal temperature (MDMT), Maximum allowable working pressure, Test pressure, Weight estimation of vessel, Development of pressure vessel construction code: Study of ASME section VIII Div. –I; Selection of material and its properties by using ASME section II for ferrous materials, Importance of codes and standards and their applications, Stress categories and stress limits. ***Self-Learning Topics:*** *Research papers/articles/handbook of codes used in process equipment design* ***Learning Outcomes :*** *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to determine process equipment design parameters. (PI 1.3.1).* *LO 1.2: Apply the knowledge of process equipment design parameters and ASME codes in the process of material selections in various applications. (PI 1.4.1).* *LO 1.3: Identify variables, parameters and codes associated with process equipment design. (PI 2.1.2)* *LO 1.4: Identify the mathematical, engineering and other relevant knowledge that applies to process equipment design. (PI 2.1.3)*	**7-9**
02.	**Design of Pressure Vessels** ***Learning Objective:*** *To employ fundamental principles of process equipment design for the sizing and design of pressure vessels and their supporting structures.* **Contents:** Types of pressure vessels; Types of head or end closure; Complete design as per ASME code of cylindrical and spherical shells: Pressure vessel subjected to internal pressure; Pressure vessel subjected to External pressure; Design of various end closures, Design of flanged joints, Design of opening such as nozzle, manhole etc., Gasket selection, Design of Tall tower; Determination of wind load and seismic load; Determination of period of vibration; Determination of deflection of tower and elastic instability. ***Self-Learning Topics:*** *Modern pressure vessel used in industrial application.*	**7-9**

	Learning Outcomes : *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to calculate design parameters such as internal/external pressure, allowable stress, and shell thickness. (PI 1.3.1)* *LO 2.2 Apply mechanical engineering principles to design heads, flanged joints, and nozzle reinforcements as per ASME code. (PI 1.4.1)* *LO 2.3: Identify the pressure vessel system, operating conditions and design parameters such as allowable stress, corrosion allowance, and joint efficiency required for safe design. (PI 2.1.2)* *LO 2.4: Identify the mathematical, engineering and other relevant knowledge that applies to design pressure vessels. (PI 2.1.3)* *LO 2.5: Extract engineering requirements from ASME Codes while designing pressure vessels. (PI 3.1.4)* *LO 2.6: Determine design objectives of pressure vessel according to its functional requirements and arrive at specifications. (PI 3.1.6)*	
03.	**Vessel Supports** ***Learning Objective:*** *To employ fundamental principles of process equipment design for the sizing and design of pressure vessels and their supporting structures.* **Contents:** Introduction and types of vessel support; Design of saddle support; Design of lug supports; Design of leg supports; Design of skirt support; Design of support components: Base plate, Skirt bearing plate, Anchor bolts. ***Self-Learning Topics:*** *Types of Vessels support used in industry.* ***Learning Outcomes :*** *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to determine load distribution and stability requirements for vessel supports. (PI 1.3.1)* *LO 3.2: Apply mechanical engineering principles to design saddle, skirt, and lug supports considering loads. (PI 1.4.1)* *LO 3.3: Identify the vessel support system and key parameters including load distribution, material properties and geometric constraints for saddle, skirt, and lug supports. (PI 2.1.2)* *LO 3.4: Identify the mathematical, engineering and other relevant knowledge that applies to design vessels supports. (PI 2.1.3)* *LO 3.5: Extract engineering requirements from relevant engineering standards while designing pressure vessel supports. (PI 3.1.4)* *LO 3.6: Determine design objectives of vessels supports according to its functional requirements and arrive at specifications. (PI 3.1.6)* *LO 3.7 Design a pressure vessel for a given application. (PI 8.1.1, PI 8.1.2, PI 8.2.1, PI 9.1.3, PI 9.3.1, PI 11.1.2, PI 11.3.1)* *Students will work in teams (max 4) to:* *i.* ***Define Design Requirements:*** *State the application, operating conditions (pressure, temperature), and constraints.* *ii.* ***Apply ASME Code Requirements:*** *Determine design pressure, temperature, allowable stresses, corrosion allowance, and joint efficiency.* *iii.* ***Perform Complete Design Calculations:*** *Calculate shell thickness, head design, nozzle sizing, and reinforcement.*	**6-8**

	iv. ***Design Structural Supports:*** *Select and design appropriate support type (saddle, skirt, lug) with calculations.* v. ***Prepare Deliverables:*** *Submit a report with calculations, code references, CAD drawings, and justification for design choices.*	
04.	**Design of Storage Tanks** ***Learning Objective:*** *To utilize design fundamentals for developing storage tanks, heat exchangers, and agitators tailored to specific process requirements.* **Contents:** Introduction to API code; Types of storage tanks for storing volatile and non-volatile fluid etc.; Types of roofs used in storage vessels; Complete API design of storage tank; Calculation of shell thickness by one-foot method and variable design point method; Shell attachment design; Wind girder design; Design of rectangular tank. ***Self-Learning Topics:*** *Types of storage tanks used in industry.* ***Learning Outcomes :*** *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to compute shell thickness and roof design using API methods. (PI 1.3.1)* *LO 4.2: Apply mechanical engineering principles to design wind girders and structural attachments for storage tanks. (PI 1.4.1)* *LO 4.3: Identify the storage tank system and relevant variables such as fluid properties, design pressure, shell height, roof type, and wind load to determine design requirements as per API standards. (PI 2.1.2)* *LO 4.4: Identify the mathematical, engineering and other relevant knowledge that applies to design storage tank. (PI 2.1.3)* *LO 4.5: Extract engineering requirements from API Codes while designing storage tank. (PI 3.1.4)* *LO 4.6: Determine design objectives of storage tank according to its functional requirements and arrive at specifications. (PI 3.1.6)*	**7-9**
05.	**Heat Exchangers and Agitators** ***Learning Objective:*** *To utilize design fundamentals for developing storage tanks, heat exchangers, and agitators tailored to specific process requirements.* **Contents:** **Heat Exchangers:** Introduction to TEMA code; Classification of TEMA heat exchangers; Nomenclature of heat exchanger components: Tube and tube bundle, Tube sheet, Tube pattern, Tube length, Baffle etc; Calculation of effective shell side and tube side design pressure; Study of various types of jacket such as half pipe, limpet coil. **Agitator:** Types of impellers; General procedure of choice of impeller type and speeds; Design of agitator shaft: Calculation of shaft diameter, Bearing load calculation, Calculation of critical speed, Calculation of deflections.	**7-9**

	Self-Learning Topics: *Types of Heat exchangers and Agitators used in various industrial applications.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to estimate heat transfer area and calculate LMTD for heat exchangers. (PI 1.3.1)* *LO 5.2: Apply mechanical engineering principles to design agitator shafts and select impeller types based on process requirements. (PI 1.4.1)* *LO 5.3: Identify the heat exchanger and agitator systems along with critical parameters such as heat duty, LMTD, flow rates, tube dimensions, agitator speed, and shaft diameter for process-specific design. (PI 2.1.2)* *LO 5.4: Identify the mathematical, engineering and other relevant knowledge that applies to design heat exchanger. (PI 2.1.3)* *LO 5.5: Extract engineering requirements from TEMA Codes while designing of heat exchanger. (PI 3.1.4)* *LO 5.6: Determine design objectives of heat exchanger according to its functional requirements and arrive at specifications. (PI 3.1.6)* *LO 5.7 Design of a Heat Exchanger for given application (PI 8.1.1, PI 8.1.2, PI 8.2.1, PI 9.1.3, PI 9.3.1, PI 11.1.2, PI 11.3.1)* *Students will work in teams (max 4) to:* *i.* ***Define Service Conditions:*** *Hot and cold fluid properties, flow rates, inlet/outlet temperatures.* *ii.* ***Compute Heat Duty:*** *Calculation of heat for both streams.* *iii.* ***Calculate LMTD and Correction Factor (F):*** *Use given/select flow arrangement (e.g., 1-2 pass).* *iv.* ***Estimate Overall Heat Transfer Coefficient (U****): Assume typical values or use simple correlations.* *v.* ***Determine Required Area (A):*** *By using Standard methods.* *vi.* ***Select Tube Size and Number of Tubes:*** *Based on standard dimensions and area requirement.* *vii.* ***Prepare a Simple Sketch:*** *Show shell, tube bundle, and nozzle positions.* *viii.* ***Prepare Deliverables:*** *Calculation sheet (Q, LMTD, U, A, number of tubes), Simple schematic drawing of the heat exchanger.*	
06.	**Testing and inspection techniques** ***Learning Objective:*** *To implement appropriate testing and inspection techniques to ensure operational reliability and safety of process equipment.*	**3-5**
	Contents: **Brief introduction:** Standard hydrostatic test; Standard pneumatic test; Post weld heat treatment; Radiographic examination; Process flow diagram; Process and instrumentation diagram.	
	Self-Learning Topics: *Non Destructive Testing used in industry.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify requirement of testing for process equipment's. (PI 1.3.1)* *LO 6.2: Apply the knowledge of various methods of testing process equipment's. (PI 1.4.1)*	

	LO 6.3: Identify latest testing method having more exposure to the advanced properties as compared to the traditional methods. (PI 2.2.4) *LO 6.4: Select a proper testing method for given application. (P.I.2.4.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

PI No.	PI Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.1.2	Implement norms of effective teamwork (rules, roles, agendas, charters) to accomplish a goal.
8.2.1	Demonstrate effective communication, problem–solving, conflict resolution and leadership skills.
9.1.3	Create flow in a document or presentation—logical progression of ideas so that the main point is clear.
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations.
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate ability to source information to close this gap.
11.3.1	Source and comprehend technical literature and credible information.

Course Outcomes: Learner will be able to

1 Analyse and apply engineering fundamentals to interpret process equipment design parameters and relevant codes and standards. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6)*

2 Design pressure vessels and their supports for given applications by applying engineering concepts and complying with ASME codes. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7)*

3 Design storage tanks for volatile and non-volatile fluids using API standards and engineering principles. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*

4 Develop designs for heat exchangers and agitators based on process requirements and TEMA standards. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 5.7)*

5 Implement appropriate testing and inspection techniques to ensure reliability and safety of process equipment. *(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
MEPEC7033.1	3	3	--	--	--	--	--	--	--	--	--
MEPEC7033.2	3	3	3	--	--	--	--	3	3	--	3
MEPEC7033.3	3	3	3	--	--	--	--	--	--	--	--
MEPEC7033.4	3	3	3	--	--	--	--	3	3	--	3
MEPEC7033.5	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.

Text Books:

1. Process Equipment and Plant Design: Principles and Practices by Subhabrata Ray Gargi Das, Publisher: CRC Press
2. Process Equipment Design by Browell and Young, Publisher: John Wiley & Sons

Reference Books:

1. Pressure vessel Design Manual: Dennis Moss
2. Pressure Vessel Design Handbook: Henry H Bednar
3. Pressure Vessel Design Manual by Dennis Moss, Publisher: Elsevier
4. Pressure Vessel Handbook: Eugene F. Megyesy
5. Guidebook for the Design of ASME section VIII Pressure Vessels by James R. Farr and Maan H. Jawad
6. Standard Codes such as: ASME SEC-VIII, Div I & II; Section II part A, Part D; ASTM; API; TEMA.

Other Resources:

1. NPTEL Course: **"Equipment Design: Mechanical Aspects",** By Prof. Shabina Khanam, Department of Chemical Engineering, IIT Roorkee
   Link: Equipment Design: Mechanical Aspects - Course (nptel.ac.in)
2. TEMA Standards for Heat Exchanger Design: Free summaries and guidelines available on TEMA website.

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

MCQ test as per GATE exam pattern	:	05 Marks
Open book Test	:	05 Marks
Task based Activity	:	05 Marks
Regularity and active participation	:	05 Marks

2. **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 syllabus coverage up to the Mid Semester Examination (MSE) carrying 20-30% weightage, and the syllabus covered from MSE to ESE carrying 70-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7041	NON-DESTRUCTIVE TESTING	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. MEPCC303 - Material Science and Engineering
2. MEPCC408 - Manufacturing Technology

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO3: Conduct Investigations of Complex Problems
4. PO4: Conduct investigations of complex problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO11: Life-Long Learning

Course Objectives:

1. To understand the fundamental principles and importance of non-destructive testing in ensuring material integrity and reliability.
2. To understand various conventional and advanced NDT techniques, their operating principles, and practical applications.
3. To develop the ability to apply appropriate NDT methods for detecting, locating, and characterizing material defects.
4. To analyze test results to interpret indications and assess structural soundness of engineering components.
5. To evaluate the effectiveness, limitations, and selection criteria of different NDT techniques for specific industrial applications.

Module	Details	Hrs.
	Course Introduction The course focuses on the principles, techniques, and applications of evaluating materials and components without impairing their serviceability. It covers a wide range of inspection methods, including visual, ultrasonic, radiographic, magnetic particle, eddy current, and dye penetrant testing. Emphasis is placed on understanding defect detection, signal interpretation, equipment operation, and standards for quality assurance and reliability.	**01**

01.	**Introduction to Non-Destructive Testing** ***Learning Objective/s:*** *The learner is expected to understand the fundamentals, scope, and significance of Non-Destructive Testing, differentiate it from destructive methods, classify defect types and testing techniques, and evaluate appropriate NDT methods for quality and safety applications.*	**7-9**
	Contents: • Definition, purpose, and scope of NDT • Comparison: Destructive vs. Non-Destructive Testing • Types of defects (surface, subsurface, volumetric) • Role of NDT in quality assurance, safety, and life-cycle management • Overview and classification of various NDT methods • Selection criteria for NDT methods • Codes, Standards and Certifications related to NDT	
	Self-Learning Topics: *Role of NDT in quality assurance, safety, and life-cycle management*	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to describe the definition, purpose, and scope of Non-Destructive Testing for evaluating material integrity. (PI 1.3.1)* *LO 1.2: Apply mechanical and materials engineering knowledge to differentiate destructive and non-destructive testing methods based on their operating principles and effects on components. (PI 1.4.1)* *LO 1.3: Identify defect characteristics—such as morphology, location, and detectability—and determine key variables influencing their classification. (PI 2.1.2)* *LO 1.4: Compare and contrast alternative NDT methods to evaluate their suitability for surface, subsurface, and volumetric defect detection in different industrial scenarios. (PI 2.2.4)* *LO 1.5: Identify and select modern NDT tools and equipment—including sensors, gauges, and inspection devices—based on application requirements and inspection constraints. (PI 5.1.1)* *LO 1.6: Interpret NDT codes, standards, and certification requirements (ASTM, ASME, ISO) to ensure proper inspection planning and compliance. (PI 5.2.1)*	
02.	**Visual Inspection and Liquid Penetrant Testing (LPT)** ***Learning Objective/s:*** *The learner is expected to understand the principles and procedures of visual and liquid penetrant testing, identify suitable equipment and materials, analyze test sensitivity and limitations, and apply relevant ASTM and ISO standards for surface defect detection.*	**6-8**
	Contents: • Visual Inspection: Equipment, lighting, magnification, surface condition, limitations • Liquid Penetrant Testing: Principle, types of penetrants, emulsifiers, developers • Procedure, sensitivity, advantages, and limitations	

	• Applications: Medical Implants, Aerospace Component Inspection, Assembly/Plant Maintenance, etc.	
	Self-Learning Topics: *Standards and codes (ASTM, ISO)*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to describe the principles, equipment, and surface-preparation requirements used in visual inspection. (PI 1.3.1)* *LO 2.2: Apply mechanical engineering knowledge to classify penetrant types, emulsifiers, and developers based on test sensitivity and material suitability. (PI 1.4.1)* *LO 2.3: Identify key variables—such as lighting conditions, surface roughness, dwell time, and developer type—that influence the effectiveness of visual and liquid penetrant testing. (PI 2.1.2)* *LO 2.4: Compare and contrast alternative LPT techniques to evaluate their limitations and select the most appropriate method for medical implants, aerospace, and maintenance applications. (PI 2.2.4)*	
03.	**Magnetic Particle Testing (MPT)**	**6-8**
	Learning Objective/s: *The learner is expected to analyze the principles of magnetism and magnetization techniques in ferromagnetic materials, evaluate the effectiveness of various detection media and testing parameters, and apply appropriate interpretation, demagnetization, and safety practices to ensure reliable defect detection and quality assurance.*	
	Contents: • Principles of magnetism in ferromagnetic materials • Magnetization methods (yokes, prods, coils) • Detection media – dry and wet powders • Interpretation of indications and limitations • Demagnetization and safety precautions • Numerical Problems • Applications: Aerospace landing-gear, Railway axle fatigue, Power-plant turbine shafts	
	Self-Learning Topics: *Demagnetization and safety precautions*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to describe the principles of magnetism and magnetic flux behavior in ferromagnetic materials used for MPT. (PI 1.3.1)* *LO 3.2: Apply mechanical engineering knowledge to distinguish between magnetization methods such as yokes, prods, coils, and central conductors for various inspection tasks (PI 1.4.1)* *LO 3.3: Examine MPT procedures—including surface preparation, magnetization, and indication development—to evaluate methods, tools, and testing techniques involved in inspection. (PI 4.1.2)* *LO 3.4: Analyze MPT indications and test data to identify defect patterns, assess limitations, and recognize possible errors in interpretation. (PI 4.3.2)*	

	LO 3.5: Identify safety responsibilities related to magnetization equipment, electrical hazards, and handling of magnetic particles to ensure protection of personnel and public safety. (PI 6.1.1) *LO 3.6: Interpret applicable codes and standards (ASTM, ISO) governing MPT procedures, acceptance criteria, and demagnetization requirements. (PI 6.2.1)*	
04.	**Ultrasonic Testing (UT)** ***Learning Objective/s:*** *The learner is expected to evaluate ultrasonic testing principles and wave behaviors to analyze material integrity, interpret complex scan data for accurate defect characterization, and apply calibration standards to ensure precision and compliance in advanced inspection scenarios.* **Contents:** • Basic principles of sound propagation • Types of ultrasonic waves (longitudinal, shear, surface) • Pulse-echo system, transducers, calibration • Interpretation of A-scan, B-scan, C-scan • Defect characterization, sensitivity, and limitations • Standards and calibration blocks • Numerical Problems related to Ultrasonic Testing • Applications: Boiler Tubes, Forgings, Additive Manufactured parts, etc. ***Self-Learning Topics:*** *Standards and calibration blocks* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to describe the principles of ultrasonic wave propagation and their interaction with engineering materials. (PI 1.3.1)* *LO 4.2: Apply mechanical engineering knowledge to differentiate longitudinal, shear, and surface waves and assess their suitability for specific inspection tasks. (PI 1.4.1)* *LO 4.3: Examine ultrasonic testing tools—including transducers, pulse-echo systems, and calibration blocks—to determine appropriate setup for acquiring reliable inspection data. (PI 4.1.2)* *LO 4.4: Analyze the different scan outputs to identify discontinuities, assess defect characteristics, and evaluate limitations in ultrasonic inspection results. (PI 4.3.2)* *LO 4.5: Identify safety, health, and societal responsibilities associated with ultrasonic testing setups, including high-voltage instruments, couplants, and operator protection requirements. (PI 6.1.1)* *LO 4.6: Interpret relevant UT codes, standards, and calibration requirements to ensure regulatory compliance and safeguard industrial and public safety. (PI 6.2.1)*	**6-8**
05.	**Radiographic Testing (RT)** ***Learning Objectives:*** *The learner is expected to understand the principles of radiography using X-rays and gamma rays, and critically evaluate exposure techniques, interpret film and digital images for defect detection, ensure adherence to safety and quality standards, and compare radiographic and ultrasonic methods for optimal inspection strategy selection.* **Contents:** • Principle of radiography using X-rays and gamma rays • Exposure techniques and image formation	**6-8**

	• Film and digital radiography, image quality indicators (IQI) • Radiographic interpretation and safety precautions • Comparison of RT and UT methods • Numerical Problems related to Radiographic Testing • Applications: Welds, Pressure vessels, castings, etc.	
	Self-Learning Topics: *Comparison of RT and UT methods*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to describe the principles of radiography using X-rays and gamma rays and relate them to material behavior during inspection. (PI 1.3.1)* *LO 5.2: Apply mechanical and materials engineering knowledge to evaluate exposure parameters, imaging systems, and IQI selection for different component geometries and thicknesses. (PI 1.4.1)* *LO 5.3: Examine radiographic setups—including source positioning, filtration, and calibration blocks—to determine their suitability for acquiring reliable inspection data. (PI 4.1.2)* *LO 5.4 Analyze film and digital radiographic images to identify defect signatures, characterize discontinuities, and assess limitations arising from sensitivity, contrast, noise, and geometric unsharpness. (PI 4.3.2)* *LO 5.5 Identify gaps in emerging radiographic technologies—such as digital RT, automated image interpretation, and advanced detectors—and use appropriate strategies to update professional knowledge. (PI 11.1.2)* *LO 5.6: Locate and interpret technical literature, codes, and standards (ASME, ASTM, ISO) to support continuous learning and effective application of radiographic inspection techniques. (PI 11.3.1)*	
06.	**Advanced and Emerging NDT Methods**	**6-8**
	Learning Objective/s: *The learner is expected to apply advanced principles and instrumentation of emerging NDT techniques—such as Eddy Current, Acoustic Emission, Thermography, and Leak Testing—to evaluate material integrity and process performance.* *The learner is expected to integrate modern digital technologies including Phased Array UT, Computed Radiography, Digital Tomography, and AI-driven analytics to design intelligent inspection systems and enhance decision-making in complex industrial applications.*	
	Contents: • Eddy Current Testing (ECT) – principles, instrumentation, applications, Numerical problems • Acoustic Emission Testing (AET) – transient wave analysis • Thermography and Infrared Testing – heat flow and imaging • Leak Testing – bubble, pressure, halogen, and mass spectrometer methods, Numerical problems • Modern trends: Phased Array UT, Computed Radiography (CR), Digital Tomography, AI in NDT • Case Studies: Automated Corrosion Detection in Nuclear Fuel Canisters, Vision-based Autonomous Structural Damage Detection in Wind Turbine Structures, Drone-based Visual & Infrared (Thermography) Inspections for Bridges and Infrastructure	
	Self-Learning Topics: *Leak Testing – bubble, pressure, halogen, and mass spectrometer methods*	

	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply fundamental engineering concepts to describe the principles and material interactions governing Eddy Current Testing, Acoustic Emission Testing, Thermography, and Leak Testing. (PI 1.3.1)* *LO 6.2: Apply mechanical and materials engineering knowledge to distinguish among advanced NDT techniques—including PAUT, digital radiography, and tomography—based on physics of operation and inspection requirements. (PI 1.4.1)* *LO 6.3: Design an inspection methodology integrating appropriate NDT techniques—such as PAUT, CR, and digital tomography—to address complex industrial evaluation problems. (PI 3.1.1)* *LO 6.4: Conduct investigations using simulation, imaging tools, or signal-analysis techniques to interpret multi-modal NDT data for accurate defect characterization. (PI 3.4.1)* *LO 6.5: Identify the safety, ethical, and societal responsibilities involved in deploying advanced NDT technologies such as high-energy radiography, drone-based inspection, and AI-driven evaluations. (PI 6.1.1)* *LO 6.6: Evaluate how advanced and digital NDT methods influence technical performance in relation to socio-economic and environmental sustainability, including energy usage, inspection efficiency, and waste reduction. (PI 6.3.2)*	
	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 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
3.1.1	Design an investigation methodology using scientific principles and engineering concepts.
3.4.1	Analyze data using appropriate techniques (tools, simulation, signal processing, imaging) to interpret results and support conclusions.
4.1.2	Examine relevant tools and techniques of experiment/inspection design
4.3.2	Analyze 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
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
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
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
11.1.2	Identify gaps in knowledge and apply strategies for independent learning.
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: Learner will be able to

1. Apply engineering and analytical knowledge to classify defect types, compare NDT and destructive testing methods, and select appropriate NDT techniques and standards for quality and safety applications. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6)*
2. Apply principles of visual and liquid penetrant testing to identify surface defects, evaluate test sensitivity and influencing parameters, and ensure compliance with relevant codes and safety requirements. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Analyze magnetization principles, detection media, and indication interpretation techniques to conduct MPT inspections and uphold safety and standard compliance. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6)*
4. Conduct investigations using ultrasonic and radiographic testing methods by analysing wave behaviour, image data, calibration standards, and radiation safety to accurately characterize defects and evaluate inspection quality. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO LO 4.5, LO 4.6, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*
5. Integrate advanced NDT techniques—such as eddy current, acoustic emission, thermography, leak testing, PAUT, CR, and AI-driven methods—to design intelligent inspection strategies and evaluate industrial case-study applications. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6., LO. 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC7041.1	3	3	-	-	3	-	-	-	-	-	-
MEPEC7041.2	3	3	-	-	-	-	-	-	-	-	-
MEPEC7041.3	3	-	-	3	-	3	-	-	-	-	-
MEPEC7041.4	3	-	-	3	-	3	-	-	-	-	3
MEPEC7041.5	3	-	3	-	-	3	-	-	-	-	-
Average	**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. Paul E. Mix, *Introduction to Non-destructive Testing: A Training Guide*, Wiley, 2005.
2. Peter J. Shull, *Non-destructive Evaluation: Theory, Techniques and Applications*, Marcel Dekker, 2002.
3. Baldev Raj, T. Jayakumar, and M. Thavasimuthu, *Practical Non-Destructive Testing*, Narosa Publishing, 2018.

Reference Books:

1. ASM Handbook, Vol. 17 – Non-destructive Evaluation and Quality Control, ASM International, 2019.
2. ASTM Volume 03.03: Non-destructive Testing, ASTM, 2020.
3. Hellier, C., Handbook of Non-destructive Evaluation, McGraw Hill, 2012.

Other Resources:

1. NPTEL course: **Automation in Manufacturing,** by Prof. Shrikrishna N. Joshi, IIT Guwahati,
   Link: https://onlinecourses.nptel.ac.in/noc25_me154/preview
2. NPTEL course: **Manufacturing Systems Technology I & II,** by Prof. Shantanu Bhattacharya, IIT Kanpur,
   Link: https://onlinecourses.nptel.ac.in/noc25_me156/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Class Test (2 Tests, *one before MSE and one after*)	:	10 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 carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7042	CONDITION MONITORING	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. MEPCC302 - Mechanics of Solids
2. MEPCC509 - Mechanical Vibrations

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Modern tool usage
5. PO 8: Individual and team work
6. PO 9: Communication

Course Objectives :

1. To introduce basic concepts of machinery diagnostic for assessing the health, performance, and reliability of industrial machinery.
2. To acquaint with the principles of vibration measuring instruments and condition monitoring.
3. To apply signal processing technique for vibration measurement.
4. To enable learners to interpret NDT data and apply diagnostic tools for system health assessment.
5. To develop competency in evaluating machine health by interpreting oil-analysis parameters and applying machine-learning techniques to fault diagnosis.

Module	Details	Hrs
	This course provides a comprehensive understanding of modern Condition Monitoring techniques used for assessing the health, performance, and reliability of industrial machinery. It covers the fundamentals of vibration analysis, signal processing, and non-destructive testing methods essential for fault detection and diagnosis in rotating and mechanical systems. Students will learn advanced oil analysis, sensor technologies, and practical approaches to identify machine faults using time- and frequency-domain tools. The course also introduces the integration of Machine Learning for intelligent diagnostics, enabling data-driven fault classification, anomaly detection, and predictive maintenance. Through	**01**

	real-world case studies of electrical and mechanical equipment—including fans, pumps, centrifuges, fiberizers, gearboxes, and bearings—students will gain hands-on insights into industrial applications and develop skills aligned with modern predictive maintenance and Industry 4.0 practices.	
01.	**Vibration Based Condition Monitoring** ***Learning Objective/s:*** *To introduce the fundamental vibration concepts and diagnostic techniques for identifying faults in rotating machinery using time-, frequency-, and phase-based vibration signatures.*	**6-7**
	Contents: Basics of Vibration Periodic and random motion, Spectral Amplitude Scaling: RMS, Peak and Peak to-Peak Conversion and Selection, Time and frequency domain analysis, Phase analysis, Orbit analysis, Understanding signal pattern, Importance of speed in accurate diagnosis, Importance of side bands in frequency spectrums. Introduction to vibration based condition monitoring maintenance principles, Vibration based fault prognosis, Goal of vibration monitoring, Steps in vibration monitoring, Benefits of vibration based condition monitoring.	
	Self-Learning Topics: *Breakdown, preventive and predictive maintenance*	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Apply the fundamental of harmonic motion to explain periodic and random vibration behaviour in engineering systems. (PI 1.2.1)* *LO 1.2 Apply core engineering concepts—such as time-frequency domain representation to analyse and interpret vibration signals. (PI 1.3.1)* *LO 1.3: Identify system variables (speed, load, stiffness, damping) and vibration parameters (amplitude, frequency, phase, sidebands) that influence machine health assessment. (PI 2.1.2)* *LO 1.4: Identify the steps, goals, and benefits of vibration-based predictive maintenance and evaluate their applicability for different engineering systems. (PI 2.1.2)*	
02.	**Vibration Measurement** ***Learning Objective/s:*** *To equip students with the knowledge of vibration measurement instruments, sensor selection criteria, and correct mounting techniques for reliable data acquisition.*	**5-6**
	Contents: Vibration measuring instruments: displacement, velocity, acceleration; Sensors for sound measurement, Force measurement, Laser based measurements: laser vibrometer Sensor Selection Criteria , Sensor – Mounting Locations and Techniques.	
	Self-Learning Topics: *Vibration limits & Standards.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to select appropriate vibration, sound, and force sensors based on measurement range, frequency response, sensitivity, and environmental conditions. (PI 1.3.1)*	

	LO 2.2: Apply laser vibrometer data to interpret vibration responses and propose engineering solutions. (PI 1.4.1) *LO 2.3: Identify engineering principles underlying sound, force, and laser-based vibration measurements (PI 2.1.3)* *LO 2.4: Identify, assemble, and critically evaluate sensor selection criteria and mounting techniques. (PI 2.2.2))*	
03.	**Signal Processing for Vibration Analysis** ***Learning Objective/s:*** *To equip students with fundamental and advanced signal processing techniques for extracting meaningful features from vibration data and accurately diagnosing faults in rotating machinery.* **Contents:** Basic signal processing techniques: Classification of signals, Signal analysis, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Time-frequency analysis, Shock pulse method, Kurtosis. ***Self-Learning Topics:*** *--* ***Learning Outcomes :*** *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to classify the signals of a vibrating system (PI 1.2.1)* *LO 3.2: Apply an appropriate technique for effective analysis of vibration analysis (PI 1.3.1)* *LO 3.3: Examine the relevant signal-processing information and tools—such as FFT analysers, digital filters, Cepstrum algorithms—and examine their suitability for experiment design, system calibration, and vibration data analysis. (PI 4.1.2)* *LO 3.4: Apply the mathematical basis of shock pulse generation and use of appropriate software tools to interpret SPM for fault detection. (PI 4.1.3)* *LO 3.5: Apply team norms and collaborative practices to analyse vibration signals using Fourier analysis, Hilbert transform, Cepstrum, and digital filtering techniques. (PI 8.1.2)* *LO 3.6: Demonstrate effective communication and problem-solving skills while interpreting time-frequency features, shock pulse indicators, and statistical measures such as kurtosis for fault diagnosis. (PI 8.1.1, PI 8.1.2, PI 8.2.1, PI 9.1.3, PI 9.3.1, PI 11.1.2, PI 11.3.1* *Each group (maximum of 4 students) will collaboratively analyse how signal processing techniques contribute to machine condition monitoring and fault diagnosis. Students will conduct a literature review, perform simulations or analytical tasks, discuss findings within the group, and deliver a structured presentation. The activity will cover the following aspects:* 1. *Classification of Signals* 2. *Signal Analysis Techniques* 3. *Fourier Analysis* 4. *Hilbert Transform & Envelope Detection* 5. *Cepstrum Analysis* 6. *Digital Filtering* 7. *Time–Frequency Analysis* 8. *Shock Pulse Method* 9. *Kurtosis and Statistical Indicators*	**9-10**
04.	**Techniques of Condition Monitoring** ***Learning Objective/s:*** *To equip students with the knowledge to analyze machine behavior using NDT tools, natural frequency evaluation, and time–frequency domain techniques for accurate fault detection.*	**9-10**

	Contents: Different Nondestructive techniques – Visual, Dye Penetration, Acoustic Emission and its applications, Thermography, X-ray, Radiographic, Magnetic Flux test, UT test, Temperature monitoring, Vibration analysis, Oil analysis, Natural frequency and resonance tests (Practical approach), Time and Frequency domain analysis to identify faults in rotating systems.	
	Self-Learning Topics: *Order tracking for variable-speed machinery*	
	Learning Outcomes : *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to interpret condition-monitoring results from various non-destructive techniques. (PI 1.3.1)* *LO 4.2: Apply nondestructive testing techniques such as visual inspection, dye penetration, acoustic emission, thermography, radiography, magnetic flux, and ultrasonic testing to identify defects in mechanical components. (PI 1.4.1)* *LO 4.3: Use of mathematical and engineering knowledge to interpret and validate NDT data, including ultrasonic wave reflections, thermal intensity maps, frequency-domain vibration signatures, and acoustic emission spectra. (PI 2.4.2)* *LO 4.4: Identify the mathematical and engineering knowledge required to analyse natural frequency and resonance tests, as well as time- and frequency-domain vibration signatures, to distinguish common fault conditions in rotating systems. (PI 2.1.3)*	
05.	**Oil Analysis**	**6-7**
	Learning Objectives: *To educate on analytical skills to interpret oil properties, corrosion indicators, and particle characteristics for effective predictive maintenance.*	
	Contents: Oil Analysis – Oil degradation analysis, Abrasive Particle in oil, counters, Particle classification and counter, Spectrometric oil analysis, Performance trend monitoring – Primary and secondary parameters, Ferrography, Corrosion monitoring techniques, Advanced testing using RPVOT and RULER test.	
	Self-Learning Topics: *Gas Chromatography (GC) for Contaminant Detection.*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to interpret oil-analysis, for diagnosing machinery health. (PI 1.3.1)* *LO 5.2: Apply oil analysis techniques—including degradation assessment, to diagnose mechanical system health and identify lubrication-related faults. (PI 1.4.1)* *LO 5.3: Identify engineering systems, variables, and parameters relevant to oil condition monitoring—such as primary and secondary performance trend parameters, particle size distribution. (PI 2.1.2)* *LO 5.4: Identify the mathematical, analytical, and engineering knowledge required to evaluate oil contamination, wear-particle behaviour, spectrometric concentration trends, and ferrography signatures for fault diagnosis and maintenance planning. (PI 2.1.3)* *LO 5.5: Examine particle counter data, spectrometric results, ferrograms, corrosion monitoring outputs, and RPVOT/RULER test results for predictive maintenance. (PI 4.1.2)* *LO 5.6 Apply appropriate oil-analysis instrumentation and software tools—such as automatic particle counters, spectrometric analysers, and ferrography imaging systems—to measure, record, and interpret oil quality parameters accurately. (PI 4.1.3)*	

06.	**Machine Learning Applications in Condition Monitoring**	**6-7**
	Learning Objective/s: *To familiarize students to machine learning techniques for fault diagnosis and enable them to apply data-driven models for intelligent condition monitoring of industrial systems.*	
	Contents: Machine learning for fault diagnosis: Introduction to ML in vibration analysis, Supervised learning for fault classification (SVM, Decision Trees), Unsupervised learning for anomaly detection (K-means, PCA), Feature selection and model validation, Integration of ML with monitoring systems, Machine Learning for bearing fault detection. Case study related to Electrical Systems, Mechanical Systems- Centrifuge, ID/FD Fan, Sugarcane Fiberizer, Feed Pumps, Gearbox, and Bearings.	
	Self-Learning Topics: Generative AI for synthetic fault data (GANs)	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply the principles and applications of ML in vibration monitoring. (PI 1.3.1)* *LO 6.2: Apply unsupervised learning techniques such as K-means and PCA to detect anomalies in vibration data from rotating machinery. (P.I. 1.4.1)* *LO 6.3: Identify and evaluate ML technique for labeled datasets, extracted features, performance metrics, and case-study data to support model training and validation. (PI 5.1.1)* *LO 6.4: Demonstrate proficiency in Python, MATLAB, and ML libraries for vibration-data preprocessing, feature extraction, ML model development, and performance evaluation in condition monitoring applications. (PI 5.2.2)* *LO 6.5: Interpret ML analysis results clearly and communicate fault diagnosis outcomes through well-structured technical documents, demonstrating effective communication, technical interpretation, and problem-solving skills. (PI 8.1.2,1, PI 8.2.1)* *LO 6.6: Present team-based analyses and case studies on ML-based feature selection and model validation (centrifuges, ID/FD fans, gearboxes, feed pumps, bearings) in clear, well-organized technical documents reflecting cohesive team effort. (PI 9.1.2, PI 9.1.3, PI 9.3.1, PI 11.1.2, PI 11.3.1))* *Each group (maximum of 4 students) will conduct a structured study on vibration-based condition monitoring, analyzing fault detection techniques, machine health assessment, and compliance with ISO standards. The task involves literature review, case study analysis, and presentation, covering the following aspects:* 1. *Condition Monitoring Techniques: Identification, Comparison, and Selection* 2. *Sensor Selection and Placement for Condition Monitoring* 3. *Fault Detection and Diagnosis Techniques* 4. *Data Collection, Processing, and Validation* 5. *Measurement Accuracy Evaluation in Fault Diagnosis* 6. *Advanced Vibration Monitoring Techniques: AI-Based Fault Detection*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
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.
2.3.1	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.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
4.1.2	Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
8.2.2	Treat other team members respectfully
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1	Read, understand and interpret technical and non-technical information.

Course Outcomes : Learner will be able to

1. Apply basic concepts of machinery diagnostic for industrial application in a better way. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Select appropriate vibration, sound, force, and laser-based sensors for engineering applications by evaluating sensor parameters and features. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Identify signal processing technique for vibration measurement. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4 LO 3.5, LO 3.6)*
4. Apply non-destructive and condition-monitoring techniques to assess machine health. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*
5. Familiarize with machine learning techniques to classify faults, and interpret vibration-based condition-monitoring data. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEPEC7042.1	3	3	--	--	--	--	--	--	--	--	--
MEPEC7042.2	3	3	--	--	--	--	--	--	--	--	--

MEPEC7042.3	3	3	--	3	--	--	--	3	3	--	3
MEPEC7042.4	3	3	--	--	--	--	--	3	3	--	--
MEPEC7042.5	3	3	--	--	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.

Text Books :

1. A.R. Mohanty, "*Machine Condition Monitoring: Principles and Practices*", (CRC Press)
2. R.A. Collacott, "*Mechanical Fault Diagnosis and Condition Monitoring",* (Chapman and Hall)
3. Robert Bond Randall, "*Vibration-based Condition Monitoring: Industrial, Automotive and Aerospace Applications*", 2nd Edition, (Wiley)

Reference Books :

1. William W.Seto , *Mechanical Vibrations*- Schaum's outline series, (McGraw Hill)
2. S.Graham Kelly, *Fundamentals of Mechanical Vibration* (Tata McGraw Hll)
3. J.S.Rao, K. Gupta, *Theory and Practice of Mechanical Vibrations*. (New Age International Publications)
4. R.A. Collacott, "*Mechanical Fault Diagnosis and Condition Monitoring*",1st Edition, (Chapman and Hall), ISBN: 978-94-009-5723-7

Other Resources :

1. **Machinery Fault Diagnosis and Signal Processing,** Prof. A. R. Mohanty, IIT Kharagpur
   Link: https://nptel.ac.in/courses/112105232

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
A task based group activity	:	05 Marks
Article reading and 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 carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	MEPEC7043	WELDING TECHNOLOGY	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. MEPCC303 - Materials Science and Engineering
2. MEPCC408 - Manufacturing Technology

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems:
5. PO5: Modern tool usage
6. PO6: The engineer and society and Environment and sustainability
7. PO11: Project management and finance

Course Objectives:

1. Introduce the concepts of Welding like, processes, joints, positions, symbols and equipment
2. Acquaint with the different types of Welding methods.
3. Familiarize with the different types of filler metals, concept of welding metallurgy and estimate welding related costs.
4. Acquaint with welding distortion and stresses, understand welding parameters, and follow safety precautions related to welding.
5. Impart knowledge of welding defects, visual and NDT inspections, and relevant welding codes and standards.
6. Use CAD tools associated with welding, understand welding automation with robotics and IoT, and describe advanced welding processes.

Module	Details	Hrs
	Course Introduction The Welding Technology course enhances comprehensive understanding and practical proficiency in the complex field of welding by building upon existing foundational knowledge and extending into current technologies, advanced materials, and sophisticated welding processes essential for modern industrial applications. It integrates both theoretical concepts and practical implications	**01**

	related to welding processes, metallurgy, process optimization, automation, and stringent quality control procedures, enabling participants to confidently address demanding welding challenges across manufacturing, construction, and research environments.	
01.	**Introduction to Welding** ***Learning Objective/s:*** *The learner is expected to apply, analyze and design the parameters for the various methods and equipment used in Welding.*	**7-9**
	Contents: • Introduction to welding: definition, historical evolution, and industrial significance • Overview and classification of welding processes, including gas welding, arc welding, and resistance welding • Fundamentals of weld joint design and selection of appropriate joint types for various applications • Practice and understanding of welding positions such as flat, horizontal, and vertical • Interpretation and application of standard weld symbols	
	Self-Learning Topics: *Weld Symbols*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to explain the definition, historical evolution, and industrial significance of welding. (PI 1.3.1)* *LO 1.2: Apply mechanical engineering concepts to classify and differentiate gas, arc, and resistance welding processes based on their operating principles and applications. (PI 1.4.1)* *LO 1.3: Apply engineering fundamentals to select suitable weld joint types for specific fabrication applications. (PI 1.3.3)* *LO 1.4: Identify welding system parameters such as joint type, welding position, and heat considerations relevant to different welding methods. (PI 2.1.2)* *LO 1.5: Interpret standard weld symbols by applying scientific principles and engineering concepts used in welding design documentation. (PI .2.3.1)*	
02.	**Welding Processes: Concepts and Applications** ***Learning Objective/s:*** *The learner is expected to identify, explain, and apply the principles, equipment, and techniques of Oxy-Acetylene Welding, Arc Welding, Resistance Welding, and Brazing/Soldering processes.*	**9-11**
	Contents: **Oxy-Acetylene Welding:** • Principle: Chemistry of the oxy-acetylene flame, flame types, and their applications. • Equipment: Selection and use of torches, regulators, hoses, and accessories. • Welding Techniques: Setup procedures, tacking methods, and execution of various weld joints. • Oxy-Acetylene Cutting: Cutting principles, techniques, and industrial applications.	

	Arc Welding: • Shielded Metal Arc Welding (SMAW): Principles, electrode classifications, and typical applications. • Gas Tungsten Arc Welding (GTAW): Process principles, power sources, tungsten types, and applications. • Gas Metal Arc Welding (GMAW): Principles, metal transfer modes, shielding gases, and applications. • Submerged Arc Welding (SAW): Fundamentals, equipment, flux types, and applications. **Resistance Welding:** • Principles, equipment basics, and industrial applications.	
	Self-Learning Topics: *Submerged Arc Welding*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to explain the principles of oxy-acetylene welding, arc welding processes (SMAW, GTAW, GMAW, SAW), and resistance welding. (PI 1.3.1)* *LO 2.2: Apply engineering fundamentals to identify and select appropriate welding equipment—including torches, power sources, electrodes, fluxes, regulators, and accessories—for specific welding processes. (PI 1.3.3)* *LO 2.3: Identify key welding variables such as flame type, current, voltage, metal transfer mode, pressure, and clamping force that influence the selection and application of welding and cutting methods. (PI 2.1.2)* *LO 2.4: Compare and contrast alternative welding processes to select the most suitable method for given materials, joint types, and industrial applications. (PI 2.2.4)*	
03.	**Material Selection and Process Economics**	**7-9**
	Learning Objective/s: *The learner is expected to identify and select appropriate filler metals for different welding processes, explain key concepts in welding metallurgy, and evaluate welding costs through basic economic analysis.*	
	Contents: • Material Properties: Understanding the properties of different metals and alloys. • Filler Metal Selection: Choosing the right filler metal for different materials and welding processes. • Welding Metallurgy and Dissimilar Metal Welding • Welding Economics: Principles of cost estimation, cost influencing factors, and overall economic evaluation of welding operations • Case Studies on Material Selection for Specific Applications	
	Self-Learning Topics: *Dissimilar Metal Welding*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to explain the properties of metals and alloys relevant to welding and material selection. (PI 1.3.1)* *LO 3.2: Apply mechanical and materials engineering knowledge to select appropriate filler metals for different welding processes and material combinations. (PI 1.4.1)* *LO 3.3: Identify relevant engineering and metallurgical knowledge required to analyze welding metallurgy and dissimilar metal welding challenges. (PI 2.1.3)*	

	LO 3.4: Identify existing methods and assumptions used in evaluating welding costs, including material consumption, energy usage, and operational factors. (PI 2.2.3) *LO 3.5: Interpret relevant safety regulations, standards, and environmental considerations applicable to material and filler metal selection in welding operations. (PI 6.2.1)* *LO 3.6: Identify safety, environmental, and societal considerations associated with selecting materials and filler metals, especially in applications involving hazardous alloys or welding fumes. (PI 6.1.1)*	
04.	**Thermal and Thermo-Mechanical Analysis** ***Learning Objective/s:*** *The learner is expected to identify welding distortion and stresses, adjust welding parameters, apply correct techniques for quality welds, and follow safety precautions.*	**7-9**
	Contents: • Key Parameters: Control of voltage, amperage, travel speed, and wire feed rate. • Core Techniques: Proper torch/electrode handling and heat control for quality welds. • Distortion Control: Measures to minimize distortion and residual stresses. • Safety Essentials: PPE, ventilation, fire safety, and safe equipment handling. • Case Study Application: Practical examples demonstrating parameter control, technique selection, and safety compliance in real welding scenarios	
	Self-Learning Topics: *Safe equipment handling*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts to explain how voltage, amperage, travel speed, and wire feed rate influence weld quality and heat input. (PI 1.3.1)* *LO 4.2: Apply specialized welding knowledge to describe proper torch/electrode handling and heat control techniques required for producing quality welds. (PI 1.4.1)* *LO 4.3: Determine functional requirements and specifications for selecting appropriate welding techniques to minimize distortion and residual stresses. (PI 3.1.6)* *LO 4.4: Identify suitable criteria for evaluating alternative welding parameters and technique combinations to achieve defect-free and dimensionally accurate welds. (PI 3.2.3)* *LO 4.5: Identify safety requirements and engineering responsibilities related to PPE, ventilation, fire safety, and safe handling of welding equipment to protect operators and surroundings. (PI 6.1.1)* *LO 4.6: Interpret welding safety standards, regulations, and best practices applicable to parameter adjustment, equipment operation, and safe work environments. (P.I. 6.2.1)*	
05.	**Quality Control and Inspection** ***Learning Objectives:*** *The learner is expected to identify welding defects, perform visual and NDT inspections, and apply relevant welding codes and standards.*	**3-5**
	Contents: • Inspection & Testing: Use of VT, PT, MT, RT, and UT to identify discontinuities and verify weld integrity. • Defects & Prevention: Recognition of common weld defects and implementation of corrective and preventive measures.	

	• Standards & Qualifications: Compliance with AWS/ASME/ISO/EN standards and proper qualification of WPS, PQR, and welders. • Process Control & Documentation: Monitoring key welding parameters, and maintaining essential quality record.	
	Self-Learning Topics: *Implementation of corrective and preventive measures of defects*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Examine appropriate NDT and visual inspection tools, techniques, and procedures (VT, PT, MT, RT, UT) to detect weld discontinuities. (PI 4.1.2)* *LO 5.2: Analyze defect indications from NDT results to determine root causes, trends, and limitations of inspection data. (PI 4.3.2)* *LO 5.3: Interpret welding codes and standards (AWS/ASME/ISO/EN) and explain their role in ensuring public safety, product integrity, and regulatory compliance. (PI 6.2.1)* *LO 5.4: Identify societal, health, and safety implications associated with improper inspections, welding defects, and non-compliance with WPS/PQR requirements. (PI 6.1.1)* *LO 5.5: Source and comprehend welding standards, NDT handbooks, and technical documents required for inspection and quality control documentation. (PI 11.3.1)* *LO 5.6: Identify knowledge gaps related to inspection techniques or defect prevention and demonstrate the ability to seek new information to update skills. (PI 11.1.2)*	
06.	**Recent advancements in Welding Technology**	**4-6**
	Learning Objective/s: *The learner is expected to use CAD tools associated with welding, understand welding automation with robotics and IoT, and describe advanced welding processes.*	
	Contents: • High-Precision & Hybrid Welding: Advances in laser, hybrid laser–arc, and friction stir welding. • Automation & AI: Robotics, adaptive control, and AI-driven parameter optimization and defect detection. • Additive Manufacturing (WAAM): Use of WAAM for large and complex metal components. • Advanced Processes: Inverter-based systems, pulsed/synergic controls, CMT, tandem GMAW, and high-productivity SAW. • Digital & Sustainable Solutions: Real-time monitoring, cloud-based weld management, and energy-efficient, low-emission technologies	
	Self-Learning Topics: *High-productivity SAW*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply mechanical engineering concepts to explain the principles of advanced welding technologies such as laser welding, hybrid laser–arc welding, and friction stir welding. (PI 1.4.1)* *LO 6.2: Apply engineering fundamentals to interpret the operating characteristics of inverter-based machines, pulsed/synergic controls, and controlled metal transfer (CMT) processes. (PI 1.3.3)* *LO 6.3: Identify modern engineering tools—including CAD, robotic systems, adaptive control units, and digital monitoring platforms—used in welding automation and WAAM. (PI 5.1.1)*	

	LO 6.4: Verify the credibility and limitations of digital weld monitoring, AI-based defect detection, and cloud-based weld management systems used in modern welding operations. (PI 5.3.2) *LO 6.5: Identify safety implications, public welfare considerations, and operator risks associated with robotic welding, laser systems, and high-energy welding processes. (PI 6.1.1)* *LO 6.6: Apply preventive engineering and sustainability principles to evaluate energy-efficient, low-emission welding technologies and digital eco-friendly solutions. (P.I. – 6.4.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.3.3	Apply fundamental engineering concepts through correct interpretation of processes.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.3	Identify existing processes/solution methods and justified assumptions
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate and interpret models
3.1.6	Determine design objectives, functional requirements, and arrive at specifications
3.2.3	Identify suitable criteria for evaluating alternative design solutions
4.1.2	Examine relevant tools and techniques of experiment/inspection design
4.3.2	Analyze data for trends, errors, and limitations
5.1.1	Identify modern engineering tools (CAD, 3D modeling, simulation) for welding applications.
5.3.2	Verify credibility of CAD/CAE or simulation results for welding processes.
6.1.1	Identify engineering roles related to public safety, health, and protection within welding practice.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to the discipline
6.4.2	Apply principles of sustainable development to welding processes and products.
11.1.2	Identify deficiencies in knowledge and source information to close the gaps
11.3.1	Source and comprehend technical literature and credible information

Course Outcomes : Learner will be able to

1. Apply, analyze, and design the parameters for various welding methods and equipment, demonstrating proficiency in optimizing welding processes for different applications. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5)*

2. Identify and apply the principles, equipment, and techniques of Oxy-Acetylene Welding, Arc Welding, Resistance Welding, and Brazing/Soldering processes. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*

3. Identify and select appropriate filler metals for different welding processes, explain key concepts in welding metallurgy, and evaluate welding costs through basic economic analysis. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6)*

4. Identify welding distortion and stresses, adjust welding parameters, apply correct techniques for quality welds, and follow safety precautions. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*

5. Identify welding defects, perform visual and non-destructive testing (NDT) inspections, and apply relevant welding codes and standards. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*

6. Utilize CAD tools for welding design, explain the principles of welding automation using robotics and IoT, and describe advanced welding processes. *(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
MEPEC7043.1	3	3	--	--	--	--	--	--	--	--	--
MEPEC7043.2	3	3	--	--	--	--	--	--	--	--	--
MEPEC7043.3	3	3	--	--	--	3	--	--	--	--	--
MEPEC7043.4	3	--	3	--	--	3	--	--	--	--	--
MEPEC7043.5	--	--	--	3	--	3	--	--	--	--	3
MEPEC7043.6	3	--	--	--	3	3	--	--	--	--	--
Average	**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. Welding Metallurgy and Weldability of Stainless Steels, by John C. Lippold & Damian J. Kotecki, 2005, Wiley-Interscience Publication
2. A Textbook of Welding Technology by O. P. Khanna, 1999, Dhanpat Rai Publications
3. Welding: Principles and Applications by Larry Jeffus, 1999, Delmar Publishers
4. Welding Engineering: An Introduction, First Edition. David H. Phillips. 2016, John Wiley & Sons
5. Welding Engineering and Technology by R. S. Parmar, 2013, Khanna Publishers
6. Welding Metallurgy by Sindo Kou, 2003 John Wiley & Sons
7. Fabrication and Welding Engineering by Roger Timings, 2008, Routledge

Reference Books:

1. AWS WHB-10. 1 Welding Handbook, 10th Edition (5 Voloumes), 2019, American Welding Society
2. ASM Handbook, Volume 6: Welding, Brazing and Soldering by Joseph R. Davis, Kelly Ferjutz, Nikki D. Wheaton, 1993, ASM International
3. The Procedure Handbook of Arc Welding by James F Lincoln, 199, James F. Lincoln Arc Welding Foundation
4. Welding Skills, by B. J. Moniz, 2015, American Technical Publishers
5. The Science and Practice of Welding: Welding science and technology by A. C. Davies, 1992, Cambridge University Press
6. Welder's Handbook, The: A Guide to Plasma Cutting, Oxyacetylene, Arc, MIG and TIG Welding by Richard Finch, 2007, HP Books

Other Resources :

1. NPTEL Course: **Advances in Welding and Joining Technologies** by Prof. Swarup Bag, IIT Guwahati,

   Link - https://onlinecourses.nptel.ac.in/noc25_me149/preview
2. NPTEL Course: **Welding Application Technology** by Prof. Pankaj Biswas, IIT Guwahati

   Link - https://onlinecourses.nptel.ac.in/noc25_me150/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Class Test (2 tests)	:	10 Marks
Technical report writing based on Lab Task	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
OEC	OEC7011	PRODUCT LIFE CYCLE MANAGEMENT	03

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

Program Outcomes addressed:

1. PO3 : Design / Development of Solutions
2. PO6 : The engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Introduction to Product Lifecycle Management (PLM)**	**9-11**
	Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications, PLM Strategies: Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	
02.	**Product Design**	**9-11**
	Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	

03.	**Product Data Management (PDM)**	**5-7**
	Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	
04.	**Virtual Product Development Tools**	**5-7**
	For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	
05.	**Integration of Environmental Aspects in Product Design**	**5-7**
	Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	
06.	**Life Cycle Assessment and Life Cycle Cost Analysis**	**4-6**
	Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes : Learner will be able to

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

References :

1. John Stark, “Product Lifecycle Management: Paradigm for 21st Century Product Realisation”, Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, “Product Design for the environmentA life cycle approach”, Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, “Product Life Cycle Management”, Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, “Product Lifecycle Management: Driving the next generation of lean thinking”, Tata McGraw Hill, 2006, ISBN: 0070636265

Course Type	Course Code	Course Name	Credits
OEC	OEC7012	RELIABILITY 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. ---

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO 4: Conduct investigations of complex problems
5. PO 5: Engineering Tool Usage

Course Objectives:

1. To familiarize the students with various aspects of probability theory.
2. To acquaint the students with reliability and its concepts.
3. To introduce the students to methods of estimating the system reliability of simple and complex systems.
4. To understand the various aspects of Maintainability, Availability and FMEA procedure.

Module	Details	Hrs.
	Course Introduction Reliability Engineering is a vital discipline within engineering that focuses on ensuring systems and components perform their intended functions consistently over their expected lifetime. The course introduces students to the principles, tools, and methodologies used to analyze, predict, and improve the reliability of engineering systems. Students will explore key concepts such as failure mechanisms, probability models, reliability metrics, system configurations, maintenance strategies, and life data analysis. Through theoretical understanding and practical applications, the course aims to develop the ability to design reliable products, evaluate system performance, and implement reliability improvement programs in real-world engineering environments. By the end of the course, learners will gain a strong foundation in reliability concepts and become capable of applying these principles across various domains including mechanical, electrical, electronic, and manufacturing systems.	**01**

01.	**Probability Theory** ***Learning Objective:*** *Learner will be able to impart the knowledge of fundamental concepts in Probability to solve the problems.* **Contents:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. Rules for combining probabilities, independent, mutually exclusive, complimentary, conditional events, simultaneous occurrence of events. ***Self-Learning Topics:*** *---* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply mathematical technique such as statistics to solve problems of Probability. (PI 1.1.1)* *LO 1.2: Apply numerical methods to solve Baye's theorem problems. (PI 1.3.1)* *LO 1.3: Identify conditional probabilities using appropriate formulas or diagrams. (PI 2.1.2)* *LO 1.4: Compare rules for combining probabilities.(PI 2.2.4)*	**5-7**
02.	**Reliability Concepts** ***Learning Objective:*** *Learner will be able to acquaint with concept of quality and reliability.* **Contents:** Reliability definitions, Reliability functions, Importance of Reliability, Quality Assurance and Reliability. Failure- causes of failures, modes of failures, Bath Tub Curve Failure Data Analysis: Failure density, Mean Time to Failure (MTTF), Mean time between failure (MTBF). ***Self-Learning Topics:*** *---* ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to create reliable and quality system to ensure product quality, safety, and performance in engineering systems. (PI 1.3.1)* *LO 2.2: Identify the modern reliability analysis tools to generate, interpret, and analyze the Bath Tub Curve for engineering components to identify different failure phases. (PI 5.1.1)* *LO 2.3: Identify failures, their causes, and various modes of failures in mechanical and engineering systems. (PI 2.1.2)* *LO 2.4: Identify the failure rate characteristics of the three phases of the Bath Tub Curve (early life, useful life, wear-out). (PI 2.1.3)* *LO 2.5: Apply fundamental mathematical concepts to calculate Mean Time To Failure (MTTF) and Mean Time Between Failure (MTBF) from provided failure data. (PI 1.1.1)* *LO 2.6: Adapt appropriate modern quality and reliability tools such as control charts, FMEA, and reliability software to analyze and improve product and process performance. (PI 5.1.2)*	**7-9**
03.	**Reliability Hazard Models** ***Learning Objective:*** *Learner will be able to acquaint with concept of hazard models.*	**6-8**

	Contents: Hazard rate, Constant Hazard, Hazard Models –Constant Failure Rate, linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution MTTF in terms of failure Density, Mean time in failure in integral form functions and reliability analysis. ***Self-Learning Topics:*** *---* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Apply the mathematical concepts to derive the reliability function for systems with constant and time dependent hazard rates. (PI 1.1.2)* *LO 3.2: Apply mathematical concepts to find the hazard rate. (PI 1.1.1)* *LO 3.3: Investigate real-world failure data using two- and three-parameter Weibull models to estimate shape and scale parameters and predict component life characteristics. (PI 4.1.1)* *LO 3.4: Compare different hazard models and their implications on system design and maintenance. (PI 2.2.4)* *LO 3.5: Analyze hazard rate functions including constant, linearly increasing, and time-dependent failure rate models. (PI 4.1.2)* *LO 3.6: Identify hazard functions and their significance in system performance. (PI 2.1.2)*	
04.	**System Reliability** ***Learning Objectives:*** *Learner will be able to calculate System reliability for basic configurations including series, parallel and mixed configuration.* **Contents:** System Configurations: Series, parallel, mixed configuration, k- out of n structure, Complex systems. Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. ***Self-Learning Topics:*** *---* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Apply the fundamental engineering concept for System reliability. (PI 1.3.1)* *LO 4.2: Apply the fundamental of mathematics to calculate the overall system reliability for basic configurations. (series, parallel, mixed) (PI 1.1.1)* *LO 4.3: Design systems by evaluating system reliability for series, parallel, mixed, and k-out-of-n configurations. (PI 3.2.1)* *LO 4.4: Identify different redundancy strategies to improve system reliability. (PI 2.2.2)* *LO 4.5: Compare and contrast different redundancy strategies. (PI 2.2.4)* *LO 4.6: Identify suitable criteria for the evaluation of alternate design solutions by using the redundancy techniques. (PI 3.2.3)*	**5-7**
05.	**Maintainability and Availability** ***Learning Objectives:*** *Learner will be able to acquaint with concept of maintainability and availability.* **Contents:** Maintainability, System Down time, Reliability and Maintainability tradeoff.	**7-9**

	Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability– qualitative aspects, Availability measures	
	Self-Learning Topics: *---*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify and specify essential maintenance requirements early in the design life cycle. (PI 2.2.1)* *LO 5.2: Apply engineering concepts to develop strategies to minimize unplanned downtime through improved design for maintainability. (PI 1.4.1)* *LO 5.3: Identify the differences in analyzing the reliability of a repairable and non-repairable system. (PI 2.1.2)* *LO 5.4: Design a system to incorporate Maintainability into systems and products. (PI 3.2.1)* *LO 5.5: Differentiate between reliability, maintainability and availability. (PI 2.2.4)* *LO 5.6: Design system components or processes that meet specified needs with appropriate consideration to reduce the system down time. (PI 3.2.2)*	
06.	**Failure Mode, Effects & Criticality Analysis and Fault Tree Analysis** ***Learning Objectives:*** *Learner will be able to familiarize with various aspects of failure mode, effects & criticality analysis and fault tree analysis*	**7-9**
	Contents: Failure Mode, Effects and Criticality Analysis: Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, Fau1t tree analysis and Event Tree Analysis. Fault Tree Analysis, basic symbols, development of functional reliability block diagram, Fault tree analysis and Event Tree Analysis.	
	Self-Learning Topics: *---*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify and prioritize potential failure modes and their risks in a System. (PI 2.1.2)* *LO 6.2: Apply engineering knowledge to identify and analyze failure modes. (PI 1.3.1)* *LO 6.3: Develop effective risk mitigation strategies and recommend design changes based on FMECA results to improve overall system reliability, safety and Performance. (PI 3.2.1)* *LO 6.4: Identify cost-effective strategies to prevent failures before they happen. (PI 2.1.2)* *LO 6.5: Design a Fault Tree Analysis (FTA) to determine the causes of a system failure using basic symbols. (PI 3.2.3)* *LO 6.6: Identify and utilize the basic symbols of FTA (e.g., AND gates, OR gates, basic events, undeveloped events, top event) to graphically represent Logical relationships leading to system failure. (PI 2.2.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub-problems
2.2.2	Identify, assemble and evaluate information and resources
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
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
3.2.2	Build models/prototypes to develop a diverse set of design solutions
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions
4.1.1	Define a problem, its scope and importance for purposes of investigation
4.1.2	Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation
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

Course Outcomes : Learner will be able to

1. Apply the concept of Probability theory to engineering problems. (*LO 1.1, LO 1.2, LO 1.3, L1.4*)
2. Understand fundamental concept of reliability to calculate different reliability parameters. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)*
3. Differentiate between reliability hazard models. (*LO 3.1, LO 3.2, LO3.3, LO 3.4, LO 3.5, LO 3.6*)
4. Illustrate the understanding of System Reliability. (*LO 4.1, LO 4.2, LO 4.4, LO 4.5, LO 4.6*)
5. Ilustrate the various aspects of Maintainability and Availability (*LO5.1, LO 5.2, LO5.3, LO5.4, LO5.5, LO 5.6*)
6. Familiarize with the FMECA and able to construct fault tree diagrams. (*LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7012.1	3	3	--	--	--	--	--	--	--	--	--
OEC7012.2	3	3	--	--	3	--	--	--	--	--	--

OEC7012.3	3	3	--	3	--	--	--	--	--	--	--
OEC7012.4	3	3	3	3	--	--	--	--	--	--	--
OEC7012.5	3	3	3	--	--	--	--	--	--	--	--
OEC7012.6	3	3	3	--	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	**3**	**3**	--	--	--	--	--	--

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

Text Books :

1. L.S. Srinath, "Reliability Engineering", Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. E. Balagurusamy, "Reliability Engineering", Mcgraw Hill Education (India), 2003.

Reference Books :

1. P.D.T. Conor, "Practical Reliability Engineering", John Wiley & Sons, 1985.
2. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.3
3. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Other Resources :

1. Introduction to Reliability Engineering
   Link - https://nptel.ac.in/courses/127105234

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

Class Test	:	05 Marks
MCQ test as per GATE exam pattern / level	:	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
OEC	OEC7013	MANAGEMENT INFORMATION SYSTEM	03

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

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO6 : The engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
4. Identify the basic steps in systems development

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Introduction To Information Systems (IS)**	**3-5**
	Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	
02.	**Data and Knowledge Management**	**7-9**
	Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	
03.	**Ethical issues and Privacy**	**7-9**
	Information Security. Threat to IS, and Security Controls	
04.	**Social Computing (SC)**	**7-9**
	Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	
05.	**Computer Networks**	**6-8**
	Wired and Wireless technology, Pervasive computing, Cloud computing model	

06.	**Information System within Organization**	**7-9**
	Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes : Learner will be able to

1. Explain how information systems Transform Business.
2. Identify the impact information systems have on an organization
3. Describe IT infrastructure and its components and its current trends
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

References :

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Type	Course Code	Course Name	Credits
OEC	OEC7014	DESIGN OF EXPERIMENTS	03

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO4 : Conduct Investigations of Complex Problems
4. PO5 : Engineering Tool Usage

Course Objectives :

1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Introduction** Strategy of Experimentation, Typical Applications of Experimental Design, Guidelines for Designing Experiments, Response Surface Methodology	**5-7**
02.	**Fitting Regression Models** Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of new response observation, Regression model diagnostics, Testing for lack of fit	**8-10**
03.	**Two-Level Factorial Designs** The 2^2 Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^k Design, The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design, Split-Plot Designs	**7-9**
04.	**Two-Level Fractional Factorial Designs** The One-Half Fraction of the 2k Design, The One-Quarter Fraction of the 2 k Design, The General 2k-p Fractional Factorial Design, Resolution III Designs, Resolution IV and V Designs, Fractional Factorial Split-Plot Designs	**7-9**
05.	**Response Surface Methods and Designs** Introduction to Response Surface Methodology , The Method of Steepest Ascent, Analysis of a Second-Order Response Surface, Experimental Designs for Fitting Response Surfaces	**7-9**
06.	**Taguchi Approach** Crossed Array Designs and Signal-to-Noise Ratios, Analysis Methods, Robust design examples	**3-5**
	Course Conclusion	**01**
	Total no. of hours	**45**

Course Outcomes: Learner will be able to

1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

References :

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3 rd edition,John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

Course Type	Course Code	Course Name	Credits
OEC	OEC7015	OPERATION RESEARCH	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

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO6: The Engineer & The world
5. PO10: Project Management & Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To introduce the concept of formulation of a real-world problem as a mathematical programming model.
2. To impart the knowledge of the mathematical tools that are needed to solve optimization problems.
3. To make learner able to use mathematical software to solve the proposed models.
4. To impart the mathematical understanding to analyse and solve integer programming from a wide range of applications.

Module	Detailed Contents	Hrs
00.	**Course Introduction** Operations Research (OR) course is an interdisciplinary field that applies advanced analytical, mathematical, and statistical methods to make better decisions in complex systems, optimizing processes and resource allocation. Students learn to identify problems, formulate mathematical models like linear programming, and use algorithms to find optimal solutions for real-world issues in areas such as engineering, management, finance, and logistics.	01
01.	**Introduction to Operations Research** **Content:** Introduction, Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming:** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method, Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis	15-17

	Transportation Problem: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem:** Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
02.	**Queuing models** **Contents:** Queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population.	**04-06**
03.	**Simulation** **Contents:** Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	**06-08**
04.	**Dynamic programming** **Contents:** Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	**06-08**
05.	**Game Theory** **Contents:** Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	**04-06**
06.	**Inventory Models** **Contents:** Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model	**04-06**
	Course Conclusion	**01**
Total		**45**

Course Outcomes: Learner will be able to

1. Apply simplex method, analyse the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change
3. Solve specialized linear programming problems like the transportation and assignment problems.
4. Solve network models like the shortest path, minimum spanning tree, and maximum flow problems
5. Analyse the applications of integer programming and a queuing model and compute important performance measures

Text Books :

1. Operations Research - An Introduction, Taha, H.A., Seventh Edition 2002, Prentice Hall.
2. Operations Research, S. D. Sharma, First Edition, 2012, KedarNath Ram Nath-Meerut Company
3. Operations Research, Kanti Swarup, P. K. Gupta and Man Mohan, Twentieth Edition, 2022 Sultan Chand & Sons

Reference Books :

1. Operation Research-Methods and problems, Saiesini M.,Yaspan A., First Edition, 1959, Prentice Hall
2. Operations Research: Principles and Practice, Ravindran, A, Phillips, D. T and Solberg, J. J., Second edition, 2009, John Willey and Sons.
3. Introduction to Operations Research, Hiller, F. S. and Liebermann, G. J., Fourth edition, 2002, Tata McGraw Hill

Other Resources :

1. NPTEL Course: Introduction to Operation Research, Prof. G.Srinivasa, IIT Madras
   Web Link- https:// nptel.ac.in/courses/110106062
2. NPTEL Course: Operations Research, Prof. Kusum Deep, IIT Roorkee
   Web Link- https://onlinecourses.nptel.ac.in/noc22_ma48/preview

Course Type	Course Code	Course Name	Credits
OEC	OCE7016	CYBER SECURITY AND LAWS	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. ESL103- Programming Laboratory-I (C)
2. CEPCC408- Computer Networks

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design and Development of Solution
4. PO 4: Conduct investigation of Complex Problem
5. PO 5: Engineering Tool Usage
6. PO 11: Life-long learning

Course Objectives:	
1.	To define and categorize various forms of cybercrime, including malware attacks, social engineering, financial fraud, and network intrusions, while understanding their technical and societal impacts.
2.	To analyse the legal frameworks governing cyber activities, with a focus on distinguishing between different types of cyber laws at national and international levels.
3.	To examine the key provisions and structure of the Indian IT Act, 2008, and to evaluate the implications of its latest amendments on digital governance, privacy, and cybercrime adjudication.
4.	To identify and compare global information security standards and compliance frameworks, such as ISO 27001, PCI-DSS, GDPR, HIPAA, and NIST, and their relevance to organizational security postures.
5.	To apply legal and compliance knowledge in practical scenarios, enabling students to assess organizational compliance requirements and recommend appropriate security controls within legal boundaries.

Module	Details	Hrs.
	Course Introduction This course provides a comprehensive introduction to the principles, practices, and legal frameworks of cyber security. Students will explore various types of cybercrimes, attack methodologies, and defensive strategies, with a strong emphasis on legal and regulatory compliance. The course covers Indian cyber laws and compliances, including the IT Act 2000 and its amendments, as well as global security standards. Through theoretical insights, learners will be equipped to identify, analyse, and respond to cyber threats within a legal and ethical context.	**01**
01.	**Introduction to Cybercrime** ***Learning Objective:*** *Learners will be able to define cybercrime and its origins, explain its relationship with information security, classify cybercrime types, analyse the Indian IT Act 2000's role in addressing cybercrime, and compare global cybercrime trends and legal responses.* **Contents:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes. ***Self-Learning Topics: Cybercrime Laws in Different Countries*** ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply fundamental cybersecurity principles to define and categorize different types of cybercrime, and analyse their origins and evolution within a global digital context. (P.I. 1.3.1)* *LO 1.2: Apply the theory and principles of computer science engineering to analyze the relationship between cybercrime and information security, and develop a structured classification of cyber threats. (P.I. 1.4.1)* *LO 1.3: Identify the key legal and technical developments in cybercrime regulation, including the role of the Indian IT Act 2000 and global frameworks, to justify the necessity of proactive legal and security measures in cyberspace. (P.I. 2.1.2)* *LO 1.4: Identify the appropriate legal and investigative stage applicable to a given cybercrime scenario, such as classification, evidence handling, or international jurisdiction. (P.I. 2.1.3)*	**5-6**
02.	**Cyber offenses & Cybercrime** ***Learning Objective:*** *Learners will be able to analyze cyberattack planning methods and mobile/wireless security threats, and develop organizational policies to mitigate risks in modern computing environments.* **Contents:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.	**7-8**

	Self-Learning Topics: Security Implications of 5G & IoT Mobility	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply engineering fundamentals to analyze and classify various attack vectors—including social engineering, botnets, and mobile-based threats—and identify key security vulnerabilities in modern computing environments. (P.I. 1.3.1)* *LO 2.2: Apply the principles of computer science engineering to evaluate security challenges posed by mobile devices, cloud computing, and wireless networks, and synthesize these findings into structured risk assessments. (P.I. 1.4.1)* *LO 2.3: Compare and contrast attack methodologies—such as phishing, malware distribution, and authentication bypass techniques—to select appropriate defensive strategies based on organizational context and threat landscape. (P.I. 2.2.4)* *LO 2.4: Arrive at validated security policies through systematic analysis of mobile and wireless threats, integrating multiple data sources to formulate comprehensive organizational security measures. (P.I. 2.4.4)* *LO 2.5: Implement and integrate security frameworks and mitigation techniques including registry entries, authentication safeguards, and mobile device management to translate threat analysis into actionable controls. (P.I. 3.4.2)* *LO 2.6: Explore security alternatives by evaluating attack trends and compliance requirements to develop detailed organizational security policies that addresses technical vulnerabilities. (P.I. 3.2.1)*	
03.	**Tools and Methods Used in Cyberspace**	**7-8**
	***Learning Objective**: Learners will be able to identify, explain, and compare various cyber-attack methods—including phishing, malware, network exploits, and identity theft and analyse their mechanisms, impacts, and mitigation strategies.*	
	Contents: Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	
	Self-Learning Topics: Steganography, Cyber Attack Defence Plan	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply foundational knowledge of cyber-attack methods, including phishing, malware, and network exploits, to analyse a given cyber incident and identify the primary attack vectors used. (P.I. 1.3.1)* *LO 3.2: Explore and compare various cyber-attack techniques and tools to evaluate their effectiveness, risks, and potential countermeasures in different attack scenarios. (P.I. 3.2.1)* *LO 3.3: Consult with cybersecurity experts and team members to choose the best security tools and methods to use in practice. (P.I. 3.3.2)* *LO 3.4: Define the scope and significance of a given cyberattack method (e.g. phishing or SQL injection), identify applicable modern security tools and techniques for its analysis, and explain the critical importance of staying updated on evolving cyber threats and defensive technologies in the field of cybersecurity. (P.I. 2.1.3, 4.1.1, 5.1.1, 11.2.2)* *LO 3.5: Analyze and compare multiple attack methods, design a structured testing procedure to evaluate their impact, configure existing security tools for threat simulation, and assess the feasibility of countermeasures based on sourced research. (P.I. 3.2.1, 4.2.1, 5.1.2, 11.3.2)*	

04	**The Concept of Cyberspace**	**7-8**
	***Learning Objective**: Learners will be able to understand the concept of cyberspace and analyze the legal, security, contractual, evidentiary, criminal, and intellectual property aspects of cyber law, with particular emphasis on the necessity and applicability of Indian cyber laws in addressing emerging digital challenges.*	
	Contents: The Concept of Cyberspace, E-Commerce, The Contract Aspects in Cyber Law, The Security Aspect of Cyber Law, The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law, The Criminal Aspect in Cyber Law, Global Trends in Cyber Law, Legal Framework for Electronic Data Interchange, Law Relating to Electronic Banking, The Need for an Indian Cyber Law.	
	Self-Learning Topics: Recent Amendments and Case Laws Related to Indian Cyber Law	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply fundamental engineering and legal knowledge to explain the concept of cyberspace and identify key legal domains such as e-commerce, cyber contracts, security, and electronic banking within cyber law. (P.I. 1.3.1)* *LO 4.2: Analyze contractual, intellectual property, and evidentiary aspects of cyber law to determine their relevance in resolving legal issues arising from digital transactions and electronic data exchange. (P.I. 2.1.2)* *LO 4.3: Analyze cybercrime scenarios by examining criminal and security aspects of cyber law to interpret applicable legal provisions and identify potential violations in cyberspace. (P.I. 2.1.3)* *LO 4.4: Apply knowledge of global cyber law trends and Indian cyber law frameworks to justify the need for a comprehensive national legal structure to govern cyberspace and protect digital stakeholders. (P.I. 1.4.1)*	
05	**Indian IT Act**	**5-6**
	***Learning Objective**: Learners will be able to understand and analyze the cybercrime adjudication framework under the Information Technology Act, 2000 and its amendments, including penalties, adjudication authorities, and appellate mechanisms, to interpret legal remedies and enforcement procedures in cybercrime cases.*	
	Contents: Cyber Crime and Criminal Justice, Penalties under the IT Act, 2000, Adjudication Mechanism, Appeals under the IT Act, Information Technology Act, 2000, IT Act, 2008 and its Amendments.	
	Self-Learning Topics: Recent Cyber Crime Judgments and Landmark Cases under the IT Act, 2000.	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply fundamental engineering and legal knowledge to explain cybercrime penalties and enforcement provisions under the Information Technology Act, 2000 and its amendments. (P.I. 1.3.1)* *LO 5.2: Analyze cybercrime cases to identify appropriate adjudication mechanisms and authorities involved in handling offences under the IT Act. (P.I. 2.1.2)* *LO 5.3: Analyze appeal procedures under the IT Act by examining procedural stages and legal remedies to arrive at substantiated conclusions for cybercrime disputes. (P.I. 2.4.4)* *LO 5.4: Apply knowledge of amendments to the IT Act, 2008 to evaluate their impact on cybercrime investigation, adjudication, and criminal justice administration in India. (P.I. 1.4.1)*	

06	**Information Security Standard compliances**	**4-5**
	***Learning Objective**: Learners will be able to understand and analyze major international information security laws and compliance standards to evaluate their objectives, scope, and applicability in securing organizational information systems*	
	Contents: SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	
	Self-Learning Topics: Comparative Study of Global Information Security Compliances.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply fundamental engineering and information security knowledge to explain the objectives, scope, and core requirements of major compliance frameworks such as SOX, GLBA, HIPAA, ISO, FISMA, NERC, and PCI. (P.I. 1.3.1)* *LO 6.2: Analyze organizational scenarios to identify applicable security laws and compliance standards based on system type, data sensitivity, and regulatory requirements. (P.I. 2.1.2)* *LO 6.3: Compare and contrast multiple information security compliance frameworks to determine suitable standards for addressing specific security, privacy, and governance challenges. (P.I. 2.2.4)* *LO 6.4: Apply knowledge of international security regulations to justify compliance decisions and recommend appropriate frameworks for protecting critical information assets. (P.I. 1.4.1)*	
	Course Conclusion This course equips learners with essential knowledge of cybercrime, cybersecurity practices, and cyber laws governing the digital ecosystem. Students gain an understanding of the Indian IT Act and its amendments, various aspects of cyber law, cybercrime investigation and adjudication processes, and major information security compliance standards. Overall, the course enables learners to analyze cyber threats, interpret legal and regulatory requirements, and apply security and compliance principles for secure and lawful use of information systems.	

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.4	Compare and contrast alternative solution/methods
2.4.4	Arrive at conclusions with respect to the objectives.
3.2.1	Able to explore design alternatives
3.3.2	Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4.2	Able to implement and integrate the modules.

4.1.1 Define a problem for purposes of investigation, its scope and importance

4.2.1 Able to choose appropriate procedure/algorithm, dataset and test cases.

5.1.1 Identify modern engineering tools, techniques and resources for engineering activities

5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems

11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

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

Course Outcomes: A learner will be able to –

1. Classify various types of cybercrimes, cyber threats, and attack techniques, and analyze their technical and societal impacts in digital environments. *(LO1.1, LO1.2)*
2. Analyze cyberattack scenarios and security challenges to identify vulnerabilities, attack vectors, and appropriate technical and organizational security measures. *(LO2.1, LO2.2, LO2.3, LO2.4, LO2.5, LO2.6, LO3.1, LO3.2, LO3.3 LO3.4, LO3.5)*
3. Interpret and apply provisions of the Indian Information Technology Act, 2000 and its amendments to address cybercrime investigation, adjudication, and legal issues. *(LO1.3, LO1.4, LO4.3, LO5.1, LO5.2, LO5.3, LO5.4)*
4. Analyze different aspects of cyber law, including cyberspace governance, e-commerce, digital contracts, intellectual property, electronic evidence, and criminal liability. *(LO4.1, LO4.2, LO4.4)*
5. Apply cybersecurity, legal, and compliance knowledge to real-world scenarios to recommend lawful, secure, and compliant practices in the design and use of information systems. *(LO6.1, LO6.2, LO6.3, LO6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OCE7016.1	3	-	-	-	-	-	-	-	-	-	-
OCE7016.2	3	3	3	3	3	-	-	-	-	-	3
OCE7016.3	3	3	-	-	-	-	-	-	-	-	-
OCE7016.4	3	3	-	-	-	-	-	-	-	-	-
OCE7016.5	3	3	-	-	-	-	-	-	-	-	-
Average	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**3**

Text Books:

1. Nina Godbole, Sunit Belapure, “Cyber Security”, Wiley India, New Delhi.
2. “The Indian Cyber Law” by Suresh T. Vishwanathan; Bharat Law House New Delhi.
3. “The Information technology Act, 2000”; Bare Act- Professional Book Publishers, New Delhi.

Reference Books:

1. "Cyber Law & Cyber Crimes" By Advocate Prashant Mali; Snow White Publications, Mumbai.
2. William Stallings, "Cryptography and Network Security", Pearson Publication.
3. Kennetch J. Knapp, Cyber Security & Global Information Assurance Information Science Publishing.

Other Resources:

1. The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
2. A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer professionals-33538

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

One 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
OEC	OEC7017	Digital Business Management	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: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solution
4. PO5: Modern tool Usage
5. PO7: Ethics

Course Objectives:

1. To familiarize students with fundamental concepts, models, and transformation drivers that define digital business ecosystems.
2. To convey strategic frameworks, digital roadmaps, organizational readiness, and performance metrics used in digital transformation.
3. To explain key digital marketing techniques, customer acquisition methods, automation tools, and attribution models.
4. To provide understanding of ecommerce and Omni channel operations, including platforms, logistics, payments, and customer service systems.
5. To develop competency in data-driven decision-making, analytics tools, dashboards, SQL basics, and AI applications in business.
6. To familiarize with platform business models, API integrations, agile/lean product development, and ethical, legal, and security considerations in digital environments.

Module	Details	Hrs.
	Course Introduction Digital Business Management focuses on how digital technologies transform traditional business systems, processes, and decision-making. This course introduces foundations of digital business, digital strategy, marketing, ecommerce, data analytics, platforms, and product delivery, emphasizing the differences between traditional and digital business models. With growing reliance on cloud platforms, analytics, AI, and Omni channel systems, engineering graduates must understand how technical solutions enable digital transformation and value creation. The	**01**

	course equips with managerial and analytical perspectives required to design, evaluate, and manage technology driven business solutions in modern digital enterprises.	
01.	**Foundations of Digital Business** **Contents:** Introduction to Digital Business: Definition and scope Key terminology: digitization, digitalization, transformation Traditional vs Digital Business Models Digital Transformation Drivers Digital Maturity & Culture Digital Business Models – Marketplaces, Subscription, Freemium, PaaS, Value Chains Network Effects & Customer Experience	**06-08**
02.	**Digital Strategy & Transformation** **Contents:** Strategy Frameworks for Digital Initiatives Organizational Change & Governance Digital Roadmap Development Digital Leadership skills: innovation, risk-taking, cross-functional alignment Metrics for Digital Success (Engagement, Retention, Lifetime Value, Customer Acquisition Cost) KPI Dash boarding & Review	**06-08**
03.	**Digital Marketing & Customer Acquisition** **Contents:** Digital Marketing Fundamentals Search Engine Optimization & Search Engine Marketing Basics Social Media & Influencer Marketing Content Marketing & Campaign Design Customer Journey Mapping Personalization & CRM Tools Attribution Models & Optimization Campaign optimization: A/B testing basics	**06-08**
04.	**Ecommerce & Omni channel Operations** **Contents:** Ecommerce Models (B2B, B2C, C2C, D2C) Payments, Fulfilment, Returns, Last-mile Logistics Omni channel Commerce Inventory Visibility & Order Management Digital Customer Service Tools Platform Selection & vendor Evaluation	**06-08**
05.	**Data, Analytics & AI for Business** **Contents:** Data-driven Decision Making Data Pipelines & SQL Basics Descriptive & Diagnostic Analytics Predictive Analytics Recommendation Engines	**07-09**

	KPI Dashboards (Tools) Communicating Data Insights	
06.	**Platforms, Ecosystems, Product Delivery & Ethics**	**06-08**
	Contents: Platform Business Models & Ecosystems Product Management Basics Agile & Lean Startup API Economy & Partnerships Ethical, Legal & Security Considerations	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: A learner will be able to -

1. Summarize the fundamental concepts, models, transformation drivers and customer experience elements of digital business.
2. Analyse the digital strategies, organizational reediness, transformation plans & business performance metrics to evaluate digital initiatives.
3. Apply digital marketing, customer acquisition methods, automation tools, and attribution techniques to develop data driven marketing insights.
4. Classify ecommerce and omnichannel models, evaluate digital platform, and analyse operational workflow to propose process improvements.
5. Use analytical tools, dashboards, SQL fundamental and AI concepts to interpret business data and communicate insights effectively.
6. Analyse platform ecosystem, select product development methodologies, interpret API based integrations and identify ethical/ legal concerns in digital system.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7017.1	3	3	-	-	-	-	-	-	-	-	-
OEC7017.2	3	3	3	-	-	-	-	-	-	-	-
OEC7017.3	-	3	3	-	3	-	-	-	-	-	-
OEC7017.4	-	3	-	-	3	-	-	-	-	-	-
OEC7017.5	-	3	-	-	3	-	3	-	-	-	-
OEC8028.6	-	3	-	-	-	-	-	-	-	-	-
Average	**3**	**3**	**3**	**-**	**3**	**-**	**3**	**-**	**-**	**-**	**-**

Text Books :

1. K. C. Laudon and J. P. Laudon, Management Information Systems: Managing the Digital Firm, latest ed. Harlow, U.K.: Pearson Education.
2. D. L. Rogers, The Digital Transformation Playbook: Rethink Your Business for the Digital Age, New York, NY, USA: Columbia Business School Publishing, 2016.
   K. Sandeep & J. J. Jose, Digital Business Management, Himalaya Publishing House.
3. A. Osterwalder and Y. Pigneur, Business Model Generation, Hoboken, NJ, USA: Wiley, 2010.
4. E. Brynjolfsson and A. McAfee, The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, New York, NY, USA: W. W. Norton & Company, 2014.
5. P. Kotler, H. Kartajaya, and I. Setiawan, Marketing 5.0: Technology for Humanity, Hoboken, NJ, USA: Wiley, 2021.

Reference Books :

1. T. Eisenmann, G. Parker, and M. Van Alstyne, Platform Revolution: How Networked Markets Are Transforming the Economy, New York, NY, USA: W. W. Norton & Company, 2016.
2. R. T. Rust, M.-H. Huang, and S. J. Lin, Service Analytics and Digital Transformation, Springer, Cham, Switzerland, 2019.
3. S. Sharda, D. Delen, and E. Turban, Business Intelligence, Analytics, and Data Science: A Managerial Perspective, 4th ed. Boston, MA, USA: Pearson, 2020.
4. M. Porter and J. Heppelmann, How Smart, Connected Products Are Transforming Companies, Boston, MA, USA: Harvard Business Review Press, 2015.
5. A. Chaffey and F. Ellis-Chadwick, Digital Marketing: Strategy, Implementation and Practice, 8th ed. Harlow, U.K.: Pearson Education, 2022.

Other Resources :

1. Digital Business – IIT Kharagpur (Prof. S. Ray) NPTEL Course – Highly aligned with Digital Strategy, Platforms, Digital Models.
2. Marketing Management – IIT Roorkee / IIT Kanpur (Digital marketing modules included) Covers customer journey, campaigns, analytics basics.
3. Introduction to Industry 4.0 and Industrial Internet of Things – IIT Kharagpur Useful for Module 1 (Digital Transformation Drivers).

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested break up of distribution:

a) Activities/Case studies: 10 Marks

c) Open book test/Class assignment: 05 Marks

d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (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
OEC	OEC7018	ENERGY AUDIT AND MANAGEMENT	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: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO6: The Engineer and The World
5. PO11: Life-long learning

Course Objectives:

1. To understand the importance of energy security in achieving sustainable development and to learn the fundamental principles of energy conservation.
2. To introduce performance evaluation criteria for electrical and thermal installations to support effective energy management.
3. To utilize data obtained from performance evaluations to identify and prioritize energy-saving measures.

Module	Details	Hrs.
	Course Introduction Energy is a critical resource for economic growth, industrial productivity, and sustainable development. With rising energy costs, increasing demand, and growing environmental concerns, efficient use of energy has become essential across all sectors. Energy Audit and Management focuses on the systematic evaluation, monitoring, and optimization of energy consumption to improve efficiency, reduce operating costs, and minimize environmental impact. This course introduces the principles and practices of energy management, including energy auditing techniques, energy efficiency measures, and the use of modern tools for energy analysis. Students will learn how to assess energy usage in industrial, commercial, and residential facilities, identify energy-saving opportunities.	**01**
01.	**Energy Scenario** **Contents:** Primary and Secondary Commercial and non- commercial energy Renewable and Non Renewable Energy, Present Global and Indian Energy Scenario, Energy Security, Energy Conservation and its	**5-7**

	Importance, Energy efficiency benefits. Energy Conservation Act-2001 and its Features. Schemes of BEE under EC Act-2001.	
02.	**Energy Audit Principles:**	**8-10**
	Contents: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit Instruments. Elements of monitoring& targeting, benefits of M&T; Data and information-analysis. Investment need, Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	
03.	**Energy Management and Energy Conservation in Electrical System:**	**9-11**
	Contents: Basics of Electrical Energy, power factor, Motor loading calculations, relationship between power, voltage and current. Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, harmonics. Energy efficiency measures in lighting system, lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers, General energy saving opportunities in lighting system, Energy conservation opportunities in induction motors, Energy efficient motors, Motor retrofitting, soft starters, variable speed drives. Case studies based on P.F improvement, EEM, Lighting system	
04.	**Energy Management and Energy Conservation in Thermal Systems:**	**9-11**
	Contents: Thermal Energy basics, specific heat, sensible heat, latent heat, energy content in fuel, Heat transfer basics Energy unit and conversions. Review of different thermal loads: Boiler System, performance evaluation of boilers, energy conservation opportunities in boiler Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, efficient steam utilization and energy saving opportunities. Characteristics of efficient furnace, performance evaluation of a typical fuel fired furnace, general fuel economy measures in furnaces Need and benefits of insulation, simplified formula for heat loss calculation, Purpose of heat exchanger, LMTD HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and energy savings opportunities. Case Studies based on boiler, furnace and insulation	

05.	**Energy Performance Assessment:**	**3-5**
	Contents: On site Performance evaluation techniques, Energy performance assessment and its improvement: lighting system, Installed Load Efficacy Ratio (ILER) method, Motor, Heat Exchanger-LMTD, Boiler and Furnace.	
06.	**Energy conservation in Buildings:**	**3-5**
	Contents: Energy Conservation Building Codes (ECBC), ECBC guidelines on HVAC system, lighting system, Electric power, energy efficiency measures in buildings, Energy performance assessment of buildings, Green Building.	
	Course Conclusion This course provides a comprehensive understanding of energy auditing principles and energy management practices. Learners gain knowledge of energy consumption patterns, audit methodologies, and energy performance evaluation techniques for electrical and thermal utilities. The course emphasizes the identification of energy conservation opportunities, and implementation of energy-efficient technologies.	**01**
	Total	**45**

Course Outcomes :

1. Understand global and Indian energy scenario, Energy Conservation Act-2001, ECBC guidelines, to promote energy-efficient and sustainable buildings.
2. Conduct energy audits, analyse energy performance, identify energy-saving opportunities, and evaluate the financial feasibility of energy conservation measures.
3. Apply energy efficiency measures in lighting and motor systems, improve power factor, and identify practical energy conservation opportunities through case studies.
4. Apply energy-saving opportunities in boilers, furnaces, steam distribution, insulation, and HVAC systems, and practical solutions through case studies to improve energy efficiency.
5. Analyse the energy performance of lighting, motors, boilers, furnaces, and heat exchangers on-site and recommend effective energy-saving improvements.

CO-PO mapping table with correlation level:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
OEC7018.1	3	-	-	-	-	3	-	-	-	-	-
OEC7018.2	3	3	-	3	-	3	-	-	-	-	3
OEC7018.3	3	-	-	-	-	-	-	-	-	-	-
OEC7018.4	3	-	-	-	-	-	-	-	-	-	-
OEC7018.5	-	3	-	-	-	3	-	-	-	-	3
Average	**3**	**3**	**-**	**3**	**-**	**3**	**-**	**-**	**-**	**-**	**3**

Text Books:

1. General Aspects of Energy Management and Energy Audit, BEE, Fourth Edition,2015
2. Energy Efficiency in Thermal Utilities, BEE, Fourth Edition,2015
3. Energy Efficiency in Electrical Utilities, BEE, Fourth Edition,2015
4. Energy Performance Assessment for Equipment and Utility Systems, BEE, Fourth Edition,2015

Reference Books:

1. Handbook of Electrical Installation Practice, by Geoffrey Stokes, Blackwell Science, 4th Edition
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press

Web References:

1. http://www.bee-india.nic.in/
2. https://nceexam.in/

IN-SEMESTER ASSESSMENT (50 MARKS)

Suggested breakup of distribution

1. **Continuous Assessment (20 Marks)**
   - 01 MCQ test: 05 Marks
   - 01 Class test: 10 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
OEC	OEC7019	DEVELOPMENT 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: NIL

Program Outcomes addressed:

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

Course Objectives :

1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a ‘good’ human being, a ‘good’ professional, a ‘good’ society and a ‘good life’ in the context of work life and the personal life of modern Indian professionals
4. To understand the Nature and Type of Human Values relevant to Planning Institutions

Module	Details	Hrs
	Course Introduction	**01**
01.	**Introduction to Rural Development**	**8-10**
	Contents: Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	
02.	**Post-Independence rural Development**	**4-6**
	Contents: Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people’s participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development	

03.	**Rural Development Initiatives in Five Year Plans** **Contents:** Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	**6-8**
04.	**Post 73rd Amendment Scenario** **Contents:** 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments	**4-6**
05.	**Values and Science and Technology** **Contents:** Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom	**10-12**
06.	**Ethics** **Contents:** Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**3-5**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Apply knowledge for Rural Development.
2. Apply knowledge for Management Issues.
3. Apply knowledge for Initiatives and Strategies
4. Develop acumen for higher education and research
5. Master the art of working in group of different nature.
6. Develop confidence to take up rural project activities independently

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7019.1	-	-	-	-	-	3	-	-	-	-	-
OEC7019.2	-	-	-	-	-	3	-	-	-	-	-
OEC7019.3	-	-	-	-	-	3	-	-	-	-	-
OEC7019.4	-	-	-	-	-	3	-	-	-	-	3
OEC7019.5	-	-	-	-	-	3	3	-	-	-	-
OEC7019.6	-	-	-	-	-	3	3	-	-	-	3
Average	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**3**

References :

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory andPractice, Vol. 4, No.4, pp.395 – 407

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 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	MELBC710	IOT & SMART SYSTEMS LABORATORY	01

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

Pre-requisite:

1. MESBL301 - Python Programming Laboratory
2. MELBC302 - Industrial Electronics Laboratory

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. PO8: Individual and Collaborative team work
8. PO9: Communication
9. PO11: Life-long learning

Course Objectives:

1. To demonstrate interfacing of sensors and actuators using microcontrollers and single-board computers
2. To apply appropriate wireless communication protocols such as Wi-Fi, Bluetooth, Zigbee, and RFID to demonstrate effective IoT data communication.
3. To introduce cloud-based IoT data acquisition and visualization.
4. To encourage design, teamwork, and presentation through IoT-application based course projects.

Module	Details	Hrs.
	Course Introduction The IOT & Smart Systems Laboratory provides practical exposure to sensor interfacing, data communication, and IoT application development. Learner's design connected and intelligent systems addressing engineering and societal needs through data acquisition, analysis, and control.	**1**
01	**Interfacing of Sensors with Microcontroller** ***Learning Objective:*** *Learner will be able to demonstrate the skill to effectively interface sensor with micro controller*	**4**
	Contents: Study of sensors (like temperature, flow, humidity). Interfacing sensors with Arduino board and displaying data on the Serial Monitor.	

	Task 1: To interface sensors with an Arduino, write and upload code to read real-time data, and display the measured physical quantities on the Serial Monitor.	
	Self-Learning Topics: *Characteristics and Types of different sensors*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: learner will be able to Interface sensors with a microcontroller, develop code to display real-time physical quantities on the Serial Monitor, and analyze their technical and environmental implications for sustainable solutions (P.I.: 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.5,3.2.1, 4.2.1, 4.3.1, 5.1.1, 5.2.2, 6.1.1,6.3.2, 9.1.1,9.3.1).*	
02.	**Interfacing Sensors with Raspberry Pi** ***Learning Objective:*** *Learner will be able to demonstrate the skill to effectively interface sensors with Raspberry Pi using Python programming.*	**4**
	Contents: Study of sensors such as PIR motion sensor, ultrasonic sensor, temperature sensor, or similar input devices. Interfacing sensors with Raspberry Pi GPIO pins and displaying real-time data using Python scripts. Task 2 To interface sensors with the Raspberry Pi using correct GPIO connections, develop and execute Python code to read real-time data, and display the corresponding physical quantities through terminal or script output.	
	Self-Learning Topics: *Characteristics and types of different sensors.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Learner will be able to interface sensors with Raspberry Pi GPIO pins, develop Python scripts to acquire real-time data, and interpret the corresponding physical quantities through terminal-based output (P.I.: 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.5,3.2.1, 4.2.1, 4.3.1, 5.1.1, 5.2.2, 6.1.1,6.3.2, 9.1.1,9.3.1).*	
03.	**Interfacing of Actuators with Arduino** ***Learning Objective:*** *Learner will be able to demonstrate the skill to effectively interface different types of actuators with the microcontroller for automation and control applications.*	**4**
	Contents: Study and interfacing of pneumatic actuators, solenoid valves, and servo motors using microcontroller digital and PWM pins. **Task 3:** To interface actuators with a microcontroller using appropriate driver circuits and wiring, and to develop and upload code for controlling actuator motion or switching using digital I/O and PWM signals	

	Self-Learning Topics: *Types and control characteristics of actuators*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: A learner will be able to develop appropriate procedures, wiring connections, and code for effective interfacing and control of actuating devices (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.5,3.2.1, 5.1.1, 5.2.2, 9.1.1,9.3.1).*	
04.	**Interfacing of Actuators with Raspberry Pi** ***Learning Objectives:*** *A learner will be able to demonstrate the skill to effectively interface different types of actuators with a Raspberry Pi using Python for automation tasks*.	**4**
	Contents: Study and interfacing of pneumatic actuators, solenoid valves, and servo motors using Raspberry Pi GPIO pins, software-based PWM, and appropriate driver circuits or relay modules. **Task 4** To interface actuators with a Raspberry Pi using proper drivers, relays, and safe wiring, and to develop Python code using GPIO digital outputs and PWM to control and verify their operation.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 4.1: A learner will be able to develop appropriate procedures, tools, techniques, and Python code to interface and reliably control actuators using Raspberry Pi GPIO and PWM (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.5,3.2.1, 5.1.1, 5.2.2, 9.1.1, 9.3.1)*	
05.	**Communication Using Wireless Medium** ***Learning Objective/s:*** *Learner will be able to demonstrate the skill of wireless data transmission techniques in IoT systems*	**4**
	Contents: Study and implementation of wireless communication methods such as WiFi, Bluetooth, Zigbee, and RFID using microcontroller. **Task 5** To interface a wireless module with the microcontroller and develop code to establish, test, and verify wireless data communication.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: A learner will be able to configure and interface wireless communication modules with a microcontroller and develop code for reliable wireless data transmission between IoT devices (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.6,3.2.1, 5.1.1, 5.2.2, 9.1.1,9.3.1).*	

06.	**Cloud Platform Setup and Sensor Data Logging** ***Learning Objective/s:*** *Learner will be able to demonstrate the skill to Implement a cloud-based platform for real-time data visualization and analysis*	**4**
	Contents: Study and setup of cloud platforms for uploading, storing, and visualizing live sensor data from microcontroller. **Task 6** To configure the cloud platform and write microcontroller code to upload sensor data for real-time logging, visualization, and verification.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 6.1: A learner will be able to connect IoT hardware to a cloud platform, transmit real-time sensor data, and interpret the data using cloud visualization tools (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 3.1.6,3.2.1, 5.1.1, 5.2.2, 9.1.1,9.3.1).*	
07.	**Real-Time IoT Implementation Project** ***Learning Objective****:* *Develop and demonstrate a complete IoT-based system prototype.* **Task 7** To create an IoT based project from identifying the problem to building, testing, and demonstrating the prototype.	**5**
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 7.1 Design and implement a functional IoT-based application while demonstrating effective teamwork, communication, and ethical responsibility (P.I. 3.2.1,3.2.2, 4.1.4, 5.1.1, 5.2.2, 6.3.2, 8.2.1, 8.3.1, 9.1.1,9.2.1, 9.3.1, 11.2.1, 11.3.1).*	
	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.
2.1.1	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
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

3.2.2 Build models/prototypes to develop a diverse set of design solutions

4.1.4 Establish a relationship between measured data and underlying physical principles.

4.2.1 Design and develop an experimental approach, specify appropriate equipment and procedures

4.3.1 Use appropriate procedures, tools and techniques to conduct experiments and collect data

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

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

6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability

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

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

9.2.1 Listen to and comprehend information, instructions, and viewpoints of others\

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

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

Course Outcomes: Learner will be able to

1. Interface various sensors and actuators with microcontrollers and single-board computers *(LO1.1, LO1.2,LO2.1,LO2.2, LO3.1,LO3.2, LO4.1.LO4.2).*

2. Implement wireless data communication using different IoT protocols *(LO5.1, LO5.2).*

3. Configure and manage cloud platforms for real-time data logging and visualization *(LO6.1,LO6.2).*

4. Apply analytical and problem-solving skills to develop smart IoT-based solutions while demonstrating effective teamwork, communication, and ethical responsibility during project execution. *(LO7.1, LO7.2)*

CO–PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	P05	PO6	PO8	PO9	PO11
MELBC710.1	3	3	3	3	3	3	--	3	--
MELBC710.2	3	3	3	--	3	--	--	3	--
MELBC710.3	3	3	3	--	3	--	--	3	--
MELBC710.4	--	--	3	3	3	2	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Text Books

1. Vijay Madisetti & Arshdeep Bahga, Internet of Things (A Hands-on Approach), Universities Press.
2. E.O. Doebelin, Measurement Systems: Applications and Design, McGraw-Hill.
3. Adrian McEwen (Author), Hakim Cassimally". Designing the Internet of Things", Wiley publication, ISBN: 978-1-118-43062-20, November 2013.

Reference Books

1. Zach Shelby, Carsten Bormann,"6LoWPAN: The Wireless Embedded Internet" Wiley, ISBN: 9781119965343-August 2011.
2. Daniel Minoli John Wiley & Sons," Building the internet of things with ipv6 and mipv6, The Evolving World of M2M Communications", Wiley, ISBN: 978-1-118-64705-9-June 2013.

Other Resources:

1. **Internet of Things** by Prof. Sudip Misra, IIT Kharagpur
   Link- https://onlinecourses.nptel.ac.in/noc22_cs53/preview
2. **Internet of Things** by Prof. Prabhakar T V, IIT Kharagpur, IISc Bangalore
   Link- https://onlinecourses.nptel.ac.in/noc21_ee85/preview

IN SEMESTER ASSESMENT (25 Marks)

Continuous Assessment (25 Marks)

Lab Experiments performance	:	15 Marks
Course Project Evaluation	:	05 marks
Attendance	:	05 marks

END SEMESTER EXAMINATION (Practical and Oral Exam) (25 Marks)

Performance of experiments	:	15 marks
Oral	:	10 Marks

Practical & Oral Exam: Practical and oral exam of 25 marks will be held based on the above syllabus. Two examiners, one Internal and one External will do the evaluation

Course Type	Course Code	Course Name	Credits
LBC	MELBC711	MAINTENANCE ENGINEERING LABORATORY	01

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

Pre-requisite:

1. MEPCC406 - Theory of Machines
2. MEPCC509 - Mechanical Vibrations

Program Outcomes addressed:

1. PO2: Problem analysis
2. PO3: Design/development of solutions
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO6:The Engineer and the world
6. PO8: Individual and Collaborative Team work
7. PO9: Communication

Course Objectives:

1. To develop an understanding of various maintenance strategies and their practical implementation.
2. To familiarize students with industrial maintenance tools, techniques, and procedures.
3. To impart hands-on experience in condition monitoring and fault diagnosis of mechanical systems.
4. To enable learners to analyse machine health using vibration data.

Module	Detailed Contents	Hrs
	Course Introduction Maintenance Engineering focuses on ensuring the reliability and efficiency of industrial equipment through systematic inspection, servicing, and monitoring. Modern practices emphasize predictive and proactive maintenance to minimize unplanned failures and optimize performance. Predictive maintenance uses condition-monitoring tools such as vibration analysis, thermography, and oil testing to detect faults before breakdown occurs. Proactive maintenance goes further by identifying and eliminating root causes of failures through continuous monitoring using ML, IoT and AI. Together, these approaches enhance equipment life, reduce downtime, and promote cost-effective, reliable operation of mechanical systems.	**01**
01.	***Learning Objective/s:*** *1. To understand the purpose and classification of tools and instruments used in maintenance work.* *2. To learn the correct handling, safety precautions, and storage of maintenance equipment.*	**07**

	To get acquainted to Essentials of Maintenance Engineering covering the following topics: *Introduction to Maintenance Engineering* *Types of Maintenance* *Selection of tools and techniques*	
	Task: Categorize maintenance strategies and Demonstrate maintenance actions such as cleaning, oiling by disassembling and assembling the components. **Expectations:** i. Compare Breakdown, preventive, predictive maintenance and proactive maintenance strategies. ii. Identifications of different Tools used for maintenance (Spanner, Plier, Screw Driver, Allen Keys, Puller etc.) iii. Assembling and Disassembling the machine component in proper sequence.	
	Self-Learning Topics: *Fundamentals of maintenance.*	
	Learning Outcome : *A learner will be able to* *LO 1.1: Identify various maintenance strategies, tools used in assembling and disassembling the machine components with proper sequence. (PI 2.1.2, 2.2.3, 2.4.2, 6.3.1, 6.3.4)*	
02.	***Learning Objective/s:*** *1. To understand the fundamentals of vibration measurement and its role in condition monitoring.* *2. To learn the use of vibration for identifying equipment faults.*	**08**
	Experimental investigation through Vibration analysis to detect rotating machinery faults such as Unbalance, Misalignment and looseness. *Analyse the defects like unbalance, misalignment and looseness on the vibration Test Rig by performing vibration analysis using FFT analyser*	
	2.1 Experimental investigation through Vibration analysis to detect rotating machinery Unbalance. **Tasks:** Identify the Unbalance in a rotating machine using vibration based condition monitoring. **Expectations:**	
	i. Measure baseline vibration data of the rotating machine under healthy conditions. ii. Introduce controlled unbalance by adding a known mass to the rotor. iii. Record vibration signals for both healthy and unbalanced conditions at different operating speeds. iv. Perform FFT analysis to observe increase in vibration amplitude at 1× running speed.	

v. Compare spectra to confirm unbalance characteristics and document the findings to conclude the presence and severity of unbalance.

Self-Learning Topics:
Working principle of accelerometer and its mounting techniques

Learning Outcome:
A learner will be able to

LO 2.1: Measure and interpret vibration data using suitable DAQ system to identify unique vibration characteristics of imbalance. (PI: 2.4.2, 2.4.4, 3.4.2, 4.3.3, 5.1.1,5.2.2, 9.1.1)

2.2 Experimental investigation through Vibration analysis to detect misalignment in rotating machinery.

Tasks:

Determine parallel and angular misalignment characteristics in rotating machine using vibration analysis.

Expectations:

i. Record baseline vibration data under properly aligned conditions.
ii. Introduce parallel and angular misalignment by shifting the bearings then capture corresponding vibration signals.
iii. Perform FFT analysis to observe changes at 1× and 2× running speed.
iv. Compare vibration patterns to distinguish between parallel and angular misalignment.
v. Document results and conclude misalignment characteristics.

Self-Learning Topics:
Working principle of accelerometer and its mounting techniques

Learning Outcomes:
A learner will be able to

LO 2.2: Analyze vibration signatures to identify and distinguish between parallel and angular misalignment in rotating machinery. *(PI: 2.4.2, 2.4.4, 3.4.2, 4.3.3, 5.1.1,5.2.2, 9.1.1)*

2.3 Experimental investigation through Vibration analysis to detect mechanical looseness in rotating machinery.

Tasks:

Mechanical Looseness detection in rotor bearing system using Vibration analysis

Expectations:

i. Record baseline vibration data of the rotor–bearing system under proper fastening conditions.
ii. Introduce controlled mechanical looseness by slightly loosening bearing housings or mounting bolts.
iii. Measure vibration signals for both healthy and looseness conditions.
iv. Perform FFT and time-waveform analysis to observe harmonics, sub-harmonics, and impacts typical of looseness.

	v. Compare baseline and faulty spectra to confirm looseness characteristics Also document observations and conclude the type and severity of mechanical looseness.	
	Self-Learning Topics: *Working principle of accelerometer and its mounting techniques*	
	Learning Outcomes: *A learner will be able to* *LO 2.3: Analyze vibration data to identify characteristic signatures of mechanical looseness in a rotor–bearing system. (PI: 2.4.2, 2.4.4, 3.4.2, 4.3.3, 5.1.1,5.2.2, 9.1.1)*	
03.	***Learning Objective/s:*** 1. *To become conversant in identifying characteristic vibration patterns associated with bearing, pump, and gearbox defects.* 2. *To learn machine learning techniques for processing vibration data, extracting key features, and classifying different types of machinery faults.*	**06**
	Experimental investigation through Vibration analysis and machine learning to detect Bearing Defects, Pump Faults and Gearbox Defects *Analyse the defects like gear tooth, broken vane and bearing faults on the vibration Test Rig by performing vibration analysis using FFT analyser.* *Develop a machine learning algorithm to detect the machine faults.*	
	3.1 Experimental investigation through Vibration analysis and machine learning to detect Bearing Defects **Tasks:** Determine Rolling Element Bearing Defects using vibration based fault diagnosis and machine learning.	
	Expectations: i. Set up the vibration measurement system and ensure proper sensor placement on the bearing housing and record baseline vibration data for a healthy bearing. ii. Acquire vibration signals for bearings with known defects (inner race, outer race, ball/roller, cage) and calculate the fault frequencies at given operating speed. iii. Generate FFT spectra and extract key fault frequencies (BPFO, BPFI, BSF, FTF) and Compare baseline and faulty spectra to identify defect-specific vibration patterns. iv. Diagnose the type of bearing defect based on characteristic frequency peaks. v. Extract the features of vibration data for healthy and faulty condition and select most influencing features. vi. Choose and Train the machine learning model using experimental data and test it. vii. Determine the accuracy of the algorithm.	

Self-Learning Topics:
Selection of machine learning algorithm, WEKA software

Learning Outcomes :
A learner will be able to

LO 3.1: Interpret vibration signatures and frequency spectra to detect and distinguish between various bearing defects. (PI:2.4.2, 2.4.4, 3.4.2)

LO3.2: Extract statistical features and develop a basic machine learning model using the selected features to classify bearing faults. (PI: 2.4.4,3.3.1,4.3.2,5.1.1,5.2.2, 5.3.2)

3.2 Experimental investigation through Vibration analysis and machine learning to diagnose centrifugal pump vane defects

Tasks:

Verify the broken vane condition in a centrifugal pump using vibration analysis and machine learning

Expectations:

i. Measure baseline vibration data of a healthy centrifugal pump.
ii. Record vibration signals for the pump operating with a broken vane condition and calculate the Vane Pass Frequency (VPF) analytically.
iii. Perform FFT analysis to identify VPF caused by the broken vane experimentally.
iv. Extract relevant time- and frequency-domain features from the vibration data.
v. Train and test a machine learning model to classify healthy vs. broken-vane conditions and check the accuracy.
vi. Compare predicted results with actual conditions and document findings.

Self-Learning Topics:
Selection of machine learning algorithm, WEKA software

Learning Outcomes:
A learner will be able to

LO 3.3: Interpret vibration signatures to detect and verify broken vane conditions in a centrifugal pump. (PI:2.4.2, 2.4.4, 3.4.2)

LO3.4: Apply machine learning techniques to classify pump health by analyzing vibration features. (PI: 2.4.4,3.3.1,4.3.2,5.1.1,5.2.2, 5.3.2)

3.3 Experimental investigation through Vibration analysis and machine learning to analyse gear tooth defects.

Tasks:

Demonstrate the effect of Broken tooth of a gear on vibration spectrum using machine learning model.

Expectations:

i. Record baseline vibration data of a healthy gearbox.
ii. Record vibration data with a broken-tooth condition and calculate Gear Mesh Frequency (GMF) analytically.
iii. Generate FFT spectra to observe changes at gear-mesh frequency and sidebands.

	iv. Extract key vibration features from both conditions. v. Train a machine learning model to classify healthy vs. broken-tooth conditions. vi. Evaluate model accuracy and document the results.	
	Self-Learning Topics: *Selection of machine learning algorithm, WEKA software*	
	Learning Outcomes: *A learner will be able to* *LO 3.5: Analyze vibration spectra to identify characteristic signatures of a broken gear tooth in a gearbox. (PI:2.4.2, 2.4.4, 3.4.2)* *LO3.6: Classify gearbox defects using statistical features by applying machine learning techniques. (PI: 2.4.4,3.3.1,4.3.2,5.1.1,5.2.2, 5.3.2)*	
04.	***Learning Objective/s:*** *1. To comprehend various maintenance philosophies and their industrial applications.* *2. To become conversant suitable maintenance strategies for specific machines and operational conditions.*	**08**
	Case Study / Mini Project on Condition-Based Maintenance covering following points *Type of maintenance* *Analysis Types: Vibration Analysis, Acoustic analysis, oil analysis or Thermography* *Pre and post maintenance scenario.*	
	Task: Select a predictive/ proactive maintenance case study and discuss the findings/ maintenance actions taken with presentation and report. (To be conduct in a group of 4 students) **Expectations:** i. Choose a real-life industrial case and collect relevant information such as machine type, failure mode, maintenance action, cost, and outcome. ii. Summarize the background and problem observed and identify the maintenance strategy was implemented. iii. Record data such as downtime, cost, frequency of failure, and results after maintenance and identify key performance indicators. iv. Evaluate which strategy and discuss how proper maintenance planning improves equipment life and plant reliability. v. Identify lessons learned from each case and their industrial significance. vi. Suggest possible improvements or integration of strategies (e.g., combining preventive and predictive maintenance). vii. Compile all findings into a structured report by including charts, graphs, and photos from case studies and present the analysis and conclusions through power point presentation.	
	Self-Learning Topics: *Preventive maintenance scheduling*	

	Learning Outcomes : *A learner will be able to* *LO 4.1: Analyze real-world case study to identify predictive trends and effectively present, document condition monitoring results with appropriate maintenance recommendations. (PI:2.4.3, 2.4.4, 4.3.2, 8.2.1, 8.3.1, 9.2.2, 9.3.1)*	
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.
2.4.3	Identify sources of error in the solution process, and limitations of the solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
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 the design
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data and drawing of conclusions.
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling, and analysis; techniques and resources for engineering activities.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity
6.3.4	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
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.
9.1.1	Read, understand and interpret technical and non-technical information
9.2.2	Deliver effective oral presentations to technical and non-technical audiences
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations

Course Outcomes: Learner will be able to

1. Demonstrate various tools, and instruments used in assembling and disassembling a machine component in proper sequence. *(LO 1.1)*
2. Analyze vibration data to identify and classify mechanical faults in rotating machinery. *(LO 2.1, LO 2.2, LO 2.3, LO3.1,LO 3.3, LO 3.5)*
3. Apply machine learning techniques to detect mechanical faults in rotating machinery.*(LO 3.2, LO 3.4, LO 3.6)*
4. Analyze maintenance and condition monitoring data to support predictive maintenance decisions and effectively communicate findings through a technical report. *(LO 4.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MELBC711.1	--	3	--	--	--	3	--	--	--	--	--
MELBC711.2	--	3	2	2	3	--	--		2	--	--
MELBC711.3	--	3	3	3	3	--	--	--	--	--	--
MELBC711.4	--	3	--	--	--	--	--	3	3	--	--
Average	--	**3**	**2**	**3**	**3**	--	--	**3**	**3**	--	--

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

Text Books :

1. A.R. Mohanty, "*Machine Condition Monitoring: Principles and Practices*", CRC Press
2. R.A. Collacott, "*Mechanical Fault Diagnosis and Condition Monitoring*", Chapman and Hall
3. Robert Bond Randall, "*Vibration-based Condition Monitoring: Industrial, Automotive and Aerospace Applications*", 2nd Edition, Wiley.

Reference Books :

1. J. N. Reddy, *An Introduction to the Finite Element Method*, 4th ed. New York, NY: McGraw-Hill, 2019.
2. C. S. Krishnamoorthy, *Finite Element Analysis: Theory and Programming*. New Delhi, India: Tata McGraw-Hill, 1994.
3. B. S. Gupta, *Introduction to Finite Elements in Engineering.* New Delhi, India: Oxford and IBH Publishing, 1991.
4. A. W. Date, *Introduction to Computational Fluid Dynamics.* Cambridge, UK: Cambridge University Press, 2005.
5. K. Muralidhar and T. Sundararajan, *Computational Fluid Flow and Heat Transfer*, 2nd ed. Alpha Science International, 2014.
6. P. Roache, *Verification and Validation in Computational Science and Engineering*. Albuquerque, NM: Hermosa Publishers, 1998.

Other Resources :

1. Machinery Fault Diagnosis and Signal Processing, IIT Kharagpur

   Link - https://nptel.ac.in/courses/112105232
2. https://www.mobiusinstitute.com/

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment (25 Marks)

Suggested breakup of distribution

Performance based on completion of task (Marks will be awarded to students based on task performance with proper understanding)	:	10 Marks
Oral based on tasks	:	05 Marks
Case Study Presentation (max 4 students)	:	05 Marks
Regularity and Active Participation	:	05 Marks

END SEMESTER EXAMINATION (25 MARKS)

- Students will be assessed based on three parameters:
  Condition Monitoring through Vibration Analysis concepts / understanding
  Practical performance
  Oral
- Students will be randomly allocated a task from the list of tasks performed during the semester (or any other similar task) and will be asked to write brief procedure related to the execution of the task including the diagram and/or calculation if any. The procedure and/or calculation is checked by the examiners (Internal and External) and evaluated out of 5 Marks.
- Then the student will be allowed to complete the task.
- The students will be allocated 1 hour to complete the execution. The students are required to complete the given task and write conclusion for the result and compare it with conclusions drawn from the literature. The completed task will be checked by both the examiners for its correctness. The weightage is 10 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

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

Course Type	Course Code	Course Name	Credits
MJP	MJP701	Major Project-A	02

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 & The World
7. PO7 : Ethics
8. PO8 : Individual and Collaborative Teamwork
9. PO9 : Communication
10. PO10: Project Management & Finance
11. PO11: Life-Long learning

Course Objectives

1. To motivate students to review the knowledge and skills they acquired during their program.
2. To ensure students can analyze a specific problem or issue, and they can demonstrate proficiency in project design, research methods application, data collection and analysis, and results presentation.
3. To foster self-learning and research skills.

Course Outcomes

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

1. Identify and define a problem of societal or research relevance through a comprehensive literature review and a detailed problem analysis.
2. Apply appropriate engineering principles, analytical methods, and modern tools to design feasible and effective solutions for the identified problem.
3. Conduct investigations using suitable research methodologies, data collection, and analysis techniques to validate the proposed solution.
4. Evaluate the proposed solution considering societal, environmental, and ethical aspects to ensure sustainable engineering practices.
5. Demonstrate effective teamwork, project management, and communication skills in preparing and presenting project outcomes.
6. Engage in self-directed learning and continuous improvement to enhance technical competence and professional growth.

A. Guidelines for the Major Project-A

Guidelines

1. Project Topic Selection and Allocation

- **Towards the end of Semester VI, students will be introduced to potential project domains and problem areas.**
- **Project topics must be finalized in consultation with the guide, ensuring technical feasibility and alignment with the guide's domain expertise.**
- **Students should refer to recent research papers (preferably from IEEE, Elsevier, ACM, or similar sources) not older than three years.**
- **Students are encouraged to propose original ideas, including problem statements inspired by Digital India initiatives, Smart India Hackathon (SIH), and other innovation platforms.**

Criteria for Topic Finalization:

- **Novelty: The work should introduce new contributions or address clear gaps in existing systems.**
- **Technological Relevance: Use of current and emerging tools, platforms, methods, and technologies.**
- **Originality: Avoid repetition of projects undertaken in the past three years.**
- **Product Orientation (Preferred): Solutions that can evolve into a deployable product or prototype.**

Project Team & Execution:

- **Each group must consist of 3–4 students (within the same or across departments).**
- **Projects may be executed internally or in collaboration with industry, research organizations, or external agencies.**
- **Guides will be allotted to monitor progress, review weekly work, and maintain attendance and log records.**
- **Topic proposals will be reviewed domain-wise, and final approval will be given by the HoD and the project coordination committee.**

2. Project Progress Monitoring

- **Each department shall constitute a Project Progress Monitoring Committee.**
- **Minimum two formal progress presentations must be conducted during the semester.**
- **Internal guides may coordinate with industry/external partners for off-campus project supervision if required.**

3. Project Report Format

The final report should follow the institute guidelines and include:

1. **Abstract**
2. **Introduction**
3. **Literature Review / Existing System**
4. **Research Gap / Limitations**
5. **Problem Statement and Objectives**
6. **Proposed System**

- **Analysis / Algorithm / Framework**
- **Design Methodology**

7. **Experimental Setup**
    - **Input Data / Dataset Details**
    - **Software and Hardware Specifications**
    - **Evaluation Parameters**
8. **Results and Discussion**
9. **Conclusion and Future Scope**
10. **References**
11. **Appendices (if applicable: Certificates, Publications, etc.)**

Students are encouraged to complete relevant certification courses that support the technical requirements of their project.

B. In-Semester Continuous Assessment (Evaluation)

Total Marks: 50 (Semester VII)

Component	Description	Marks
Topic Approval Presentation	**Evaluation by Project Monitoring Committee**	**10**
Mid-Semester Progress Presentation	**Demonstration of progress in methodology and implementation**	**15**
Final Report & Presentation	**Quality of report, implementation, teamwork, and final demonstration**	**20**
Regularity and active participation	**Consistent attendance, timely submission of weekly progress logs, proactive involvement in group discussions, task ownership, and meaningful contribution to project development throughout the semester.**	**05**

Quality Evaluation Parameters

- **Relevance and quality of the problem selected**
- **Clarity in problem definition, objectives, and scope**
- **Originality and relevance to current industry/research trends**
- **Quality of system design, methodology, and implementation**
- **Clarity, organization, and technical depth of the report**
- **Effectiveness of oral presentation**
- **Individual contribution and teamwork**

Course Type	Course Code	Course Name	Credits
HSS	HSS703	FINANCIAL PLANNING	02

Program Outcomes addressed:

1. PO2 : Problem Analysis
2. PO6 : The Engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. Develop a foundational understanding of financial principles and their relevance to personal financial planning
2. Enhance analytical skills to assess financial situations and propose effective solutions.
3. Acquire practical financial management skills through budgeting, investment analysis, and debt management
4. Foster ethical and responsible financial behaviour in alignment with professional standards and societal values

Module	Details
01.	**Setting Financial goals, Budgeting & cash flow management** Understanding financial goals: short, medium, long-term, and setting them using the SMART criteria, Introduction to budgeting: covering income, expenses, savings, and investments, Budgeting techniques: zero-based budgeting, envelope system, and the 50/30/20 rule, Cash flow management strategies for maintaining financial stability.
02.	**Saving Strategies & Investments, Borrowing & Credits** Importance of saving and investing for financial growth, Introduction to different types of savings accounts and investment options, Understanding the risk-return tradeoff in investing, Diversification and asset allocation strategies, Responsible borrowing practices and managing debt, Credit management: credit scores, types of credit, and building good credit history.
03.	**Risk Management** Concept of financial risk and its implications, Types of financial risks: market risk, inflation risk, interest rate risk, credit risk, Introduction to insurance: types of insurance (life, health, property, auto), coverage options, Importance of emergency fund and risk mitigation strategies Evaluating risk tolerance and creating a risk management plan
04.	**Income tax Fundamentals** Basics of income tax: taxable income, tax deductions, tax credits, Understanding tax brackets and marginal tax rates, Types of taxes: income tax, payroll tax, capital gains tax, Filing tax returns: forms,

	deadlines, filing options, Tax-saving strategies: deductions, credits, retirement accounts
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. Demonstrate a comprehensive understanding of financial concepts
2. Analyze complex financial scenarios, identify financial challenges, and propose effective strategies to achieve financial goals.
3. Apply financial planning principles and techniques to develop personalized financial plans aligned with individual goals and circumstances.
4. Utilize financial tools, software applications, and online resources proficiently
5. Adhere to ethical standards and professional codes of conduct in financial decision-making
6. Recognize the societal impact of financial decisions and promote responsible financial behavior

Text Books :

1. Personal Finance by Jeff Madura and Hardeep Rai, Pearson Education
2. Financial Management: Principles and Applications, by Sheridan Titman, Arthur J. Keown, and John D. Martin, Pearson Education
3. Project Management: The Managerial Process, by Erik W. Larson and Clifford F. Gray, McGraw-Hill Education

Reference Books :

1. The Total Money Makeover: A Proven Plan for Financial Fitness, by Dave Ramsey, Thomas Nelson
2. Investing 101: From Stocks and Bonds to ETFs and IPOs, an Essential Primer on Building a Profitable Portfolio, by Michele Cagan , Adams Media
3. Financial Risk Management: A Practitioner's Guide to Managing Market and Credit Risk, by Steve L. Allen (Publisher: Wiley)

Other Resources:

3. NPTEL Course: Behavioral And Personal Finance, By Prof. Abhijeet Chandra, Vinod Gupta School of Management, IIT Kharagpur :-Web link- https://onlinecourses.nptel.ac.in/noc24_mg07/preview

4. NPTEL Course: Financial Management, By CA Amita Bissa, Jai Narain Vyas University, Jodhpur:-Web link- https://onlinecourses.swayam2.ac.in/cec20_mg05/preview

Course Type	Course Code	Course Name	Credits
OEC	OEC8021	Project Management	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:

BSC101 : Engineering Mathematics- I

BSC204 : Engineering Mathematics- II

AEC201 : Professional Communication and Ethics- I

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO5: Engineering Tool Usage
5. PO9 : Communication
6. PO10: Project Management and Finance
7. PO11: Life-long learning

Course Objectives:

1. To familiarize students with fundamental project management concepts, frameworks, tools, and standard terminology relevant to engineering projects.
2. To enable students to analyze project requirements and apply systematic project selection techniques and portfolio management approaches for informed decision-making.
3. To enable students to plan projects effectively by developing work breakdown structures, schedules, budgets, and comprehensive risk management plans.
4. To equip students to monitor and control project progress using quantitative performance measurement techniques, including Earned Value Management.
5. To evolve students' leadership, communication, ethical awareness, and technical documentation skills necessary for effective project execution and formal project closure.

Module	Detailed Contents	Hrs.
	Course Introduction In today's technology-driven and highly competitive engineering environment, effective project management has become critical for delivering complex projects within defined time, cost, quality, and resource constraints. Rapid technological advancements, multidisciplinary teams, and increased stakeholder expectations demand a structured approach to planning, execution, monitoring, and control of projects. This course provides students with a comprehensive understanding of project management principles, practices, and tools essential for managing engineering projects successfully. It covers key areas such as project selection and feasibility analysis, scope definition, scheduling techniques, cost and quality management, risk assessment, and performance monitoring using methods such as Earned Value Management. The course also addresses leadership, communication, and ethical considerations, enabling students to manage projects systematically in professional and industry-oriented environments.	**01**
01.	**Fundamentals of Project Management** *Learning Objective:* *To explore fundamental project management concepts, project life cycle phases, stakeholder roles, and organizational structures to manage projects systematically and effectively.*	**4-6**
	Contents: Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI).	
	Self-Learning Topics: *Evolution of Project Management and Global PM Standards (PMBOK, PRINCE2, Agile)* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply engineering fundamentals to interpret the concept of projects and project management, including project characteristics, objectives, and constraints. (P.I.-1.3.1)* *LO 1.2: Apply laws of natural science to construe with the phases of the project life cycle and the key activities performed in each phase. (P.I.-1.2.1)* *LO 1.3: Apply engineering fundamentals to interpret the roles and responsibilities of project stakeholders and the project manager in different organizational structures. (P.I.-1.3.1)* *LO 1.4: Apply laws of natural science to interpret negotiations and resolving conflicts.(P.I.-1.2.1)*	
02.	**Project Selection, Initiation, and Feasibility Analysis** ***Learning Objective:*** *To analyze potential projects using structured selection and feasibility techniques to justify project initiation decisions based on technical, economic, and operational considerations.*	**6-8**
	Contents: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio	

	Self-Learning Topics: *Project Portfolio Management and Strategic Alignment* *Case Studies on Project Failure Due to Poor Feasibility Analysis* *Use of Decision-Support Tools for Project Selection* ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Evaluate problem statements and identifies objectives for project proposals.(P.I. - 2.1.1)* *LO 2.2: Compare and contrast alternative methods for project viability using project selection methods and feasibility analysis techniques. (P.I.- 2.2.4)* *LO 2.3: Identify the tasks and the resources required to complete an engineering activity using project charter in formal project initiation. (P.I.-10.3.1)* *LO 2.4: Analyze and select the most appropriate proposal based on economic and financial considerations. (P.I.-10.2.1)* *LO 2.5: Apply engineering fundamentals to interpret the stages of team development and Growth.(P.I.-1.3.1)* *LO 2.6: Apply laws of natural science to construe with team dynamics.(P.I.-1.2.1)*	
03.	**Project Planning and Scheduling Techniques** ***Learning Objective:*** *To design comprehensive project plans by applying work breakdown structures, budgeting, scheduling methods, and modern project management tools to optimize time and resource utilization.*	**7-9**
	Contents: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).	
	Self-Learning Topics: *Software Tools for Project Planning and Scheduling (MS Project, Primavera)* *Agile Planning Methods: Scrum and Sprint Planning* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Develop a Work Breakdown Structure (WBS) to define a precise problem statement with objectives and scope, and identify and document system requirements.(P.I.- 3.1.1)* *LO 3.2: Identify appropriate modern project management tools and scheduling techniques for planning and organizing project activities. (P.I.- 5.1.1)* *LO3.3: Apply Gantt charts for activity scheduling and use PERT and CPM techniques to analyze project networks and determine the critical path. (P.I. – 5.2.2)*	
	LO 3.4: Identify project tasks and associated resource requirements by analyzing project objectives and scope. (P.I. – 10.3.1) *LO 3.5: Apply appropriate project management planning and scheduling techniques to design structured project execution plans for effective organization and management of project activities.(P.I.- 3.2.1)* *LO 3.6: Analyze and select the most appropriate proposal based on economic and financial considerations. (P.I. – 10.2.1)*	

04.	**Planning Project and Risk Management** ***Learning Objective:*** *To evaluate and control project quality and risk by applying quality assurance and risk management techniques to ensure successful project outcomes.*	**6-8**
	Contents: Planning Projects: Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan, Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks.	
	Self-Learning Topics: *Six Sigma and Total Quality Management (TQM) in Projects* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Identify and apply resource loading and resource levelling techniques to allocate and balance project resources effectively under scheduling constraints. (P.I. – 10.3.1)* *LO 4.2: Use project management tool - Goldratt's Critical Chain method- to schedule an engineering project and manage uncertainties and improve schedule reliability. (P.I.-10.3.2)* *LO 4.3: Interpret project stakeholder information by reading and understanding technical and non-technical project documents. (P.I.-9.1.1)* *LO4.4: Deliver effective project information clearly and appropriately to different stakeholders using a structured project communication plan. (P.I.-9.2.2)* *LO4.5: Identify project risks and analyze their impact by applying qualitative and quantitative risk assessment techniques. (P.I. – 2.1.2)* *LO4.6: Compare and contrast project risks using probability–impact matrices and determine appropriate response strategies for positive and negative risks. (P.I. – 2.2.4)*	
05.	**Project Monitoring, Control, and Contracting** ***Learning Objective:*** *To monitor and control project performance using quantitative measurement techniques and project management tools to assess progress, manage changes, and achieve project objectives.*	**6-8**
	Contents: Executing Projects: Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings. Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit. Project Contracting, Project procurement management, contracting and outsourcing.	
	Self-Learning Topics: *Advanced Earned Value Management (EVM) Applications* *Project Auditing and Performance Review Techniques* ***Learning Outcomes:*** *A learner will be able to* *LO 5.1: Identify key parameters and constraints in planning, monitoring, and controlling cycles to analyze deviations and performance issues.(P.I. – 2.1.2)* *LO 5.2: Identify sources of risk, scope creep, and change requests, and examine their impact on project objectives. (PI.- 2.4.3)* *LO 5.3: Identify appropriate modern project management tools for monitoring project progress and tracking milestones during project execution. (P.I.- 5.1.1)*	

	LO 5.4: Apply modern project management tools and techniques to perform Earned Value Management analysis and measure project performance. (P.I.- 5.2.2) *LO 5.5: Apply project management practices to plan stakeholder engagement, coordinate teams,and manage communication. (P.I.- 10.3.2)* *LO 5.6: Identify project procurement activities including contracting and outsourcing for effective execution of projects. (P.I.- 10.3.1)*	
06.	**Project Leadership, Closure and Documentation** ***Learning Objective:*** *Demonstrate effective leadership, teamwork, ethical practices, and communication skills while executing project closure activities and documenting lessons learned.*	**4-6**
	Contents: Introduction to project leadership, ethics in projects, Multicultural and virtual projects. Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lesson learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	
	Self-Learning Topics: *Ethical Dilemmas in Project Management: Real-World Cases* *Post-Project Review and Knowledge Management Practices* ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Apply engineering fundamentals to interpret the process of project termination. (P.I.- 1.3.1)* *LO 6.2: Apply theory and principles of engineering to close the project.(P.I.-1.4.1,9.1.2)* *LO 6.3: Identify reasons, types, and processes of project termination and elucidate procedures for customer acceptance and formal project closure.(P.I.-11.3.1)* *LO 6.4:Demonstrate continuous professional learning by preparing project closure documentation including final reports, lessons learned analysis, and use of project management templates and resources.(P.I.-9.2.2,11.3.2)*	
	Course Conclusion: Upon completion of the Project Management course, students will be able to systematically plan, manage, monitor, and close engineering projects using established project management principles and tools. They will demonstrate the ability to work effectively in teams, manage risks and stakeholders, make informed managerial decisions, and document lessons learned. The course prepares students to take on professional roles that require project coordination, leadership, and ethical responsibility in real-world engineering and organizational environments.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply engineering fundamentals.
1.4.1	Apply theory and principles of engineering to solve an engineering problem. (Modifided)
2.1.1	Evaluate problem statements and identifies objectives
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.1	Reframe the computer-based system into interconnected subsystems
2.2.4	Compare and contrast alternative solution/methods to select the best methods.
2.4.3	Identify the limitations of the solution and sources/causes.
3.2.1	Able to explore design alternatives.
3.1.2	Able to identify and document system requirements from stake- holders.
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
5.2.2	Demonstrate proficiency in using discipline-specific tools
9.1.1	Read, understand and interpret technical and non-technical information
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
9.2.2	Deliver effective oral presentations to technical and non-technical audiences
10.2.1	Analyze and select the most appropriate proposal based on economic and financial considerations.
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.
11.3.1	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 engineering fundamentals to interpret project management concepts, project life cycle phases, stakeholder roles, and organizational structures required for systematic project execution. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Analyze and evaluate project proposals using structured selection and feasibility techniques, identify tasks and resources for project initiation, assess economic viability, and apply engineering principles to understand team development and dynamics. (LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)
3. Design and develop comprehensive project plans using work breakdown structures, cost estimation, and scheduling techniques, apply modern project management tools to optimize time and resource utilization, and evaluate project plans based on economic and financial considerations. (LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6)
4. Apply project planning, communication, and risk management techniques to allocate and optimize resources, manage schedule uncertainties, engage stakeholders effectively, and analyze project risks to select appropriate response strategies for successful project execution. (LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)

5. Analyze, Monitor and control project performance using planning and execution parameters, applying quantitative measurement and modern project management tools, managing stakeholder communication and team coordination, and identifying procurement and contracting activities to ensure effective project execution. (LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)
6. Apply, demonstrate, and document project leadership and communication skills to execute project closure activities, manage project termination processes, ensure customer acceptance, and prepare formal closure reports and lessons learned for professional growth and knowledge management.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
CEPEC7031.1	3	-	-	-	-	-	-	-	-	-	-
CEPEC7031.2	3	3	-	-	-	-	-	-	-	3	-
CEPEC7031.3	-	-	3	-	3	-	-	-	-	3	-
CEPEC7031.4	-	3	-	-	-	-	-	-	3	3	-
CEPEC7031.5	-	3	-	-	3	-	-	-	-	3	-
CEPEC7031.6	3	-	-	-	-	-	-	-	3	-	3
Average	3	3	3	-	3	-	-	-	3	3	3

Text Books:

1. Project Management: A Managerial Approach, Meredith, J. R. and Mantel, S. J. Jr., 2017, Wiley India, ISBN: 978-1-119-36911-7, 9th Edition.
2. Project Management: Planning, Scheduling, and Controlling, Chitkara, K. K., 2014, Tata McGraw-Hill Education, ISBN: 978-0-070-67713-9, 2nd Edition.
3. Project Management: The Managerial Process, Gray, C. F. and Larson, E. W., 2018, McGraw-Hill Education, ISBN: 978-1-259-66271-6, 7th Edition.
4. Project Management, Gopalan, M. R., 2014, Wiley India Pvt. Ltd., ISBN: 978-8126550807, 2nd Indian Edition.

Reference Books:

1. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Project Management Institute, 2017, PMI Publications, ISBN: 978-1-62825-664-2, 6th Edition.
2. Successful Project Management, Gido, J. and Clements, J. P., 2018, Cengage Learning, ISBN: 978-1-337-10067-2, 6th Edition.
3. Project Management, Lock, D., 2014, Gower Publishing, ISBN: 978-1-409-46228-6, 10th Edition.

Other Resources:

1. NPTEL Course: Project Management by Prof. K. K. Aggarwal / Prof. S. C. Dutta, IIT Delhi
   Web Link – https://onlinecourses.nptel.ac.in
2. Project Management Institute (PMI), PMBOK® and Standards Repository, Online Resource
   Web Link – https://www.pmi.org
3. MIT OpenCourseWare, Project Management and Systems Engineering, Massachusetts Institute of

Technology. Web Link – https://ocw.mit.edu

4. Coursera, Project Management Principles and Practices, University of California, Irvine Web Link – https://www.coursera.org

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

1. Assignment on live problems/case studies: 10 Marks

   (Assignment on live problems/ case studies, wherein problems are given prior. Students are expected to research and collect required resources. They can use the resources and solve the problem on assigned date and time in Institute premises in presence of faculty member.)

2. Technical Report Writing: 05 Marks
3. 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
OEC	OEC8022	FINANCE MANAGEMENT	03

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

Program Outcomes addressed:

1. PO1 : Engineering Knowledge
2. PO2 : Problem Analysis
3. PO10: Project Management & Finance

Course Objectives :

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Overview of Indian Financial System**	**5-7**
	Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	
02.	**Concepts of Returns and Risks**	**6-8**
	Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuit y Due; Continuous Compounding and Continuous Discounting	

03.	**Overview of Corporate Finance**	**9-11**
	Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	
04.	**Capital Budgeting**	**10-12**
	Meaning and Importance of Capital Budgeting; Inputs forCapital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's10 Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	
05.	**Sources of Finance**	**5-7**
	Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	
06.	**Dividend Policy**	**2-4**
	Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani- Miller Approach	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes : Learner will be able to

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

References :

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Type	Course Code	Course Name	Credits
OEC	OEC8023	Entrepreneurship Development and Management	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

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO6: The Engineer & The world
3. PO8: Individual and team work
4. PO9: Communication
5. PO10: Project Management & Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To introduce the fundamental concepts of entrepreneurship and effective management of business enterprises.
2. To develop understanding of business planning, ownership structures, and legal aspects related to entrepreneurship.
3. To familiarize students with the Indian entrepreneurial environment, including MSMEs, government policies, and support institutions.
4. To encourage entrepreneurial thinking by highlighting innovation, sustainability, and problem-solving in small and medium enterprises.

Module	Detailed Contents	Hrs
00.	**Course Introduction** This course is designed to develop a clear understanding of entrepreneurship as a career option and as a driver of economic growth. It covers the fundamentals of starting, organizing, and managing new ventures with special reference to the Indian business environment. The course explains business planning, legal frameworks, financial management, and government support for entrepreneurs. Emphasis is given to MSMEs, innovation, and sustainable development. Through practical insights and case discussions, the course prepares learners to identify opportunities and manage entrepreneurial challenges effectively.	01
01.	**Overview of Entrepreneurship:** ***Learning Objective:*** *Understand the role of entrepreneurship in economic development and business ownership*.	05-07

	Content: Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship.	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Understand the definitions, roles, functions, and values of entrepreneurship. (PI- 1.3.1)* *LO 1.2 Prepare a sample business plan, implementing norms of practice (agendas, charters) to reach a common goal. (PI- 8.1.2, PI- 9.1.1)* *LO 1.3: Students will present results as a team, integrating financial analysis and market research into a logical, flowing presentation for both technical and non-technical stakeholders. (PI- 8.3.1, PI- 9.2.2)*	
02.	**Business Plans and Importance of Capital to Entrepreneurship:** ***Learning Objective:*** *Develop basic skills for starting, managing, and growing a business.*	**06-08**
	Contents: Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur. Entrepreneurship and Business Development: Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Understand the key components of business planning, financing, legal requirements, and growth options involved in starting, managing, and expanding an entrepreneurial venture. (PI- 1.3.1)* *LO 2.2: Prepare a logically structured business presentation that flows from Preliminary Plans to Conclusions, delivering the information clearly to both technical engineers and non-technical financial investors. (PI- 9.1.3, PI- 9.2.2)* *LO 2.3 Identify the various financial costs and long-term benefits of business activities, specifically calculating Start-up Costs, Insurance premiums, and the vital role of Capital in sustaining an enterprise as a case study. (PI- 10.1.1)* *LO 2.4: Select as a case study the most viable proposal—such as deciding between building a new startup or acquiring an existing one—based on rigorous analysis of Projected Financial Statements. (PI- 10.2.1)*	
03.	**Women and Social Entrepreneurship** ***Learning Objective:*** *Understand women and social entrepreneurship and their role in development.*	**08-10**

	Contents: Concept and evolution of women entrepreneurship in India. Role and importance of women entrepreneurs in economic and social development. Characteristics, strengths, and challenges faced by women entrepreneurs. Government policies, schemes, and institutional support for women entrepreneurship. Role of self-help groups (SHGs), NGOs, and microfinance institutions in promoting women-led enterprises. Case studies of successful women entrepreneurs. Concept, meaning, and scope of social entrepreneurship. Difference between social entrepreneurship and traditional entrepreneurship. Role of social entrepreneurs in addressing social, economic, and environmental issues. Models of social enterprises and sources of funding.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Understand the concepts of women and social entrepreneurship, their evolution, support systems, and roles in addressing economic, social, and environmental challenges through real-world examples and case studies.(PI- 1.3.1)* *LO 3.2: Identify the engineering role in social entrepreneurship, focusing on how technical innovation serves the public interest by addressing economic and environmental gaps in rural and urban India.(PI- 6.1.1)* *LO 3.3: Identify government regulations, codes, and industrial standards to ensure that women-led and social enterprises remain legally compliant while protecting the community. .(PI- 6.2.1)* *LO 3.4: Apply leadership and conflict-resolution skills to solve simulated hurdles faced by women entrepreneurs, such as supply chain barriers or resource scarcity.(PI- 8.2.1)* *LO 3.5: Integrate individual research into a seamless team presentation on successful women or social entrepreneurs, ensuring all contributions are logically unified. (PI- 8.3.1)* *LO 3.6: Relate historical shifts in technology to the current need for continuous education, identifying how digital literacy and green tech are now essential for modern social entrepreneurs. (PI- 11.2.1)* *LO 3.7: Extract and verify data from credible sources, such as government portals for women-specific schemes and academic journals on the evolution of social enterprise models. (PI- 11.3.1)*	
04.	**Indian Environment for Entrepreneurship:** ***Learning Objective:*** *Understand MSME regulations, government support systems, and policies for enterprise development.*	**07-09**
	Contents: key regulations and legal aspects, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organizations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc.	

	Learning Outcomes: *A learner will be able to* *LO 4.1: Understand regulatory, financial, and institutional issues related to MSME development and government support systems.(PI- 1.3.1)* *LO 4.2: Understand the entrepreneur-engineer acts as a guardian of the public interest by driving local economic growth and ensuring the safety of engineering products.(PI- 6.1.1)* *LO 4.3: Refer the MSMED Act 2006 to ensure the enterprise operates within legal codes and utilizes statutory protections against financial risks like delayed payments.(PI- 6.2.1)* *LO 4.4: Critically interpret legal documents, policy guidelines, financial schemes, and institutional reports related to MSME development and support systems.(PI-9.1.1)* *LO 4.5: Prepare well-structured written reports and presentations that logically organize information on MSME regulations, infrastructure support, and government initiatives.(PI- 9.1.3)*	
05.	**Effective Management of Business:** ***Learning Objective:*** *Identify key issues of micro and small enterprises and apply effective management practices to address them.* **Contents:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing ***Learning Outcomes:*** *A learner will be able to* *LO 5.1:Identify and study practical solutions for challenges faced by micro and small enterprises, including risk management, credit access, technology adoption, supply chain, and e-marketing. (PI- 1.3.1)* *LO 5.2 Demonstrate leadership and conflict resolution within a team-based exercise aimed at solving a simulated "Credit Crisis" or "Supply Chain Disruption" in a small firm. (PI- 8.1.2, PI- 8.2.1)* *LO 5.3: Present a comprehensive Case Study as a team, integrating technical engineering solutions with financial management strategies into a seamless oral presentation for potential investors. (PI- 8.3.1, PI- 9.2.2)* *LO 5.4: Interpret non-technical documents such as bank loan agreements, market research reports, and e-Marketing analytics to make informed management decisions.(PI- 9.1.1)*	**04-06**
06.	**Achieving Success In The Small Business** ***Learning Objective:*** *Understand the small business life cycle, growth strategies, and critical success factors.* **Contents:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business. ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Understand the stages of the small business life cycle, growth strategies, exit options, and critical success factors applied to small business situations. (PI- 1.3.1)*	**04-06**

	LO 6.2 Demonstrate leadership and conflict resolution within a team-based exercise aimed at solving a simulated "Credit Crisis" or "Supply Chain Disruption" in a small firm. (PI- 8.1.2) *LO 6.3: Integrate individual research into a single, cohesive team report that identifies the Critical Success Factors of a venture. (PI- 8.3.1)* *LO 6.4: Prepare a logically flowing presentation that explains complex growth strategies to both technical peers and non-technical investors or stakeholders. (PI- 9.1.3, PI- 9.2.2)*	
	Course Conclusion	**01**
Total		**45**

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
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 and explain their contribution to protection of the public.
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.
9.1.1	Read, understand and interpret technical and non-technical information.
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear.
9.2.2	Deliver effective oral presentations to technical and non-technical audiences.
10.1.1	Describe various economic and financial costs/benefits of an engineering activity.
10.2.1	Analyze and select the most appropriate proposal based on economic and financial considerations.
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

Course Outcomes:

Learner will be able to

1. Understand entrepreneurship fundamentals and collaboratively present a basic business plan using effective teamwork, analysis, and communication skills. *(LO-1.1, LO-1.2,LO-1.3)*
2. Interpret business planning, financing, legal, and operational aspects of entrepreneurship, demonstrating the ability to develop, evaluate, and present comprehensive business strategies. *(LO-2.1, LO-2.2,LO-2.3, LO-2.4)*
3. Understand the principles of women and social entrepreneurship and associated support systems.*(LO-3.1, LO-3.2,LO-3.3, LO-3.4, LO-3.5, LO-3.6, LO-3.7)*
4. Comprehend MSME regulations, financial schemes, and government support systems, and present structured reports for informed decision-making. *(LO-4.1, LO-4.2,LO-4.3, LO-4.4, LO-4.5)*
5. Identify challenges faced by micro and small enterprises and develop practical solutions, collaboratively presenting integrated case studies and informed management decisions. *(LO-5.1, LO-5.2,LO-5.3, LO-5.4)*
6. Understand the small business life cycle and growth strategies, and collaboratively present solutions to real world business challenges. *(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
OEC8023.1	2							3	3		
OEC8023.2	2								3	3	
OEC8023.3	2					3		3			3
OEC8023.4	2					3			3		
OEC8023.5	2							3	3		
OEC8023.6	2							3	3		
Average	**2**					**3**		**3**	**3**		**3**

Text Books :

1. Poornima Charantimath, Entrepreneurship Development – Small Business Enterprise, Pearson Education.
2. **Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd**, *Entrepreneurship*, McGraw-Hill Education.
3. **Vasant Desai**, *Entrepreneurial Development and Management*, Himalaya Publishing House.

Reference Books :

1. **T. N. Chhabra**, *Entrepreneurship Development*, Sun India Publications, New Delhi.
2. **Madhurima Lall & Shikha Sahai**, *Entrepreneurship*, Excel Books.
3. **C. N. Prasad**, *Small and Medium Enterprises in Global Perspective*, New Century Publications, New Delhi,

Other Resources :

1. www.msme.gov.in
2. www.dcmesme.gov.in
3. www.msmetraining.gov.in

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory (20 Marks)

Suggested breakup of distribution

One class test	:	05 Marks
Article reading and summarization	:	05 Marks
A task based group activity	:	05 Marks
Regularity and attentiveness	:	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
OEC	OEC8024	HUMAN RESOURCE MANAGEMENT	03

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

Program Outcomes addressed:

1. PO7 : Ethics
2. PO8 : Individual and Collaborative Teamwork
3. PO10: Project Management and Finance

Course Objectives:

1. To introduce the students with basic concepts, techniques and practices of the human resource management
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations
3. To familiarize the students about the latest developments, trends & different aspects of HRM
4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Introduction to HR**	**4-6**
	- Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions - Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues	
02.	**Organizational Behaviour (OB)**	**7-9**
	- Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues - Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness - Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior	

	- Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor); - Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development, Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. - Case study	
03.	**Organizational Structure &Design**	**6-8**
	- Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. - Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. - Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	
04.	**Human resource Planning**	**5-7**
	- Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale - Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning - Training & Development: Identification of Training Needs, Training Methods	
05.	**Emerging Trends in HR**	**6-8**
	- Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR. Organizational Change, Culture, Environment - Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation	
06.	**HR -MIS, Strategic HRM and Labor Laws & Industrial Relations**	**9-11**
	- Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries - Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals - Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes:

1. Understand the concepts, aspects, techniques and practices of the human resource management
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers

References:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Course Type	Course Code	Course Name	Credits
OEC	OEC8025	PROFESSIONAL ETHICS & CSR	03

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

Program Outcomes addressed:

1. PO6 : The engineer & The World
2. PO7 : Ethics
3. PO10: Project Management and Finance

Course Objectives:

1. To understand professional ethics in business
2. To recognized corporate social responsibility

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Professional Ethics and Business**	**3-5**
	The Nature of Business Ethics; Ethical, Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	
02.	**Professional Ethics in the Marketplace, Professional Ethics and the Environment**	**8-10**
	- Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy - Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	
03.	**Professional Ethics of Consumer Protection, Professional Ethics of Job Discrimination**	**6-8**
	- Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy - Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	
04.	**Introduction to Corporate Social Responsibility**	**5-7**
	Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	

05.	**Corporate Social Responsibility**	**8-10**
	Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	
06.	**Corporate Social Responsibility in Globalizing India**	**7-9**
	Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes : Learner will be able to

1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

References:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Course Type	Course Code	Course Name	Credits
OEC	OEC8026	CIRCULAR ECONOMY	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

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO6: The Engineer & The world
5. PO7: Ethics
6. PO10: Project Management & Finance
7. PO11: Lifelong Learning

Course Objectives:

1. To introduce the fundamentals and need for Circular Economy (CE)
2. To impart the knowledge about environmental and economic impacts of products.
3. To make learner understand circular materials and product strategies.
4. To impart the knowledge of CE business models in engineering industries.

Module	Detailed Contents	Hrs
00.	**Course Introduction** This course introduces the Circular Economy (CE) paradigm—a transformative approach that shifts from linear consumption to restorative and regenerative systems. By embracing CE principles, engineers can contribute to designing products, processes, and infrastructures that maximize resource efficiency, reduce waste, and promote economic, environmental, and social sustainability.	01
01.	**Introduction to Circular Economy** **Content:** Linear economy, Role of the Industrial revolution in Linear economy, Disadvantages of Linear economy, Replacing Linear by Circular economy, History and evolution of circular economy, Global CE initiatives (EU Circular Economy Action Plan, UN SDGs), Role of R's in circular economy, Value optimization, Design out waste, Renewable energy, A differential- Linear vs. Circular economy, Building a resilient economy, Role of engineers in CE	05-07

02.	**Systems Thinking and Life Cycle Thinking**	**06-08**
	Contents: Systems Thinking in CE, Core principles of Systems Thinking in CE, Application in the Circular Economy Concept of Loops, Circularity, Life Cycle Analysis(LCA), Importance of LCA, An efficient approach by Neptune Pumps, Case study-winnow solutions, Embodied energy and material flows, Input-output analysis in industrial systems	
03.	**Circular Design and Materials Engineering**	**07-09**
	Contents: Material recovery, waste reduction, Reducing negative externalities, Connecting Businesses and people for circularity, Butterfly diagram, Design for disassembly, modularity, repairability, Materials selection for durability and recyclability , Bio-based and regenerative materials, Eco-design principle	
04.	**Circular Business Models and Industrial Applications**	**07-09**
	Contents: Circular Business Models, Product-as-a-Service (PaaS), Reverse logistics, remanufacturing, and refurbishment, Industrial symbiosis and closed-loop systems, Digital technologies enabling CE (IoT, blockchain, AI)	
05.	**Waste Management and Resource Recovery**	**06-08**
	Contents: Circular waste hierarchy, Urban mining and e-waste recycling, Industrial and agricultural waste valorization, Waste-to-energy and bioconversion technologies	
06.	**Circular Economy Implementation and Policy**	**06-08**
	Contents: CE indicators and metrics (e.g., Circularity Gap Report), National and international CE policies, Corporate sustainability and ESG frameworks, Roadmaps and barriers to implementation	
	Course Conclusion	**01**
Total		**45**

Course Outcomes:

Learner will be able to

1. Analyze the need for Circular Economy (CE) and apply systems and life cycle thinking to engineering
2. Integrate CE in design and material selection
3. Analyse real-world industrial circular practices
4. Apply engineering approaches to waste minimization and resource recovery
5. Analyse policy, regulations, and corporate strategies and integrate CE into engineering practice

Text Books :

1. Circular Economy: Principles and Benefits, Ken Webster., First Edition 2017, Ellen MacArthur Foundation Publishing.
2. Product Design and Life Cycle Assessment, Ireneusz Zbicinski, Danuta Romanowska, Barbara Bednarowska, First Edition, 2021, Springer
3. Designing for the Circular Economy, Martin Charter, Ursula Tischner, First Edition, 2017 Routledge

Reference Books :

1. The Circular Economy: A User's Guide, Subramanian Senthilkannan Muthu, First Edition, 2020, Springer
2. Industrial Ecology and Circular Economy: Energy and Resource Efficiency in Industry, Yasemin Gursoy, Bilge Sener, First edition, 2021, Springer.
3. Cradle to Cradle: Remaking the Way We Make Things, William McDonough, Michael Braungart, First edition, 2002, North Point Press

Other Resources :

1. NPTEL Course: Sustainable Engineering Concepts and Life Cycle Analysis, Prof. Brajesh Kumar Dubey | IIT Kharagpur
   Web Link- https://onlinecourses.nptel.ac.in/noc24_ce61/preview
2. NPTEL Course: Linear to Circular Economy, Prof Shalini Goyal Bhalla, IIT Roorkee
   Web Link- https://onlinecourses.swayam2.ac.in/aic21_ge19/preview

Course Type	Course Code	Course Name	Credits
OEC	OEC8027	IPR AND PATENTING	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. VEC101 - Universal Human Values
2. AEC201 - Professional Communication and Ethics-I
3. HSS301 - Product Design
4. VEC402 - Environment and Sustainability
5. AEC502 - Professional Communication and Ethics-II
6. HSS502 - Entrepreneurship
7. ELC601 - Research Methodology
8. HSS703 - Financial Planning

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO5: Engineering Tool Usage
4. PO6: The Engineer and The World
5. PO7: Ethics
6. PO8: Individual and Collaborative Team work
7. PO9: Communication
8. PO10: Project Management and Finance

Course Objectives:

1. To introduce students to the significance of Intellectual Property and its impact on innovation and professional growth.
2. To clarify the essential concepts and distinctions among patents, copyrights, trademarks, industrial designs, trade secrets, and GI.
3. To simplify statutory provisions and legal procedures so students can confidently interpret various IPR frameworks.
4. To guide students in applying practical steps for obtaining, managing, and safeguarding different IP rights.

5. To foster ethical reasoning, holistic professional judgement, and awareness of cyber laws relevant to IPR.

Module	Details	Hrs.
	Course Introduction The course introduces students to the fundamental concepts, legal frameworks, procedures, and applications of Intellectual Property Rights (IPR). With rapid technological advancement, understanding how to protect innovations is essential for engineers. This course equips learners with the knowledge to identify different forms of intellectual property, file and maintain IP rights, and manage IP assets ethically and strategically. Students will also develop awareness of cyber laws as they relate to digital content and IP.	**01**
01.	**Introduction to IPR** ***Learning Objective:*** *To understand the meaning, nature and scope of IPR.* **Contents:** Concept of Property, Tangible and Intangible Property, Intellectual Property: Definition, Need & Importance, Types of IPR: Patents, Copyright, Trademark, GI, Trade Secrets, Industrial Design, Evolution of IP laws: Paris Convention, Berne Convention, WIPO creation, TRIPS, Indian IPR system: CGPDTM, Copyright Office, GI Registry, PVPFR Authority, Role of IPR in R&D, Innovation, and International Trade. ***Self-Learning Topics:*** *Case studies of international IP disputes, India's National IPR Policy 2016.* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1 Identify the nature and scope of Intellectual Property Rights. (PI 7.1.1)* *LO 1.2 Compare tangible and intangible property with suitable examples. (PI 2.1.1)* *LO 1.3 Classify the various types of IPR such as patents, copyrights, trademarks, GI, industrial design, and trade secrets. (PI 2.1.3)* *LO 1.4 Analyze major international IP treaties such as the Paris Convention, Berne Convention, WIPO, and TRIPS. (PI 6.1.1)* *LO 1.5 Interpret the role of IPR in innovation, R&D, and international trade using a real-world case. (PI 6.2.1)* *LO 1.6 Interpret India's National IPR Policy 2016 and present insights through a structured activity. (PI 7.2.2)*	**7-9**
02.	**Patents** ***Learning Objective:*** *To understand patent fundamentals and statutory requirements.* **Contents:** Patent definition, objectives, values and advantages, Criteria of patentability: Novelty, Inventive Step, Industrial Application, Non-patentable inventions under Indian law, Types of Specifications: Provisional, Complete, Parts of a Patent: Title, Field, Background, Description, Drawings, Claims, Abstract,	**8-10**

	Filing procedure: Forms (1, 2, 3, 5, 9, 18, 26), Examination, FER, Grant, Renewal, PCT Filing, Priority Date, Patent Cooperation Treaty, Revocation, Opposition: Pre-Grant & Post-Grant, Prior art search: Keywords, Boolean operators, Databases (WIPO, USPTO, Google Patents)	
	Self-Learning Topics: *Case studies of Indian patent disputes, Patent drafting exercise.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1 Identify fundamental concepts, objectives and advantages of patents. (PI 2.1.1)* *LO 2.2 Evaluate criteria of patentability such as novelty, inventive step and industrial application. (PI 7.1.1)* *LO 2.3 Differentiate between patentable and non-patentable inventions under Indian law. (PI 6.1.3)* *LO 2.4 Analyze the structure of a patent specification including title, field, background, description, drawings, claims and abstract. (PI 2.2.2)* *LO 2.5 Apply the procedural steps involved in patent filing including forms, examination, FER, hearings, grant and PCT filing. (PI 6.1.3)* *LO 2.6 Conduct a basic prior art search using keywords, Boolean operators and major patent databases. (PI 5.2.1)*	
03.	**Trademarks, Industrial Designs and GI** ***Learning Objective:*** *To understand trademark concepts and functions, design registration process, GI significance and registration.*	**8-10**
	Contents: Trademarks: Definition, Functions, Brand Value, Distinctiveness, Types of marks (word, device, shape, color), Registration process, challenges in non-conventional marks, Infringement, Passing off, Domain name disputes, well-known marks. Industrial Designs: Definition, Novelty, Originality, Registration process, Infringement and remedies. Geographical Indications (GI): Meaning & Importance, Registration of GI goods, Indian GI examples.	
	Self-Learning Topics: *Case study: Basmati Rice GI dispute*	
	Learning Outcomes: *A learner will be able to* *LO 3.1 Identify the meaning, functions, and importance of trademarks in branding and consumer protection. (PI 2.1.1)* *LO 3.2 Classify types of trademarks including word, device, shape and colour marks. (PI 2.1.2)* *LO 3.3 Apply the procedure for registration of trademarks and recognize challenges in protecting distinctive marks. (PI 6.1.3)* *LO 3.4 Evaluate industrial designs for novelty requirements and determine eligibility for registration. (PI 6.1.3)* *LO 3.5 Interpret the significance of Geographical Indications (GI) and identify major Indian GI products. (PI 6.1.1)*	

	LO 3.6 A task-based group activity (max 4 students), to be completed before MSE. *(Modules 1, 2 and 3 – IPR Basics, Patents, Trademarks & Designs) (PI 2.1.3, 2.2.2, 2.4.2, 5.1.1, 6.1.1, 6.1.3, 8.1.2, 8.3.1, 9.1.2, 9.3.1, 10.1.1, 10.1.2)* *Details of the task:* *A. IP Identification: Select an engineering innovation and classify applicable IPR (Patent / Trademark / Design) with justification.* *B. Prior Art / Prior Use Search: Conduct structured searches (Google Patents, WIPO, USPTO) and prepare a novelty comparison table.* *C. Drafting: Prepare a mock IP filing document (Patent specification/Trademark application/Design application) including key elements and required forms.* *D. Legal & Commercial Review: Assess registrability, infringement risks, and basic commercialization possibilities.* *E. Documentation: Prepare a concise technical report summarizing the filing process, prior art findings, legal considerations, and team responsibilities.*	
04.	**Copyright, Trade Secrets & Emerging IP** ***Learning Objectives:*** *To learn protection of copyright, rights of authors and infringement, trade secrets.* **Contents:** Copyright: Meaning, Subject Matter, Economic and Moral Rights, Ownership, Transfer, Licensing, Fair dealing, infringement, remedies, Copyright in the digital era. Trade Secrets: Conditions for protection, Misappropriation, NDAs, employment contracts. Emerging IPR: Plant varieties, Integrated circuit layout designs, Undisclosed information, Digital content issues (streaming, snippet tax) ***Self-Learning Topics:*** *Copyright vs Patent comparison* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1 Identify the scope and subject matter of copyright protection. (PI 1.3.1)* *LO 4.2 Analyze the rights of authors, including economic and moral rights. (PI 1.3.1)* *LO 4.3 Identify acts constituting infringement and determine appropriate remedies under copyright law. (PI 2.1.3)* *LO 4.4 Evaluate trade-secret protection requirements and issues related to misappropriation. (PI 2.2.2)* *LO 4.5 Classify emerging IPR forms such as plant varieties and integrated circuit layout designs. (PI 6.1.1)* *LO 4.6 Interpret copyright or trade-secret case documentation to extract key legal insights. (PI 6.1.3)*	**7-9**
05.	**Cyber Laws for Digital IP Protection** ***Learning Objective/s:*** *To understand IP acquisition, protection, commercialization and cyber laws relevant to IPR.* **Contents:** Cyber Laws: IT Act 2000**,** Cybercrimes: identity theft, phishing, e-commerce fraud**,** Digital signatures, data protection, privacy**,** International cyber law issues.	**4-6**

	Self-Learning Topics: *--*	
	Learning Outcomes : *A learner will be able to* *LO 5.1 Analyze cybercrime cases involving identity theft, phishing, or digital signatures to determine legal implications. (PI 6.1.3)* *LO 5.2 Prepare a structured technical report on cyber laws or data-protection issues using appropriate analytical methods. (PI 1.3.1)* *LO 5.3 Identify recent developments in cyber law and digital IP protection relevant to engineering responsibilities. (PI 6.1.1)* *LO 5.4 Interpret credible literature on cybersecurity, data privacy, or digital copyright to extract technical insights. (PI 1.3.1)*	
06.	**IP Management, Documentation and Commercialization** ***Learning Objective/s:*** *To understand IP acquisition, protection, commercialization and cyber laws relevant to IPR.*	**3-5**
	Contents: Managing IP: IP documentation, Letters of instruction, Joint collaboration agreements, NDA, Cease & Desist, Settlement memorandum, Assignment & Licensing, Technology Transfer (ToT), IP valuation basics.	
	Self-Learning Topics: *--*	
	Learning Outcomes : *A learner will be able to* *LO 6.1: Apply procedural requirements and legal considerations to prepare IP documentation such as NDAs, licensing agreements, or collaboration MoUs. (PI 6.1.3)* *LO 6.2: Evaluate IP valuation or technology-transfer scenarios using structured reasoning. (PI 2.2.2)* *LO 6.3: Analyze clauses in joint collaboration agreements, cease-and-desist notices, or settlement memoranda to determine legal and operational implications. (PI 6.1.3)* *LO 6.4: Interpret assignment and licensing provisions to identify ownership transfer, rights retained, and compliance requirements. (PI 2.1.3)*	
	Course Conclusion The course provides a comprehensive understanding of Intellectual Property Rights and their relevance in engineering, innovation, and global business. Learners gain practical insights into patent drafting, trademark and design registration, copyright compliance, and cyber law frameworks. By the end of the course, students are equipped with knowledge and skills necessary to create, protect, and manage intellectual assets responsibly.	**01**
	Total	**45**

Performance Indicators:

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

2.4.2 Produce and validate results using engineering tools and models.

5.2.1 Identify strengths and limitations of tools for acquiring information.

6.1.1 Recognize societal, cultural, and global relevance of engineering/legal systems.

6.1.3 Identify legal and regulatory frameworks relevant to engineering.

6.2.1 Interpret legislation, regulations, codes, and standards and explain their contribution to protection of the public.

7.1.1 Apply ethical principles to engineering decisions.

7.2.2 Examine and apply moral and ethical principles to known case studies.

8.1.2 Collaborate effectively in multidisciplinary teams.

8.3.1 Demonstrate leadership skills in team-based activities.

9.1.2 Prepare and interpret technical documentation.

9.3.1 Communicate effectively in oral and written forms.

10.1.1 Apply engineering management principles to project work.

10.1.2 Prepare project schedules and resource allocation plans.

Course Outcomes: Learner will be able to -

1. Compare fundamental IPR concepts by classifying major IP types and outlining key elements of India's IPR policy. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6*)
2. Identify key elements of patent fundamentals by outlining patentability criteria, filing steps and prior-art search procedures. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6*)
3. Identify essential aspects of trademarks, industrial designs and GI by interpreting legal and registration documentation. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6*)
4. Apply copyright, trade-secret and emerging IP provisions by identifying protected subject matter and reviewing case documentation. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5*)
5. Analyze cyber laws for digital IP protection by examining cybercrimes, preparing structured reports and evaluating credible cybersecurity and data-privacy information. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4*)
6. Evaluate IP management practices by assessing key documentation and critically examining clauses in licensing and collaboration agreements. (*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
OEC8027.1	--	3	--	--	--	3	3	--	--	--	--
OEC8027.2	--	3	--	--	2	3	3	--	--	--	--
OEC8027.3	--	3	--	--	2	3	--	3	3	3	--
OEC8027.4	3	3	--	--	--	3	--	--	--	--	--
OEC8027.5	3	--	--	--	--	3	--	--	--	--	--
OEC8027.6	--	3	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	**--**	**--**	**2**	**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. D. E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents & Trade Secrets, Cengage Learning, 2012.
2. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, 2nd ed., McGraw-Hill Education, 2010.
3. P. Narayanan, Intellectual Property Law, 3rd ed., Eastern Law House, 2010.

Reference Books :

1. F. Ali, The Law of Patents, LexisNexis, 2017.
2. R. Stim, Patent, Copyright & Trademark, 17th ed., NOLO Press, 2019.
3. WIPO, WIPO Intellectual Property Handbook, World Intellectual Property Organization, 2020.
4. K. C. Kailasam and R. Vedaraman, Law of Trademarks and Passing Off, LexisNexis, 2013.

Other Resources :

1. NPTEL Course: Intellectual Property Rights and Competition Law
   Web link- https://onlinecourses.nptel.ac.in/noc25_mg132/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory (20 Marks)

Suggested breakup of distribution

One class test	:	05 Marks
Article reading and summarization	:	05 Marks
A task based group activity	:	05 Marks
Regularity and attentiveness	:	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
OEC	OEC8028	Digital Business Management	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. NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solution
4. PO5: Modern tool Usage
5. PO7: Ethics

Course Objectives:

7. To familiarize students with fundamental concepts, models, and transformation drivers that define digital business ecosystems.
8. To convey strategic frameworks, digital roadmaps, organizational readiness, and performance metrics used in digital transformation.
9. To explain key digital marketing techniques, customer acquisition methods, automation tools, and attribution models.
10. To provide understanding of ecommerce and Omni channel operations, including platforms, logistics, payments, and customer service systems.
11. To develop competency in data-driven decision-making, analytics tools, dashboards, SQL basics, and AI applications in business.
12. To familiarize with platform business models, API integrations, agile/lean product development, and ethical, legal, and security considerations in digital environments.

Module	Details	Hrs.
	Course Introduction Digital Business Management focuses on how digital technologies transform traditional business systems, processes, and decision-making. This course introduces foundations of digital business, digital strategy, marketing, ecommerce, data analytics, platforms, and product delivery, emphasizing the differences between traditional and digital business models. With growing reliance on cloud platforms, analytics, AI, and Omni channel systems, engineering graduates must understand how	**01**

	technical solutions enable digital transformation and value creation. The course equips with managerial and analytical perspectives required to design, evaluate, and manage technology driven business solutions in modern digital enterprises.	
02.	**Foundations of Digital Business** ***Learning Objective:*** *To teach traditional and digital business systems and its models.* **Contents:** Introduction to Digital Business: Definition and scope Key terminology: digitization, digitalization, transformation Traditional vs Digital Business Models Digital Transformation Drivers Digital Maturity & Culture Digital Business Models – Marketplaces, Subscription, Freemium, PaaS, Value Chains Network Effects & Customer Experience ***Self-Learning Topics:*** ***Case study: Netflix/Amazon transformation journey:*** ***https://aws.amazon.com/solutions/case-studies/netflix-case-study/*** ***Digital disruption examples in India (UPI, Zomato, XpressBees)*** *Learning Outcomes:* *A learner will be able to* *LO 1.1: Apply fundamental engineering and management concepts to explain digital business systems and their relevance to engineering applications. (PI: 1.3.1)* *LO 1.2: Apply concepts of electronics and communication engineering and accepted practice areas to analyze digital transformation drivers in digital businesses. (PI: 1.4.1)* *LO1.3: Compare traditional and digital business systems by examining processes, technologies, and customer engagement methods. (PI: 2.1.2)* *LO1.4: Break down digital business models into value chains, revenue streams, and network effects to analyze value creation. (PI: 2.2.1)* *LO1.5: Compare digital business to select suitable models for given scenarios. (PI: 2.2.4)*	**06-08**
02.	**Digital Strategy & Transformation** ***Learning Objective:*** *To convey digital strategy frameworks and transformation.* **Contents:** Strategy Frameworks for Digital Initiatives Organizational Change & Governance Digital Roadmap Development Digital Leadership skills: innovation, risk-taking, cross-functional alignment Metrics for Digital Success (Engagement, Retention, Lifetime Value, Customer Acquisition Cost) KPI Dash boarding & Review ***Self-Learning Topics: Case study: Adoption and Challenges of Digital Payment Systems: A Study of Consumer Perception in Urban and Rural India*** ***https://jier.org/index.php/journal/article/download/1822/1526/3165***	**06-08**

	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental concepts of digital strategy frameworks to align digital initiatives with organizational vision and goals. (PI: 1.3.1)* *LO 2.2: Apply concept of governance structures, leadership roles, and capability requirements to illustrate digital transformation (PI:1.4.1)* *LO 2.3: Identify organizational, technological, and cultural factors affecting digital transformation success. (PI: 2.1.2)* *LO 2.4: Compare alternative digital transformation roadmaps to select an appropriate strategy for a given business context. (PI: 2.2.4)* *LO 2.5: Determine performance metrics for digital business outcomes and arrive at particular solution. (PI: 3.1.6)* *LO 2.6: Identify relevant organizational and technological data to develop a phased digital roadmap aligned with business objectives. (PI: 3.3.3)*	
03.	**Digital Marketing & Customer Acquisition** ***Learning Objective:*** *To educate students about different digital marketing campaigns and customer acquisition.*	**06-08**
	Contents: Digital Marketing Fundamentals Search Engine Optimization & Search Engine Marketing Basics Social Media & Influencer Marketing Content Marketing & Campaign Design Customer Journey Mapping Personalization & CRM Tools Attribution Models & Optimization Campaign optimization: A/B testing basics	
	Self-Learning Topics: ***Google Analytics beginner learning module:*** ***https://support.google.com/analytics/answer/1033863?hl=en#zippy=%2Cin-this-article***	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Identify customer journey stages and touchpoints to analyze customer behavior across digital channels. (PI: 2.1.2)* *LO 3.2: Extract conclusions from digital marketing to plan customer acquisition strategies using SEO, SEM, social media, and content marketing. (PI: 2.4.4)* *LO 3.3: Identify modern software tools and techniques to evaluate marketing campaign effectiveness using attribution models. (PI: 5.1.1)* *LO 3.4: Use CRM and marketing automation tools to improve personalization and customer engagement. (PI: 5.1.2)* *LO 3.5: Determine suitable optimization methods to improve campaign performance based on customer data. (PI: 3.1.6)* *LO 3.5: Identify relevant campaign data to design effective social media and influencer marketing strategies. (PI: 3.3.3)*	
04.	**Ecommerce & Omni channel Operations** ***Learning Objectives:*** *To teach different ecommerce models and significance of Omni channel integration in digital business.*	**06-08**

	Contents: Ecommerce Models (B2B, B2C, C2C, D2C) Payments, Fulfilment, Returns, Last-mile Logistics Omni channel Commerce Inventory Visibility & Order Management Digital Customer Service Tools Platform Selection & vendor Evaluation	
	Self-Learning Topics: *Case Studies (Amazon, Flipkart, Nykaa)* ***https://www.ijfmr.com/papers/2024/2/15084.pdf?utm***	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Identify different e-commerce business models based on business requirements to enhance customer interactions. (PI 2.1.2)* *LO 4.2: Break down e-commerce operations into payment systems, fulfilment processes, returns handling, and last-mile logistics to analyze end-to-end order delivery. (PI 2.2.1)* *LO 4.3: Compare Omni channel commerce strategies with single-channel approaches to select suitable solutions for integrated customer experiences.(PI:2.2.4)* *LO 4.4: Identify modern digital tools for inventory visibility, order management, and digital customer service to support efficient e-commerce operations.(PI:5.1.1)* *LO 4.5: Identify the strengths and limitations of e-commerce platforms and vendor tools for transaction handling, order management and scalable digital business operations. (PI: 5.2.1)*	
05.	**Data, Analytics & AI for Business** ***Learning Objective/s:*** *The guide students in data analytics and AI concepts for business enhancement.*	**07-09**
	Contents: Data-driven Decision Making Data Pipelines & SQL Basics Descriptive & Diagnostic Analytics Predictive Analytics Recommendation Engines KPI Dashboards (Tools) Communicating Data Insights	
	Self-Learning Topics: *AI Use Cases in Business:* ***https://hbr.org/2018/01/artificial-intelligence-for-the-real-world*** *Sample Power BI dashboard exploration:* ***https://learn.microsoft.com/en-us/training/powerplatform/power-bi?WT.mc_id=powerbi_landingpage-docs-link***	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Identify appropriate tools and techniques to communicate data insights effectively to stakeholders. (PI 5.1.1)* *LO 5.2: Use/modify predictive analytical tools, recommendation techniques to solve business problems. (PI 5.1.2)* *LO 5.4: Apply descriptive and diagnostic analytics to identify trends, patterns and underlying causes. (PI 2.4.1)* *LO 5.5: Extract desired understanding and conclusions consistent with data insight. (PI 2.4.4)*	

06.	**Platforms, Ecosystems, Product Delivery & Ethics** ***Learning Objective/s:*** *To familiarize learners with digital platforms and ecosystems, and develop awareness of ethical, legal, and security considerations.* **Contents:** Platform Business Models & Ecosystems Product Management Basics Agile & Lean Startup API Economy & Partnerships Ethical, Legal & Security Considerations ***Self-Learning Topics:*** ***Case study: UPI as an API-driven ecosystem: https://medium.com/digital-banking-2030/api-payment-methods-scaling-digital-payments-in-india-a2a2aa872b5c*** ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Identify platform business models and ecosystem components to improve multi-sided digital marketing. (PI: 2.1.2)* *LO 6.2: Break down product requirements into features, user stories, and constraints to analyze product scope and priorities. (PI: 2.2.1)* *LO 6.3: Identify APIs tools, partnerships and integration techniques for collaborating within digital business. (PI: 5.1.1)* *LO6.4: Use agile and lean startup practices to plan product development activities such as MVP design. (PI: 5.1.2)* *LO 6.4: Follow ethical and legal practices related to data privacy, intellectual property, and regulatory compliance in digital business platforms. (PI: 7.1.1)* *LO 6.6: Recognize the impact of security breaches, data misuse, and unethical digital practices on users, organizations, and society. (PI: 7.2.1)*	**06-08**
	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 concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.2.1	Breakdown complex problem into interconnected sub systems and analyse by proper assumptions/ justification from information and resources.
2.2.4	Compare and contrast alternative solutions to select the best methodology.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.3.3	Identify relevant data from the given resources and arrive at a best fitting design solution for particular specifications.
5.1.1	Identify modern hardware and software engineering tools, techniques and resources for engineering activities.

5.1.2 Use/adapt/modify/create tools and techniques to solve engineering problems

5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modelling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.

7.1.1 Follow ethical practices to create a document.

7.2.1 Identify and apply moral and ethical principles of IEEE professional code of ethics.

Course Outcomes: A learner will be able to -

7. Summarize the fundamental concepts, models, transformation drivers and customer experience elements of digital business. (*LO 1.1 to LO 1.5*)
8. Analyse the digital strategies, organizational reediness, transformation plans & business performance metrics to evaluate digital initiatives. (*LO 2.1 to LO 2.6)*
9. Apply digital marketing, customer acquisition methods, automation tools, and attribution techniques to develop data driven marketing insights. (*LO 3.1 to LO 3.6*)
10. Classify ecommerce and omnichannel models, evaluate digital platform, and analyse operational workflow to propose process improvements. (*LO 4.1 to LO 4.5*)
11. Use analytical tools, dashboards, SQL fundamental and AI concepts to interpret business data and communicate insights effectively. (*LO 5.1 to LO 5.4*)
12. Analyse platform ecosystem, select product development methodologies, interpret API based integrations and identify ethical/ legal concerns in digital system. (*LO 6.1 to 6.6*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7017.1	3	3									
OEC7017.2	3	3	3								
OEC7017.3		3	3		3						
OEC7017.4		3			3						
OEC7017.5		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. **K. C. Laudon and J. P. Laudon,** *Management Information Systems: Managing the Digital Firm*, latest ed. Harlow, U.K.: Pearson Education.
2. **D. L. Rogers,** *The Digital Transformation Playbook: Rethink Your Business for the Digital Age*, New York, NY, USA: Columbia Business School Publishing, 2016.

K. Sandeep & J. J. Jose, Digital Business Management, Himalaya Publishing House.

3. **A. Osterwalder and Y. Pigneur,** *Business Model Generation*, Hoboken, NJ, USA: Wiley, 2010.
4. **E. Brynjolfsson and A. McAfee,** *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York, NY, USA: W. W. Norton & Company, 2014.
5. **P. Kotler, H. Kartajaya, and I. Setiawan,** *Marketing 5.0: Technology for Humanity*, Hoboken, NJ, USA: Wiley, 2021.

Reference Books :

2. **T. Eisenmann, G. Parker, and M. Van Alstyne,** *Platform Revolution: How Networked Markets Are Transforming the Economy*, New York, NY, USA: W. W. Norton & Company, 2016.
2. **R. T. Rust, M.-H. Huang, and S. J. Lin,** *Service Analytics and Digital Transformation*, Springer, Cham, Switzerland, 2019.
3. **S. Sharda, D. Delen, and E. Turban,** *Business Intelligence, Analytics, and Data Science: A Managerial Perspective*, 4th ed. Boston, MA, USA: Pearson, 2020.
4. **M. Porter and J. Heppelmann,** *How Smart, Connected Products Are Transforming Companies*, Boston, MA, USA: Harvard Business Review Press, 2015.
5. **A. Chaffey and F. Ellis-Chadwick,** *Digital Marketing: Strategy, Implementation and Practice*, 8th ed. Harlow, U.K.: Pearson Education, 2022.

Other Resources :

1. Digital Business – IIT Kharagpur (Prof. S. Ray) NPTEL Course – Highly aligned with Digital Strategy, Platforms, Digital Models.
2. Marketing Management – IIT Roorkee / IIT Kanpur (Digital marketing modules included) Covers customer journey, campaigns, analytics basics.
3. Introduction to Industry 4.0 and Industrial Internet of Things – IIT Kharagpur Useful for Module 1 (Digital Transformation Drivers).

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested break up of distribution:

a) Activities/Case studies: 10 Marks

c) Open book test/Class assignment: 05 Marks

d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (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
OEC	OEC8029	ENVIRONMENTAL MANAGEMENT	03

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

Program Outcomes addressed:

1. PO6 : The engineer & The World
2. PO7 : Ethics
3. PO10: Project Management and Finance

Course Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Module	Details	Hrs.
	Course Introduction	**01**
01.	**Introduction and Definition of Environment**	**9-11**
	Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	
02.	**Global Environmental concerns**	**6-8**
	Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	
03.	**Concepts of Ecology**	**5-7**
	Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	
04.	**Environmental Management and Government Regulation**	**10-12**
	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	
05.	**Quality-Based Environmental Management and ISO 14000 Framework**	**5-7**
	Total Quality Environmental Management, ISO-14000, EMS certification.	

06.	**Overview of Environmental and Industrial Legislations**	**2-4**
	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	
	Course Conclusion	**01**
Total no. of hours		**45**

Course Outcomes : Learner will be able to

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

References:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Course Type	Course Code	Course Name	Credits
MJP	MJP802	Major Project-B	04

A. Guidelines for the Major Project-B

1. Project Continuation

- **The project initiated in Semester VII (Major Project – A) continues in Semester VIII.**
- **Project Objectives, Outcomes, and POs remain the same.**

2. Focus for Semester VIII

- **This phase emphasizes completion, optimization, testing, performance evaluation, and deployment (where applicable).**
- **Students should work toward:**
  - **Validation through experiments, benchmarking, or user trials**
  - **Technical documentation and dissemination (paper, poster, demonstration)**

3. Research and Innovation Encouragement

- **Teams are encouraged to:**
  - **Present papers in conferences/symposia/workshops**
  - **Participate in inter-college / national project competitions or hackathons**
  - **Submit project outcomes to innovation cells, incubation centres, etc.**
- **Such activities carry marks under In-Semester Continuous Assessment (CIA).**

4. Project Execution and Supervision

- **The guide continues to monitor weekly progress and maintain:**
  - **Work logs**
  - **Attendance**
  - **Contribution records**
- **The department's Project Progress Monitoring Committee shall evaluate at least two progress reviews during the semester.**

5. Project Report (Final Submission)

The final project report must include:

- **Revised/Final Abstract**
- **Literature Review (updated if needed)**
- **Final System Design, Implementation, and Architecture**
- **Experimental Setup and Evaluation Parameters**
- **Results with Comparative Analysis**
- **Discussion, Conclusion & Limitations**
- **Future Scope and Applications**
- **References (IEEE format preferred)**
- **Appendices (Certificates, Publications, Competition Participation, etc.)**

B. In-Semester Continuous Assessment (CIA) — *Total: 50 Marks*

Component	Description	Marks
Progress Review Presentation I	Demonstration of implementation progress with clarity in design and execution	**10**
Progress Review Presentation II	Demonstration of testing, validation, and refinement; readiness for final deployment	**10**
Research / Innovation Activities	• Participation/winning in project competitions, hackathons, etc. • Technical paper writing/presentation/publication	**05** **10**
Final Draft Report (Spiral/Soft Copy)	Quality of documentation, structure, clarity, proper referencing, and reflection of actual work	**10**
Regularity & Active Participation	Consistent attendance, timely submissions, teamwork, individual responsibility, and weekly log progress	**05**

C. End Semester Examination (ESE) — *Total: 50 Marks*

Examination by Internal + External Examiners

Component	Description	Marks
Project Demonstration / Prototype Performance	**Functional correctness, performance, robustness, completeness of implementation**	**20**
Oral Presentation and Defence	**Clarity in explaining methodology, decisions, results, and the ability to answer technical questions**	**15**
Project Report (Final Hard-Bound Submission)	**Technical depth, coherence, experimental analysis quality, formatting standards, and completeness**	**10**
Individual Contribution Assessment	**Clear evidence of individual technical contribution and responsibility within the team**	**05**