Shree Rahul Education Society's (Regd.)

SHREE L. R. TIWARI COLLEGE OF ENGINEERING

An Autonomous Institute Affiliated to University of Mumbai,

Approved by AICTE & DTE, Maharashtra State | NAAC Accredited, NBA Accredited Program | ISO 9001:2015 Certified |
DTE Code No: 3423 | Recognized under Section 2(f) of the UGC Act 1956 | Minority Status (Hindi Linguistic)

Shree Rahul Education Society's (Regd.)

Shree L.R. Tiwari College of Engineering

Shree L.R. Tiwari Educational Campus,

Mira Road–East, Thane-401107.

Maharashtra, India

www.slrtce.in

An Autonomous Institute Affiliated to the University of Mumbai

Department of Mechanical Engineering

Curriculum TY A.Y 2026-27

Third Year Syllabus

Revision: R-2025

PREAMBLE

"Think. Design. Innovate. – Learning that Leads the Future."

SLRTCE is proud to be among the youngest institutions to attain academic autonomy—an achievement that strengthens our commitment to becoming a world-class centre for socio- economic development and quality education. It is with great pride and purpose that we introduce the restructured curriculum under academic autonomy at SLRTCE. This initiative marks a significant step toward transforming engineering education by equipping our graduates with strong technical foundations, research acumen, interdisciplinary perspective, and an innovation-driven mindset essential for success in today's evolving professional landscape.

1. **Curriculum Design:** Theme-Based, Experiential, and Outcome-Oriented The autonomous curriculum adopts a bottom-up, learner-centric approach aligned with all 12 Program Outcomes. Each semester is driven by a central societal or technological theme, with problem statements rooted in local needs, socio-economic priorities, and the UN Sustainable Development Goals (UNSDGs). Students engage with these challenges through individual projects in the IDEA Lab, integrating social science methodologies with engineering solutions to foster innovation, contextual learning, and socially responsible problem-solving.

2**. Purpose of Autonomy:** Empowering Innovation and Real-World Learning Our pursuit of autonomy is rooted in bridging the gap between academic learning and industry relevance. By integrating undergraduate research through the IDEA Lab—our dedicated innovation and problem-solving hub—students engage with real-world challenges, apply interdisciplinary knowledge, and develop socially impactful solutions. This approach nurtures engineers who are not only technically sound but also responsible and creative thinkers.

3. **Alignment with National Education Policy-2020:** Aligned with NEP 2020, the curriculum emphasizes multidisciplinary, hands-on learning. Through theme-based projects, electives, value-added courses, and flexible assessments, SLRTCE ensures holistic student development driven by real-world application and academic rigor. SLRTCE, as a part of Rahul Education, benefits from being in a network of HEIs. All Higher Education Institutions under Rahul Education can collectively contribute to curriculum development, promoting multidisciplinary studies.

4. **Innovative Pedagogy Initiative by IQAC As part of its transformation strategy**, IQAC has introduced an innovative pedagogy model centred on interdisciplinary research and contextual problem-solving. The IDEA Lab enables students to apply subject knowledge through socially relevant projects, supported by design thinking and faculty mentorship. A two-tier assessment framework—covering both project execution and subject-wise application—ensures academic depth, continuous mentoring, and quality assurance.

5. **Empowering Faculty as Mentors and** Innovators: SLRTCE believes that the success of academic autonomy lies in the hands of its faculty. By empowering educators to think beyond conventional boundaries, we enable them to instil Knowledge, Skills, and Attitudes (KSA) in students while enriching their own professional growth. Faculty serve as research mentors and project guides, supported through structured training in innovation pedagogy and assessment**.**

Sincerely,

IQAC Chairperson
SLRTCE

COO
Rahul Education

PREMABLE(BOS)

The Department of Mechanical Engineering at Shree L. R. Tiwari College of Engineering (SLRTCE), in its pursuit of academic excellence and societal relevance, is proud to present a reimagined curriculum grounded in problem- based learning, interdisciplinary education, and United Nations Sustainable Development Goals (UNSDGs). In alignment with the institution's vision and guided by the framework established under the National Education Policy (NEP) 2020, this curriculum represents a radical shift from traditional teaching methods to a learner-centric, project-driven, and purpose-oriented pedagogy. At the heart of the revised curriculum lies a unique theme-based approach across all eight semesters. Each semester is anchored around a specific real-world theme, from which six problem statements are derived. These problem statements are strategically mapped to relevant UNSDGs and used to design the semester's core content—ensuring that students not only gain engineering knowledge but also understand its application in solving pressing global and local challenges.

The Mechanical Engineering syllabus has been restructured to:

- Promote experiential and contextual learning through mini-projects, hands-on labs, internships, and industry-led assignments.
- Build core competencies in design, manufacturing, energy, sustainability, automation, and digital technologies.
- Introduce multidisciplinary perspectives through minors, open electives, and entrepreneurship/management courses.
- Equip students for employability, innovation, and lifelong learning through skill development courses, real- industry projects, and value-based education. Each course—be it core or elective—is developed with explicit learning outcomes, aligned with Bloom's Taxonomy and designed to build competencies progressively.

The curriculum introduces verticals such as: Professional Core & Elective Courses tailored to each semester's problem context.

Skill-based Courses integrated into early semesters to foster practical ability and confidence. Multidisciplinary Minors and Open Electives to broaden student horizons and promote cross-functional thinking.

Humanities and Social Science Courses to instill soft skills, ethics, and a sense of societal responsibility. Furthermore, the final deliverable in each academic year, especially in the final year, is a capstone project—a tangible solution addressing the selected problem statement. This ensures that our graduates are not just academically sound but are also socially aware and innovation-ready.

With a total credit load of 160, thoughtfully distributed across all components, the curriculum ensures academic balance, manageable workload, and a pathway for students to graduate with honors/minor specializations, should they choose to do so. This forward-thinking curriculum is a testament to the department's commitment to nurture technically proficient, ethically grounded, and globally competent mechanical engineers—ready to lead in industries, research, and entrepreneurship while addressing societal and environmental needs. On behalf of the Board of Studies, I express deep appreciation to all contributors—faculty, industry experts, alumni, and academic leaders—who collaboratively shaped this transformative educational journey.

Let us move forward with the shared vision of redefining mechanical engineering education to meet the needs of Today's students, tomorrow's technologies, and humanity at large.

Dr. Abhijit Samanta
Chairperson,
Board of Studies
Mechanical Engineering Department
SLRTCE

A. Abbreviations

AEC	Ability Enhancement Course
AECL	Ability Enhancement Course Laboratory
AU	Audit Course
BSC	Basic Science Course
BSCL	Basic Science Course Laboratory
CC	Co-Curricular Courses
CEP	Community Engagement Project
ELC	Experiential Learning Course
ESC	Engineering Science Course
ESCL	Engineering Science Course Laboratory
EMC	Entrepreneurship/economics/management courses
HSSM	Humanities Social Sciences and Management
IKS	Indian Knowledge System
INTR	Internship
L	Lecture
LC	Laboratory Course
LLC	Liberal Learning Course
MDM	Multidisciplinary Minor
MDML	Multidisciplinary Minor Laboratory
OE	Open Elective
OJT	On Job Training
P	Practical
PROJ	Project
PCC	Program Core Course
PCCL	Program Core Course Lab
PEC	Program Elective Course
RM	Research Methodology
SL	Self-Learning
T	Tutorial
VEC	Value Education Course
VSEC	Vocational and Skill Enhancement Course

Curriculum Structure and Examination Scheme for B.Tech. in Mechanical (FY with Effect from AY 2026-2027) Curriculum Structure – TY Semester-V

Course Code	Course Type	Course Name	Teaching Scheme (Contact Hours Per Week)			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30)	Examination Scheme				Exam Duration for Theory (in Hrs.)	Term Work	Practical / Oral	Total
												In-Semester Assessment			End Semester Exam (ESE)				
			L	T	P	L	T	P	SL	Notional Learning		IAT-I	IAT-II	Total					
16211501	PCC	Finite Element Analysis	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	--	--	100
16211502	PCC	Thermal and Fluid Engineering	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	--	--	100
16211503	PCC	Dynamics of Machinery	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	--	--	100
16212504	PCC LAB	Finite Element Analysis Lab	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	25	50
16212505	PCC LAB	Thermal and Fluid Engineering Lab	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	25	50
16212506	PCC LAB	IDEA LAB -5 (Innovation Design Engineering and Apply)	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	25	50
1621157X	PEC-III	Program Elective Course-III	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	--	--	100
9931158WW	MDM-III	Operation Planning and control	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	--	--	100
16412509	VSEC*	Professional Communication and Ethics - II	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	--	25

99512510 WW	OE-III*	Open Elective-III	2	--	--	30	--	--	30	60	2	--	--	--	--	--	25	--	25
Total			**17**	**–**	**8**	**285**	**–**	**90**	**285**	**630**	**21**	**100**	**100**	**200**	**300**	**12.5**	**125**	**2.5**	**700**

Program Elective-III	
Course Code	**Name of the Course**
16211571	**Metrology and Mechanical Measurement**
16211572	**Industrial Engineering**
16211573	**Power Plant Engineering**

Open Elective-III	
Course Code	**Name of the Course**
9951251001	International Financial Management
9951251002	Marketing Management - I
9951251003	HR Analytics
9951251004	Operations and Supply Chain Management
9951251005	Quantitative Investment Management
9951251006	Economics of Banking and Finance Markets
9951251007	Corporate Finance
9951251008	Principles of Behavioral Economics

Students who achieve a CGPI of 7.5 or higher by the end of the semester VI are eligible to pursue an additional 18 credits from the semesters V to VIII to qualify for a B. Tech degree with Honors

Curriculum Structure and Examination Scheme for B.Tech. in Mechanical (TY with Effect from AY 2026-2027) Curriculum Structure – TY Semester-VI

Course Code	Course Type	Course Name	Teaching Scheme (Contact Hours Per Week)			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30)	Examination Scheme				Exam Duration for Theory (in Hrs.)	Term Work	Practical & Oral	Total
												In-Semester Assessment			End Semester Exam (ESE)				
			L	T	P	L	T	P	SL	Notional Learning		IAT-I	IAT-II	Total					
16211601	PCC	Machine Design	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	–	–	100
16211602	PCC	Turbo Machinery	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	–	–	100
16211603	PCC	Heating, Ventilation, Air conditioning and Refrigeration	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	–	–	100
16212604	PCC LAB	Heating, Ventilation, Air conditioning and Refrigeration Lab	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	25	50
16212605	PCC LAB	Turbo Machinery Lab	--	--	2	--	--	30	--	30	1	--	--	--	--	--	25	25	50
16212606	PCC LAB	Dissertation I	--	--	2	--	--	30	--	30	1	--	--	--	--	--	50	50	100
1621167X	PEC-IV	Program Elective Course-IV	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	–	–	100
9931168WW	MDM-IV	Product Design and Development	3	--	--	45	--	--	45	90	3	20	20	40	60	2.5	–	–	100

98452609	VEC*	Industrial Skill	2	--	--	30	--	--	30	60	2	–	–	–	–	–	25	–	25
99512610 WW	OE-IV*	Open Elective-IV	2	--	--	30	--	--	30	60	2	–	–	–	–	–	25	--	25
Total			**19**	--	**6**	**285**	**--**	**90**	**285**	**660**	**22**	**100**	**100**	**200**	**300**	**12.5**	**150**	**100**	**750**

Program Elective-IV	
Course Code	**Name of the Course**
16211671	**Automation and Artificial Intelligence**
16211672	**Mechatronics**
16211673	**Renewable Energy System**

Open Elective-IV	
Course Code	**Name of the Course**
9951261001	Moral Thinking: Introduction to Values and Ethics,
9951261002	Ethics in Engineering Practice,
9951261003	Introduction to Psychology,
9951261004	Direct foreign language courses (like German, French),
9951261005	Financial Institutions and Markets,
9951261006	Investment Management
9951261007	Introduction to Sociology
9951261008	Cultural Studies Language for Competitive Exams

Note:

1. Questions based on self-learning must not be asked in internal assessment and End semester Exam

2. IDEA Lab: The IDEA Lab fosters individual interdisciplinary projects through theme-based, subject-integrated, experiential learning, assessed via standardized rubrics for innovation, application, and documentation.

3. Notional Learning Hours: In higher education, Notional Learning Hours (NLH) indicates the estimated time that a typical learner, at a specific academic level, is expected to invest in order to achieve the set learning outcomes of a course or module. This time includes a range of structured and independent learning activities, each contributing to the development of knowledge and competencies within a module

4. Self-Learning (SL): Self-learning is integrated into both theory and practical subjects, particularly where practical sessions have only one contact hour per week. It emphasizes student-driven efforts in preparing for assignments, practicals, and examinations. Additionally, self-learning includes topics that go beyond the prescribed syllabus to align with current industry trends and requirements. Assessment of self-learning will follow a formative approach. For theory subjects that include term work, 30% of the assignment questions and student presentations/discussions should be based on self-learning topics. In subjects without term work, the corresponding laboratory sessions will incorporate self-learning, carrying a weightage of 30%. The subject with no term work and practical will have no assessment on self-learning topics. This may involve laboratory work using the latest tools or preparing technical write-ups/research papers on advanced topics.

Note:

1. Questions based on self-learning must not be asked in internal assessment and End semester Exam

2. IDEA Lab: The IDEA Lab fosters individual interdisciplinary projects through theme-based, subject-integrated, experiential learning, assessed via standardized rubrics for innovation, application, and documentation.

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THEME FOR MECHANICAL ENGINEERING FOR THIRD YEAR

SEM V

Theme: "Urban System"

Aligned with **UNSDG 4 – Quality Education, UNSDG 7: Affordable and Clean Energy, UNSDG 9: Industry, Innovation, and Infrastructure**. UN**SDG 12 – Responsible Consumption and Production**

Keywords: **core technical proficiency**, **hands-on learning**, and **computational thinking**

The theme "Engineering Foundations for Sustainable Futures" is a powerful and relevant framework for engineering education, deeply intertwined with the United Nations Sustainable Development Goals.

UNSDG 12: – Responsible Consumption and Production

- **Comprehensive Skill Development**: Projects under SDG 12 encourage students to apply a range of technical skills including mechanical design, electronics, software development, environmental science, and data analysis. These hands-on, real-world challenges help cultivate problem-solving, project management, teamwork, and innovation skills vital to future engineers.
- **Relevance and Future-Proofing**: With increasing regulations and global attention on sustainability, engineers who understand and implement responsible production strategies are highly valued. These projects expose students to global sustainability frameworks and prepare them for careers in green technology, sustainable infrastructure, and circular product design.
- **Innovation and Creativity**: Solving the challenges of sustainable production often requires out-of-the-box thinking. Students are encouraged to innovate by designing biodegradable products, improving recycling mechanisms, and rethinking traditional manufacturing systems in eco-friendly ways.
- **Interdisciplinary Approach**: SDG 12-based projects blend concepts from materials science, mechanical and electrical engineering, environmental studies, design thinking, and digital tools. This integrated learning fosters collaboration across disciplines, encouraging holistic problem-solving approaches that mirror real-world scenarios.

UNSDG 7: Affordable and Clean Energy

- **Renewable Energy Technologies:** Core technical proficiency provides the fundamental knowledge for understanding and developing renewable energy sources like solar, wind, geothermal, and hydropower. Hands-on learning allows students to build and test components of these systems, while computational thinking enables them to optimize their efficiency and integration into grids.

- **Energy Efficiency and Conservation:** Students learn to design systems and processes that minimize energy consumption. This includes optimizing building designs, developing more efficient manufacturing processes, and creating smart grids.
- **Energy Storage Solutions:** The theme supports the development of advanced energy storage technologies, crucial for the reliability of renewable energy sources. This involves understanding materials science, electrochemical processes, and computational modeling for battery design and management.
- **Policy and Economic Considerations:** While primarily technical, the theme indirectly promotes an understanding of the economic and policy landscapes surrounding affordable and clean energy, encouraging engineers to design solutions that are not only technically sound but also economically viable and accessible.

UNSDG 9: Industry, Innovation, and Infrastructure

- **Sustainable Infrastructure Design:** The theme promotes the design and construction of infrastructure that is resilient, resource-efficient, and has a minimal environmental footprint. This includes green buildings, smart cities, sustainable transportation networks, and water management systems.
- **Industrial Transformation:** Engineers with a strong foundation in this theme can drive innovation in industries by developing sustainable manufacturing processes, promoting circular economy principles, and integrating renewable energy into industrial operations.
- **Technological Advancement:** Computational thinking, in particular, drives innovation by enabling the development of advanced materials, AI-powered systems for resource optimization, and sophisticated simulations for testing new technologies before large-scale deployment.
- **Resilient Systems:** The focus on foundational engineering principles ensures that the innovations and infrastructure developed are robust and resilient, capable of withstanding environmental stresses and adapting to changing conditions. This is crucial for long-term sustainability.
- **Access to Technology:** By fostering a strong engineering foundation, the theme indirectly contributes to making technology more accessible and affordable, promoting inclusive industrialization and innovation.

Problem Statement 1: To study challenges in urban systems and demonstrate a very system for improved service efficiency.

Problem Statement 2: To observe urban resource usage and demonstrate a very system for better coordination.

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Problem Statement 3: To study urban service practices and demonstrate an every system supporting sustainability.

Problem Statement 4: To observe operational patterns in urban environments and demonstrate an every system for improvement.

Problem Statement 5: To study urban infrastructure needs and demonstrate an every system for better management.

Problem Statement 6: To observe public service usage and demonstrate an every system for efficient operation.

Problem Statement 7: To study urban system behavior and demonstrate an every system supporting organized functioning.

Problem Statement 8: To observe service-related challenges in urban areas and demonstrate an every system for enhancement.

Problem Statement 9: To study urban system behavior and demonstrate a very basic system supporting organized functioning.

Problem Statement 10: To observe service-related challenges in urban areas and demonstrate a very basic system for enhancement.

SEM VI

Theme: “Healthcare Systems"

Aligned with **UNSDG 6- Clean Water and Sanitation, UNSDG 7: Affordable and Clean Energy, and UNSDG 11: Sustainable Cities and Communities**

Keywords: **core technical competence, practical experience, and computational thinking**

The theme “Building **Resilient and Resource-Efficient Systems for Sustainable Development** " is a powerful and relevant framework for core technical thinking in order to equip students with a solid foundation in engineering, deeply intertwined with the United Nations Sustainable Development Goals.

UNSDG 6- Clean Water and Sanitation

- **Comprehensive Skill Development:** The theme directly supports quality education by fostering a holistic set of skills: foundational knowledge, practical application, and analytical thinking. This goes beyond rote memorization, encouraging deep understanding and the ability to apply learning to complex real-world challenges.
- **Relevance and Future-Proofing:** By focusing on "sustainable futures," the curriculum becomes highly relevant to global challenges. It equips students with the skills needed to address critical issues like climate change, resource scarcity, and equitable access to resources, making their education future-proof and impactful.
- **Innovation and Creativity:** Hands-on learning and computational thinking encourage innovative problem-solving and creative design. Students are empowered to not just understand existing solutions but to develop new ones that are more sustainable and efficient.
- **Interdisciplinary Approach:** Addressing sustainable futures often requires interdisciplinary collaboration. A strong engineering foundation, coupled with an understanding of sustainability principles, prepares students to work across disciplines to find integrated solutions.

UNSDG 7: Affordable and Clean Energy

- **Comprehensive Skill Development:** To advance affordable and clean energy, individuals must be trained in a range of competencies including renewable energy technologies (solar, wind, bioenergy), energy efficiency strategies, smart grid systems, and sustainable infrastructure planning. Additionally, soft skills like project management, stakeholder engagement, and policy advocacy are crucial to drive implementation and scale-up of clean energy initiatives.

- **Relevance and Future-Proofing:** As the global energy landscape shifts towards sustainability, skill development must anticipate the rising demand for green jobs. Programs should integrate real-time industry needs and prepare individuals for evolving roles in energy storage, electric mobility, carbon-neutral systems, and energy equity. Future-proofing means equipping the workforce with adaptive learning strategies to remain resilient amid rapid technological and regulatory changes.
- **Innovation and Creativity:** Solving energy access challenges, especially in off-grid and underserved areas, requires innovative thinking. Creative solutions like decentralized renewable systems, energy-as-a-service models, and clean-tech startups are vital. Encouraging innovation enables the design of context-specific technologies that are affordable, scalable, and sustainable.
- **Interdisciplinary Approach:** Achieving SDG 7 demands collaboration across engineering, environmental science, economics, social policy, and data science. Energy solutions must integrate technical design with policy frameworks, community behavior, and financial models. This interdisciplinary approach ensures more inclusive and effective energy systems that consider environmental, social, and economic dimensions.

UNSDG 11: Sustainable Cities and Communities

- **Comprehensive Skill Development:** Creating sustainable cities requires a diverse set of skills across urban planning, sustainable architecture, green infrastructure, transportation systems, waste management, and disaster resilience. Additionally, skills in stakeholder engagement, data analysis, and community participation are essential to ensure that development is inclusive, equitable, and responsive to local needs.
- **Relevance and Future-Proofing:** Urban populations are growing rapidly, and cities must adapt to challenges such as climate change, migration, housing shortages, and infrastructure strain. Equipping professionals and citizens with future-oriented skills—like smart city technologies, climate-resilient design, and circular economy principles—ensures urban systems remain livable and resilient in the face of uncertainty and change.
- **Innovation and Creativity:** Sustainable urban development thrives on innovative approaches to housing, mobility, public space, and resource use. Solutions like green roofs, community-driven urban farming, micro-mobility, and digital urban management tools rely on creative thinking to reimagine how cities can function more sustainably while enhancing quality of life.
- **Interdisciplinary Approach:** Sustainable cities are shaped at the intersection of multiple fields: urban planning, engineering, public health, environmental science, economics, and social policy. An interdisciplinary approach allows for holistic planning that integrates infrastructure, environment, governance, and culture—ensuring urban development is both human-centered and ecologically sound.

Problem Statement 1: To study healthcare practices and demonstrate a every system for improved patient support.

Problem Statement 2: To observe healthcare processes and demonstrate a every system for better care management.

Problem Statement 3: To study challenges in healthcare environments and demonstrate a every system supporting service efficiency.

Problem Statement 4: To observe health-related practices and demonstrate a every system for improved monitoring support.

Problem Statement 5: To study healthcare service needs and demonstrate a every system for better coordination.

Problem Statement 6: To observe patient-care activities and demonstrate a every system supporting effective management.

Problem Statement 7: To study healthcare system behavior and demonstrate a every system for enhancement.

Problem Statement 8: To observe health service challenges and demonstrate a every system for improved functioning.

Problem Statement 9: To study healthcare system behavior and demonstrate a very basic system for enhancement.

Problem Statement 10: To observe health service challenges and demonstrate a very basic system for improved functioning.

SEM 5

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)				Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211501	**Finite Element Analysis**	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211501	**Finite Element Analysis**	**20**	**20**	**40**	**60**	**2.5**	**--**	**--**	**100**

Rationale:

Finite Element Analysis (FEA) is a vital computational technique rooted in the principles of Mechanical Engineering, serving as a bridge between theoretical mechanics and real-world applications. The FEA course enables students to understand how complex structures and components respond to various loads, constraints, and environmental conditions by breaking them down into simpler elements.

It equips students with the skills to analyse stress, strain, deformation, and failure in components using simulation tools. This course lays a strong foundation for subjects like Advanced Structural Analysis, Machine Design, and Thermal Systems. FEA is widely applicable across multiple engineering disciplines, including Civil, Aerospace, Automotive, and Biomedical Engineering, making it essential for designing safe, reliable, and optimized engineering solutions.

Course Objectives:

1. **Understand** the fundamentals of weighted residual methods for solving differential equations relevant to engineering applications. *(Understand)*
2. **Explain** the process of deriving finite element equations from governing second-order differential equations. *(Understand)*
3. **Apply** one-dimensional finite element formulation techniques to analyze simple engineering structures and **develop** basic Python code to solve them. *(Apply/Create)*
4. **Apply** two-dimensional finite element methods to analyze mechanical components under plane stress, strain, and axisymmetric conditions. *(Apply)*
5. **Analyze** and **interpret** results related to natural frequency estimation of single-degree-of-freedom vibration systems using FEA. *(Analyze)*

6. **Demonstrate** the ability to use commercial FEA software tools to model, simulate, and solve real-life mechanical engineering problems. *(Apply/Evaluate)*

Course Outcomes:

1. **Solve** differential equations using weighted residual methods. *(Apply/Analyze)*
2. **Develop** the finite element equations to model engineering problems governed by second-order differential equations. *(Create)*
3. **Apply** the basic finite element formulation techniques to solve engineering problems using one-dimensional elements and **write** corresponding Python code. *(Apply/Create)*
4. **Apply** the finite element formulation techniques to analyze engineering problems using two-dimensional elements. *(Apply/Analyze)*
5. **Apply** two-dimensional finite element methods to analyze mechanical components under plane stress, strain, and axisymmetric conditions.. *(Apply/Analyze)*
6. Apply commercial FEA software, to solve problems related to mechanical engineering. *(Apply)*

Prerequisite: Knowledge of Engineering Mechanics, Mechanics of Solids, Heat Transfer

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Differential equations (Formulation and solution, Types-Ordinary, Partial, Order and degree of the DE and the boundary conditions) Matrix algebra (Matrix operations, gauss elimination method to get inverse the inverse of matrix) Basics of the core field (Governing laws, relationship between the various variables and constants –like in structural field stress-strain, Thermal field-temp, heat transfer rate etc		CO1
I	**Introduction to Weighted Residual Methods**	1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM 1.2 Mathematical Modelling of field problems in engineering, Governing Differential equations,	7	CO1

		primary/secondary variables, boundary conditions types- essential/natural etc 1.3 Approximate solution of differential equations, Weighted residual methods (Galerkin , Subdomain method)		
		Self-learning Topics: Differential equations for stepped bar, shaft and heat transfer	7	
II	**FEA Procedure:(Pre-processing, Processing, Post-processing)**	2.1 Discrete and Continuous Models, Weighted Residual Methods – Ritz Technique- Basic Concepts of the Finite Element Method. 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom. 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', assembly concepts to develop system equation.	8	CO2
		Self-learning Topics: Integration by partS	8	
III	**One Dimensional Problems**	3.1 One dimensional second order equations - discretization-element types - linear and higher order elements - derivation of shape functions and stiffness matrices and force vectors. 3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, Spring-Cart Systems) 3.3 Analysis of Plane trusses, Analysis of Beams	7	CO3
		Self-learning Topics: Matrix Augmentation	7	

IV	**Two Dimensional Finite Element Formulations**	4.1 Introduction, three nodes triangular element, four nodes rectangular element 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. 4.3 Convergence criterion, sources of errors	8	CO4
		Self-learning Topics: Lagrange's methods	8	
V	**Two Dimensional Vector Variable Problems**	5.1 Equations of elasticity - Plane stress, plane strain and axi-symmetric problems 5.2 Jacobian matrix, stress analysis of CST.	7	CO5
		Self-learning Topics: Stress Strain Relationship for cube	7	
VI	**Finite Element Formulation of Dynamics and Numerical Techniques:**	6.1 Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices. 6.2 Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams.	8	CO6
		Self-learning Topics: Basics of vibration	8	

Text Books:

1 Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
2 Finite Element Method by J N Reddy, TMH
3 Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu, Pearson Education

References:

1 'Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S,

Plesha ME, John- Wiley Sons
2 The Finite Element Method in Engineering by S. S. Rao, Butter Worth Heinemann
3 Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112/104/112104193/
2	https://nptel.ac.in/courses/105/106/105106051/
3	https://nptel.ac.in/courses/112/104/112104115/
4	https://nptel.ac.in/courses/112/103/112103295/
5	https://nptel.ac.in/courses/112/106/112106135/
6	https://nptel.ac.in/courses/112/106/112106130/
7	https://nptel.ac.in/courses/105/105/105105041/
8	https://nptel.ac.in/courses/112/104/112104116/

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...

- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)				Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211502	**Thermal and Fluid Engineering**	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211502	**Thermal and Fluid Engineering**	**20**	**20**	**40**	**60**	**2.5**	**--**	**--**	**100**

Rationale:

Thermal and Fluid Engineering is a core subject in mechanical and related engineering disciplines that deals with the principles of energy, heat, and fluid flow, which are essential for understanding and designing a wide range of engineering systems. This course provides a strong foundation in thermodynamics, fluid mechanics, and heat transfer, enabling students to analyze how energy is generated, converted, transmitted, and utilized in practical applications. It helps in understanding the working of equipment such as engines, turbines, boilers, pumps, compressors, and heat exchangers, which are widely used in industries like power plants, refrigeration and air-conditioning, automotive, and manufacturing. The subject also develops analytical and problem-solving skills by applying fundamental laws such as conservation of mass, momentum, and energy to real-life engineering problems. It bridges theoretical concepts with practical applications, preparing students to design, operate, and maintain efficient thermal and fluid systems.

Overall, this course is essential for building competency in energy-efficient system design, sustainable engineering practices, and industrial applications, making it highly relevant for modern engineering challenges.

Prerequisite: Basic Thermodynamics, Engineering Mathematics, Fluid Mechanics

Course Objectives:

1. To understand fluid flow principles and flow measurement methods.
2. To study compressible flow behavior and its applications.
3. To understand the construction, classification, and performance of steam generators.
4. To study the working and cycles of internal combustion engines.
5. To understand engine combustion, fuel injection, and emission control.
6. To evaluate engine testing and performance characteristics.

Course Outcomes:

1. Apply Bernoulli's equation and momentum principles to analyze fluid flow and flow measuring devices.
2. Analyze Mach number, choked flow, stagnation properties, and compressible flow systems.
3. Explain the working, classification, and performance evaluation of boilers.
4. Analyze SI and CI engine operation, valve timing, fuel-air cycles, and combustion.
5. Evaluate combustion and emission characteristics of SI and CI engines with emission standards.
6. Analyze engine performance parameters and prepare heat balance sheets.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Dynamics of Fluid Flow**	**1.1 Fundamentals of Fluid Dynamics** Introduction, equations of motion, Euler's Equation of Motion, and Bernoulli's Equation (assumptions and real fluids). **1.2 Measurement & Applications** Applications of Bernoulli's equation: Venturimeter, Orifice Meter, and Pitot Tube. **1.3 Momentum Principles & Flow Behavior** Momentum equation, moment of momentum equation, and free liquid flow.	**07**	**CO1**

		Self Learning Topic: Fluid Motion Fundamentals	**07**	
II	**Compressible Flow**	**2.1 Fundamentals of Compressible Flow** Basic equations, velocity of sound (isothermal, adiabatic, bulk modulus), Mach number, and propagation of pressure waves. **2.2 Stagnation Properties and Flow Relations** Stagnation pressure, temperature, density, and area–velocity relationship. **2.3 Compressible Flow Applications** Flow through nozzles, orifices, and tubes; critical pressure ratio, choked flow, maximum mass flow rate, and venturimeter. Mass Rate of Flow of Compressible Fluid Through Venturimeter Flow Through Tube in a Compressible Flow	**08**	**CO2**
		Self Learning Topic: Basics of Compressible Flow	**08**	
III	**Fundamentals of Steam Generators and performance**	**Steam Generators-** Layout of Thermal Power Plant, Classification of boiler, Difference between Fire tube and Water tube boiler with examples, Low pressure and high pressure boilers, once through boiler, important features of HP boilers, Mountings and accessories, Equivalent evaporation of boilers, Boiler performance, Boiler efficiency	**07**	**CO3**
		Self-Learning Topic: Steam Generator Fundamentals	**07**	
IV	**Internal Combustion Engines – Basics**	4.1 Introduction to I.C. Engines and its Classification. Working of Four stroke and Two-stroke engines, Valve Timing Diagram. Fuel air cycles, Actual cycle. 4.2 Introduction to Fuel Supply, Ignition, combustion and knocking in SI Engines. MPFI in SI Engine.	**08**	**CO4**
		Self-Learning Topic: IC Engine Working Principles	**08**	
V	**Engine Combustion and Emissions**	5.1 Introduction to Fuel Injection system, Combustion and detonation in CI Engines. **5.2 Engine Emission and Control:** Sources of Engine Emissions**,** Constituents of S.I. and C.I. Engine	**07**	**CO5**

		exhaust and their effects on environment and health. Study of emission (Euro & Bharat stage) norms, Control methods for S.I and C I engine emissions.		
		Self-Learning Topic: CI Engine Combustion Systems	**07**	
VI	**Engine Performance**	**Engine Testing and Performance**: Measurement of various performance parameters, Performance characteristic of SI and CI Engine, Effect of load and speed on performance parameters, Heat balance sheet.	**08**	**CO6**
		Self-Learning Topic: Engine Testing and Performance	**08**	

Text Books:

1. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
2. Internal Combustion Engines, Shyam Agrawal, New Age International
3. Internal Combustion Engine, Mathur and Sharma
4. Internal Combustion Engines, Mohanty, Standard Book House
5. Internal Combustion Engine, Gills and Smith
6. Internal Combustion Engines Fundamentals, John B. Heywood , TMH
7. A Textbook of Fluid Mechanics and Hydraulic Machines, R. K. Rajput.
8. A Textbook of Fluid Mechanics and Hydraulic Machines, R. K. Bansal.

References:

1. Internal Combustion Engines, Gupta H N, 2nd ed, PHI
2. Internal Combustion Engine, V Ganesan, TMH
3. Introduction to Internal Combustion Engines, Richard Stone, Palgrave Publication, 4th Edition
4. Fluid Mechanics, Frank M. White.
5. Fluid Mechanics: Fundamentals and Applications, Yunus A. Çengel & John M. Cimbala.
6. Fluid Mechanics, Pijush K. Kundu & Ira M. Cohen.
7. Fundamentals of Fluid Mechanics, Bruce R. Munson.
8. Hydraulics and Fluid Mechanics, P. N. Modi & S. M. Seth.
9. Fluid Mechanics, R. K. Rajput.

Online References:

Sr. No.	Website Name
1	https://onlinecourses.nptel.ac.in/noc25_ce107/preview?utm_source=chatgpt.com
2	https://nptel.ac.in/courses/112/104/112104033/ - Engine Combustion, IIT Kanpur https://nptel.ac.in/courses/112/103/112103262/ - IC Engines and Gas Turbines, IIT Guwahati
3	https://elearn.nptel.ac.in/shop/nptel/fluid-mechanics?utm_source=chatgpt.com Introduction to Fluid Mechanics - Course

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211503	Dynamics of Machinery	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211503	Dynamics of Machinery	20	20	40	60	2.5	--	--	100

Rationale:

This subject equips students with essential knowledge of dynamic mechanical systems. It builds foundational understanding of vibration analysis, and balancing of rotating and reciprocating masses. These concepts are critical for designing stable and efficient machines in automotive, aerospace, and industrial applications, ensuring reliability, safety, and performance in real-world engineering systems.

Course Objectives:

1. To analyse static and dynamic forces in mechanisms.
2. To develop dynamically equivalent systems for rigid bodies.
3. To understand fundamentals and modelling of mechanical vibrations.
4. To formulate and solve free and damped vibration problems.
5. To analyse forced vibrations, isolation, and vibration measurement systems.
6. To apply rotor dynamics and balancing principles in mechanical systems.

Course Outcomes:

1. Illustrate basic of static and dynamic forces.
2. Explain fundamental concepts of vibration and develop equivalent single degree of freedom (SDOF) models by converting multi-component systems into simplified representations.
3. Determine natural frequency of element/system.
4. Determine vibration response of mechanical elements / systems
5. Design vibration isolation system for a specific application
6. Demonstrate basic concepts of balancing of forces and couples

Prerequisite: Engineering mechanics, Theory of machines- Basic, Mathematics, Physics.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Mechanism Dynamics and Equivalent System Representation**	**1.1 Static and Dynamic force analysis** of Slider crank mechanism (neglecting mass of connecting rod and crank), Turning moment on crank shaft. **1.2 Dynamically equivalent systems** to convert rigid body into two mass with and without correction couple (Case study- Connecting rod)	07	CO1
		Self-Learning Topic: Slider Crank Force Analysis	07	
2	**Fundamentals and Modelling of Vibratory Systems**	**2.1 Basic Concepts of Vibration:** Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis **2.2 Equivalent Single Degree of Freedom Vibration System:** Conversion of multi springs, multi masses, multi-dampers into a single	08	CO2

		spring and damper with linear or rotational co-ordinate system.		
		Self-Learning Topic: Fundamentals of Mechanical Vibrations	08	
3	**Fundamentals of Mechanical Vibrations**	**3.1 Free Undamped Single Degree of Freedom Vibration System:** Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method	07	CO3
		Self-Learning Topic: Free Undamped Vibration Systems	07	
4	**Damped Vibrations and System Simplification**	**4.1 Free Damped Single Degree of Freedom Vibration System:** Introduction to different methods of damping, Study and analysis of **1) Viscous damped system** (under damped, critically damped, over damped; Logarithmic decrement.) **2) Coulomb's damping** (Combined Viscous and Coulomb damping excluded)	08	CO4
		Self-Learning Topic: Damped Vibration Analysis Systems	08	
5	**Forced Vibrations, Isolation, and Measurement Techniques**	**5.1 Forced Single Degree of Freedom Vibratory System:** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) **5.2 Vibration Isolation and Transmissibility:** Force Transmissibility, motion transmissibility, typical isolators & mounts. **5.3 Vibration Measuring instruments:** Principle of seismic instruments, vibrometer,	07	CO5

		accelerometer - undamped and damped, Introduction to conditioning monitoring and fault diagnosis		
		Self-Learning Topic: Forced Vibration Systems	07	
6	**Rotor Dynamics and Balancing of Mechanical Systems**	**6.1 Rotor Dynamics:** Rotor dynamics basics Critical speed of single rotor (undamped and damped) **6.2 Balancing:** Static and Dynamic balancing of multi rotor system (up to four rotors), balancing of reciprocating masses in In-line engines (up to four cylinders) , Introduction to V-engines (excluding other radial engines)	08	CO6
		Self-Learning Topic: Rotor Dynamics Critical Speed	08	

Text Books:

1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdishlal Metropolitan Book New Delhi, Company, Daryaganj, Delhi
3. Theory of Machines by S. S. Ratan Tata McGraw Hill, New Delhi
4. Theory of Machines by P. L. Bellaney Khanna publication, New Delhi
5. Theory of Machines and Mechanisms by John J Uicker, Gordon R Pennock and Joseph E Shigley, Oxford University Press
6. Theory of Vibration with Applications, by W. Thomson, 2nd edition, Pearson Education
7. Mechanical Vibrations by S. S. Rao, fourth edition, Pearson Education
8. Mechanical Vibrations by G. K. Grover
9. Fundamentals of Mechanical Vibration by S. Graham Kelly, Tata McGraw Hill

References:

1. Principles of Vibration by Benson H Tongue, 2nd Edition, Oxford University Press
2. Vibration Analysis by P. Srineevasan, TMH
3. Mechanical Vibrations- Schaum's outline series, William W. Seto, McGraw- Hill
4. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age

International

5. Elements of Vibration Analysis by Leonard Meirovitch, McGrav- Hill, New York

Online References:

Sr. No.	Links for online NPTEL/SWAYAM courses
1	**https://nptel.ac.in/courses/112/101/112101096/ -** Dynamics of Machines, IIT Bombay
2	**https://nptel.ac.in/courses/112/107/112107212/ -** Introduction to Mechanical Vibration, IIT Roorkee

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212504	Finite Element Analysis Lab	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212504	Finite Element Analysis Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce students to various finite elements and enable them to choose appropriate elements for different types of engineering problems.
2. To develop students' understanding of meshing techniques and teach them to apply mesh refinement and convergence analysis effectively.
3. To familiarize students with different types of solvers and guide them in selecting suitable solvers based on problem requirements.
4. To train students in post-processing tools and techniques to accurately interpret simulation results.
5. To build foundational knowledge of FEA principles and demonstrate their application in solving real-world engineering problems.
6. To instill the ability to critically analyze and validate simulation results by comparing with theoretical, empirical, or experimental data.

Lab Outcomes:

1. Select appropriate element for given problem
2. Select suitable meshing and perform convergence test
3. Select appropriate solver for given problem

4. Interpret the result
5. Apply basic aspects of FEA to solve engineering problems
6. Validate FEA solution

List of Experiments:

Sr. No	**List of Experiments (Minimum Six)**	**Hrs**	**LO Mapping**
1	Any two problems using bar element	2	LO1
2	Any two problems using truss element	2	LO2
3	Any two problems using CST element	2	LO3
4	Any two problem using axisymmetric element	2	LO4
5	Any one problem of free vibration analysis using bar element	2	LO5
6	Any one problem on steady state heat conduction	2	LO6
7	Any one problem for analysis of Beams.	2	LO6

Sr No	List of Assignment	Hrs
01	Any two problems using bar element	2
02	Any two problems using truss element	2
03	Any two problems using CST element	2
04	Any two problem using axisymmetric element	2
05	Any one problem of free vibration analysis using bar element	2
06	Any one problem on steady state heat conduction	2

Text Books:

1. Programming the Finite Element Method, I M Smith,D V Griffiths and Margetts WILEY

   Publications.
2. The Finite Element Method: Theory, Implementation, and Applications, Larson, Mats G.,

   Bengzon, Fredrik,Springer

3. Introduction to Finite Element Analysis and Design by N. H. Kim, B. V. Sankar, and A. V.Kumar by Wiley publication
4. Finite Element analysis using ANSYS by PaletiSrinivas,Krishna Chaitanya, Rajesh Kumar Detti, PHI Publication.
5. Finite Element Analysis Theory and Application With ANSYS by Saeed Moaveni, Pearson Publication.
6. Introduction to Finite Element Analysis Using MATLAB and Abaqus By Amar Khennane,

   CRC Press publication.

References:

1. Finite Element analysis using ANSYS by PaletiSrinivas,Krishna Chaitanya, Rajesh Kumar

   Detti, PHI Publication.
2. Finite Element Analysis Theory and Application With ANSYS by Saeed Moaveni, Pearson

   Publication.
3. Introduction to Finite Element Analysis Using MATLAB and Abaqus By Amar Khennane,

   CRC Press publication

Online Resources:

Sr. No.	**Website Name**
1.	https://innovationspace.ansys.com/product/fea-analysis-of-the-finite-element-method/
2.	https://www.youtube.com/watch?v=_5bXWeSGzX4&list=PLJuuzyTpkpy_ZmqqdYf_UyqBBz_X0nz1t

Assessment:

End Semester Practical/Oral examination

1. Pair of Internal and External Examiner should conduct practical/viva based on contents

2. Duration of practical examination is 2 hour

3. Distribution of marks for practical/viva examination shall be as follows:

a. Practical performance ……**15** marks

b. Oral…….. **10** marks

Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.

Students work along with evaluation report to be preserved till the next examination.

Term Work: Term Work shall consist of at least 6 practicals based on the above list. Also, Term work Journal must include project based on industrial application

Term Work Marks: 25 Marks (Total marks) = 10 Marks (Experiment) + 10 Marks (Project) + 5 Marks (Attendance)

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212505	Thermal and Fluid Engineering Lab	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212505	Thermal and Fluid Engineering Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. To understand fundamental concepts of fluid flow and flow measurement techniques.
2. To study compressible flow behavior and basic thermal systems like boilers.
3. To analyze working and performance of internal combustion engines.

Lab Outcomes:

1. Apply Bernoulli's equation to analyze energy conservation in fluid flow.
2. Evaluate flow measurement using Venturimeter, Orifice meter, and Pitot tube.
3. Analyze compressible flow characteristics including Mach number and choked flow.
4. Explain working and classification of steam generators (boilers).
5. Analyze working and cycles of SI and CI engines with valve timing diagrams.
6. Evaluate engine performance parameters and prepare heat balance sheet.

Prerequisite: Basic knowledge of engineering mechanics, Understanding of mechanical vibrations.

Term Work:

a) List of Experiments:

b) Assignment:

a) List of Experiments:

Sr. No	List of Experiments (Minimum Eight)	Hrs	LO Mapping
1	**Verification of Bernoulli's Equation** • Study energy conservation in fluid flow • Analyze pressure, velocity, and head variation	2	LO1
2	**Study of Flow Measurement Devices** • Theoretical analysis of Venturimeter, Orifice meter, and Pitot tube • Compare discharge coefficients and applications	2	LO2
3	**Analysis of Compressible Flow through Nozzle** • Study Mach number, choked flow, and pressure ratio • Evaluate variation of velocity and mass flow rate	2	LO3
4	**Study of Steam Generator (Boiler)** • **Classification and working of boilers** • **Analyze boiler efficiency and equivalent evaporation**	2	LO4
5	**Study of SI and CI Engine Working** • Compare 2-stroke and 4-stroke engines • Analyze valve timing diagram and engine cycles	2	LO5
6	**Engine Performance and Heat Balance**		LO6

	• Study performance parameters (BP, IP, efficiency) • Prepare theoretical heat balance sheet	2	

b) Assignment:

Sr No	List of Assignment	Hrs
01	Flow through Venturimeter and Orifice Meter	2
02	Mass flow rate and pressure ratio	2
03	Classification and working of 2-stroke and 4-stroke engines	2
04	Valve timing diagram and fuel-air cycle for SI and CI engines	2
05	Combustion and knocking in SI vs. CI engines	2
06	Heat balance sheet – purpose and calculation	2
07	Engine performance parameters – BHP, IHP, efficiency, SFC	2
08	Emission norms (EURO/Bharat stage) and control methods	2

Project Based Learning may be incorporated by judiciously reducing number of assignments.

Text Books:

1. **V. Ganesan** – *Internal Combustion Engines*
2. **Mathur & Sharma** – *Internal Combustion Engines*

Online Resources:

Sr. No	Website Name
1	**https://nptel.ac.in**
2	**https://ocw.mit.edu**
3	**https://vlab.co.in**

Assessment:

Including laboratory work and Assignment, Distribution of marks for Term Work shall be as follows

Laboratory Work: 10 Marks

Assignment: 10 Marks
Attendance: 05 Marks

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212506	**IDEA LAB -5 (Innovation Design Engineering and Apply)**	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212506	**IDEA LAB -5 (Innovation Design Engineering and Apply)**	--	--	--	--	--	**25**	**25**	**50**

Rationale:

Aligned with the National Education Policy (NEP) 2020, the institution emphasizes experiential, interdisciplinary, and project-based learning through the IDEA Lab—a central hub for hands-on innovation.

To strengthen the undergraduate research ecosystem, the institution has adopted a theme-based academic model aligned with UN SGD. Each semester features six curated problem statements based on local need and aligned with core subjects in the same semester, enabling students to apply classroom knowledge to real-world challenges. Every student selects one problem and develops an individual, subject-integrated solution—enhancing both academic understanding and research skills.

The IDEA Lab supports this initiative with facilities for design thinking, prototyping, and product development. Students maintain a project logbook throughout the semester to track their progress and reflections.

To ensure academic accountability, a two-tier assessment framework is implemented:

- Project Assessment based on standardized IDEA Lab rubrics.
- Subject-Based Term Work Assessment focused on the application of same-semester subject knowledge in the project.

Lab Objectives:

1. To promote experiential and project-based learning that bridges theoretical knowledge with real-world problem-solving.
2. To encourage interdisciplinary integration by enabling students to apply concepts from multiple subjects within a single cohesive project.
3. To develop innovation and design thinking skills through hands-on activities and iterative solution development.
4. To foster critical thinking and creativity by engaging students in open-ended problems with multiple solution pathways.
5. To enhance communication, collaboration, and documentation skills essential for professional engineering practice.
6. To build an entrepreneurial and research mindset by guiding students to develop scalable, socially-relevant, and technically viable prototype

Lab Outcomes: Student will be able to

1. Recall and articulate key concepts from core and allied subjects relevant to the assigned project.
2. Explain the interdisciplinary nature of the problem and the role of each subject in addressing it.
3. Apply appropriate tools, techniques, and theoretical knowledge to develop project components.
4. Analyze problem constraints and user requirements to structure a feasible and efficient solution.
5. Evaluate multiple design options and justify the chosen solution based on technical and practical considerations.
6. Create a functional prototype or solution that demonstrates innovation, utility, and integration of interdisciplinary knowledge

1) Guidelines for IDEA Project

a) Project Guidelines (Interdisciplinary Project Execution in IDEA Lab)

- Each student works on an individual interdisciplinary project aligned with the semester

theme.

- Faculty in-charges for the IDEA Lab are assigned according to the complexity of the project and the capacity of the respective departments.
- Faculty in-charges mentor both the academic and technical aspects, and track weekly progress.
- Project assessment will be rubric-based, ensuring depth, innovation, documentation, and ownership.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- Faculty in-charges must attend relevant FDPs to ensure uniformity in mentoring and evaluation.

b) Guidelines for same semester Subject Concepts Applied within the Project

- Termwork for each subject will partially reflect how well a student applies subject-specific concepts in their interdisciplinary project.
- Internal assessment panel will collaborate to align project components with subject learning outcomes.

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c) Role of Faculty In-Charges in IDEA Lab Projects

Faculty in-charges play a pivotal role in the success of interdisciplinary, theme-based projects under the IDEA Lab. Their responsibilities extend beyond technical supervision to include academic alignment, innovation facilitation, and active student engagement. Their key roles include:

1. **Motivating and Inspiring Students**
    - Encourage students to take ownership of their learning and projects.
    - Cultivate a mindset of curiosity, exploration, and social relevance.
    - Foster an environment where students feel empowered to take creative risks.
2. **Conducting Brainstorming and Ideation Sessions**
    - Organize structured brainstorming sessions at the start of the semester to help students define their problem statements and solution pathways.
    - Promote collaborative thinking, design exploration, and interdisciplinary integration.
3. **Arranging Guest Lectures and Expert Talks**
    - Identify and invite industry experts, researchers, and innovators for guest lectures aligned with the semester's theme or subject areas.
    - Facilitate exposure to real-world challenges, current trends, and future opportunities.
4. **Ensuring Uniqueness and Originality of Projects**
    - Actively review proposed ideas to ensure **no duplication of solutions** across students.

- Encourage students to explore novel approaches, technologies, and perspectives.

5. **Promoting Discussion and Collaborative Learning**
   - Create platforms for students to present, discuss, and receive peer and mentor feedback.
   - Facilitate idea refinement through regular discussions and group engagement.
6. **Aligning Subject Content Beyond Syllabus**
   - Faculty in-charges must **align subject content beyond the syllabus of the same semester** with the **IDEA Lab theme and assigned problem statements**.
   - This ensures relevance, depth, and meaningful interdisciplinary integration.
7. **Same Semester Faculty Requirement**
   - Faculty in-charges must be teaching subjects in the **same semester** as the students' project to ensure seamless academic integration and contextual understanding.
8. **Monitoring and Documentation**
   - Oversee project logbook maintenance, milestone tracking, and submission of progress reports.
   - Provide ongoing feedback and ensure project alignment with learning outcomes.
9. **Coordination with Subject Faculty**
   - Work in collaboration with other subject faculty to help students embed theoretical and practical aspects of their coursework into the project.
   - Facilitate subject-term mapping and contribute to termwork assessment based on evidence.

2) Implementation Strategy

a) Project Implementation in IDEA Lab

Aspect	Implementation Strategy
Faculty in-charges	**Faculty in-charges assigned based on project nature and department capacity.**
Mentoring Role	**Faculty in-charges oversee academic/technical development, interdisciplinary integration, and timely documentation.**
Capacity Building	**Faculty in-charges undergo workshops on design thinking, innovation, assessment rubrics, and outcome-based mentoring.**
Assessment Contribution	**Faculty in-charges contribute to 25 marks allocated for the IDEA Lab project termwork. The remaining assessments are conducted by the external examiner.**
Recognition & Incentives	**Faculty in-charges receive workload credits or are formally acknowledged in performance reviews.**

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b) Implementation of Subject-Term Work Mapping within Projects

Aspect	Implementation Strategy
Mapping Subject Outcomes	**Faculty in-charges align their content beyond syllabus with the student's project by coordinating with the assigned project guide.**
Independent Evaluation	**Internal assessment panel evaluate students based on their application of subject-specific concepts within the project. This contributes to a** separate 25 marks allocated for termwork based on subject **application.**
Evidence Sources	**Evaluation is supported by project logbooks, subject-specific deliverables (e.g., tools, simulations, models), and review presentation inputs.**
Outcome Assurance	**Ensures practical demonstration of subject understanding and its integration into the interdisciplinary solution.**

Implementation Notes:

- Guide faculty assess their course's contribution using specific evidence such as:
    - Logbooks
    - Subject-specific outputs (e.g., simulations, designs)
    - Paper publications or review presentations

2) Guidelines for Assessment

Two-tier rubrics are applied independently to evaluate subject concept application and innovation within the project.

a) Assessment of IDEA Lab Projects (Individual Interdisciplinary Projects) (25 Marks)

Presentation-Based Assessment Structure (Total: 25 Marks)

Assessment Month	Weightage	Marks
Month 1 (Formative 1)	20%	5 marks
Month 2 (Formative 2)	40%	10 marks
Month 3 (Formative 3)	40%	10 marks

Rubric-Based Evaluation Criteria

Criteria	Month 1 (5)	Month 2 (10)	Month 3 (10)
Problem Understanding	Connects problem to subjects	Defines interdisciplinary scope	Demonstrates deep conceptual grasp
Subject Knowledge Application	Identifies relevant concepts	Applies principles in design	Integrates multiple subject areas correctly
Innovation & Design Thinking	Proposes creative idea	Develops and tests feasible solution	Final solution shows originality and utility
Documentation & Presentation	Logbook initiated, plan presented	Mid-design log and visuals	Final report and demo completed
Progress & Ownership	Meets deadlines, shows planning	Demonstrates self-motivation	Completes project independently with reflection

b) Term Work Assessment of Subject Concepts Applied in Projects (25 Marks)

Applicable to All Subjects Integrated with Interdisciplinary Projects

To reflect meaningful application of subject knowledge, each subject will be assessed through the following rubric:

Criteria	**Marks**	**Description**
Subject Knowledge Application	8	Depth and accuracy of concept integration into the project
Practical Design or Tool Usage	5	Use of subject-specific hardware/software/simulation/tools
Documentation	4	Quality and clarity of subject-related logs and reports
Viva/Presentation	4	Ability to explain subject's relevance and role in the project
Continuous Engagement	4	Evidence of consistent participation via logbooks and feedback

c) Total Assessment Structure

Component	Marks	Assessed By
Termwork – Project Execution	25 Marks	Project Guide
Termwork – Application of Subject Concepts	25 Marks	IDEA Lab Panel
Viva Voce (Final Evaluation)	50 Marks	External Examiner

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211571	Metrology & Mechanical Measurement	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211571	Metrology & Mechanical Measurement	20	20	40	60	2.5	--	--	100

Rationale:

Metrology and Mechanical Measurement form the basis of accuracy in mechanical engineering. It deals with the science of measurement, instruments, and standards used to check dimensions, tolerances, surface finish, pressure, temperature, etc. Precise measurement ensures interchangeability of parts, product quality, safety, and performance. It minimizes rework, scrap, and cost in manufacturing. All measurements must be traceable to international standards. Thus, it bridges the gap between design and actual production, making machines reliable and efficient.

Course Objectives:

1. **Introduce fundamentals of measurement science** — standards, units, calibration, and traceability.
2. **Explain principles of metrology instruments** — linear, angular, and surface measurement devices.
3. **Develop understanding of limits, fits, and tolerances** in engineering design and manufacturing.
4. **Analyze sources of error and uncertainty** in measurement systems.
5. **Study mechanical measurement systems and transducers** for displacement, pressure, temperature, strain, and flow.
6. **Relate theoretical knowledge to industrial applications** in quality control and compliance.

Course Outcomes:

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

1. **Define and explain measurement standards** and their role in engineering practice.
2. **Describe the working principles and applications** of metrology instruments for dimensional and surface measurement.
3. **Apply tolerance and fits concepts** to interpret engineering drawings and ensure manufacturability.
4. **Identify, classify, and evaluate errors** in measurement, applying corrective methods.
5. **Explain the functioning of mechanical transducers** for measuring key engineering parameters.
6. **Connect theoretical concepts with industrial practice**, demonstrating how metrology ensures product quality and compliance.

Prerequisite:

1. Engineering Mathematics — basics of statistics, error analysis, and units.
2. Engineering Mechanics — concepts of force, stress, strain, and equilibrium.
3. Manufacturing Processes — familiarity with machining, tolerances, and surface finish.
4. Material Science — knowledge of material properties relevant to measurement (hardness, elasticity, thermal expansion).
5. Basic Physics — optics, pressure, temperature, and flow fundamentals.
6. Engineering Drawing — interpretation of dimensions, fits, and tolerances on technical drawings.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basics of Engineering Mathematics (statistics, error analysis), Physics (optics, pressure, temperature), Engineering Drawing (dimensions, fits, tolerances), Manufacturing Processes (surface finish, machining).	–	–
I	Standards & Measurement Fundamentals	International/national standards, units, calibration, traceability, classification of instruments.	8	CO1
		Self-learning Topics: History of measurement standards, BIS/ISO role in metrology.	8	

II	Linear & Angular Measurement	Vernier calipers, micrometers, comparators, angle gauges, sine bars, autocollimators.	8	CO2
		Self-learning Topics: Case study: Coordinate Measuring Machine (CMM).	8	
III	Limits, Fits & Tolerances	Definitions, types of fits, system of limits, tolerance analysis, and interchangeability.	7	CO3
		Self-learning Topics: GD&T (Geometric Dimensioning & Tolerancing) basics.	7	
IV	Errors in Measurement	Types of errors (systematic, random, environmental), statistical treatment, accuracy, precision, uncertainty.	7	CO4
		Self-learning Topics: Error analysis in industrial inspection reports.	7	
V	Mechanical Measurement Systems	Principles of transducers, measurement of displacement, pressure, temperature, strain, and flow.	8	CO5
		Self-learning Topics: Modern sensors in the automotive and aerospace industries.	8	
VI	Industrial Applications & Quality Control	Role of metrology in manufacturing, inspection, quality assurance, compliance with standards.	7	CO6
		Self-learning Topics: Case study: ISO 9001 quality audits, Six Sigma in measurement.	7	

Text Books:

1. **R.K. Jain** – *Engineering Metrology* (Khanna Publishers)
    - Comprehensive coverage of metrology instruments, standards, and measurement techniques.
2. **D.S. Kumar** – *Mechanical Measurements and Control* (Metropolitan Book Co.)
    - Focuses on mechanical measurement systems, transducers, and control applications.

3. **A.K. Sawhney** – *Mechanical Measurements and Instrumentation* (Dhanpat Rai & Sons)
    - Detailed explanations of measurement principles, errors, and industrial applications.
4. **Beckwith, Marangoni, Lienhard** – *Mechanical Measurements* (Pearson Education)
    - Strong theoretical foundation with practical examples, widely used internationally.
5. **G.R. Nagpal** – *Engineering Metrology and Instrumentation* (Khanna Publishers)
    - Simplified approach to metrology concepts, suitable for exam preparation.

References:

1. **Ernest O. Doebelin** – *Measurement Systems: Application and Design*
2. **I.C. Gupta** – *Engineering Metrology*
3. **Alan S. Morris** – *Measurement and Instrumentation Principles*

Online References:

Sr. No.	Website Name
●	**Mechanical Measurements and Metrology (IIT Madras)** ● Instructors: Prof. S.P. Venkateshan & Prof. M.S. Shunmugam ● Focus: Fundamentals of measurement, metrology instruments, calibration, and error analysis. ● 🔗 NPTEL Course Link: https://nptel.ac.in/courses/112106138
●	**Engineering Metrology (IIT Kanpur)** ● Instructor: Prof. Janakarajan Ramkumar ● Focus: Limits, fits, tolerances, linear/angular measurement, comparators, transducers, surface metrology. ● 🔗 NPTEL Course Link: https://nptel.ac.in/courses/112104314
3.	**Mechanical Measurements (IIT Madras)** ● Instructor: Prof. A. Ramesh ● Focus: Mechanical measurement systems, transducers, measurement of displacement, pressure, temperature, strain, and flow. ● 🔗 NPTEL Course Link: https://nptel.ac.in/courses/112106183

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211572	**Industrial Engineering and Management**	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211572	**Industrial Engineering and Management**	**20**	**20**	**40**	**60**	**2.5**	**--**	**--**	**100**

Rationale:

Industrial Engineering and Management focuses on the effective integration and optimization of human, material, machine, information, and financial resources to enhance productivity and competitiveness in manufacturing and service industries. The course equips students with techniques such as productivity improvement, value engineering, work study, ergonomics, facility design, and modern manufacturing philosophies including Agile, Lean, and Flexible Manufacturing. It enables learners to analyse industrial systems, improve operational efficiency, and support sustainable industrial growth.

Course Objectives:

1. To understand the principles, scope, and significance of Industrial Engineering in improving productivity and resource utilization.
2. To apply Value Engineering and Value Analysis techniques for product and process improvement.
3. To analyze work methods and measure work content using scientific work study techniques.
4. To understand ergonomic principles and work system design for enhancing human performance and workplace efficiency.
5. To evaluate facility location, plant layout, material handling, and cellular manufacturing systems for effective facility design.

6. To examine contemporary manufacturing paradigms such as Agile Manufacturing, Lean Manufacturing, and Flexible Manufacturing Systems.

Course Outcomes:

After successful completion of the course, the learner will be able to:

1. Explain the concepts, tools, and productivity improvement techniques of Industrial Engineering.
2. Apply Value Engineering and Value Analysis methodologies to enhance product value and optimize resources.
3. Perform method study and work measurement for improving productivity and establishing work standards.
4. Analyze ergonomic and work system design factors to improve workplace efficiency, safety, and employee performance.
5. Design and evaluate facility layouts, material handling systems, and cellular manufacturing arrangements for manufacturing organizations.
6. Assess and implement Agile, Lean, and Flexible Manufacturing concepts to enhance organizational competitiveness and operational excellence.

Prerequisite: Knowledge of Mathematics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Matrix operations, Solution of Linear Algebraic Equations		CO1
I	**Introduction to Industrial Engineering**	History and contribution, Industrial engineering approach, techniques of industrial engineering, objectives of industrial engineering, system approach to industrial engineering, definition and concept of productivity, productivity measurements, factors influencing productivity and productivity improvement techniques.	7	CO1

		Self-learning Topics: Study of Industrial Engineering applications in modern manufacturing industries and productivity benchmarking techniques.	7	
II	**Value Engineering and Value Analysis**	Distinction between value engineering & value analysis and their Significance. Steps in value engineering & analysis and Check lists	8	CO2
		Self-learning Topics: Case studies on Value Engineering and Value Analysis in automotive and consumer product industries.	8	
III	**Work Study**	Method study, micro-motion study and principles of motion economy, Work measurement: time study, work sampling, standard data, PMTS; MOST	7	CO3
		Self-learning Topics: Applications of Predetermined Motion Time Systems (PMTS) and MOST in industrial operations	7	
IV	**Work System Design**	Introduction to ergonomics and its scope in relation to work. Outline of discipline of anatomy, physiology and psychology, with respect to ergonomics building blocks such as anthropometry and biomechanics Job evaluation, merit rating, incentive schemes, wage administration and business process reengineering	8	CO4
		Self-learning Topics: Ergonomic assessment of workplace design using digital human modelling tools.	8	
V	**Facility Design**		7	CO5

		Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems. Concepts of Group Technology and cellular manufacturing		
		Self-learning Topics: Use of computer-aided facility layout planning software and Industry 4.0-enabled material handling systems.	7	
VI	**Agile Manufacturing**	Introduction, Developing agile manufacturing, Integration of Product/Process Development, Application of IT/IS concepts, Agile supply chain management, Design of skill and knowledge and Computer control of Agile manufacturing. Flexible manufacturing, Lean Manufacturing, Value Stream Mapping	8	CO6
		Self-learning Topics: Lean Manufacturing implementation through Value Stream Mapping and Agile Manufacturing case studies.	8	

Text Books:

1. Introduction to Work study, ILO, Geneva, and Oxford & IBH Pub Co. Pvt. Ltd.
2. Ergonomics at Work, Murrell
3. Plant Layout and Material Handling, James M. Apple, John Wiley & Sons
4. Facility Layout and Location – An Analytical Approach, Richard L. Francis& John A. White,
   Prentice Hall
5. Production Planning and Control, Samuel Elion

References:

1. Production and Operations Management, Joseph G. Monks
2. Quality planning and analysis, J M Juran, FM Gryana, TMH
3. Total Quality Management, D. H. Bester Field et al. prentice hall
4. TQM in new product manufacturing, HG Menon; TMH
5. Industrial Engineering and Management by Dr Ravi Shankar

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112107292
2	https://nptel.ac.in/courses/112103774

Assessment:
Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211573	Power Plant Engineering	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211573	Power Plant Engineering	20	20	40	60	2.5	--	--	100

Rationale:

This course provides fundamental knowledge of various power generation systems, including hydro, steam, combined cycle, and nuclear power plants. It enables students to understand the design, operation, performance, and economic aspects of power plants, helping them develop the skills required for efficient energy generation, management, and sustainable utilization of power resources

Course Objectives:

1. Understand the fundamentals of energy resources, power generation methods, and thermodynamic cycles used in power plants.
2. Study the design, construction, operation, and site selection criteria of hydroelectric power plants.
3. Analyze the working principles, components, fuel handling systems, and site selection aspects of steam power plants.
4. Understand the configuration, operation, and performance parameters of combined cycle power plants.
5. Examine the principles of nuclear energy, reactor types, nuclear power plant operation, and waste disposal techniques.
6. Evaluate power plant economics, load characteristics, tariffs, efficiency, and economic operation of power systems.

Course Outcomes:

1. Comprehend various equipment/systems utilized in power plants
2. Demonstrate site selection methodology, construction and operation of Hydro Electric Power Plants.
3. Discuss working, site selection, advantages, disadvantages of steam power plants/
4. Discuss operation of Combined Cycle Power Plants
5. Discuss types of reactors, waste disposal issues in nuclear power plants
6. Illustrate power plant economics

Prerequisite: Knowledge of Engineering Thermodynamics, Fluid Mechanics, Heat Transfer, Applied Mechanics, Basic Electrical Engineering, Engineering Mathematics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Thermodynamic laws and power cycles. Fluid flow in pipes, pumps, and turbines. Fundamentals of heat transfer. Basic concepts of forces, work, and energy. Electrical power generation and machines. Mathematical tools for engineering analysis.		CO1
I	**Introduction**	Energy resources and their availability, types of power plants, selection of the plants, review of basic thermodynamic cycles used in power plants	7	CO1
		Self-learning Topics: Renewable energy resources and their potential in India Recent trends in sustainable power generation Smart grid and distributed energy systems	7	

II	**Hydro Electric Power Plants**	Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants	8	CO2
		Self-learning Topics: Pumped storage hydroelectric plants Environmental impact of hydroelectric projects Case study of major hydroelectric power plants in India	8	
III	**Steam Power Plants**	Flow sheet and working of modern-thermal power plants, super critical pressure steam stations, site selection, coal storage, preparation, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator	7	CO3
		Self-learning Topics: a-supercritical thermal power plants Flue gas desulfurization (FGD) systems Carbon capture and storage technologies	7	
IV	**Combined Cycles**	Constant pressure gas turbine power plants, Arrangements of combined plants (steam & gas turbine power plants), re-powering systems with gas production from coal, using PFBC systems, with organic fluids, parameters affecting thermodynamic efficiency of combined cycles, Problems	8	CO4
		Self-learning Topics: Integrated Gasification Combined Cycle (IGCC) Waste heat recovery systems Hydrogen-based combined cycle power plants	8	

V	**Nuclear Power Plants**	Principles of nuclear energy, basic nuclear reactions, nuclear reactors PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled, Advantages and limitations, nuclear power station, waste disposal	7	CO5
		Self-learning Topics: Small Modular Reactors (SMRs) Nuclear safety systems and regulations Nuclear power development in India	7	
VI	**Power Plant Economics**	Load curve, different terms and definitions, cost of electrical energy, tariffs methods of electrical energy, performance & operating characteristics of power plants-incremental rate theory, input-output curves, efficiency, heat rate, economic load sharing, Problems.	8	CO6
		Self-learning Topics: Electricity market and power trading Renewable energy economics Life cycle cost analysis of power plants	8	

Text Books:

1. Power Plant Engineering, A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, New Age International Publishers
2. Power Plant Familiarization, Manual of Central Training Resources Unit of NTPC India, 1991
3. Power Plant Engineering, P.K. Nag, 2nd Edition, TMH, New Delhi
4. A Text Book of Power Plant Engineering, R.K. Rajput, Laxmi Publications

References:

1. Hydro-Electric and Pumped Storage Plants, M G Jog, New Age International Publishers
2. A Course in Power Plant Engineering, Arora, Domkundwar, DhanpatRai & Co
3. Power Plant Engineering, P.C. Sharma, S.K. Kataria& Sons
4. Power Plant Engineering, G.R. Nagpal, Khanna Publishers
5. Power station Engineering and Economy by Bernhardt G.A. Skrotzki and William A. Vopat, TMH
6. Power Plant Engineering, Manoj Kumar Gupta, PHI Learning
7. Nuclear Power Plant Engineering, James Rust, Haralson Publishing Company
8. Nuclear Power Plants, Edited by Soon Heung Chang, InTech Publishers

Online References:

Sr. No.	Website Name
1	https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me113
2	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_me29
3	https://nptel.ac.in/courses/112103421
4	https://digimat.in/nptel/courses/video/112107291

Assessment:
Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**

2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
993115801	Operations Planning and Control	3	--	--	45	--		45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
993115801	Operations Planning and Control	20	20	40	60	2.5	--	--	100

Rationale:

This course provides a comprehensive foundation in Production and Operations Management, essential for managing manufacturing and service operations efficiently. Forecasting, capacity, and aggregate planning help in matching demand with resources, while scheduling techniques enhance workflow in both job shop and project environments.

Material Requirement Planning (MRP), ERP systems, and facility layout design streamline production logistics and resource utilization. Line balancing ensures efficient assembly operations, and modern philosophies like JIT, Lean, Agile, and Synchronous manufacturing emphasize waste reduction, flexibility, and responsiveness. This curriculum equips students with the analytical tools and strategic insight necessary for effective decision-making in contemporary production and service systems.

Course Objectives:

1. To provide an exposure to Operations Planning & Control (PPC) and its significance in manufacturing and service organizations.
2. To appraise about need and benefits of planning functions related to products and processes.
3. To provide exposure to production scheduling, sequencing and project management so as to optimize resources.

4. To provide insights into MRP and ERP to minimize the total cost and to manage operations functions in a better way.
5. To demonstrate different techniques used for facility planning and assembly line balancing.
6. To develop an understanding of JIT, Lean, Agile and Synchronous Manufacturing system.

Course Outcomes:

1. Illustrate operations functions and manage operations in a better way.
2. Apply various strategies to develop aggregate production plan based on the demand forecasting.
3. Apply various algorithms in scheduling and sequencing of manufacturing and service operations.
4. Develop Material Requirements Plans (MRP) to estimate the planned order releases.
5. Apply various techniques for facility layout planning and line balancing to optimize the resources.
6. Demonstrate the importance of implementation of JIT, Lean, Agile and Synchronous manufacturing in manufacturing and service organizations.

Prerequisite: Basic knowledge of Industrial Engineering, Fundamentals of Statistics and Mathematics, Analytical thinking and problem-solving

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Production and Operations Strategy**	**1.1 Introduction:** Production and Operations Function, Production systems, make to stock, make to order, assemble to order and Engineer to order, type of layouts, Phases in OPC like Preplanning, Planning, Action & Control. **1.2 Strategic Planning for Operations and Services:** Approaches like Forced Choice model and Operations Model, Quality and Productivity strategy, Technology strategy. Operations	07	CO1

		Strategies for Services, Types or Service Operations: Quasi manufacturing, Customer as participants, Customer as product, Classification of Services, Service capacity.		
		Self Learning Topic: Production Systems Overview	07	
II	**Forecasting and Capacity Planning in Operations**	**2.1 Forecasting:** Forecasting and Prediction, need for forecasting, role of forecasting in OPC, Methods of forecasting, Qualitative methods, Quantitative methods like time series analysis, least square method, moving average method, and exponential smoothing method. Forecasting Error; Mean Absolute Deviation, Forecasting Bias **2.2 Capacity Planning:** Measurement of capacity, Measures of operating capacity, Factors influencing effective capacity, factors favoring over capacity and under capacity, short range, medium range and long range capacity planning. Capacity requirement Planning (CRP) **2.3 Aggregate planning:** Concept of aggregate planning, Pure Strategy; Mixed Strategy; Level Strategy, Rough cut capacity planning, Aggregate planning for Services; Optimal Models for Aggregate Planning; Linear Programming; Linear Decision Rules Master Production Schedule	08	CO2
		Self Learning Topic: Forecasting Methods in Operations	08	
III	**Scheduling Techniques in Manufacturing and Projects**	**3.1 Job shop/Intermittent Manufacturing Scheduling:** Factors influencing scheduling, Inputs for scheduling, Forward Scheduling, Backward Scheduling, Stages in Scheduling: Product sequencing, Loading and Dispatching, dispatching, progress report & expediting and control.	07	CO3

		Basic scheduling problems, Priority Sequencing, Gantt Charts, Johnson's Rule for optimal sequence of N jobs on 2 machine. Process N Jobs on 3 Machines (N/3 problem) and Jackson Algorithm. Processing of 2 Jobs on M Machine (2/M) problem, **3.2 Project scheduling:** Network analysis - PERT & CPM, cost analysis & crashing, resource leveling and smoothening.		
		Self Learning Topic: Job Shop Scheduling Methods	07	
IV	**Material and Enterprise Resource Planning**	**4.1 Material Requirement Planning:** Introduction, Limitations of conventional EOQ, Objectives of MRP, Inputs of MRP-I, Outputs of MRP, MRP lot sizing and Estimation of planned order releases, Manufacturing resource planning (MRP-II) **4.2 Enterprise Resource Planning (ERP):** Evolution, features, purpose of modeling an enterprise, ERP model for OPC, Modules in ERP, ERP Implementation Life Cycle, ERP packages like SAP-R3/Baan/PeopleSoft	08	CO4
		Self Learning Topic: Material Requirement Planning	08	
V	**Facility Layout and Line Balancing Techniques**	**5.1 Facility layout planning:** Factors influencing Plant Layout, Material Flow Patterns, Tools and Techniques used for Plant Layout Planning. **5.2 Line Balancing:** Objectives, constraints, terminology in assembly line, heuristic methods like Kilbridge-Wester, Largest Candidate rule, Rank positional weight	07	CO5
		Self Learning Topic: Facility Layout Planning	07	

VI	**Modern Manufacturing Approaches: JIT, Lean, and Agile**	Introduction to JIT system, Lean, Agile and Synchronous manufacturing: Concept, Characteristics, Components and Implementation.	08	CO6
		Self Learning Topic: Lean Agile Manufacturing Systems	08	

Text Books:

1. "Production and Operations Management", K. Aswathappa & K. Shridhara Rao, Himalaya Publishing House, Revised 2nd Edition (2008)
2. "Industrial Engineering and Production Management", Martand Telsang, S. Chand, New Delhi (2009)
3. "Modern Production Operations Management", Elwood S Buffa and Rakesh K Sarin, 8th Edition, Wiley Eastern, New York (1999) ISBN: 978-0471819059
4. "Production and Operations Management", Panneer Selvan R, 3rd Edition 2002Prentice Hall India, New Delhi, ISBN: 978-8120345553
5. "Production Planning and Control", Samuel Eilon, Universal Publication, ISBN: 9788185027548
6. "Production Planning and Control", L C Jhamb ,12th Edition 2010, Everest Pub House.

References Books:

1. "Production Planning and Control", W. Boltan-Longman Scientific & Technical (1994), ISBN: 978-0582228207
2. "Production Systems- Planning, Analysis & Control", James. L. Riggs, John, 4th Edition 1987, Wiley & Sons, ISBN: 9780471847939
3. Manufacturing Planning and Control Systems, Thomas E. Vollman, William L. Berry & Others,4th Edition 1997, McGraw Hill Pub, ISBN: 978-0786312092
4. "Manufacturing Process Planning and Systems Engineering", Anand Bewoor, Dreamtech Press 2009, ISBN: 978-8177229967
5. "Production and Operations Management", S.N. Chary, 3rd Edition 2004, TMH publishing company, ISBN: 978-0070583559
6. Modernization & Material Management, L.C. Jhamb - Everest Publishing House

Online References:

Sr. No.	Links for online NPTEL/SWAYAM courses
1	https://youtube.com/playlist?list=PLLy_2iUCG87A-kHGx4YUY97ShTTqBfA6-&feature=shared

2	https://youtube.com/playlist?list=PLSGws_74K01_MBJaKLVaP0iCupVawlL6i&feature=shared

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16412509	**Professional Communication &Ethics-II**	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16412509	**Professional Communication &Ethics-II**	--	--	--	--	--	**25**	--	**25**

Rationale:

The syllabus is designed to help students face the corporate requirement with respect to interpersonal skills, resume drafting, presentation giving and to crack the interviews.

Course Objectives:

1) To develop students interpersonal and professional communication skills.
2) To train in group discussion techniques and collaborative communication for selection processes and teamwork.
3) To prepare effective resumes and perform confidently in interviews.
4) To train students to answer confidently and cracked HR interview
5) To build competence in drafting notices, agendas and minutes of the meetings.
6) To enhance the ability to deliver structured presentations and prepare professional reports.

Course Outcomes:

CO1: Explain the concepts and importance of interpersonal skills in professional environments.

CO2: Describe the structure, types, and evaluation criteria of group discussions.

CO3: Explain the principles and components of effective resume writing.

CO4: Describe interview processes, techniques, and professional etiquette.

CO5: Explain formats and principles of formal communication including notices and meetings.

CO6: Describe the structure and techniques of presentations and report writing. Prerequisite: Professional Communication & Ethics.

DETAILED SYLLABUS:

Sr. No.	Module Name	Detailed Content	Hours	CO Mapping	Self-Learning Topics
1	Interpersonal Skills	Definition, importance, and scope of interpersonal skills; Emotional Intelligence; leadership and teamwork concepts; communication in teams; empathy and assertiveness; conflict management strategies.	5	CO1	Self-assessment of interpersonal skills via SWOT analysis.
2	Group Discussion	Purpose of GD in recruitment and teamwork; types of GD; structure of GD; evaluation parameters; GD etiquette; do's and don'ts.	5	CO2	Latest GD topics related to current affairs, social issues, and technology.
3	Resume Building	Purpose and importance of resumes and CVs; types of resumes; key	4	CO3	Industry-specific resume formats for IT, Core,

		sections; principles of effective resume writing; customization for job roles.			Engineering, and Management.
4	HR / Personal Interviews	Meaning and types of interviews; common HR interview questions; STAR method; interview etiquette; handling stress questions; preparation strategies.	5	CO4	Frequently asked HR and behavioural interview questions.
5	Notice, Agenda and Meeting	Features of formal English; types of notices; format and structure of notices; agenda and minutes of meetings; importance of professional documentation.	5	CO5	Study of real corporate meeting agendas and minutes.
6	General Topic Presentation & Report Making	Principles of effective presentations; structure of presentation; audience analysis; presentation techniques;	6	CO6	Different types of reports such as technical, survey, and analytical reports.

		slide design principles.			

Sr. No.	Documents required to be submitted for internal orals
1	Reflection report on GD.
2	Resume drafted in latest format.
3	Corporate meeting – Frame Notice, Agenda, and Minutes of the Meeting.
4	Short report format and a case study for the same.

References

- Communication Skill for Engineers & Scientists (2nd Edition) by Sangeeta Sharma & Mohan N. Mishra.
- Art of Effective Communication in Group Discussion and Interview by O. P. Singh.

Online References:

Sr. No.	Free Online Courses / References
1	LPU Blog: Comprehensive GD guide with techniques, frameworks, phrases, and topic types.
2	Tech Interview Handbook: ATS-friendly resume guide for software engineers.

Assessment:

Internal Assessment:

Term work marks – (Total 25 marks)

Group Discussion - 10 marks

Mock PI - 5 marks

Mock Meeting and Roleplay -5 marks

Attendance - 5 marks

SEM 6

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)				Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211601	Machine Design	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211601	Machine Design	20	20	40	60	2.5	--	--	100

Rationale:

Machine Design is one of the core subjects of Mechanical Engineering that deals with the design and development of machine elements and mechanical systems subjected to various loading and operating conditions. The course provides knowledge of design procedures, material selection, standard design practices, and failure theories required for safe, reliable, and economical machine component design. It develops the ability to analyze engineering problems and design components such as shafts, springs, bearings, gears, couplings, clutches, brakes, and power transmission systems using standard codes and design data books. The course also enhances analytical thinking, problem-solving ability, and practical design skills required in manufacturing, automotive, aerospace, thermal, and industrial engineering applications.

Course Objectives:

1. To study basic principles of machine design
2. To familiarize with use of design data books & various codes of practice
3. To acquaint with functional and strength design principles of important machine elements

4. To familiarize selection of standard elements such as rolling element bearings, belts etc.

5. To make conversant with preparation of working drawings based on designs

Course Outcomes:

1) Use design data book/standard codes to standardize the designed dimensions
2) Design Knuckle Joint, cotter joint and Screw Jack
3) Design shaft under various conditions and couplings
4) Select bearings for a given applications from the manufacturers catalogue
5) Select and/or design belts and flywheel for given applications
6) Design springs, clutches and brakes

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Introduction**	Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Manufacturing consideration in design, Design consideration of casting and forging, Basic principle of Machine Design, Modes of failures, Factor of safety, Design stresses, Theories of failures 08(Selection in the process of designing), Standards, I.S. Codes, Preferred Series and Numbers Thick Cylinders: Design of thick cylinders subjected to an internal pressure using Lame's equation	07	CO1
		Self-Learning Topic: Mechanical Design Fundamentals	07	
II	**Design against static loads**	Design against static loads: Socket and Spigot Cotter joint, Knuckle joint, Bolted and welded joints under eccentric loading;	07	CO2
		Self-Learning Topic:	07	

		Static Load Machine Design		
III	**Design against fluctuating loads**	**3.1 Design against fluctuating loads:** variables stresses, reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Endurance limit- estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, **3.2 Design of Shaft:** power transmitting, power distribution shafts, Module (excluding crank shaft) under static and fatigue criteria. **Keys:** Types of Keys and their selection based on shafting condition. **Couplings:** Classification of coupling, Design of Flange couplings, Bush pin type flexible couplings	08	CO3
		Self-Learning Topic: Fatigue Design Against Fluctuating Loads	08	
IV	**Design of Bearings**	4.1 Rolling Contact Bearings: Types of bearing and designation, selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self-aligning bearing and thrust bearing) 4.2 Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (self-contained), Introduction to hydro static bearings,	08	CO4
		Self-Learning Topic: Rolling Contact Bearing Selection	08	
V	**Design of Belt, Chain and Flywheel**	5.1 Design and selection of Belts: Flat and V-belts with pulley construction. 5.2 Design and selection of standard roller chains. 5.3 Design of Flywheel – Introduction, Fluctuation of energy and speed, turning moment diagram, estimating inertia of	08	CO5

		flywheel for reciprocating prime movers and machines, Weight of the flywheel, flywheel for punches, rim constructions, stresses in rims and arms, Construction of flywheel.		
		Self-Learning Topic: Belt Drive Design Selection	08	
VI	**Design of Springs, clutch and Brakes**	6.1 Design of Springs: Helical compression, Tension Springs under Static and Variable loads, Leaf springs. 6.2 Design of Clutches: Introduction, types, Basic theory of plate and cone type clutches, Design of single plate, multi-plate and with spring, lever design and thermal, wear considerations. 6.3 Design of Brakes: Design of single shoe brake.	07	CO6
		Self-Learning Topic: Spring Design Fundamentals	07	

Text / Reference Books:

1) Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2) Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3) Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
4) Machine Design by Pandya & Shah, Charotar Publishing
5) Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6) Machine Design by Reshetov, Mir Publication
7) Machine Design by Black Adams, McGraw Hill.
8) Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill.
9) Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas& Co.
10) Design of Machine Elements by V.M.Faires.
11) Design of Machine Elements by Spotts.
12) Recommended Data Books – Design Data: Data Book of Engineers by PSG College, Kalaikathir Achchagam

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112/105/112105124/

2	https://nptel.ac.in/courses/112/106/112106137/

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1. **Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks**
2. **No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.**

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)				Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211602	Turbo Machinery	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211602	Turbo Machinery	20	20	40	60	2.5	--	--	100

Rationale:

This subject provides foundational knowledge of fundamentals of turbomachines, pumps, compressors, turbines, and gas-based energy systems. It helps students understand the construction, classification, and working principles of thermal and fluid machines. Emphasis is placed on performance analysis through efficiency, work estimation, and characteristic curves.

The course introduces turbo machines using Euler's theory and covers real-world systems like thermal power plants, jet engines, and gas turbines. Students also learn about advanced topics such as multistage compression, cavitation, and vibration in compressors. This knowledge is essential for careers in power, process, and manufacturing industries. It bridges theory with practical design and operation of energy-conversion systems.

Course Objectives:

1. To apply principles of thermodynamics and fluid mechanics to turbomachines.
2. To learn the design and significance of various components of the turbomachine.
3. To estimate various parameters related to turbo machines using the governing equations.
4. To evaluate the performance of turbo machines.

Course Outcomes:

1. Explain fundamentals of turbomachinery and apply performance parameters and Euler's theory to analyze energy transfer in pumps, turbines, and compressors.
2. Apply the principles of impulse and reaction turbines to analyze performance parameters and determine work output and efficiency.
3. Understand the classification, construction, and performance characteristics of centrifugal and reciprocating pumps.
4. Explain the working, classification, and performance aspects of reciprocating and centrifugal compressors, including concepts of multistaging, surging, and choking.
5. Apply the principles of impulse and reaction turbines to interpret velocity diagrams and calculate performance parameters for steam turbines.
6. Explain the working principles, classification, and performance parameters of gas turbines and jet propulsion systems.

Prerequisite: Thermodynamics (Basic & Applied), Engineering Mechanics, Fluid Mechanics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Fundamentals of Turbomachinery**	**Fundamentals of Turbomachinery:** Definition and classification of turbomachines, Applications of turbomachines, Review of thermodynamic principles relevant to turbomachinery, Basics of fluid flow and compressible flow relations **Performance Parameters and Energy Transfer:** Non-dimensional parameters and similarity laws, Specific speed and its significance, Euler's equation of turbomachinery, Application of Euler's theory to pumps, turbines, and compressors, Concept of energy transfer in turbomachines	07	CO1
		Self Learning Topic: Turbomachinery Fundamentals	07	
II	**Hydraulic Turbines**	**Hydraulic Turbines:** Basic theory, classification of turbines, theory of	08	CO2

		impulse and reaction turbines, estimation of work done, efficiency, characteristics of turbines, concept of draft tube and its types		
		Self Learning Topic: Hydraulic Turbines Basics	08	
III	**Pumps**	**Pumps:** Classification of pumps, definition of pumping systems and system characteristics. **Centrifugal pumps:** Construction, estimation of work done, efficiency, characteristics, determination of operating point, cavitation and NPSH, specific speed of pumps **Positive Displacement pumps:** Types and applications, general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram (no numerical on reciprocating pump). Use of air vessel (only application no numerical).	07	CO3
		Self Learning Topic: Pump Systems and Types	07	
IV	**Air compressor**	**Air compressor-** Introduction and general classification of reciprocating compressor positive displacement, Multi Staging of reciprocating compressor (no derivation, numerical on single stage and two stage compressor). Centrifugal compressor, surging and choking of compressor (No numerical on centrifugal compressor).	08	CO4
		Self Learning Topic: Air Compressor Fundamentals	08	

V	**Steam Turbine**	**Steam Turbine:** Basic of steam turbine, Classification, compounding of turbine, Impulse turbine –velocity diagram, Condition for max efficiency Reaction turbine, Numerical on Simple Impulse turbine (De-Laval turbine) of single stage only. Degree of reaction, Parson's turbine, Condition for maximum efficiency, Numerical on Parson's turbine only.	07	CO5
		Self Learning Topic: Steam Turbine Fundamentals	07	
VI	**Gas Turbines & Jet Propulsion Engines**	**Gas Turbines**: Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration, Effect of operating variable on thermal efficiency and work ratio. **Jet Propulsion Engines:** Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency.	08	CO6
		Self Learning Topic: Gas Turbine Fundamentals	08	

Text Books:

1. Thermal Engineering, Ajoy Kumar, G. N. Sah, Narosa Publishing House, New Delhi
2. Fluid Mechanics and Machinery; CSP Ojha, R. Berndtsson, Oxford University.
3. Fluid Mechanics and Fluid Machines by Gautam Biswas, S. K. Som, Suman Chakraborty - Tata McGraw-Hill Education Pvt. Ltd.
4. Turbines, Compressors and Fans by S. M. Yahya, McGraw-Hill Education Pvt. Ltd.
5. Turbomachinery Design and Theory by Aijaz and Gorla
6. Fluid Mechanics, thermodynamics of turbomachinery- S. L. Dixon,
7. Amsterdam; Boston: Elsevier-Butterworth-Heinemann

References Books:

1. R. K. Rajput; Engineering Fluid Mechanics; S. Chand publications.
2. Dr. Mody & Seth; Hydraulics and Fluid Mechanics; Standard book house
3. S. Ramamrutham, Hydraulic, Fluid Mechanics & Fluid Machines, Dhanpat Rai publishing

company.
4. Strecter, Fluid Mechanics, Tata McGraw Hill.
5. Thermal Engineering, R K. Rajput, Laxmi Publication
6. Fluid Mechanics: Fundamentals and application; Yunus A Cengel and John M Cimbala Publisher: Special India

Online References:

Sr. No.	Links for online NPTEL/SWAYAM courses
1	https://nptel.ac.in/courses/112/106/112106303/ - Introduction to Turbomachines, IIT Madras
2	https://nptel.ac.in/courses/112/106/112106200/ - Fluid Dynamics and Turbomachines, IIT Madras

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks

2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211603	Heating, Ventilation, Air conditioning and Refrigeration	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211603	Heating, Ventilation, Air conditioning and Refrigeration	20	20	40	60	2.5	--	--	100

Rationale :

Thermodynamics concepts are useful in understanding and designing systems involving energy transfer and energy transformation.

Prerequisite: Basic Thermodynamics

Course Objectives:

1. Learning the fundamental principles and different methods of refrigeration and air conditioning
2. Study of various refrigeration cycles and evaluate performance of each cycle.
3. Study of components of refrigeration and air-conditioning systems along with the applications

Course Outcomes:

1. Illustrate the fundamental principles and applications of refrigeration and air conditioning systems.
2. Identify various HVAC&R components
3. Evaluate performance of various refrigeration system
4. Estimate cooling and heating loads for an air conditioning system.
5. Select air handling unit & design air distribution system
6. Apply the knowledge of HVAC for the sustainable development of refrigeration and air conditioning systems.

Prerequisite: Basic Knowledge of Thermodynamics and Heat Transfer

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Carnot refrigerator Carnot heat pump, Carnot coefficient of performance, Reversed Carnot cycle, and its limitation Effect of temperature and pressure on COP of the cycle	0	
I	**Basic Concepts**	**Refrigerants:** Classification, Designation, Selection of refrigerant, Physical and chemical properties of refrigerants, Secondary Refrigerants **Air Refrigeration System:** Bell Coleman cycle, Necessity of air cooling, Factors considered for the selection of air refrigeration system, Types of air refrigeration system with schematic and T-S diagram, Numerical based on simple and	7	CO1

		bootstrap air refrigeration system.		
		Self-Learning Topic: Refrigerants and Properties Air Refrigeration Systems	7	
II	**Refrigeration System & Heat Pump**	**Vapour Compression Refrigeration System:** Simple system on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, actual cycle, Numerical based on standard vapour compression system byusing P-h chart .and refrigerant table **Vapour Absorption Refrigeration System.** Simple and practical, vapour absorption system Refrigerant-adsorbent properties, COP of ideal vapour absorption system, Domestic Electrolux refrigerator, Lithium-bromide absorption system. **Heat Pump:** performance, Primary energy ratio, Energy efficiency Introduction, Coefficient of ratio, Heating season performance factor, Seasonal energy efficiency, ratio, Classification of heat pump, Vapour compression heat pump systems Heat pump application in an industry.	8	CO2
		Self-Learning Topic: Vapour Compression Refrigeration Vapour Absorption Systems Heat Pump Systems	8	

III	**Thermal Comfort Conditions:**	**Thermal Comfort Conditions:** Selection of inside design conditions, thermal comfort, heat balance equation for a human being, factors affecting thermal comfort, Effective temperature, comfort chart and factors governing effective temperature, selection of outside design conditions **Psychrometry** of Air Conditioning Processes Psychrometry properties, relations and processes, Adiabatic air mixing, process Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor, Apparatus dew point Numerical based on psychometric chart and Classification of air conditioning system, relations **Cooling Load Estimation** Introduction, Components of cooling load Different heat sources, Various load Estimation, Design of air conditioning system Building survey and economic aspect used in design**.**	7	CO3
		Self-Learning Topic: Thermal Comfort Basics Psychrometry and Air Processes Cooling Load Estimation	7	
IV	**Air Distribution System:**	**Duct** Classification of ducts, duct material, pressure in duct, Flow through duct, pressure losses in duct Air flow through simple duct	8	CO4

		system Equivalent diameter, Methods of duct system design: **Air Handling Unit** Introduction to Fan coil unit, Types of fans used air conditioning applications, Fan laws Filters, supply and return grills, Sensors.		
		Self-Learning Topic: Duct Design and Airflow Air Handling Units	8	
V	**HVACR & Components**	Working of reciprocating, screw and scroll compressors, working of air cooled, and water cooled and evaporative condensers, Working of DX, Flooded, and Forced feed evaporators, Expansion devices Capillary tube, TXV, EXV, Type of insulation materials.	7	CO5
		Self-Learning Topic: Refrigeration Components Operation Expansion Devices and Insulation	7	
VI	**Application of HVAC&R**	Ice plant, Food storage plants, dairy and food processing plants, freeze drying, A/c in textile, Printing pharmaceutical industry and Hospitals ,Cold chain Technology, Transport air conditioning, Solar refrigeration.	8	CO6
		Self-Learning Topic: Industrial and Specialized HVAC Cold Chain and Solar Refrigeration	8	

Text / References Books:

1. Refrigeration and Air Conditioning by C.P.Arora, McGraw Hill education (India) (P) limited, New Delhi

2. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
3. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
4. Refrigeration and Air Conditioning by S.C.Arora and S.Domkundwar, Dhanpatrai and sons, Delhi
5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
6. ISHRAE Air Conditioning Handbook
7. ISHRAE Refrigeration Handbook
8. ASHRAE Handbook of Fundamentals
9. ASHRAE Handbook of Equipment
10. ASHARE Handbook of System
11. Open Source Software/learning website

Online References:

Sr. No.	Website Name
1	**https://nptel.ac.in/courses/112/107/112107208** **Refrigeration and Air Conditioning, IIT Roorkee**
2	**https://nptel.ac.in/courses/112/105/112105128** **Refrigeration and Air Conditioning, IIT Kharagpur**

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.

- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks
2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212604	Heating, Ventilation, Air conditioning and Refrigeration Lab	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212604	Heating, Ventilation, Air conditioning and Refrigeration Lab	--	--	--	--	--	25	25	50

Rationale:

Thermodynamics concepts are useful in understanding and designing systems involving energy transfer and energy transformation.

Prerequisite: Basic Thermodynamics

Course Objectives:

1. To study working and operating principle of vapour Compression and vapour absorption system.

2. To study Controls and Components of refrigeration and Air-conditioning system.

3. To design air conditioning systems using cooling load calculation.

Course Outcomes:

1. Aware of the roles and ethics of HVACR engineers in related industries.

2. Present the impact of professional engineering solutions in societal and environmental contexts.

3. Performance of HVACR systems Evaluate

4. Develop awareness of the engineering and technological aspects in the HVACR industries.

5. Communicate effectively through the preparation of report and practical presentation.

6. Analyse design aspects of HVAC&R in various application

Prerequisite: calculus and integrals

DETAILED SYLLABUS:

List of Experiments

Sr. No	List of Experiments (Minimum Eight)	Hrs	LO Mapping
1	Study and performance on simple vapour compression test rig .	5	LO1
2	Study and performance of heat pump test rig	5	LO2
3	Trial on Vapour absorption refrigeration test rig.	5	LO3
4	Perform humidification and dehumidification air conditioning process on air conditioning test rig	5	LO4
5	Study and performance of cooling tower based on the cooling load and approach to wet bulb temperature.	5	LO5
6	Study and performance of refrigeration cycle on Ice plant.	5	LO6

Part -B

Case studies through Seminar Poster presentation on

1. Chiller unit
2. Building Management system (Introduction)
3. Effect on Ozone depletion and Global warming,
4. Alternative Refrigerants.

5. Refrigerant Different Protocols used in
6. Variable refrigerant flow technology & its smart control

Term Work

Term work shall consist of

1. Minimum Six experiments
2. Industrial visit on any HVACR plant
3. Case study report

Distribution of Term work marks as follow

1. Experiments: 10 marks
2. Case study: 5 marks
3. Industrial Visit Report: 5 Marks
4. Attendance (Theory + Practical): 5 marks

End Semester Practical/Oral examination:

1. Pair of Internal and External Examiner should conduct practical/viva based on contents

2. Practical examination (in a group of not more than 5 students) duration is 2 hours
3. Distribution of marks for practical/viva examination shall be as follows:
    a. Practical performance ……15 marks
    b. Oral..... 10 marks

4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.

5. Evaluation of oral examination to be done based on the entire syllabus

6. Students work along with evaluation report to be preserved till the next examination

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212605	Turbo Machinery Lab	--	--	2	--	--	30	--	30	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212605	Turbo Machinery Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. To familiarize with momentum equation of turbomachinery.

2. To familiarize with hydraulic energy conversion devices.

3. To familiarize with thermal energy conversion devices.

Lab Outcomes:

1. Apply principles of momentum equation to turbomachinery problems.

2. Conduct a trial on reciprocating compressor / centrifugal compressor.

3. Conduct a trial on impulse turbine and analyze its performance.

4. Conduct a trail on reaction turbine and analyze its performance.

5. Conduct a trial on Centrifugal pump and analyze its performance.

6. Conduct a trial on Reciprocating pump and analyze its performance.

List of Experiments. (Minimum 6-7 experiments)

Sr. No	List of Experiments	Hrs.	LO Mapping
01	Impact of jet	02	LO1
02	Trial on Impulse turbine (Pelton Wheel Turbine)	02	LO1
03	Trial on Reaction turbine (Francis Turbine)	02	LO2
04	Trial on Reaction turbine (Kaplan Turbine)	02	LO2
05	Study of Centrifugal pump	02	LO3
06	Trial on centrifugal pump (Series arrangement)	02	LO3
07	Trial on centrifugal pump (Parallel arrangement)	02	LO4
08	Trial on reciprocating pump.	02	LO5
09	Trial on two stage reciprocating air compressor	02	LO5
10	Industrial visit to a power plant or any industry which cover turbomachines	02	LO6

Virtual Labs:

1. http://fm-nitk.vlabs.ac.in/# - Fluid Mechanics Lab, NITK Surathkal
2. https://fmc-nitk.vlabs.ac.in/fluid-machinery/ - Fluid Machinery Lab, NITK Surathkal

Assessment:

Term Work: Term work shall consist of all the experiments from the list, 3 assignments containing numerical based on Centrifugal Pump, Reciprocating Pump and centrifugal compressor and a visit report.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments): 10 marks
- Assignments: 05 marks
- Visit report: 05 Marks
- Attendance: 05 marks

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16212606	**Dissertation I**	--	--	2	--	--	30	30	60	1

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16212606	**Dissertation I**	**--**	**--**	**--**	**--**	**--**	**50**	**50**	**100**

Objectives:

The Project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification, analyzing the problem and designing solutions.

Outcomes:

1. Students will be able to develop the understanding of the problem domain through extensive review of literature.
2. Students will be able to identify and analyze the problem in detail to define its scope with problem specific data.
3. Students will be able to identify various techniques to be implemented for the selected problem and related technical skills through feasibility analysis.
4. Students will be able to design solutions for real-time problems that will positively impact society and environment.
5. Students will be able to develop clarity of presentation based on communication, teamwork and leadership skills.
6. Students will be able to inculcate professional and ethical behavior.

Guidelines for Dissertation:

1. Project Topic Selection and Allocation:

- Project topic selection Process to be defined and followed:

    - Project orientation can be given at the end of sixth semester.
    - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
    - Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
    - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.
- Topics can be finalized with respect to following criterion:
    - **Topic Selection:** The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
    - **Technology Used:** Use of latest technology or modern tools can be encouraged.
    - Students should not repeat work done previously (work done in the last three years).
- **Project work must be carried out by the group of at least 2 students and maximum 4.**
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels.

2. Project Report Format:

At the end of semester, each group need to prepare a project report as per the guidelines issued.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey
- Survey of Existing systems
- Limitations of Existing systems or research gaps
- Motivation (Challenges that are encouraging to choose the problem)
- Problem Statement and Proposed Solution
- Scope of the system
- Proposed System
    - General Workflow/Block diagram

- Analysis and Modeling (only applicable diagrams)
- Design
    - Architectural View
    - Algorithms/ Methodology
- Experimental Set up
    - Details of Database or details about input to systems or selected data
    - Performance Evaluation Parameters (for Validation)
    - Software and Hardware Set up
- Implementation Plan for Next Semester
    - Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- Summary
- References

Desirable:

Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects).

3. Term Work:

Distribution of marks for term work shall be done based on following:

Sr. No.	Component	Marks	Justification
1.	Weekly Log Report	10	Evaluates consistency, individual involvement, and regular documentation.
2.	Project Work Contribution	15	Assesses technical input, innovation, teamwork, and problem-solving ability.
3.	Project Report (Spiral Bound, Both Side Print)	10	Judges structure, clarity, formatting, and eco-friendly submission.
4.	Term End Presentation (Internal)	15	Tests presentation skills, concept clarity, Q&A handling, and teamwork.

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Term work evaluation:

Term work evaluation for Project I should be conducted by **Internal examiner on continuous basis** throughout the semester.

Component	Marks	Assessed By
Term work – Project Execution	50 Marks	Project Guide

Component	Marks	Assessed By
Viva Voce (Final Evaluation)	50 Marks	External Examiner

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211671	Automation and Artificial Intelligence	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211671	Automation and Artificial Intelligence	20	20	40	60	2.5	--	--	100

Rationale:

Automation and Artificial Intelligence is an emerging interdisciplinary course that integrates principles of automation, control systems, sensors, robotics, machine learning, and intelligent systems to solve modern engineering problems. The course provides fundamental knowledge of industrial automation and AI techniques used in manufacturing, smart systems, robotics, autonomous systems, and Industry 4.0 applications. It enables students to understand intelligent decision-making, data-driven control, and real-time automation processes used in modern industries. The course develops analytical thinking, problem-solving skills, and awareness of advanced technologies such as machine learning, expert systems, computer vision, and industrial automation tools. The knowledge gained through this course prepares students for careers in smart manufacturing, robotics, automation industries, and emerging AI-driven engineering applications.

Course Objectives:

1. **To understand the need and justification of automation**
2. To study design of pneumatic and hydraulic circuits.
3. To study and understand electro pneumatic circuits and PLC Design.
4. To familiarize with robotic systems in automated manufacturing processes.

5. To study and understand AI and machine learning technologies for automation

Course Outcomes:

1) Demonstrate understanding of fundamentals of industrial automation and AI.
2) Design & develop pneumatic / hydraulic circuits.
3) Design and develop electro pneumatic circuits and PLC ladder logics.
4) Demonstrate understanding of robotic control systems and their applications.
5) Demonstrate understanding of various AI and machine learning technologies.
6) Analyse and apply concepts of artificial intelligence, neural networks, machine learning, and Industry 4.0 technologies for automation applications.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Introduction**	1.1 Introduction to Automation Definition and fundamentals of automation, Elements of Automated system, Automation principles and strategies, Levels of automation, types of automation, Advanced automation functions 1.2 Introduction to Artificial Intelligence Introduction, Historical development, Intelligent Systems, Types of Intelligent Agents, Components of AI, Foundations of AI, Scope of AI, Current trends in AI, Relevance to Mechanical Engineering	07	CO1
		Self-Learning Topic: Introduction to Artificial Intelligence	07	
II	**Pneumatic & Hydraulic Circuits**	2.1 Design of Pneumatic Circuits Design of Pneumatic sequencing circuits using Cascade method and Shift register method (up to 2 cylinders) 2.2 Design of Hydraulic Circuits Basic Hydraulic Circuits: Meter in, meter out and Bleed off circuits; Intensifier circuits, Regenerative Circuit, Counter balance valve circuit and sequencing circuits.	08	CO2

		Self-Learning Topic: Pneumatic Circuit Design Hydraulic Circuit Design	08	
III	**Electro-pneumatic Circuits**	3.1 Electro-pneumatic Circuits Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping; 3.2 PLC Discrete Control Systems Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.	7	CO3
		Self Learning Topic: Electro-Pneumatic Circuit Design PLC-Based Pneumatic Control	07	
IV	**Robotics**	Robots and their applications: Introduction to Robots, Types, Classifications, Selection of Robots, Robot Degrees of freedom, Robot configuration, Accuracy and repeatability, Specification of a Robot, Robot feedback controls: Point to point control and Continuous path control, Control system for Robot joint, Adaptive control, Drives and transmission systems, End effectors, Industrial robot applications, Nex-gen robots.	08	CO4
		Self Learning Topic: Robotics and Applications	08	
V	**Problem Solving**	(Concept and Algorithms, No programming or numerical) 5.1 Problem Solving: Tree and Graph Search, Uninformed v/s informed search, uninformed methods: depth first search, breadth first search, Informed search: heuristic search, Best first search, branch and bound 5.2 Machine Learning: Introduction, types of machine learning: supervised, unsupervised, reinforcement	07	CO5

		learning 5.3 Learning with Decision Trees: Introduction to Decision Trees, Classification and Regression Trees, K means clustering algorithm, K nearest neighbors algorithm, hierarchical clustering, Concept of ensemble methods: bagging, boosting, random forests		
		Self Learning Topic: Problem Solving Algorithms Introduction to Machine Learning Decision Trees and Clustering	07	
VI	**Artificial Intelligence**	(Concept and Algorithms, No programming or numericals) 6.1 Learning with regression: Linear regression, Logistic regression 6.2 Artificial Neural Networks Concept of ANN, Basic Models of Artificial Neural Networks Important Terminologies of ANNs McCulloch-Pitts Neuron, NN architecture, perceptron, delta learning rule, backpropagation algorithm, Gradient Descent algorithm, feed forward networks, activation functions 6.3 Introduction to AI Technologies in the realm of Automation Concept of Natural Language Processing, Machine Vision, Deep learning, Expert systems, Genetic Algorithms, Industry 4.0	08	CO6
		Self-Learning Topic: **6.1** Regression Learning Concepts **6.2** Artificial Neural Networks **6.3** AI Technologies in Automation	08	

Text / Reference Books:

1) Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
2) Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition
3) Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson education
4) Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education

5) Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
6) Industrial Hydraulics: Pippenger
7) Mechatronics, Nitaigour Mahalik, Tata McGraw-Hill.
8) M.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, New Delhi.
9) Yoram Korean, "Robotics for engineers", McGrew Hill Co.
10) Artificial Intelligence by Elaine Rich, Kevin Knight and Nair ISBN-978-0-07008770-5, TMH.
11) Artificial Intelligence & Machine Learning by Vinod Chandra .S.S. Anand Harindran. S. (PHI).
12) A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112/103/112103174/
2	https://nptel.ac.in/courses/112/103/112103293/
3	https://nptel.ac.in/courses/112/102/112102011/
4	https://nptel.ac.in/courses/112/101/112101098/
5	https://nptel.ac.in/courses/112/103/112103280/
6	https://nptel.ac.in/courses/106/106/106106139/

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks
2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			eaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211672	Mechatronics	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211672	Mechatronics	20	20	40	60	2.5	--	--	100

Rationale:

Mechatronics is an interdisciplinary field that integrates mechanical engineering, electronics, control systems, sensors, actuators, and computer-based automation technologies for the development of intelligent engineering systems. The course provides fundamental knowledge of mechatronic system design, sensor and actuator selection, data acquisition systems, pneumatic and hydraulic automation, control systems, and PLC-based industrial automation. It develops the ability to analyze, design, and implement automated systems used in manufacturing, robotics, automotive systems, process industries, and smart machines. The course also introduces modern control and automation techniques that are essential for Industry 4.0 and advanced manufacturing environments. The knowledge gained through this course helps students develop problem-solving skills, system integration capability, and practical understanding of industrial automation and intelligent control systems.

Course Objectives:

1) To study key elements of Mechatronics system and its integration
2) To familiarise concepts of sensors characterization and its interfacing with microcontrollers
3) To acquaint with concepts of actuators and its interfacing with microcontrollers
4) To study continuous control logics i.e. P, PI, PD and PID
5) To study discrete control logics in PLC systems and its industrial applications.

Course Outcomes:

1) Identify and select suitable sensors and actuators for mechatronic systems based on application requirements.
2) Select appropriate logic control systems for industrial automation applications.
3) Analyze continuous and sequential control logics for standard input conditions in mechatronic systems.
4) Develop PLC ladder logic programs for automation and control applications.
5) Design hydraulic and pneumatic circuits for industrial automation systems.
6) Design and integrate mechatronic systems using sensors, actuators, control systems, and automation principles.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Introduction to Mechatronics and System Representation**	Introduction to Mechatronics and its block diagram representation, Key elements of mechatronics, Applications of Mechatronics in domestic and industrial sectors, Representation of mechatronic systems using block diagrams, Concept of transfer function for each element of mechatronic systems, Reduction methods and numerical treatment for represented block diagrams	07	CO1
		Self-Learning Topic: Applications of Mechatronics in Smart Systems, Transfer Function Modeling of Mechatronic Systems	07	
II	**Selection of Sensors and Actuators**	Sensors: Criteria for selection of sensors based on requirements, principle of measurement, sensing methods, performance characteristics for displacement, temperature, acceleration, force/pressure sensors based on static and dynamic characteristics. Actuators: Selection criteria based on principle of operation, performance characteristics, loading conditions and safety. Principle	08	CO2

		and selection of DC motors, Stepper motors, Solenoid actuators, Servo motors and BLDC motors		
		Self-Learning Topic: Industrial Sensor Applications, Smart Actuators and Motor Selection Techniques	08	
III	**Data Acquisition, Signal Conditioning and Microcontroller System Theory**	Concept of bit accuracy/width and sampling speed, Sampling theorem, Aliasing, Nyquist criteria, ADC using successive approximation method and sample-and-hold circuitry, DAC using R-2R circuits and DAC resolution, Signal Filters: Low pass, High pass and Band pass filters with simple circuit diagrams	7	CO3
		Self-Learning Topic: ADC/DAC Applications in Embedded Systems, Signal Conditioning Techniques in Mechatronics	07	
IV	**Pneumatics and Hydraulics**	Hydraulic and pneumatic devices, Different types of valves, Actuators and auxiliary elements in pneumatic and hydraulic systems, Applications and use of ISO symbols, Synthesis and design of pneumatic, electro-pneumatic, hydraulic and electro-hydraulic circuits (up to 2 cylinders)	08	CO4
		Self-Learning Topic: Pneumatic Circuit Design, Electro-Hydraulic Automation Systems	08	
V	**Control Systems**	Control system design and analysis using Root Locus Method, Frequency response methods, Stability margin, Nyquist diagram, Bode diagram, P, I and D control actions, P, PI, PD and PID control systems, Transient response characteristics: Percentage overshoot, Rise time, Delay time, Steady state error, PID tuning using manual and Ziegler-Nichols methods	07	CO5

		Self-Learning Topic: PID Controller Applications, Frequency Response Analysis Techniques	07	
VI	**Discrete Control System and PLC**	Introduction to PLC, PLC architecture, Ladder logic programming for different logic gates, Latching circuits, Timers, Counters, Practical examples of ladder programming	08	CO5
		Self-Learning Topic: PLC Programming for Industrial Automation, Advanced Ladder Logic Applications	08	

Text / Reference Books:

1. Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc

2. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press

3. Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition

4. Introduction to Mechatronics and Measurement Systems, Alciatore and HistandTata McGraw-Hill

5. Mechatronics, Necsulescu, Pearson education

6. Mechatronics - Electromechanics and Control Mechanics , Mill Springer-Verlag

7. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson eduaction

8. Mechatronics - Electronics in products and processes , Bradley, et al. Chapman and Hall

9. Mechatronics - Mechanical System Interfacing , Auslander and Kempf, Prentice Hall

10. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education

11. Pneumatic Circuits and Low Cost Automation by Fawcett JR

12. The Art of Electronics, Horowitz and Hill Cambridge, University Press

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112107298
2	https://onlinecourses.nptel.ac.in/noc25_ee142/
3	https://onlinecourses.nptel.ac.in/noc25_ee88/
4	https://nptel.ac.in/courses/108106098
5	https://onlinecourses.nptel.ac.in/noc25_ee57/
6	https://onlinecourses.nptel.ac.in/noc25_me154/

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)
Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

  Note: -

  1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks

  2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
16211673	Renewable Energy Sources	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
16211673	Renewable Energy Sources	20	20	40	60	2.5	--	--	100

Rationale:

This subject aims to provide fundamental knowledge of various renewable energy sources such as solar, wind, biomass, hydrogen, geothermal, and ocean energy. It emphasizes the working principles, technologies, and practical applications of renewable systems.

The course also introduces energy management and auditing concepts to promote efficient and sustainable energy usage. With a focus on current global and national energy scenarios, it equips students with the skills to analyze, implement, and evaluate green energy solutions for a sustainable future.

Course Objectives:

1. To study working principles of various renewable energy sources and their utilities.
2. To study design and installation criteria of various equipment's to convert the renewable energy into useful energy.
3. To study economics of harnessing energy from renewable energy sources.

Course Outcomes:

1. Describe the need for renewable energy and its potential for the development of a sustainable environment.
2. Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy.
3. Identify and analyze various wind turbine energy harnessment techniques.
4. Design biogas plant for harnessing energy from organic waste.
5. Describe significance of hydrogen energy to fulfill present and future energy needs.
6. Describe the operating principle of geothermal energy and ocean energy and their role in sustainable development.

Prerequisite: Thermodynamics, **Heat Transfer**, **Fluid Mechanics**

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Introduction to Renewable Energy and Solar Radiation**	**1.1: Introduction to Renewable Energy** Sources and Solar Radiation: Global and National current energy scenarios, Prospects of renewable energy sources and renewable energies role in developing sustainable model. **1.2: Solar radiation terms**, solar geometry, earth sun angles, attenuation and measurement of solar radiation on horizontal and inclined surfaces, methods of solar radiation estimation.	07	CO1
		Self Learning Topic: Renewable Energy Overview	07	
II	**Solar Thermal Energy**	**Solar Thermal Energy:** **2.1: Introduction and working** principle of flat plate collectors, thermal performance analysis of flat plate	08	CO2

		collectors, concentrating collectors, Installation and maintenance criteria of solar thermal systems. **2.2: Solar thermal devices-** Solar air heater and different types of solar air heaters, solar water heater and different types of solar water heaters, solar dryers, solar pond, solar distillation, solar still, solar cooker. 2.3: Solar space heating & cooling, solar refrigerator, solar thermal energy storage systems. Case Study: Solar thermal power plant working operation.		
		Self Learning Topic: Solar Collector Systems	08	
III	**Solar Photovoltaic Energy**	**Solar Photovoltaic Energy:** **3.1:** Introduction and working principle of a solar PV systems, types of solar PV cells, solar tracking systems, controls and measurement methods of solar PV systems. **3.2:** Methods to improve the efficiency of PV cells, parameters which affect the efficiency and life cycle of PV cells. Case Study: Installation of 1 kW of solar PV plant.	07	CO3
		Self Learning Topic: Solar PV System Basics	07	
IV	**Wind Energy**	**4.1: Basic components and working** principle of wind energy conversion systems, wind data and site selection considerations, various types of wind energy conversion systems, constructional features of horizontal and vertical axis wind machines,	08	CO4

		performance analysis of horizontal and vertical axis wind machines. **4.2: Estimation of power output**- betz limits, Environmental impacts of wind energy.		
		Self Learning Topic: Wind Energy Systems Basics		
V	**Energy from Biomass and Hydrogen Technologies**	**5.1: Energy from Biomass:** Introduction of bioenergy, conversion technologies, types of biogas generation plants, design and construction details of biogas plant (KVIC), site selection, digester design consideration, filling a digester for starting, maintaining biogas production, utilization of biogas. **5.2: Hydrogen Energy:** Introduction and application, General introduction to infrastructure requirement for hydrogen production, storage, dispensing & utilization. Principles of fuel cells, types of fuel cells, power generation by fuel cells, applications of fuel cells.	07	CO5
		Self Learning Topic: Biomass and Biogas Energy	07	
VI	**Geothermal, Ocean Energy and Sustainable Energy Practices**	**6.1: Geothermal Energy:** Introduction to geothermal technologies and methods of extracting geothermal energy, prospects of geothermal energy in India. **6.2: Energy from the ocean**: Wave energy characteristics and wave energy conversion devices, tide energy conversion devices, Ocean Thermal Energy Conversion (OTEC) systems.	08	CO6

		6.3: Energy management and economics: Energy conservation, energy security, energy economics, energy audit- definition, need, types of energy audit, Energy management (audit) approach-understanding energy costs, Energy conservation in Buildings: Energy Conservation Building Codes (ECBC): Green Building, LEED rating.		
		Self Learning Topic: Geothermal Energy Systems	08	

Text Books:

1. "Non-conventional Energy Sources", G.D. Rai, 6th Edition, Khanna Publishers, ISBN: 978-81-7409 073-7
2. "Renewable Energy: Power for a Sustainable Future", Edited by Godfrey Boyle, 3rd Edition 2012, Oxford University Press, ISBN: 978-0199681273
3. "Solar Energy: Principles of Thermal Collection and Storage", SP Sukhatme and J K Nayak, 4th Edition, Tata McGraw Hill Publishing Co. Ltd.
4. "Solar Energy: Fundamentals and Applications", H.P. Garg& Jai Prakash, First Revised Edition, Tata McGraw-Hill Education.
5. "Wind Power Technology", Joshua Earnest, 2nd Edition, PHI Learning, 2015.
6. "Solar Engineering of Thermal Processes", John A. Duffie and William A Bechman, 4th Edition, Wiley Publications.

References:

1. "Renewable Energy Sources", J W Twidell& Anthony D. Weir, 3rd Edition 2015, ELBS Pub, ISBN: : 978-1-315-76641-6

2. "Energy Conversion Systems", Rakosh Das Begamudre, New Age International (P) Ltd., Publishers, New Delhi, 2007, ISBN: 9788122412666

3. "Solar Photovoltaics: Fundamentals, Technologies and Applications", C S Solanki, 3rd Edition, PHI Learning.

4. "Biomass Regenerable Energy", D. D. Hall and R. P. Overend, John Wiley, New York, ISBN:047190919X

5. "Wind and Solar Power Systems", Mukund R Patel, 2nd Revised Edition, CRC Press, ISBN: 9780429114960

6. "Wind Energy Explained: Theory, Design and Application", J F Manwell, J.C. McGowan, A. L. Rogers,2nd Edition 2009, John Wiley and Sons.

Online References:

Sr. No.	Links for online NPTEL/SWAYAM courses
1	https://nptel.ac.in/courses/103103206
2	https://nptel.ac.in/courses/103107157
3	https://nptel.ac.in/courses/115105127

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)
Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks

2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
993116801	Product Design and Development	3	--	--	45	--	--	45	90	3

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
993116801	Product Design and Development	20	20	40	60	2.5	--	--	100

Rationale:

This course emphasizes the importance of product development to meet customer needs and market expectations. It integrates engineering and industrial design with systematic design processes and models.

Students learn to apply tools like QFD to translate user needs into technical specifications. Creative thinking methods foster innovation in concept generation. Industrial design principles and DFMA ensure usability, sustainability, and manufacturability. Prototyping techniques bridge the gap between design and real-world application.

Course Objectives:

1. To understand the basic concepts of engineering design and product design & development, focusing on the front-end processes.
2. To demonstrate an understanding of the overview of all the product design & development processes.
3. To demonstrate knowledge of concept generation and the selection of tools.
4. To study the applicability of product design & development in industrial applications.

Course Outcomes:

1. Describe the need, process, and societal relevance of product design and development.
2. Employ design models, concept evaluation methods, and product architecture principles in the development of engineering design solutions
3. Create product design specifications by applying customer needs analysis, QFD, and competitive benchmarking techniques.
4. Demonstrate creative thinking and problem-solving techniques to generate and develop innovative design concepts.
5. Fabricate product design models incorporating industrial design principles, human factors, and environmental considerations.
6. Work collaboratively to apply DFMA principles and prototyping techniques using computer-aided tools for product development.

Prerequisite: Basic knowledge of manufacturing processes and CAD modeling, Knowledge of basic market research methods and product requirement analysis, Basic engineering and design awareness

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Product Design Process and Market Relevance in Engineering**	Need for developing products, The importance of Engineering and Industrial design, The design process, Relevance of product lifecycle issues in design, Societal considerations in Engineering and Industrial Design, Generic product development process, Various phases of product development,	08	CO1
		Self-learning Topics: Planning for products, Establishing markets - market segments - relevance of market research.	08	

II	**Design Processes: From Concept Generation to Product Architecture**	The design processes, Descriptive and prescriptive design models, Concept development & evaluation, Pugh's total design activity model, Concept generation and selection method, Embodiment design, **Self-learning Topics:** Product architecture, and Steps in developing product architecture.	08	CO2
III	**Human-Cantered Design: Needs, Benchmarking, and QFD**	Identifying customer needs, Voice of Customer (VoC), Customer populations, Hierarchy of human needs, Need gathering methods, Establishing engineering characteristics, Competitive benchmarking, Quality Function Deployment (QFD), House of Quality (HoQ), **Self-learning Topics:** Product design specification, Development of product design with specifications using QFD, Relevant case studies.	08	CO3
IV	**Creativity and Innovation in Engineering Design**	Creative thinking, Creativity and problem-solving methods, Creative thinking methods, Brainstorming technique, Gorden technique, Check listing technique, Synectic technique, Morphological Analysis, and Attribute Listing technique. **Self-learning Topics:** Generating design concepts, Systematic methods of designing.	07	CO4
V	**Aesthetic and Functional Aspects of**	Industrial design, Basic forms & elements, Integrating basic forms & elements such as balance, rhythm, proportion, The golden rule of	07	CO5

	Industrial Design	proportions, human factors, and design, User-friendly design, **Self-learning Topics:** Design for serviceability, Design for environment.		
VI	**Rapid Prototyping and DFMA in Modern Product Design**	Concept of Design for Manufacturing and Assembly (DFMA). Role of computers in product design and manufacturing process, Prototyping techniques such as Stereolithography (SLA), Selective laser sintering (SLS), Fused disposition Modelling (FDM), Laminated object manufacturing (LOM), **Self-learning Topics:** 3-D printing, and Ballistic Particle Manufacturing (BPM).	07	CO6

Text Books:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, "Product Design," Indian Reprint 2004, Pearson Education, ISBN 9788177588217.

References Books:

1. Clive L. Dym, Patrick Little, "Engineering Design: A Project-based Introduction," 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C. Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process," 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

Online References:

Sr. No.	Links for online NPTEL/SWAYAM courses
1	https://youtube.com/playlist?list=PLSGws_74K018yZOnbSaqWJZ837QyBB7vu&feature=shared – Product Design and Development, IIT, Roorkee
2	https://youtube.com/playlist?list=PLp6ek2hDcoNALWidcTcFur34atzXNYHjD&feature=shared - Product Design and Development, IIT, Delhi

Assessment:

Summary of Internal Assessment (IA) and End Semester Examination (ESE)

Internal Assessment (IA) – 40 Marks

- Two compulsory Internal Assessment Tests (IATs) of **20 marks each** will be conducted.
- **IAT-I** will cover three CO's and **IAT-II** will cover the remaining three CO's (Course Outcomes).
- Duration of each test: **1 hour**.
- The **summation of both tests** will be considered for IA marks.

End Semester Examination (ESE) – 60 Marks

- Duration: **2 Hours 30 Minutes**
- Question paper consists of **six compulsory questions**, **10 marks each**.
- Questions will be set module-wise: Q1 – Module I, Q2 – Module II, Q3 – Module III and so on...
- Each question may have **two alternatives (Option A / Option B)** from the same module.
- Both options should be of **similar difficulty level** and assess similar learning outcomes.
- Internal choice may be provided within questions.
- Questions should cover the **entire syllabus**, all Course Outcomes, and different levels of learning as per **Bloom's Taxonomy**.

Note: -

1.Internal Assessment (IA) – 40 Marks + End Semester Examination (ESE) – 60 Marks = Total – 100 Marks
2.No questions shall be asked from self-learning modules in either the Internal Assessment or the End Semester Examination.

Course Code	Course Name	Teaching Scheme (Contact Hours Per Week			Teaching Scheme (Contact Hours Per Semester)					Total Credits (C) (Notional Learning Hour/30
		L	T	P	L	T	P	SL	Notional Learning Hour	
98452609	Industrial Skill	2	--	--	30	--	--	30	60	2

Course Code	Course Name	Examination Scheme					Term work	Pract / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total					
98452609	Industrial Skill	--	--	--	--	--	25	--	25

Rationale:

This course is designed to develop essential professional, communication, cognitive, and industrial skills required for engineering graduates in academic and industrial environments. The course focuses on computer proficiency, aptitude development, along with measurement techniques and control engineering concepts which helps to understand working of critical mechanical and related industrial systems.

Course Objectives:

1. Develop proficiency in computer applications and office productivity tools.
2. Improve aptitude, analytical thinking, and logical reasoning abilities.
3. To study fundamentals of inspection methods and systems
4. To study characteristics of Mechanical Measurement systems
5. To study identification and rectification of error present in Measurement System
6. To study the characteristics of Control Systems and their application in industries.

Course Outcomes:

1. **Apply computer applications and office productivity tools** to prepare technical reports, analyze data, and present engineering solutions effectively.
2. **Demonstrate aptitude, analytical thinking, and logical reasoning skills** by solving engineering problems and interpreting measurement data.
3. **Explain and evaluate inspection methods and systems** for assessing dimensional accuracy and surface quality in mechanical components.
4. **Analyze the characteristics of mechanical measurement systems** including sensitivity, accuracy, precision, and calibration requirements.
5. **Identify, quantify, and propose rectification methods for errors** present in measurement systems to improve reliability and accuracy.
6. **Interpret and apply control system principles** (open & close loop) to industrial automation and mechanical engineering applications.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Basics of Computers and Office Productivity Tools	Basics of computers, Desktop/Laptop operations, File handling, Introduction to operating systems, Microsoft Office tools. MS Word: Page setup, text formatting, templates, SmartArt, editing tools, Ribbon bar. MS Excel: Spreadsheet creation, formulas, charts, pivot tables, basic VBA concepts. MS PowerPoint: Presentation preparation, themes, animations, presentation techniques. **Self-Learning Topics:** Cloud-based office tools, Advanced presentation tools	5 5	CO1

II	Aptitude and Logical Reasoning	Quantitative aptitude concepts, Arithmetic aptitude, Analytical aptitude, Verbal and non-verbal reasoning, Problem-solving approaches, Practice exercises and mock tests. **Self-Learning Topics:** Competitive examination aptitude techniques, Online aptitude platforms	5 5	CO2
III	Inspection Methods	Concept of Metrology and Measurement including Limit Gauge Design. **Self-Learning Topics:** Design a set of limit gauges used for inspection in industries.	5 5	CO3
IV	Mechanical Measurement System	Measuring Mechanical Measurement parameters using various equipment. **Self-Learning Topics:** understanding different physical quantities required in industrial application and methods to measure them.	5 5	CO4
V	Errors in Measurement System	Identify and Compute error and also methods to rectify the errors in Measurement System **Self-Learning Topics:** Comparing errors in industrial inspection devices and method to rectify them as per applications.	5 5	CO5

VI	Introduction to Control systems	Understanding working of various control systems used in industries and comparing open loop and close loop systems. **Self-Learning Topics:** Compare open loop and close loop systems used in industrial applications.	5 5	CO6

Assignments:

Sr No	List of Assignment	Hrs
01	Application of MS Office skills (Individual) Create and edit Word documents Create and execute MS Excel functions Create and enhance MS PPT	2
02	Aptitude and Logical reasoning tests/practice sheets	2
03	Limit Gauge Design	2
04	Mechanical measurement techniques	2
05	Errors in Measurement	2
06	Introduction to Control Systems	2

Case studies on problem-solving to be done as a team activity.

Books recommended/References/ Resources:

1. Thorpe, Edgar and Showick Thorpe. Objective English, Pearson, 2013. (7 th edition Amazon)
2. Thorpe, Edgar. Test of Reasoning: for All Competitive Examination. 7 th edition., Amazon
3. Sinha, Nishit K., Reasoning, Pearson.
4. Aggarwal, R.S., A Modern Approach to Logical Reasoning, S. Chand.
5. Various Quantitative aptitude books and websites list
6. https://eduly.in/best-quantitative-aptitude-books/

7. https://prepinsta.com/learn-aptitude/
8. **Mechanical Measurements and Instrumentation** – *R.K. Rajput*, S. Chand
9. **Dimensional Metrology** – *M. L. Aggarwal*, Khanna Publishers
10. **Measurement Systems: Application and Design** – *Ernest O. Doebelin & Dhanesh Manik*, McGraw Hill

Online Resources:

Sr. No.	Website Name
1	**Creativity https://nptel.ac.in/courses/109101017**
2	**MS Excel https://www.coursera.org/projects/introduction-microsoft-excel**
3	**Problem solving https://www.coursera.org/learn/problem-solving**
4	http://ial-coep.vlabs.ac.in/ - Industrial Automation Laboratory, COEP

Assessment:

Distribution of marks for Term Work shall be as follows:

Assignment: 20 Marks

Attendance: 05 Marks