

**Bharati Vidyapeeth**  
**(Deemed to be University)**  
**College of Engineering, Pune**  
**Department of Mechanical Engineering**

**Course Structure & Syllabus**

**For**

**B. Tech. Mechanical Semester- VII & VIII**

**(CBCS 2023 Course as Per NEP 2020 Guidelines)**



**Bharati Vidyapeeth**  
**(Deemed to be University)**  
**College of Engineering, Pune**  
**Department of Mechanical Engineering**



**Vision of the Bharati Vidyapeeth (Deemed to be University) College of Engineering is:**

*To be a world-class institute for Social Transformation through Dynamic Education*

**Missions of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:**

- *To provide quality technical education with advanced equipment, qualified faculty members, and infrastructure to meet the needs of the profession & society.*
- *To provide an environment conducive to innovation, creativity, research, and entrepreneurial leadership.*
- *To practice and promote professional ethics, transparency, and accountability for the social community, economic & environmental conditions.*

**Goals of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:**

- *Experienced recruiting faculty.*
- *Organizing faculty development programs.*
- *Identifying socio-economically relevant areas & emerging technologies.*
- *Constant review & upgradation of curricula.*
- *Upgradation of laboratories, library & communication facilities.*
- *Collaboration with industry and research & development organizations.*
- *Sharing of knowledge, infrastructure, and resources.*
- *Training, extension, testing, and consultancy services.*
- *Promoting interdisciplinary research.*

**The vision of the Mechanical Engineering Department is:**

*To develop high-quality Mechanical Engineers through dynamic education to meet social and global challenges.*

**Mission Statements of the Mechanical Engineering Department are:**

- *To provide extensive theoretical and practical knowledge to the students with well-equipped laboratories and ICT tools through motivated faculty members.*
- *To inculcate aptitude for research, innovation, and entrepreneurial qualities in students.*
- *To acquaint students with ethical, social, and professional responsibilities to adapt to the demands of the working environment.*

## **Program Educational Objectives (PEOs) of the B. Tech. Mechanical are:**

*Graduates will be able,*

- *To fulfill the needs of industry and society with theoretical and practical knowledge.*
- *To engage in research, innovation, lifelong learning, and continued professional development.*
- *To fulfill professional ethics and social responsibilities.*

## **Knowledge and Attitude Profile (WK)**

*WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.*

*WK2: Conceptually based mathematics, numerical analysis, data analysis, statistics, and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.*

*WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.*

*WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.*

*WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.*

*WK6: Knowledge of engineering practice (technology) in the practice areas of the engineering discipline.*

*WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.*

*WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.*

*WK9: Ethics, inclusive behavior, and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability, etc., with mutual understanding and respect, and of inclusive attitudes.*

## **PROGRAM OUTCOMES**

*PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals, and an engineering specialization as specified in WK1 to WK4, respectively, to develop solutions to complex engineering problems.*

*PO2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems, reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)*

*PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society, and environment as required. (WK5)*

*PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge, including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).*

*PO5: Engineering Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering & IT tools, including prediction and modelling, recognizing their limitations to solve complex engineering problems. (WK2 and WK6)*

*PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for their impact on sustainability with reference to economy, health, safety, legal*

*framework, culture, and environment. (WK1, WK5, and WK7).*

*PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity, and inclusion; adhere to national & international laws. (WK9)*

*PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.*

*PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, making effective presentations considering cultural, language, and learning differences*

*PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.*

*PO11: Life-Long Learning: Recognize the need for and have the preparation and ability for i) independent and life-long learning, ii) adaptability to new and emerging technologies, and iii) critical thinking in the broadest context of technological change. (WK8)*

### **Statements of Program Specific Outcomes (PSOs)**

*PSO1: Use the knowledge of thermal, design, manufacturing engineering, and computational sciences to solve Mechanical Engineering problems.*

*PSO2: Use Mechanical Engineering principles for research, innovation, and develop entrepreneurial skills*

**B. Tech. Mechanical: Semester I (CBCS 2023 Course as per NEP 2020 Guidelines)**

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	BM	BM1113101	Engineering Mathematics- I	3	-	1	60	40	-	-	-	100	3	-	1	4
2.	BP	BP1113102	Engineering Physics	3	2	-	60	40	50	-	-	150	3	1	-	4
3.	EE	EE1107103	Electrical Engineering Systems	4	2	-	60	40	25	-	-	125	4	1	-	5
4.	ES	ES1111104	Computer Aided Engineering Graphics <sup>#</sup>	4	2	-	60	40	50	-	-	150	4	1	-	5
5.	MJ	MJ1111105	Mechanical Engineering Systems	3	2	-	60	40	25	-	-	125	3	1	-	4
6.	UH	UH1113106	Universal Human Values	-	2	-	-	-	50	-	-	50	-	1	-	1
7.	SE	SE1111107	Skill-Based Course-I: Programming in C/C++	-	4	-	-	-	25	-	25	50	-	2	-	2
<b>Total</b>				<b>17</b>	<b>14</b>	<b>1</b>	<b>300</b>	<b>200</b>	<b>225</b>	<b>-</b>	<b>25</b>	<b>750</b>	<b>17</b>	<b>7</b>	<b>1</b>	<b>25</b>

**B. Tech. Mechanical: Semester – II (CBCS 2023 Course as per NEP 2020 Guidelines)**

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	BM	BM1113201	Engineering Mathematics- II	3	-	1	60	40	-	-	-	100	3	-	1	4
2.	BC	BC1113202	Engineering Chemistry	3	2	-	60	40	50	-	-	150	3	1	-	4
3.	ES	ES1108203	Electronics Engineering Systems	4	2	-	60	40	50	-	-	150	4	1	-	5
4.	ES	ES1102204	Engineering Mechanics	4	-	-	60	40	-	-	-	100	4	-	-	4
5.	MJ	MJ1111205	Computer-Aided Machine Drawing <sup>#</sup>	3	4	-	60	40	50	-	-	150	3	2	-	5
6.	AE	AE1113206	Communication Skills	-	2	-	-	-	50	-	-	50	-	1	-	1
7.	SE	SE1111207	Skill-Based Course-II: Workshop Technology	-	4	-	-	-	25	-	25	50	-	2	-	2
<b>Total</b>				<b>17</b>	<b>14</b>	<b>1</b>	<b>300</b>	<b>200</b>	<b>225</b>	<b>-</b>	<b>25</b>	<b>750</b>	<b>17</b>	<b>7</b>	<b>1</b>	<b>25</b>

# Indicates 4 Hrs. Theory Paper during End Semester Examination



**B. TECH. MECHANICAL: COURSE STRUCTURE: (CBCS 2023 Course) As per NEP 2020 Guidelines**

**B. Tech. Mechanical Sem.-V**

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	MJ	MJ1111501	Heat Transfer-Principles & Applications	3	2	-	60	40	25	-	25	150	3	1	-	4
2.	MJ	MJ1111502	Turbo Machinery	3	2	-	60	40	25	-	25	150	3	1	-	4
3.	MJ	MJ1111503	Renewable Energy Technologies	3	-	-	60	40	-	-	-	100	3	-	-	3
4.	MJ	MJ1111504	Computer-Integrated Manufacturing	3	2	-	60	40	25	-	25	150	3	1	-	4
5.	MJ	MJ1111505	Machine Design & Analysis -II*	3	-	1	60	40	-	-	-	100	3	-	1	4
6.	SE	SE1111506	Skill-Based Course-V: Computer-Oriented Numerical Methods	-	2	-	-	-	25	-	25	50	-	1	-	1
7.	AC	AC1102507	Environmental Studies**	4	-	-	60	40	-	-	-	100	4	-	-	4
			<b>Total</b>	<b>19</b>	<b>8</b>	<b>1</b>	<b>360</b>	<b>240</b>	<b>100</b>	<b>-</b>	<b>100</b>	<b>800</b>	<b>19</b>	<b>04</b>	<b>1</b>	<b>24</b>

\*End Sem. Examination of 4 Hrs; \*\*Mandatory Audit Course.

**B. Tech. Mechanical Sem.-VI**

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	MJ	MJ1111601	Introduction to CFD & FEA	3	2	-	60	40	25	25	-	150	3	1	-	4
2.	MJ	MJ1111602	Industrial Automation	3	-	-	60	40	-	-	-	100	3	-	-	3
3.	MJ	MJ1111603	Refrigeration & Air Conditioning	3	2	-	60	40	25	-	-	125	3	1	-	4
4.	PE	PE1111604	Program Elective-I	3	0	-	60	40	-	-	-	100	3	-	-	3
5.	MJ	MJ1111605	Mechanical System Design*	3	2	-	60	40	25	-	25	150	3	1	-	4
6.	SE	SE1113606	Professional Skills	-	2	-	-	-	25	-	-	25	-	1	-	1
7.	SE	SE1111607	Skill-Based Course-VI: Introduction to Data Science	-	2	-	-	-	25	-	25	50	-	1	-	1
			<b>Total</b>	<b>15</b>	<b>10</b>	<b>-</b>	<b>300</b>	<b>200</b>	<b>125</b>	<b>25</b>	<b>50</b>	<b>700</b>	<b>15</b>	<b>5</b>	<b>-</b>	<b>20</b>
8.	VA	VA1111608	Value-added courses-II <sup>#</sup>	2	-	-	-	50	-	-	-	50	2	--	-	2
9.	AE	AE1111609	MOOC-II	2	-	-	-	--	-	-	-	--	-	-	-	2

<sup>#</sup>Value added Course-II: 1. Solar PV Installation; 2. Area Service Manager

Program Elective-I: 1. Industrial Engineering & Management; 2. Engineering Economics; 3. Additive Manufacturing and Rapid Prototyping; 4. Reliability and Machine Condition Monitoring; 5. Carbon Footprint and GHG Accounting

## B. Tech. Mechanical: (CBCS 2023 COURSE) As per NEP 2020 Guidelines

### B. Tech. Mechanical Sem.-VII & VIII

#### Track/Module-I

S. No.	Category	Course Code	Course	Teaching Scheme Hrs./Week			Examination Scheme-Marks						Credits			
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	PE	PE1111701	Program Elective-II/III	4	-	-	60	40	-	-	-	100	4	-	-	4
2.	SM	SE1111702	Seminar	-	4	-	-	-	50	-	50	100	-	2	-	2
3.	IN	IN1111703	Internship*	-	-	-	-	-	100	-	100	200	-	14	-	14
<b>Total</b>				<b>04</b>	<b>04</b>	<b>-</b>	<b>60</b>	<b>40</b>	<b>150</b>	<b>-</b>	<b>150</b>	<b>400</b>	<b>4</b>	<b>16</b>	<b>-</b>	<b>20</b>

\*Note: The students can opt for either Industry or In-house Internship for one semester (14 Weeks)

#### Track/Module-II

S. No.	Category	Course Code	Course	Teaching Scheme Hrs./Week			Examination Scheme-Marks						Credits			
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	MJ	MJ1111801	Power Plant Technologies	4	-	-	60	40	-	-	-	100	3	1	-	4
2.	MJ	MJ1111802	Industrial Product Design	4	-	-	60	40	-	-	-	100	4	-	-	4
3.	PE	PE1111803	Program Elective-II/III	4	-	-	60	40	-	-	-	100	4	-	-	4
4.	RP	RP1111804	Project Work	-	16	-			100	-	50	150	-	8	-	8
<b>Total</b>				<b>12</b>	<b>16</b>	<b>-</b>	<b>180</b>	<b>120</b>	<b>100</b>	<b>-</b>	<b>50</b>	<b>450</b>	<b>11</b>	<b>9</b>	<b>-</b>	<b>20</b>

#### List of Program Electives

Program Elective-II & III	
• Lean, Agile Manufacturing & Six Sigma	• Project Management & Ethics
• Artificial Intelligence & Machine Learning	• Augmented & Virtual Reality
• Production Planning & Control	• Mobile Robot & Drone Technology
• Operations Research	• Advanced Automotive Technology
• Waste to Energy Conversion	• Energy Audit & Management

**Note:** Students may choose any two elective courses from the given list. Upon selection of a track, the first elective opted by the student will be designated as *Program Elective-II*, and the second elective will be designated as *Program Elective-III*.

## **Instructions**

1. Students shall be permitted to opt for either Module I or Module II at a given time; simultaneous enrolment in both modules shall not be allowed.
2. The total credit allocation for Programme Specific Courses (PSC) and Programme Specific Electives (PSE) shall be 4. The distribution of teaching hours among theory, practical, and tutorial components shall be structured appropriately to ensure alignment with the prescribed total of 4 credits.
3. While the distribution of marks for a given module may vary, the total credit allocation shall remain uniform and consistent with the prescribed structure.
4. The Research Work component shall be integrated within the Project Work. Separate guidelines for Project Work may be framed, wherein the expected outcomes shall explicitly include deliverables in the form of research-oriented outputs.

## Course Codes and Definitions

Course Code	Definitions
AC	Audit Course
AE	Ability Enhancement Course
BC	Basic Chemistry Course
BM	Basic Mathematics Course
BP	Basic Physics Course
CC	Co-curricular Courses
EC	Extra-Curricular Course
EE	Electrical Engineering
ES	Engineering Science Course
GE	General Elective Course
ID	Inter-disciplinary Course
IN	Internship
L	Lecture
MD	Multidisciplinary Course
MI	Minor Course
MJ	Major (Core) Course
O	Oral
OE	Open Elective Course
P	Practical
PC	Practical Courses
PE	Programme Elective Course
RP	Research Project Course
SE	Skill Enhancement Course
SEE	Semester End Examination
SM	Seminar
T	Tutorial
TW	Term Work
UH	Course Related to Universal Human Values
VA	Value Added Course
VE	Vocational Enhancement Course
VS	Vocational Skill Courses

### Programme Code:

Commencement/ Revised Year	Faculty Code (Engg & Tech.)	Programme Type (UG)	Programme Number (Mech.)	Programme Code
23	11	2	11	2311211

### Course Code:

Type of Course	Faculty Code	Programme Number	Sem/Year	Course Number	Course Code
MJ	11	11	3	01	MJ1111301

**Program Elective: II/III: LEAN, AGILE MANUFACTURING & SIX SIGMA  
(Course No. PE1111701/803)**

Designation of Course	Lean, Agile Manufacturing & Six Sigma		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: 04 Hours/Week	Semester End Examination	60 Marks	Theory: 04
Practical:- 00 Hours/Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/Week	Term Work	- Marks	
	Oral	- Marks	
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites</b>	Students should know of 1. Students should have Basic knowledge of Industrial Engineering. 2. Students should have Basic knowledge of statistics.
<b>Course Objectives:</b>	Students should be able to 1. Use of the Six Sigma technique to reduce variation 2. Use of Lean manufacturing for process improvement 3. Use of Agile manufacturing
<b>Course Outcomes:</b>	The learner will be able to 1. Explain the principles of Lean Manufacturing and apply tools such as Value Stream Mapping, Kanban, 5S, JIT, and Kaizen to identify and eliminate waste in manufacturing systems. 2. Describe the concepts of Agile manufacturing and illustrate agile practices in product development, production planning, and organizational collaboration. 3. Analyze the role of management and organizational systems in supporting agile culture, leadership, team development, and performance measurement. 4. Apply statistical tools such as probability distributions, hypothesis testing, ANOVA, and process capability analysis for quality improvement and process evaluation. 5. Explain the Six Sigma framework and apply DMAIC methodology and associated tools such as Pareto charts, value stream mapping, and project charters for process improvement. 6. Analyze manufacturing processes using Six Sigma tools such as control charts, measurement system analysis, hypothesis testing, and design of experiments to improve process performance.

**Course Content**

Unit-I	Lean Manufacturing	(8 Hrs.)
Origin and objectives of lean manufacturing, 3M concept, study of Ford and Toyota Production system, Just in Time (JIT) manufacturing, lean building blocks. Value Creation and Waste elimination, seven types of waste, pull production, different models of pull production, Kanban system, design of Kanban quantities, Kaizen, tools for continuous improvement. The value stream benefits the mapping process. Current state maps-mapping icons, mapping steps. VSM exercise. Takt time calculations standardize work- standard work sequence, timing, and working progress. Quality at source-Automation/Jidoka, Visual management system, Mistake Proofing/Poka-Yoke.5s		

technique-Elements and waste elimination through 5s. Advantages and benefits, 5S audit, Visual control aids for improvements, and a Flexible workforce.		
<b>Unit-II</b>	<b>Agile Production System and Practices</b>	<b>(8 Hrs.)</b>
Agile production includes the task of allied organization-production planning and control, quality assurance, purchasing, maintenance, overview of production support, business operations, engineering, finance, and accounting. Agile Practices-Agile practice for product development, manufacturing Agile practice, Interpreting the value of investment in people.		
<b>Unit-III</b>	<b>Management in the Agile Organization</b>	<b>(8 Hrs.)</b>
Old management styles, role of management in agile organization: vision champion, team leader, coach, business analyzer, supporting the new culture-performance appraisal system, selection system, reward and recognition system, organizational measurement, organizational learning Processes.		
<b>Unit-IV</b>	<b>Statistics and probability distribution</b>	<b>(8 Hrs.)</b>
Basic statistics, probability distributions, normal distribution, central limit theorem, measurement system analysis – precision, accuracy, bias, linearity, gage repeatability & reproducibility. Process Capability analysis. Multivariate analysis, sampling techniques, Hypothesis testing, testing with normal data, one-way ANOVA, and nonparametric tests for non-normal data. Chi-square tests		
<b>Unit-V</b>	<b>Introduction to Six Sigma</b>	<b>(8 Hrs.)</b>
Six Sigma Defined, Calculating the Sigma Level – Toolset, Six Sigma Framework, DMAIC – The Six Sigma Improvement Process, Introduction to Measure, Introduction to Define, Process Thinking, Spaghetti Charts, Value Stream Mapping Toolset, Pareto Chart Toolset, Project Selection Toolset, Project Charter Toolset.		
<b>Unit-VI</b>	<b>Six Sigma in Manufacturing</b>	<b>(8 Hrs.)</b>
Introduction to Measure, Measurements, Discrete vs. Continuous Measurements, Measurement Subjects, Measurement as a Process, The Analysis of Measurement Systems, Statistical Process Control – Introduction and Background, Introduction to Control Charts, Control Chart Limits, More On Control Limits, Cause & Effect Diagram Toolset, Introduction to Hypothesis Testing, The Process on Trial, The Hypothesis – Accept or Reject, Types of Error, Hypothesis Testing, Confidence Intervals, Design of Experiments, Design for Six Sigma (DFSS), Benchmarking, Brainstorming		

### **Project-Based Learning**

1. Chart preparation showing different methods of waste elimination.
2. Chart preparation for showing the various elements of the JIT system.
3. Study of a system based on value stream mapping.
4. Demonstration of elimination of waste using the 5S system.
5. Demonstration of a cause-and-effect diagram for a system.
6. Demonstration of control charts for a system.
7. Study of the system using Six Sigma for reduction in variation.
8. Formulation of Hypothesis, testing, and analysis.

**Textbooks:**

1. Jain R. K., "Engineering Metrology", Khanna Publishers
2. Hume K. J., "Engineering Metrology", Macdonald, 1950
3. Sharp K. W. B., "Practical Engineering Metrology", Pitman Publication, 1970.
4. Pyzdek, T. & Keller, P., "The Six Sigma Handbook", McGraw-Hill.
- 5 Pande, P. & Holpp, L., What is Six Sigma? McGraw-Hill.

**Reference Books :( Minimum 5)**

1. George, M. L., "Lean Six Sigma for Service", McGraw-Hill.
2. George, M. L., Maxey, J., Rowlands, D., & Price, M., "The Lean Six Sigma Pocket Tool Book", McGraw-Hill.
3. Pande, P. & Holpp, L., "What is Six Sigma?", McGraw-Hill.

**Program Elective: II/III- ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING  
(Course No. PE1111701/803)**

Designation of Course	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: - 04 Hours/Week	Semester End Examination	60 Marks	03
Practical: - 00 Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/ Week	<b>Total</b>	<b>100</b>	<b>04</b>

<b>Course Prerequisite:-</b>	1. Engineering mathematics-III, Statistics and Numerical Methods, Sensors Technology
<b>Course Objective:-</b>	To provide Knowledge about 1. To understand the artificial intelligence algorithms for robotics problems. 2. To understand the performance of AI algorithms 3. To compute the complex problems in flexible automation
<b>Course Outcomes:-</b>	On completion of the course, students will be able to 1. <b>Explain</b> the fundamental concepts of Artificial Intelligence, including intelligent agents, rationality, problem-solving approaches, and natural language processing techniques. 2. <b>Apply</b> fuzzy set theory principles and fuzzy inference mechanisms to design simple fuzzy rule-based systems and fuzzy logic controllers for real-world problems. 3. <b>Analyze</b> machine learning problems by selecting appropriate algorithms and performing feature engineering for real-world datasets. 4. <b>Interpret</b> data science concepts, including data types, data sources, and data storage techniques, and apply appropriate data handling methods for industrial applications. 5. <b>Demonstrate</b> awareness and a fundamental understanding of AI techniques in intelligent agents and artificial neural networks 6. <b>Design</b> intelligent systems using metaheuristic techniques for solving engineering design and manufacturing problems.

**Course Content**

<b>Unit I</b>	<b>Introduction to artificial intelligence techniques</b>	<b>(8 Hrs.)</b>
Agents and Environments, the concept of rationality, the nature of environments, the structure of agents, problem-solving agents, programming in an AI environment, developing an artificial intelligence system, and natural language processing.		
<b>Unit II</b>	<b>Fuzzy logic</b>	<b>(8 Hrs.)</b>
Basic concepts in fuzzy set theory, operations of fuzzy sets, fuzzy relational fuzzy logic principles, fuzzy inference, fuzzy rule-based systems, Fuzzy logic controllers, fuzzy decision making, and various industrial applications of fuzzy logic control.		
<b>Unit III</b>	<b>Fundamentals of Machine Learning</b>	<b>(8 Hrs.)</b>
Introduction to ML, Definition & Real-world Applications, Feature Engineering, Introduction to ML Models, Overview of ML Algorithms: Linear Regression, Decision Trees, K-Means, Regression, Classification, Clustering.		
<b>Unit IV</b>	<b>Introduction to Data Science</b>	<b>(8 Hrs.)</b>

Definition of data science, Importance and applications of data science in various industries, Foundations of Data Science, Data types (structured, unstructured, semi-structured), Data sources and data collection methods, Data storage and retrieval techniques.		
<b>Unit V</b>	<b>Artificial neural networks</b>	<b>(8 Hrs.)</b>
Fundamentals of neural networks, neural network architectures, Neural Learning, Supervised Learning, Unsupervised Learning, taxonomy of neural network architectures, standard back propagation algorithms.		
<b>Unit VI</b>	<b>Intelligent systems</b>	<b>(8 Hrs.)</b>
Recent advances: Fundamentals of genetic algorithms, hybrid systems, meta-heuristic techniques like simulated annealing, tabu search, ant colony optimization, artificial immune systems, applications in design and manufacturing.		

**Reference Books:-**

1. S. Russel and P. Norvig, “Artificial Intelligence – A Modern Approach”, Second Edition, Pearson Education
2. David Poole, Alan Mackworth, Randy Goebel, “Computational Intelligence: a logical approach”, Oxford University Press.
3. G. Luger, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Fourth Edition, Pearson Education.
4. J. Nilsson, “Artificial Intelligence: A New Synthesis”, Elsevier Publishers

**Text Book:-**

1. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
2. Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN: 9788131804896
3. Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN9788121939485
4. Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978- 93-85046-52-0
5. Jain N, Artificial Intelligence: making a system intelligent, 2018, ISBN: 9788126579945

**Program Elective: II/III- PRODUCTION PLANNING AND CONTROL  
(Course No. PE1111701/803)**

Designation of Course	Production Planning and Control		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: - 04 Hours/Week	Semester End Examination	60 Marks	04
Practical: - 00 Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/ Week	<b>Total</b>	<b>100</b>	<b>04</b>

<b>Course Prerequisite:-</b>	The student should have 1. Basic knowledge of Industrial Engineering & Management. 2. Basic knowledge of statistics. 3. Basic knowledge of resources of production: Man, Machine, and Material.
<b>Course Objective:-</b>	The student should 1. To acquire the knowledge of the scope, objective, and application of Production Planning and Control in manufacturing Industries. 2. To acquire knowledge of forecasting, material planning, and purchasing. 3. To acquire the knowledge of Inventory control and recent trends in PPC.
<b>Course Outcomes:-</b>	The students should be able to– 1. Explain the objectives, functions, and organizational structure of Production Planning and Control and analyze manufacturing systems and product design considerations in industrial production. 2. Apply forecasting techniques and analyze capacity planning methods to estimate demand and determine effective production capacity. 3. Analyze material planning systems, including MRP, MRP II, Master Production Schedule, and Bill of Materials, and evaluate purchasing decisions such as make-or-buy and vendor development. 4. Apply production control techniques such as process planning, line balancing, scheduling, loading, sequencing, and project management tools (PERT/CPM) for efficient manufacturing operations. 5. Apply inventory control models and analyze selective inventory management techniques and store management practices for efficient material handling and storage. 6. Explain and analyze modern production planning systems and emerging practices such as ERP, APS, JIT, Kanban, Kaizen, and computer-integrated production planning.

**Course Content**

<b>Unit I</b>	<b>Introduction</b>	<b>(8 Hrs.)</b>
Definition, Objectives of PPC, Functions of PPC, PPC Department Organization, Coordination of PPC with other Departments. Types of Manufacturing systems: intermittent system and continuous system. Product development and design-Factor determining the design of a product, Essentials of good design, Product Life Cycle, Steps in new product design and development, Effect of competition on design, Product Analysis, Tools for product development.		
<b>Unit II</b>	<b>Forecasting and Capacity Planning</b>	<b>(8 Hrs.)</b>

Forecasting- Introduction, Needs of Sales forecasting, Forecasting Methods, Statistical methods for making a forecast-Moving average method, Exponential smoothing, Regression analysis. Capacity planning: concept of capacity, measurement of capacity, measures of capacity, factors influencing effective capacity, capacity planning procedure. Aggregate planning.		
<b>Unit III</b>	<b>Planning Materials and Purchasing</b>	<b>(8 Hrs.)</b>
Scope and requirement of MRP, MRP I and MRP II, Master Production Schedule, Bill of Materials, and Capacity Requirement Planning. Purchasing - Documentation, Make or Buy decisions, Vendor Development.		
<b>Unit IV</b>	<b>Techniques And Production Control</b>	<b>(8 Hrs.)</b>
Process planning, route sheet, factor influencing process planning. Line Balancing-Heuristic Method, Rank Position Weightage Method. Scheduling procedure of scheduling, scheduling devices, Gantt Chart, loading devices, Machine Loading Chart, Scheduling and loading techniques, Sequencing of operations - Johnson's rule, Loading, Dispatching, Follow-up, Evaluation, PERT, CPM		
<b>Unit V</b>	<b>Inventory Control and Store Control</b>	<b>(8 Hrs.)</b>
Inventory- Definition, characteristics, objectives, limitations, and Types of Inventories. Cost associated with Inventory, EOQ- basic model, and production model. Quality standards of inventory control, Selective Inventory Management, ABC analysis, and Replenishment Systems. Stores Management: Function of store keeping, Types of stores, Store layout, and storage systems. Stores Documentation, Stores Control, and Control of Wastage and Surplus.		
<b>Unit VI</b>	<b>Recent Trends in PPC</b>	<b>(8 Hrs.)</b>
Introduction to computer-integrated production planning systems, Applications of computers in production planning and control, Enterprise Resource Planning (ERP), Automation of repetitive processes, Customer Relationship Management (CRM), Advanced Planning and Scheduling (APS), MRP software, JIT- elements of Just in Time Systems, Kanban System, Kaizen Strategy.		

### **Project-Based Learning**

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. Basic production control problem in the automobile industry and the best ways of solving it.
2. Impact of inventory management on productivity in an organization.
3. Impact of production planning and control in a manufacturing organization.
4. The effect of stock control profit maximization in a manufacturing company.
5. The effect of material management techniques on production planning processes.
6. The impact of production planning and control on productivity in the manufacturing industry.
7. Impact of quality control as an effective tool in product standardization.
8. An appraisal of material management concept as a strategy for achieving higher productivity.
9. The impact of production planning and control on the operational cost of the manufacturing industry.
10. Minimizing defective products through effective production planning and control.
11. Effect of manpower planning on organization performance.
12. The impact of quality control techniques on the profitability of manufacturing organizations.
13. An assessment of the impact of marketing segmentation on production planning in an organization.
14. An optimal inventory control of raw materials and network analysis of production planning.
15. Minimizing defective products through effective production planning and control in defence.

### **Textbooks:**

1. "Production Systems - Planning, Analysis, and Control", J. L. Riggs, John Wiley & Sons.
2. "Industrial Engineering and Production and Operations Management" Sanjay S. Patil, Nandakumar K. Hukeri, Electrotech Publication.
3. "Production and Operation Management", S N Chary, Tata McGraw-Hill
4. "Production Planning And Inventory Control" Mager and Boodman
5. "Production Planning and Control, A. K. Bewoor", Satya Publication
6. "Production Planning and Cost Control" Jain and Arrawal, Khanna Publisher

**Reference Books:**

1. "Operations Management - Design, Planning & Control for Manufacturing and Services", J. B. Dilworth, McGraw-Hill
2. "Production Management" Martin Star
3. "Process Engineering" Erry Johnson
4. "Industrial Engineering and Production Management" Mart and Telsang" S. Chand and Co. Ltd
5. "Elements of PPC, Samuel Elion, Universal Book Company

**Program Elective: II/III: OPERATIONS RESEARCH**  
(Course Code: PE1111701/803)

Designation of Course	Operations Research		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Lectures: - 04 hours/Week	Semester End Examination	60 Marks	4
Practical: - 00 hours/Week	Internal Assessment	40 Marks	
	Term Work	00 Marks	-
	Practical	-	-
	<b>Total</b>	<b>100 Marks</b>	<b>4</b>

<b>Course Prerequisites:</b>	Good knowledge of mathematics.
<b>Course Objective: -</b>	The students will be able to understand various models in operations research used in industries to solve problems.
<b>Course Outcomes</b>	<p>At the end of this course, the students will be able to:</p> <ol style="list-style-type: none"> <li>1. Explain and analyze the concepts, types, and phases of Operations Research methodology to formulate mathematical models for decision-making problems.</li> <li>2. Formulate and solve linear programming problems using graphical and simplex methods, and analyze duality concepts and sensitivity analysis for optimal decision-making.</li> <li>3. Apply optimization techniques to solve transportation and assignment problems using appropriate methods and evaluate optimal solutions.</li> <li>4. Analyze and apply project management techniques such as PERT and CPM to determine critical paths, project completion time, and time–cost trade-offs.</li> <li>5. Apply and analyze inventory control models such as EOQ, POQ, and probabilistic inventory models to optimize inventory management decisions.</li> <li>6. Analyze queuing models and apply simulation techniques to evaluate the performance of service systems and support operational decision-making.</li> </ol>

**Course Contents**

Unit 1	Introduction to Operation Research	(08 Hrs.)
	Origin of OR and its definition. Concept of optimizing performance measure, Types of OR problems, Deterministic vs. Stochastic optimization, Phases of OR problem approach – problem formulation, building mathematical model, deriving solutions, validating model, controlling, and implementing solution.	
Unit 2	Linear Programming:	(08 Hrs.)
	<p>Linear programming – Examples from industrial cases, formulation &amp; definitions, Matrix form. Implicit assumptions of LPP.</p> <p>Geometric method: 2-variable case, Special cases – infeasibility, unboundedness, redundancy &amp; degeneracy, Sensitivity analysis.</p> <p>Simplex Algorithm – slack, surplus &amp; artificial variables, computational details, Big-M method, identification, and resolution of special cases through simplex iterations. Duality – formulation,</p>	

results, fundamental theorem of duality, dual-simplex, and primal-dual algorithms.		
<b>Unit 3</b>	<b>Transportation and Assignment problems:</b>	<b>(08 Hrs.)</b>
<p>Transportation Problem - Examples, Definitions – decision variables, supply &amp; demand constraints, formulation, Balanced &amp; unbalanced situations, Solution methods – NWCR, minimum cost and VAM, test for optimality (MODI method), degeneracy and its resolution.</p> <p>Assignment Problem - Examples, Definitions – decision variables, constraints, formulation, Balanced &amp; unbalanced situations, Solution method – Hungarian, test for optimality (MODI method), degeneracy &amp; its resolution</p>		
<b>Unit 4</b>	<b>PERT – CPM:</b>	<b>(08 Hrs.)</b>
<p>Project definition, Project scheduling techniques – Gantt chart, PERT &amp; CPM, Determination of critical paths, Estimation of Project time and its variance in PERT using statistical principles, Concept of project crashing/time-cost trade-off.</p>		
<b>Unit 5</b>	<b>Inventory Control</b>	<b>(08 Hrs.)</b>
<p>Functions of inventory and its disadvantages, ABC analysis, Concept of inventory costs, Basics of inventory policy (order, lead time, and types), Fixed order-quantity models – EOQ, POQ &amp; Quantity discount models. EOQ models for discrete units, sensitivity analysis, and Robustness, Special cases of EOQ models for safety stock with known/unknown stock out situations, models under prescribed policy, and probabilistic situations.</p>		
<b>Unit 6</b>	<b>Queuing Theory</b>	<b>(08 Hrs.)</b>
<p>Definitions – queue (waiting line), waiting costs, characteristics (arrival, queue, service Discipline of the queuing system, queue types (channel vs. phase).</p> <p>Kendall’s notation, Little’s law, steady state behavior, Poisson’s Process &amp; queue, Models with examples - M/M/1 and its performance measures; M/M/m and its performance measures; brief description about some special models.</p> <p>Simulation Methodology:          Definition and steps of simulation, random number, random number generator, Discrete Event System Simulation – clock, event list, Application in Scheduling, Queuing systems, and Inventory systems.</p>		

### List of Project-Based Learning Topics:

1. Students must work on one of the projects listed below (but not limited to) during the semester.
2. Find the companies that used OR as a tool to sort a problem successfully and unsuccessfully. Compare them and analyze as to why certain strategies worked and others failed.
3. Visit any industry and choose one of its products. Develop an LPP for maximizing profits on the sale of that product, considering the various constraints on it. Solve the LPP and make suggestions for the same for the company.
4. Develop a software that helps in making a timetable for the department by making and solving an LPP.
5. Visit a small departmental store/hotel, collect data, and make an LPP for optimum use of space. Solve the LPP and make relevant suggestions.
6. Write a research paper on how LPP helps companies to solve problems, referencing the latest papers.
7. Write a research paper on how assignment tools help companies to solve problems, referencing the latest papers.
8. Write a research paper on how transportation tools help companies to solve problems, referencing the latest papers.

9. Visit a small-scale industry. Collect data and make a WBS and a network diagram. Solve it by the CPS and PERT methods and make relevant suggestions.
10. Write a research paper on how network analysis tools help companies to solve problems, referencing the latest papers.
11. Write a research paper on how queuing models help companies to solve problems, referencing the latest papers.
12. Go to a nearby petrol pump, bank, departmental store, or hotel. Record the arrival and service rates for multiple days. Analyze the data and make relevant suggestions.
13. Write a research paper on how inventory models help companies to solve problems, referencing the latest papers.
14. Go to a nearby petrol pump, departmental store, or hotel. Record inventory levels and inventory practices for multiple days. Analyze the data and make relevant suggestions.

**Textbooks:**

1. Operations Research. Prem Kumar Gupta & D. S. Hira
2. Operations Research: An Introduction. H.A. Taha.
3. Introduction to Operations Research. F.S. Hiller and G.J. Lieberman.
4. Principles of OR with Application to Managerial Decisions. H.M. Wagner.

**Reference Books:**

1. Linear Programming. K.G. Murthy.
2. Linear Programming. G. Hadley.
3. Elements of Queuing Theory. Thomas L. Saaty.
4. Operations Research and Management Science, Handbook: Edited by A. Ravi Ravindran.
5. Management Guide to PERT/CPM. Wiest & Levy.
6. Modern Inventory Management. J.W. Prichard and R.H. Eagle.

**Program Elective II/III - Waste to Energy Conversion**  
(Course No. PE1111701/803)

Designation of Course	Waste to Energy Conversion		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical: 00 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	00 Marks	00
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites:-</b>	<ol style="list-style-type: none"> <li>1. Mechanical Engineering Systems.</li> <li>2. Thermodynamic Principles</li> <li>3. Thermodynamic Applications</li> </ol>
<b>Course Objectives:-</b>	<p>To enable students to understand the concept of Waste to Energy (WTE). To teach about the best available technologies for waste-to-energy</p>
<b>Course Outcomes:-</b>	<p>On completion of the course, students will be able to–</p> <ol style="list-style-type: none"> <li>1. <i>Explain</i> the sources, characteristics, and processing methods of solid waste and evaluate their role in sustainable waste management and energy recovery systems.</li> <li>2. <i>Analyze</i> the environmental, social, and regulatory aspects of WTE plants, including greenhouse gas emissions, air quality, and integration with recycling systems.</li> <li>3. <i>Examine</i> the principles, reactor designs, and performance characteristics of pyrolysis and combustion technologies used for energy recovery from municipal solid waste.</li> <li>4. <i>Evaluate</i> different waste gasification technologies and their capability to produce syngas, fuels, and chemicals from municipal and plastic waste.</li> <li>5. <i>Assess</i> anaerobic digestion processes, reactor configurations, and emerging technologies for biogas and biomethane production from organic waste streams.</li> <li>6. <i>Assess</i> air pollution control technologies and emission management strategies used in WTE plants to ensure compliance with environmental regulations.</li> </ol>

Unit -I	Introduction to Waste and Waste Processing	(08 Hrs.)
<p>Sources, classification, and characteristics of solid waste; physical, chemical, and biological properties of municipal solid waste (MSW); global waste generation trends and environmental impacts; circular economy concept and waste hierarchy (reduce–reuse–recycle–recover–dispose). Waste management systems: collection, transportation, transfer stations, waste segregation and preprocessing techniques; size reduction, drying, densification, and refuse-derived fuel (RDF) production. Waste minimization strategies, recycling, and material recovery facilities (MRF).</p>		

<p>Overview of waste treatment and energy recovery technologies: composting, anaerobic digestion, incineration, pyrolysis, gasification, and emerging waste-to-energy technologies. Treatment technologies for biomedical, pharmaceutical, and hazardous waste. Environmental impacts of waste processing systems and mitigation measures.</p>		
<b>Unit -II</b>	<b>Environmental and Social Impacts of WTE plants</b>	<b>(08 Hrs.)</b>
<p>Role of WTE systems in integrated waste management and sustainable energy systems. Contribution of WTE to waste reduction, energy security, and climate change mitigation. Greenhouse gas emissions, carbon footprint, and life cycle assessment (LCA) of WTE systems. Air quality considerations, emission standards, and residue management (bottom ash and fly ash). Compatibility of WTE with recycling and circular economy approaches. Health, safety, and public acceptance issues; environmental risk assessment; social and regulatory aspects. Integrated planning and site selection of WTE facilities; policy frameworks and global best practices. Future trends in WTE include carbon capture, energy recovery efficiency improvements, and digital monitoring systems.</p>		
<b>Unit -III</b>	<b>Pyrolysis and Combustion Technologies</b>	<b>(08 Hrs.)</b>
<p>Principles of thermochemical conversion of waste.  Pyrolysis: fundamentals, reaction mechanisms, operating parameters, and reactor configurations (fixed bed, rotary kiln, fluidized bed). Pyrolysis of municipal solid waste and plastic waste; product distribution (bio-oil, syngas, and char); upgrading and utilization of pyrolysis products. Commercial and pilot-scale pyrolysis plants: techno-economic considerations.  Combustion technologies: fundamentals of combustion chemistry; efficiency and combustion control; process stabilization. MSW incineration systems: grate firing, fluidized bed combustion, RDF combustion technologies. Energy recovery systems in incineration plants; combined heat and power (CHP). Modern developments in combustion systems include high-efficiency incinerators and emission control integration.</p>		
<b>Unit -IV</b>	<b>Gasification technologies</b>	<b>(08 Hrs.)</b>
<p>Fundamentals of gasification and chemical reactions involved.  Gasification of municipal and industrial wastes: key operational parameters and performance criteria. Types of gasifiers: fixed bed, fluidized bed, entrained flow, and slagging gasifiers. Syngas generation, cleaning, and utilization for power, fuels, and chemicals. Tar formation and mitigation techniques in gasification systems. Advanced gasification technologies: plasma gasification, plasma arc reactors, and thermal plasma systems. Gasification of plastic waste and refuse-derived fuel (RDF). Production of synthetic fuels, hydrogen, and chemicals from waste-derived syngas. Commercial status of gasification plants and global case studies.</p>		
<b>Unit -V</b>	<b>Anaerobic Digestion and Biogas Generation</b>	<b>(08 Hrs.)</b>
<p>Fundamentals of anaerobic digestion and microbial processes involved in biogas production. Stages of anaerobic digestion: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Feedstock for anaerobic digestion includes municipal waste, agricultural waste, industrial waste, and wastewater. Bioreactor configurations: batch, continuous stirred tank reactor (CSTR), plug flow, and high-rate digesters. Operational parameters affecting biogas yield. Advanced anaerobic</p>		

digestion technologies: thermophilic digestion, co-digestion, and two-stage digestion. Biogas upgrading to biomethane; integration with natural gas grids. Power-to-gas concepts, bi-methanation, and hydrogen utilization in anaerobic systems. Emerging technologies such as microbial electrochemical systems and bio-electrochemical reactors.

<b>Unit -VI</b>	<b>Air Pollution Control &amp; Emission Management in WTE Plants</b>	<b>(08 Hrs.)</b>
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Air quality considerations and environmental regulations for waste-to-energy facilities. Emission sources from WTE plants and characterization of pollutants. Air pollution control systems in waste combustion and gasification plants. Acid gas removal systems (scrubbers), particulate control devices (cyclones, electrostatic precipitators, and bag filters). Control of nitrogen oxides (NO<sub>x</sub>), dioxins, furans, and other hazardous air pollutants. Residue management, including fly ash and bottom ash treatment. Cost–benefit analysis of emission control technologies. Recent innovations in emission control include carbon capture technologies, advanced filtration systems, and real-time emission monitoring.

### **Project-Based Learning**

Following is the list of Topics for project-based learning (Not Limited to) based on the syllabus

1. Energy Potential Assessment of Municipal Solid Waste
2. Design of a Small-Scale Plastic Waste Pyrolysis Reactor
3. Performance Analysis of a Biomass/Waste Gasifier
4. Design and Analysis of Refuse-Derived Fuel (RDF) Briquettes
5. Design of a Biogas Plant for Organic Waste Management
6. Thermodynamic Analysis of Waste-to-Energy Incineration Systems
7. Heat Recovery System Design for Waste Incineration Plants
8. Comparative Study of Pyrolysis, Gasification, and Incineration
9. Design of a Fluidized Bed Combustor for Waste Fuels
10. Air Pollution Control System Design for Waste-to-Energy Plants
11. Techno-Economic Feasibility of a Waste-to-Energy Plant for a Smart City
12. Conversion of Plastic Waste to Liquid Fuel – Process Analysis

### **Text Books:**

1. Nicholas P Cheremisinoff, Handbook of Solid Waste Management and Waste Minimization Technologies, An Imprint of Elsevier, New Delhi, 2003.
2. P Aarne Vesilind, William A Worrell, and Debra R Reinhart, Solid Waste Engineering, 2<sup>nd</sup> edition, 2002.
3. M Dutta, B P Parida, B K Guha, and T R Surkrishnan, Industrial Solid Waste Management and Landfilling Practice, Reprint Edition, New Delhi, 1999.
4. M. L. Davis and D. A. Cornwell, Introduction to Environmental Engineering, International Edition, 2008.
5. C. S. Rao, Environmental Pollution Control Engineering, Wiley Eastern Ltd. New Delhi, 1995.

6. S. K. Agarwal, Industrial Environment Assessment and Strategy, APH Publishing Corporation, New Delhi, 1996.

**Reference Books:**

1. Rogoff, M.J. and Screve, F., Waste-to-Energy: Technologies and Project Implementation, Elsevier Store.
2. Young G.C., Municipal Solid Waste to Energy Conversion processes, John Wiley and Sons.
3. Harker, J.H. and Backhurst, J.R., Fuel and Energy, Academic Press Inc.
4. EL-Halwagi, M.M., Biogas Technology- Transfer and Diffusion, Elsevier Applied Science.
5. Hall, D.O. and Overeed, R.P., Biomass - Renewable Energy, John Willy and Sons.
6. Mondal, P. and Dalai, A.K. eds., 2017. Sustainable Utilization of Natural Resources. CRC Press.
7. C Parker and T Roberts (Ed), Energy from Waste, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
8. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, Reprint Edition, 2000.
9. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
10. G Rich et al., Hazardous Waste Management Technology, Podvan Publishers, 1987.

**SEMINAR**  
**(Course Code-MD1111702)**

Designation of Course	Seminar		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: - -- Hours/ Week	Semester End Examination	-- Marks	--
Practical: - 04 Hours/ Week	Internal Assessment	- Marks	
Tutorial: 00 Hours/ Week	Term Work	50 Marks	02
	Oral Examination	50 marks	
	<b>Total</b>	<b>100 Marks</b>	<b>02</b>

<b>Course Prerequisites: -</b>	<ul style="list-style-type: none"> <li>• Basic knowledge of core Mechanical Engineering subjects such as Thermodynamics, Fluid Mechanics, Heat Transfer, Manufacturing, and Machine Design.</li> <li>• Fundamental understanding of engineering research methods and technical report writing.</li> <li>• Basic knowledge of computer tools for presentations.</li> <li>• Familiarity with technical literature sources such as journals, conference papers, patents, and technical reports.</li> </ul>
<b>Course Objectives: -</b>	<p>The course aims to:</p> <ol style="list-style-type: none"> <li>1. To develop the ability to identify and study emerging topics in Mechanical Engineering through a literature survey.</li> <li>2. To enhance students' analytical, presentation, and technical communication skills.</li> <li>3. To train students in reviewing research papers, patents, and technical reports related to modern mechanical engineering technologies.</li> <li>4. To prepare students for their major project by identifying research problems, methodologies, and possible solutions.</li> <li>5. To encourage students to explore recent trends, innovations, and interdisciplinary applications in Mechanical Engineering.</li> </ol>
<b>Course Outcomes: -</b>	<p>On completion of the course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Identify and analyze recent trends and emerging technologies in Mechanical Engineering through a literature survey.</li> <li>2. Review and interpret research papers, patents, and technical articles related to advanced mechanical engineering topics.</li> <li>3. Develop technical reports and seminar documents using standard engineering documentation practices.</li> <li>4. Deliver effective technical presentations and communicate engineering concepts clearly using appropriate visual aids.</li> <li>5. Critically evaluate engineering problems and propose possible research directions relevant to their major project.</li> <li>6. Demonstrate independent learning and professional skills required for research and innovation in Mechanical Engineering.</li> </ol>

**Course Contents**

Unit I	Introduction to Technical Seminar and Topic Identification	(08 Hrs.)
<p>Purpose and importance of technical seminars in engineering education. Role of seminars in research and professional development. Identification of emerging areas in Mechanical Engineering, such as advanced manufacturing, renewable energy systems, smart materials, robotics and automation, electric vehicles, AI in mechanical systems, and sustainable engineering. Methods for selecting an appropriate seminar topic aligned with current technological developments and potential major project areas. Guidelines for defining the problem statement, objectives, and scope of the seminar</p>		

topic.		
<b>Unit II</b>	<b>Literature Survey and Information Sources</b>	<b>(08 Hrs.)</b>
Introduction to literature survey and its importance in engineering research. Sources of technical information include journals, conference proceedings, patents, technical reports, standards, and online databases (Google Scholar, ScienceDirect, IEEE Xplore, ASME Digital Collection, etc.). Techniques for identifying relevant research papers and reviewing literature. Understanding research gaps, trends, and technological advancements in Mechanical Engineering. Ethical use of literature and avoiding plagiarism. Referencing styles and citation methods.		
<b>Unit III</b>	<b>Analysis and Interpretation of Technical Literature</b>	<b>(08 Hrs.)</b>
Methods for reading and analyzing research papers. Understanding research methodology, experimental setups, modeling approaches, and simulation techniques used in mechanical engineering studies. Interpretation of graphs, experimental results, and numerical data. Comparative analysis of different technologies and methods reported in the literature. Identifying advantages, limitations, and future research opportunities related to the selected seminar topic.		
<b>Unit IV</b>	<b>Preparation of Technical Report and Documentation</b>	<b>(08 Hrs.)</b>
Structure of a technical seminar report: title page, abstract, introduction, literature review, methodology/technology overview, discussion, conclusion, and references. Guidelines for technical writing, formatting, and use of figures, tables, and diagrams. Preparation of process flow charts, schematic diagrams, and graphical illustrations. Use of word processing and documentation tools for report preparation. Importance of proper referencing and bibliography preparation.		
<b>Unit V</b>	<b>Seminar Presentation and Communication Skills</b>	<b>(08 Hrs.)</b>
Principles of effective technical presentation. Preparation of presentation slides using appropriate visualization tools. Organizing technical content for clear and logical presentation. Use of charts, graphs, animations, and diagrams for better understanding. Communication skills, including clarity of explanation, confidence, body language, and time management. Handling questions, technical discussions, and feedback during seminar presentations.		
<b>Unit VI</b>	<b>Seminar Delivery, Discussion, and Project Orientation</b>	<b>(08 Hrs.)</b>
Seminar presentation by students on selected topics related to recent trends in Mechanical Engineering. Critical discussion and evaluation of the topics presented. Identification of research gaps and future scope of technology. Correlation of seminar topic with potential major project areas. Feedback from faculty and peers for improvement. Preparation and submission of the final seminar report incorporating suggestions and technical improvements.		

### Textbooks

1. Rath, P. M., and Dash, S. K., *Technical Communication: Principles and Practice*, Oxford University Press, New Delhi.
2. Barun K. Mitra, *Personality Development and Soft Skills*, Oxford University Press.
3. David V. Thiel, *Research Methods for Engineers*, Cambridge University Press.

### Reference Books

1. Michael Alley, *The Craft of Scientific Presentations*, Springer.
2. Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams, *The Craft of Research*, University of Chicago Press.
3. Robert W. Bly, *Technical Writing: Structure, Standards and Style*, McGraw-Hill Education.
4. Day, R. A. and Gastel, B., *How to Write and Publish a Scientific Paper*, Cambridge University Press.
5. ASME, *Guide for Preparing Technical Papers*, American Society of Mechanical Engineers.
6. IEEE, *IEEE Editorial Style Manual*, Institute of Electrical and Electronics Engineers.

## INDUSTRY INTERNSHIP (FOURTEEN WEEKS)

(Course Code: IN111703.1)

<u>TEACHING SCHEME:</u>	<u>EXAMINATION SCHEME:</u>	<u>CREDITS:</u>
Theory: 00 Hours/ Week	Term Work Marks: 100 marks	Practical: 12
Practical: 30 Hours/ Week	Oral/ Practical Examination Marks: 100 marks	
<b>Total</b>	<b>200 marks</b>	<b>12 Credits</b>

<b>Course Prerequisites: -</b>	The students should know of Basics of mechanical engineering, Engineering drawing, Machine design, thermal engineering, theory of machine, strength of machinery, industrial management,
<b>Course Objectives: -</b>	<ol style="list-style-type: none"> <li>1. To expose technical students to the industrial environment.</li> <li>2. To provide possible opportunities to learn, interpret, and sharpen the real-time technical and managerial skills required at the job.</li> <li>3. To familiarize yourself with various materials, processes, products, and their applications, along with relevant aspects of quality control.</li> <li>4. To acquaint the social, economic, and administrative considerations that influence the working environment of an industrial organization.</li> <li>5. To familiarize students with industrial standards such as ISO, safety norms, and ethical practices in the automation industries.</li> </ol>
<b>Course Outcomes: -</b>	<p>The students should be able to–</p> <ol style="list-style-type: none"> <li>1. Interpret the latest changes in the technological world and use fundamental principles of science and engineering.</li> <li>2. Create the ability to identify, formulate, and model problems and use them to find engineering solutions based on a system approach.</li> <li>3. Interpret the importance of sustainability and cost-effectiveness in the design and development of engineering solutions.</li> <li>4. Create the ability to be a multi-skilled engineer with good technical knowledge, management, leadership, and entrepreneurship skills.</li> <li>5. Create awareness of social, cultural, global, and environmental responsibility as an engineer.</li> <li>6. Create the ability to communicate efficiently.</li> </ol>

### Course Contents

<b>Introduction</b>
<p>Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as employers are looking for employees who are properly skilled and have awareness about the industry environment, practices, and culture. An internship is structured, short-term, supervised training often focused on tasks or projects with defined time scales. The core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom, and hence create competent professionals in the industry, and to interpret the social, economic, and administrative considerations that influence the working environment of industrial organizations. Engineering internships are intended to provide students with an opportunity to apply theoretical knowledge from academics to the realities of the field work/training.</p>
<b>Duration</b>
The internship shall be completed over six months in Semester VII and will be evaluated at the end of the Semester.
<b>Internship Work Identification</b>
<ul style="list-style-type: none"> <li>• Students shall identify internship opportunities in core areas of Mechanical engineering, such as Manufacturing and production, Energy and power, HVAC, etc. The process of contacting industries and confirming internship placement should begin in Semester VI in coordination with the Training and</li> </ul>

Placement Cell/Internship Cell to ensure timely commencement.

- Students may undertake internships in industries, government organizations, MSMEs, research laboratories, startups, or approved innovation and entrepreneurship projects relevant to Mechanical Engineering
- Online or hybrid internships are permitted only if they involve substantial technical work such as AI /ML-based system design, data analysis, or real-time industrial projects.
- Students opting for innovation or startup-based internships must demonstrate measurable outcomes such as prototype development, system design, product development, patent filing, or business model creation.

#### **Internship Diary/ Internship Workbook**

- Students must maintain a Daily Internship Logbook containing:
  - Daily activities performed
  - Tools and software used (e.g., AutoCAD, SolidWorks, CATIA, PTC Creo, Siemens NX, ANSYS MATLAB, Python, etc.)
  - Observations and learning outcomes
  - Technical drawings, circuit diagrams, or screenshots (if permitted)
  - Problems faced and solutions implemented
  - Weekly review signed by Industry Supervisor

#### **Internship Work Evaluation**

- The evaluation of internship activities shall be carried out by the Cell In-charge/Faculty Mentor in consultation with the Industry Supervisor (External Supervisor from the organization) based on the overall compilation of internship work, duration, and supporting evidence submitted by the student.
- The assessment shall comprise:
  - Post-Internship Internal Evaluation – 100 Marks
  - Internship Diary/Workbook and Internship Report – 100 Marks

#### **Evaluation through Seminar Presentation/Viva-Voce at the Institute**

- The student shall deliver a seminar presentation based on the Internship Report before a duly constituted departmental committee. The presentation shall highlight the objectives, methodology, technical work carried out, tools and technologies used, results obtained, challenges faced, and learning outcomes.
- The Viva-Voce examination will assess the student's depth of technical knowledge, practical exposure, analytical and problem-solving ability, communication skills, professional ethics, and overall understanding of industrial practices in the field of Mechanical Engineering.

#### **Feedback from internship supervisor (External and Internal)**

- After completion of the internship, structured feedback shall be obtained from both the External Industry Supervisor and the Internal Faculty Mentor. The feedback shall assess the student's technical knowledge, practical skills, discipline, punctuality, commitment, communication ability, teamwork, leadership qualities, problem-solving skills, and professional behavior.

## IN-HOUSE INTERNSHIP (FOURTEEN WEEKS)

(Course Code: IN1111703.2)

<u>TEACHING SCHEME:</u>	<u>EXAMINATION SCHEME:</u>	<u>CREDITS:</u>
Theory: 06 Hours/Week	University Examination Marks: 00	Theory: 00
Practical: 24 Hours/ Week	Internal Assessment Marks: 00	
Tutorial: 00 Hours/Day	Term Work Marks: 100	Practical:12
	Oral Examination Marks: 100	Tutorial: 00
<b>Total Credits (Combined for the modules to be completed in 14 Weeks)</b>		12

### Module 1: CNC Training

**Period: 1 Week** (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)

<b>Course Prerequisites:-</b>	<ol style="list-style-type: none"> <li>1. Basic knowledge of Manufacturing Processes (Turning, Milling, Drilling operations).</li> <li>2. Fundamentals of Engineering Drawing &amp; Blueprint Reading.</li> <li>3. Basic understanding of Workshop Technology and Machine Tools</li> </ol>
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand the fundamentals of CNC machines and their components.</li> <li>2. To learn CNC part programming concepts and G &amp; M codes.</li> <li>3. To develop hands-on skills in CNC turning and milling operations.</li> </ol>
<b>Course Outcomes:-</b>	<p>The students will be able to</p> <ol style="list-style-type: none"> <li>1. Explain the fundamentals of CNC machines and identify their major components.</li> <li>2. Interpret engineering drawings for CNC part programming and machining.</li> <li>3. Develop CNC part programs using standard G and M codes.</li> <li>4. Select appropriate tooling, apply tool/work offsets, and utilize canned cycles for basic turning and milling operations.</li> <li>5. Operate CNC lathe and milling machines to perform facing, turning, tapering, drilling, threading, contouring, and pocket milling with proper simulation and dry run</li> <li>6. Execute complete CNC jobs safely, perform program editing and error correction, and demonstrate workshop discipline and safety practices.</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
<b>Introduction to CNC:</b> Evolution of CNC machines, Types of CNC Machines- CNC Lathe & CNC Milling, Comparison between Conventional and CNC machines	01
<b>Introduction to CNC: Construction</b> and Working Principle of CNC Machines, Axes, Nomenclature and Coordinate System, Advantages and Applications of CNC Machines.	01
<b>CNC Programming Fundamentals:</b> Basics of Part Programming, Structure of CNC Program, Program Format, and Block Structure.	01
<b>CNC Programming Fundamentals:</b> G-codes and M-codes, Absolute and Incremental Programming, Tool Offset and Work Offset.	01
<b>Advanced Concepts:</b> Tooling System and Tool Selection, Introduction to Canned Cycles (Drilling, Tapping, etc.)	01
<b>Advanced Concepts:</b> Introduction to CAM Software (Overview), Safety Practices in CNC Workshop, Course Summary & Discussion.	01
<b>Practical Contents</b>	
Course Contents	No. of Hours

<b>Machine Familiarization:</b> Identification of Machine Parts (Lathe & Milling), Control Panel Operations and MDI Mode, Machine Homing and Referencing, Setting Workpiece Zero, and Tool Offsets.	04
<b>Basic CNC Turning Operations:</b> Writing Simple Turning Programs, Facing Operation, Straight Turning Operation, Program Execution, and Dry Run.	04
<b>Basic CNC Turning Operations:</b> Step Turning, Taper Turning, Drilling Operation (Basic), Threading Operation (Basic), Final Program Execution on Machine.	04
<b>Basic CNC Milling Operations:</b> Introduction to CNC Milling Machine, Writing Simple Milling Programs, Basic Contour Programming, Program Simulation.	04
<b>Basic CNC Milling Operations:</b> Pocket Milling, Drilling Cycles (G81, G83, etc.), Tool Offset Setting in Milling, Program Execution, and Dry Run.	04
<b>Program Simulation &amp; Final Practice:</b> Complete Job Program (Turning or Milling), Program Editing and Error Correction, Final Execution on Machine, Safety Practices, and Workshop Discipline.	04
<b>Mini Project</b>	
Design and manufacturing of a CNC-machined component, including preparation of part drawing, manual part programming, machining, inspection & measurement, and report preparation.	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. Patil, R. B. (2010). <i>Automation, Production Systems, and Computer-Integrated Manufacturing</i>. Prentice Hall India.</li> <li>2. Farazdak Haideri <i>CAD/ CAM and Automation</i>, Nirali Prakashan</li> <li>3. Radhakrishnan, P. &amp; Subramanian, S. — <i>CAD/CAM/CIM – New Age International</i> (covers CAD/CAM integration with CIM)</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. Mattson, M. (2010). <i>CNC programming: Principles and applications</i> (2<sup>nd</sup> ed.). Cengage Learning.</li> <li>2. Rao, P. N. (2010). <i>Computer numerical control: Principles and applications</i> (3<sup>rd</sup> ed.). McGraw-Hill Education.</li> <li>3. Adithan, M., &amp; Pabla, B. S. (2008). <i>CNC machines</i>. New Age International Publishers.</li> <li>4. Walker, J. R. (2013). <i>Machining fundamentals</i> (10<sup>th</sup> ed.). Goodheart-Willcox.</li> </ol>	

## Module 02- Idea lab

**Period: 2 Weeks** (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)

<b>Course Prerequisites:-</b>	Basic knowledge of Engineering Drawing, Manufacturing Processes, Electronics fundamentals, and Programming basics.	
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To develop innovative product ideas using Design Thinking methodology.</li> <li>2. To fabricate functional prototypes using AICTE Idea Lab machines (3D Printer, CNC, Laser Cutter, PCB prototyping systems).</li> <li>3. To integrate mechanical design with electronics and embedded systems.</li> <li>4. To evaluate product feasibility, costing, and commercialization potential.</li> <li>5. To orient students towards the startup ecosystem and entrepreneurship development.</li> </ol>	
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Identify real-world problems and convert them into structured product design statements.</li> <li>2. Develop parametric CAD models and generate STL files for rapid prototyping.</li> <li>3. Fabricate mechanical components using 3D printing, CNC routing, and laser cutting.</li> <li>4. Design and assemble basic PCB circuits and integrate Arduino/IoT-based control systems.</li> <li>5. Test and validate functional prototype performance under defined operating conditions.</li> <li>6. Prepare a business model canvas including cost estimation, market analysis, and pitch presentation.</li> </ol>	
<b>Theory Contents</b>		
Course Contents		No. of Hours
Design Thinking Process: Empathy, Define, Ideate, Prototype, Test.		01
Problem identification and need analysis techniques		01
Concept generation and selection (Pugh Matrix).		01
Product architecture and modular design principles.		01
Product architecture and modular design principles.		01
Additive Manufacturing fundamentals (FDM process parameters).		01
Laser cutting and CNC routing process planning.		01
PCB design basics and circuit layout principles.		01
Embedded systems and Arduino programming basics.		01
IoT fundamentals and sensor integration.		01
Cost estimation, break-even analysis, and LCOE for the product.		01
Startup ecosystem, IPR basics (patents), and funding opportunities.		01
<b>Practical Contents</b>		
Course Contents		No. of Hours
Brainstorming session and problem statement finalization		04
CAD modeling of selected product concept.		04

STL generation and 3D printing of a prototype component.	04
Laser cutting of acrylic/wood parts for enclosure fabrication.	04
CNC routing of mechanical components.	04
Assembly of the mechanical prototype.	04
PCB design using software and fabrication demo.	04
Arduino-based circuit wiring and sensor integration.	04
Functional testing and debugging of the prototype.	04
Performance validation and iterative design modification.	04
Cost estimation and preparation of technical documentation.	04
Startup pitch presentation before faculty/industry mentor and submission of final prototype report.	04
<b>Mini Project</b>	
Development of a functional product prototype addressing a real-world problem, including CAD design, fabrication (3D print/CNC/Laser), embedded integration, cost analysis, and startup pitch presentation.	
<b>Textbooks:</b>	
1. Tim Brown, Change by Design (Design Thinking). 2. Ibrahim Zeid, CAD/CAM Theory and Practice.	
<b>Reference Books:</b>	
1. Additive Manufacturing Handbook – Springer. 2. Arduino Official Documentation. 3. Startup India & IPR Guidelines (Government of India).	

### Module 3- Six Sigma Training

**Period: 1 Week** (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)

<b>Course Prerequisites:-</b>	Basic knowledge of Engineering Mathematics, Statistics, Manufacturing Processes, and Quality Control	
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand the DMAIC methodology for process improvement.</li> <li>2. To apply statistical tools for quality analysis and defect reduction.</li> <li>3. To analyze industrial process data and improve process capability</li> <li>4. To develop problem-solving skills using Lean and Six Sigma tools</li> </ol>	
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to</p> <ol style="list-style-type: none"> <li>1. Define process problems and develop SIPOC diagrams for industrial cases</li> <li>2. Apply statistical tools (mean, standard deviation, Cp, Cpk) to evaluate process capability.</li> <li>3. Construct and interpret control charts (<math>\bar{X}</math>, R, p-chart) for quality monitoring</li> <li>4. Perform root cause analysis using Fishbone and 5-Why techniques</li> <li>5. Develop improvement strategies using Lean tools and validate results statistically</li> <li>6. Prepare a structured Six Sigma project report based on industrial data</li> </ol>	
<b>Theory Contents</b>		
Course Contents		No. of Hours
Introduction to Six Sigma, DMAIC framework, Roles (Green Belt/Black Belt), Industrial case examples.		01
Define & Measure Phase: SIPOC, CTQ identification, Data collection planning, Basic statistics.		01
Analyze Phase: Process capability (Cp, Cpk), Histogram analysis, Pareto principle.		01
Control Charts: $\bar{X}$ -R charts, p-charts, Interpretation of control limits and process stability.		01
Improve Phase: Root cause analysis (Fishbone, 5 Whys), FMEA basics, Lean tools.		01
Control Phase: Control plans, Standard operating procedures, Cost of poor quality, Case review.		01
<b>Practical Contents</b>		
Course Contents		No. of Hours
Industrial case selection and preparation of SIPOC diagram; Identification of CTQs.		04
Statistical data analysis using Excel/Minitab: Mean, standard deviation, histogram plotting.		04
Process capability analysis and interpretation (Cp, Cpk calculation)		04
Preparation of $\bar{X}$ -R and p control charts; Identification of out-of-control conditions.		04
Root cause analysis using Fishbone diagram and 5-Why method; FMEA worksheet preparation.		04
Industrial Visit / Training at Manufacturing Unit: Study of quality control department, SPC implementation; Submission of Six Sigma project report.		04
<b>Mini Project</b>		
Control Plan & SOP Development for Any Academic/Industrial Process/ FMEA Study of a Classroom, Lab, or Small Workshop Process		

**Textbooks:**

- 1 Thomas Pyzdek & Paul Keller, The Six Sigma Handbook, McGraw-Hill.
2. P.S. Pande et al., What is Six Sigma?, McGraw-Hill.

**Reference Books:**

1. Montgomery, Introduction to Statistical Quality Control, Wiley.
- 2 BIS/ISO 9001 Quality Management Standards.
3. Industrial SPC Manuals and Case Studies.

<b>Module 4: EDM &amp; CMM Training</b>	
<b>Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)</b>	
<b>Course Prerequisites:-</b>	<ol style="list-style-type: none"> <li>1. Basic knowledge of manufacturing processes and workshop practices.</li> <li>2. Fundamental understanding of engineering, drawing, and dimensioning.</li> <li>3. Basic knowledge of engineering materials and measurement tools.</li> </ol>
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand the working principles and process parameters of Electric Discharge Machining (EDM).</li> <li>2. To develop practical skills in operating ZNC EDM and perform cavity machining.</li> <li>3. To impart knowledge of precision measurement and inspection using the Coordinate Measuring Machine (CMM).</li> </ol>
<b>Course Outcomes:-</b>	<p>After successful completion of the course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Explain the principle, components, and classification of EDM processes.</li> <li>2. Select suitable electrode material and machining parameters for ZNC EDM.</li> <li>3. Operate the ZNC EDM machine safely and perform basic cavity machining.</li> <li>4. Analyze machining performance based on surface finish, MRR, and tool wear.</li> <li>5. Perform dimensional inspection using CMM with proper calibration and datum setting.</li> <li>6. Prepare machining and inspection reports as per industrial standards.</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
<b>Introduction to Advanced Machining:</b> Need for Non-Traditional Machining, Classification of Advanced Machining Processes. Comparison: Conventional vs EDM.	01
<b>Electric Discharge Machining (EDM) – Working Principle, Principle of Spark Erosion, Basic components of EDM, Dielectric fluid and its function, Material removal mechanism</b>	01
<b>ZNC EDM Machine:</b> Construction and working of ZNC EDM, Servo control system, Pulse generator & machining parameters, Tool electrode materials (Copper, Graphite)	01
<b>EDM Process Parameters:</b> Peak current, pulse on/off time, Gap voltage, Surface finish & MRR, Tool wear, and overcut.	01
<b>Introduction to CMM:</b> Need for precision measurement, Construction and types of CMM, Probes and probing system, Accuracy and repeatability	01
<b>Measurement &amp; Inspection Concepts:</b> Calibration and alignment, Measurement errors, Inspection planning, Report preparation.	01
<b>Practical Contents</b>	
Course Contents	No. of Hours
<b>ZNC EDM Machine Familiarization:</b> Identification of machine parts, Control panel operations, Dielectric tank & filtration system, Safety precautions.	04
<b>Electrode Preparation &amp; Setup:</b> Selection of electrode material, Electrode mounting & alignment, Workpiece clamping, Setting zero reference	04
<b>Basic EDM Operations:</b> Parameter setting (current, pulse time), Machining square cavity, Observation of spark gap, Monitoring machining process.	04

<b>Advanced EDM Practice:</b> Machining complex cavity, Surface finish improvement, Measuring tool wear, Error correction & troubleshooting.	04
CMM Machine Operation: Machine startup & homing, Probe calibration, Measuring basic dimensions, Datum setting.	04
Inspection & Final Project: Inspection of EDM machined cavity using CMM, Measurement of depth, diameter, profile, Preparation of inspection report, Viva & demonstration.	04
<b>Mini Project</b>	
Machining of a square/rectangular cavity using ZNC EDM or Dimensional inspection using CMM	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. Mikell P. Groover (2016). <i>Fundamentals of Modern Manufacturing</i>. Wiley.</li> <li>2. P. N. Rao (2018). <i>Manufacturing Technology Volume 2</i>. McGraw-Hill.</li> <li>3. N. V. Raghavendra &amp; L. Krishnamurthy. <i>Engineering Metrology and Measurements</i>. Oxford University Press.</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. V. K. Jain (2001). <i>Advanced Machining Processes</i>. Allied Publishers.</li> <li>2. Benedict, G. F. (1987). <i>Nontraditional Manufacturing Processes</i>. Marcel Dekker.</li> <li>3. I. C. Gupta. <i>Engineering Metrology and Measurements</i>. Dhanpat Rai Publications.</li> </ol>	

## Module 5 - Design Engineering

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Engineering Drawing, Strength of Materials, Machine Design basics, and CAD fundamentals.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To develop competency in 3D modeling and assembly design using CAD tools.</li> <li>2. To integrate design calculations with CAD-based modeling.</li> <li>3. To perform basic CAE analysis for structural validation.</li> <li>4. To understand the industrial product development workflow from concept to validation.</li> </ol>
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Create parametric 3D models of mechanical components using industry-standard CAD software.</li> <li>2. Develop complete assembly models with appropriate constraints and motion relationships.</li> <li>3. Generate detailed manufacturing drawings with GD&amp;T and BOM.</li> <li>4. Perform basic finite element analysis (FEA) to evaluate stress and deformation.</li> <li>5. Modify design based on CAE results and optimization considerations.</li> <li>6. Prepare a professional design report aligned with industrial documentation standards.</li> </ol>

### Theory Contents

Course Contents	No. of Hours
Product design process: Concept generation, design stages, and industrial design workflow.	01
Parametric modeling concepts, sketch constraints, feature-based modeling.	01
Assembly modeling, mating constraints, and interference detection.	01
Engineering drawing standards, GD&T application, Bill of Materials (BOM).	01
Introduction to Finite Element Analysis: Meshing, boundary conditions, static structural analysis.	01
Design validation, optimization techniques, and industrial case study review.	01

### Practical Contents

Course Contents	No. of Hours
3D modeling of a machine element (shaft/bracket) using parametric constraints.	04
Creation of sub-assembly and complete assembly model with motion simulation.	04
Preparation of detailed 2D manufacturing drawings with GD&T annotations.	04
Finite element analysis of designed components (stress & deformation study).	04
Design modification and optimization based on FEA results.	04

Industrial Visit / Training at Design & Development Firm: Study of product lifecycle management (PLM), documentation standards; Submission of design validation report.	04
<b>Mini Project</b> 1. Design and validate a mechanical assembly (e.g., gearbox housing or fixture) including CAD modeling, FEA validation, drawing preparation, and cost estimation.	
<b>Textbooks:</b> 1. G Shigley's Mechanical Engineering Design, McGraw-Hill. 2. Ibrahim Zeid, CAD/CAM Theory and Practice, McGraw-Hill.	
<b>Reference Books:</b> 1. Klaus-Jurgen Bathe, Finite Element Procedures. 2. ISO 2768 – General Tolerances. 3. Industrial CAD/CAE Software Manuals (SolidWorks/ANSYS/Creo).	

## Module 6- Thermal Engineering

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	<ol style="list-style-type: none"> <li>1. Basic knowledge of Engineering Mathematics and Thermodynamics</li> <li>2. Familiarity with Heat Transfer, Fluid Mechanics and IC Engines</li> <li>3. Introductory exposure to mechanical engineering systems</li> </ol>
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. Introduce students to thermal systems and their applications, including HVAC, refrigeration, and internal combustion engine performance analysis.</li> <li>2. Develop a strong understanding of heat transfer modes and governing laws applicable to industrial thermal systems.</li> <li>3. Enable students to analyze the types and performance of heat exchangers using standard evaluation methods.</li> <li>4. Provide knowledge of the working principles and performance characteristics of boilers, condensers, and cooling systems.</li> <li>5. Familiarize students with refrigeration and air-conditioning systems, their components, and performance evaluation methods.</li> <li>6. Train students in thermal system performance testing and basic energy auditing, with an emphasis on efficiency improvement and thermal optimization.</li> </ol>
<b>Course Outcomes:-</b>	<p>The students will be able to</p> <ol style="list-style-type: none"> <li>1. Fundamentals of thermal systems and identify their applications in power generation, HVAC, refrigeration, and IC Engines.</li> <li>2. Analyze heat transfer by conduction, convection, and radiation using appropriate governing laws and thermal resistance concepts.</li> <li>3. Analyze exchangers and evaluate their performance using LMTD and effectiveness–NTU methods</li> <li>4. Analyze the performance of boilers, condensers, and cooling systems.</li> <li>5. Analyze vapour compression refrigeration and air-conditioning systems and evaluate their performance using COP and system parameters.</li> <li>6. Conduct basic thermal system performance testing and energy audits</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
Introduction to Thermal Systems: Overview of thermal engineering applications, HVAC, refrigeration, and IC engine performance analysis.	01
Heat Transfer Modes and Governing Laws: Conduction, convection, and radiation, Fourier’s law, Newton’s law of cooling, Stefan–Boltzmann law, Thermal resistance concept, Practical examples in industrial systems	01
Heat Exchangers – Types and Performance: Classification of heat exchangers, Parallel, counter-flow, and cross-flow arrangements, LMTD and effectiveness–NTU methods, Performance parameters	01
Boilers, Condensers, and Cooling Systems: Types of boilers and condensers, Cooling towers: working principle, Thermal efficiency and losses	01
Refrigeration and Air Conditioning Basics: Vapour compression refrigeration cycle, Components: compressor, condenser, expansion device, evaporator, COP and performance evaluation, Applications in industry and buildings	01
Thermal System Performance Testing and Energy Audit: Measurement of temperature, pressure, and flow, Heat balance and energy audit basics, Performance testing of thermal equipment, Introduction to thermal optimization and efficiency improvement.	01

<b>Practical Contents</b>	
Course Contents	No. of Hours
Trial on multi-cylinder petrol engine – Morse Test.	04
Performance testing of a shell-and-tube or double pipe heat exchanger	04
Industrial Visit / Training at Thermal Power Plant or HVAC Plant	04
Performance testing of the vapour compression refrigeration system	04
Conduct a boiler performance test and calculate thermal efficiency	04
Conduct an energy audit of a laboratory/building and propose efficiency improvement measures with estimated energy savings and payback period.	04
<b>Mini Project (If any)</b>	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. R S Khurmi and J K Gupta, Textbook of Thermal Engineering, S Chand Publications</li> <li>2. P. K. Nag, Power Plant Engineering, TMH, 3rd Edition, 2002</li> <li>3. Sukhatme S. P., “A Textbook on Heat Transfer”, Universities Press.</li> <li>4. Sachdeva R.C., “Fundamentals of Engineering Heat and Mass Transfer”, New Age Science</li> <li>5. Khurmi R. S. and Gupta J. K., “Refrigeration and Air Conditioning”, S Chand Publication</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. R. K. Rajput, Thermal Engineering, Laxmi Publications</li> <li>2. Y. Cengel &amp; Boles, “Thermodynamics -An engineering approach”, Tata McGraw Hill Publications</li> <li>3. M. M. El Wakil, Power Plant Technology –McGraw-Hill. Int. Edition.</li> <li>4. Incropera F. P., Dewitt D. P., “Fundamentals of Heat and Mass Transfer”, John Wiley.</li> <li>5. Arora C. P., “Refrigeration and Air Conditioning”, Tata McGraw-Hill</li> </ol>	

## Module 7: Renewable Energy Technology

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Basic knowledge of Thermodynamics, Heat Transfer, Fluid Mechanics, and Electrical fundamentals.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To provide practical exposure to solar, wind, and biomass energy conversion systems.</li> <li>2. To analyze performance characteristics of renewable energy systems through experimental investigation.</li> <li>3. To evaluate the techno-economic feasibility of renewable energy installations.</li> <li>4. To understand industrial practices in renewable energy plants.</li> </ol>
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Calculate solar radiation parameters and estimate solar PV system output for given load conditions.</li> <li>2. Experimentally determine I–V and P–V characteristics of PV modules and evaluate efficiency.</li> <li>3. Analyze wind turbine performance using wind speed data and compute the power coefficient.</li> <li>4. Evaluate biomass/biogas plant efficiency and calorific value of biomass fuels.</li> <li>5. Perform techno-economic analysis, including payback period and LCOE.</li> <li>6. Prepare an industrial visit technical report detailing plant configuration and operational challenges.</li> </ol>

### Theory Contents

Course Contents	No. of Hours
Solar radiation geometry, solar angles, estimation of global radiation; PV cell construction and efficiency.	01
I–V characteristics, MPPT techniques, grid-connected and standalone PV systems.	01
Wind energy fundamentals, Betz limit, wind turbine components, and site selection.	01
Biomass energy conversion, gasification, biogas plant working, and efficiency analysis.	01
Energy storage systems, battery technologies, and hybrid renewable systems.	01
Techno-economic analysis: LCOE, payback period, carbon reduction, and sustainability metrics.	01

### Practical Contents

Course Contents	No. of Hours
Measurement of solar radiation using a pyranometer and tilt angle optimization.	04
Experimental plotting of I–V and P–V characteristics of solar PV module.	04
Wind turbine setup: Wind speed measurement using an anemometer and power calculation.	04
Biogas plant model study and calorific value determination using a bomb calorimeter.	04
Battery charge-discharge testing and hybrid PV-battery system analysis.	04
Industrial Visit / Training at Solar Plant / Wind Farm: Study of layout, inverter room, grid synchronization, safety practices; Technical report submission.	04

**Mini Project**

Design of a 5 kW rooftop solar PV system, including load assessment, sizing, inverter selection, and payback calculation.

**Textbooks:**

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers.
2. B.H. Khan, Non-Conventional Energy Resources, McGraw-Hill.

**Reference Books:**

1. C.S. Solanki, Solar Photovoltaics, PHI.
2. S.P. Sukhatme & J.K. Nayak, Solar Energy, McGraw-Hill.
3. MNRE Guidelines and BIS Standards for Solar & Wind Installations.

<b>Module 8: Engineering Material</b>	
<b>Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)</b>	
<b>Course Prerequisites:-</b>	Engineering Metallurgy, Strength of Materials, and Manufacturing Processes.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand structure–property relationships of engineering materials.</li> <li>2. To perform mechanical and metallurgical testing of materials.</li> <li>3. To analyze failure mechanisms and heat treatment processes.</li> <li>4. To study industrial material selection practices and standards.</li> </ol>
<b>Course Outcomes:-</b>	<ol style="list-style-type: none"> <li>1. Interpret phase diagrams and predict the microstructure of ferrous alloys.</li> <li>2. Perform tensile, hardness, and impact testing and evaluate material properties.</li> <li>3. Analyze microstructures using a metallurgical microscope.</li> <li>4. Conduct heat treatment (annealing, quenching, tempering) and evaluate property changes.</li> <li>5. Identify common material failure modes (fatigue, creep, corrosion).</li> <li>6. Select appropriate materials for engineering applications based on standards and performance requirements.</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
Iron–Carbon phase diagram and equilibrium cooling.	01
Ferrous and non-ferrous alloys and their applications.	01
Mechanical properties and testing standards (ASTM/IS).	01
Heat treatment processes and TTT diagrams.	01
Failure analysis: fatigue, creep, and fracture mechanisms.	01
Corrosion mechanisms and prevention techniques.	01
<b>Practical Contents</b>	
Course Contents	No. of Hours
Tensile test on Universal Testing Machine and stress-strain curve analysis.	04
Hardness testing (Brinell, Rockwell, Vickers) and comparison study.	04
Charpy impact test and fracture surface observation.	04
Metallographic specimen preparation and microstructure examination.	04
Heat treatment of steel specimens and hardness comparison.	04
Industrial Visit / Training at Heat Treatment or Foundry Industry: Study of furnaces, microstructure control, and quality inspection; Submission of technical report.	04
<b>Mini Project</b>	
Comparative study of mechanical properties and microstructure of untreated and heat-treated steel specimens, including failure analysis and application suitability report	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. William D. Callister, Materials Science and Engineering, Wiley.</li> <li>2. V. Raghavan, Physical Metallurgy, PHI Learning.</li> </ol>	

**Reference Books:**

1. ASTM Standards for Mechanical Testing.
2. ASM Handbook – Materials Engineering.
3. IS Standards for Material Testing and Heat Treatment.

<b>Module 9- Nano Composite Materials</b>	
<b>Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)</b>	
<b>Course Prerequisites:-</b>	Engineering Materials, Polymer Science, and Basic Chemistry
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand the fundamentals of nanomaterials and nanocomposites.</li> <li>2. To study synthesis and fabrication techniques of nano-reinforced composites.</li> <li>3. To evaluate the mechanical and thermal properties of nanocomposites.</li> <li>4. To analyze industrial applications and scalability challenges</li> </ol>
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Explain size-dependent properties and classification of nanomaterials.</li> <li>2. Fabricate polymer-based nanocomposite specimens using the solution casting or hand lay-up method.</li> <li>3. Evaluate tensile and hardness properties of nanocomposite samples.</li> <li>4. Analyze dispersion quality using microscopic examination.</li> <li>5. Compare the property enhancement with varying nanoparticle concentration.</li> <li>6. Prepare a technical report on potential industrial applications of the developed nanocomposite.</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
Introduction to Nanotechnology and classification of nanomaterials.	01
Mechanical, thermal, and electrical properties at the nanoscale.	01
Types of nanocomposites (polymer, metal, ceramic matrix).	01
Synthesis methods: Sol-gel, ball milling, chemical vapor deposition.	01
Dispersion techniques and interfacial bonding mechanisms.	01
Applications in aerospace, automotive, and biomedical sectors.	01
<b>Practical Contents</b>	
Course Contents	No. of Hours
Preparation of nanofiller–polymer mixture using mechanical stirring.	04
Fabrication of nanocomposite specimen by hand lay-up/VARTM.	04
Curing process and specimen finishing	04
Tensile testing of a nanocomposite specimen	04
Hardness testing and comparison with the base polymer.	04
Industrial Visit / Training at Composite Manufacturing Unit or Research Lab: Study of advanced composite fabrication and characterization techniques; Submission of technical report.	04
<b>Mini Project</b>	
Fabrication and characterization of polymer-based nanocomposite with varying nanoparticle percentages and comparative property analysis.	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. T. Pradeep, Nano: The Essentials, McGraw Hill.</li> <li>2. S. Thomas et al., Polymer Nanocomposites, Wiley.</li> </ol>	

**Reference Books:**

1. ASM Handbook – Composites.
2. Journal articles on nanocomposite fabrication and testing.
3. ISO standards for composite material testing.

## Module 10- Robotics and Automation

**Period: 2 weeks (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Robot terminology, Robot configuration, Conceptual knowledge of sensors, Conceptual knowledge of basic programming language like C/C++, Python
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To introduce the fundamentals of robotics and robotic programming.</li> <li>2. To develop hands-on skills in robot configuration, calibration, and control.</li> <li>3. To enable participants to write, simulate, and deploy robotic programs.</li> <li>4. To understand sensors, actuators, and integration with controllers.</li> <li>5. To implement basic automation tasks using industrial/mobile robots.</li> <li>6. To expose students to safety standards and real-world industrial applications.</li> </ol>
<b>Course Outcomes:-</b>	<p>The students will be able to</p> <ol style="list-style-type: none"> <li>1. Explain basic robotics concepts, terminology, and robot classifications.</li> <li>2. Configure and program a robotic system using a teach pendant or software interface.</li> <li>3. Develop motion control programs (linear, joint, and circular).</li> <li>4. Interface sensors and actuators with robotic controllers.</li> <li>5. Implement pick-and-place and simple automation tasks.</li> <li>6. Apply safety procedures in robotic work environments.</li> </ol>

### Theory Contents

Course Contents	No. of Hours
Day 1: Introduction to Robotics, History & Applications (Industrial, Medical, Service)	01
Day 2: Robot Anatomy (Manipulator, End Effector, Controller), Types of Robots (Cartesian, SCARA, Articulated, Delta, Mobile)	01
Day 3: Robot Coordinate Systems (World, Tool, Joint)	01
Day 4: Degrees of Freedom, Motion Types (PTP, Linear, Circular)	01
Day 5: Types of Sensors (Proximity, Vision, Force)	01
Day 6: End Effectors (Grippers, Welding Torch) , Input/output (I/O) Concepts	01
Day 7: Pick & Place Operations, Safety Standards in Robotics (ISO Basics)	01
Day 8: Palletizing & Material Handling	01
Day 9: Introduction to ROS (Robot Operating System)	01
Day 10: Robot Kinematics (Forward & Inverse Basics)	01
Day 11: Machine Vision Basics, Path Planning Concepts	01
Day 12: Introduction to AI in Robotics	01
Course Contents	No. of Hours
Day 1: Lab Introduction & Safety Training, Introduction to Robot Programming Interface	04
Day 2: Power-up & Basic Robot Movement, Jogging in Joint & Cartesian Mode	04
Day 3: Creating a Basic Robot Program, Writing Simple Motion Commands	04
Day 4: Speed & Acceleration Settings, Program Simulation & Execution	04
Day 5: Connecting Digital Inputs & Outputs, Programming Gripper Control	04

Day 6: Sensor-Based Conditional Programming, Error Handling & Debugging	04
Day 7: Pick & Place Programming, Palletizing Simulation	04
Day 8: Cycle Time Optimization	04
Day 9: Installing ROS Environment, Writing Basic ROS Node	04
Day 10: Controlling Robot via ROS, Simulation in Gazebo / Equivalent	04
Day 11: Vision-Based Object Detection Demo, Path Planning Program, Integrating Camera with Robot	04
Day 12: Industry /field Visit to any robotics-based firm	04
<b>Mini Project (If any)</b>	
<b>Mini Project Development:</b>	
<ol style="list-style-type: none"> <li>1. Automated Pick &amp; Place System</li> <li>2. Sorting System using Sensor</li> <li>3. Mobile Robot Navigation</li> </ol>	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. Mikell P. Groover, <i>Industrial Robotics: Technology, Programming and Applications</i>, McGraw-Hill.</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. John J. Craig, <i>Introduction to Robotics: Mechanics and Control</i>, Pearson.</li> <li>2. Saeed B. Niku, <i>Introduction to Robotics: Analysis, Control, Applications</i>, Wiley.</li> <li>3. Morgan Quigley, Brian Gerkey, William D. Smart, <i>Programming Robots with ROS</i>, O'Reilly.</li> </ol>	

<b>Module 11- Electric Vehicles</b>	
<b>Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)</b>	
<b>Course Prerequisites:-</b>	Basic knowledge of IC Engines, Electrical Machines, Power Electronics, and Automotive Systems.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand architecture and subsystems of electric vehicles.</li> <li>2. To analyze battery technologies and battery management systems (BMS).</li> <li>3. To evaluate motor drive performance and regenerative braking.</li> <li>4. To study EV charging infrastructure and safety standards.</li> <li>5. To gain exposure to EV workshop and diagnostic practices.</li> </ol>
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Explain EV architecture, including drivetrain, battery pack, and controller integration.</li> <li>2. Analyze Li-ion battery characteristics and calculate State of Charge (SOC).</li> <li>3. Evaluate the performance of the BLDC/PMSM motor used in EV applications.</li> <li>4. Perform basic EV diagnostics and interpret fault codes.</li> <li>5. Assess charging time, efficiency, and energy consumption for given driving cycles.</li> <li>6. Prepare an industrial EV workshop training report highlighting system layout and safety practices.</li> </ol>
<b>Theory Contents</b>	
Course Contents	No. of Hours
Introduction to Electric Vehicles: Types (BEV, HEV, PHEV), comparison with the IC engine vehicles.	01
Battery technologies: Li-ion chemistry, SOC, SOH, charging characteristics.	01
Battery Management System (BMS): Protection, balancing, thermal management.	01
Electric motors for EVs: BLDC, PMSM, torque-speed characteristics.	01
Power electronics & motor controllers; Regenerative braking system.	01
EV charging infrastructure: AC/DC charging, standards (CCS, CHAdeMO), safety regulations.	01
<b>Practical Contents</b>	
Course Contents	No. of Hours
Identification of EV components and subsystem layout study.	04
Battery pack testing: Voltage, current, and SOC estimation.	04
Motor performance testing (BLDC/PMSM) and torque-speed analysis.	04
Controller parameter study and regenerative braking demonstration.	04
EV diagnostic scan tool usage and fault code analysis.	04
Industrial Visit / Training at EV Workshop or Manufacturing Unit: Study of battery assembly, safety protocols, charging station operation; Submission of workshop report.	04
<b>Mini Project</b>	
Design and energy consumption analysis of a small electric two-wheeler, including battery sizing, motor selection, and range estimation.	

**Textbooks:**

1. Mehrdad Ehsani et al., Modern Electric, Hybrid Electric and Fuel Cell Vehicles, CRC Press.
2. C.C. Chan, Electric Vehicle Technology Explained, Wiley.

**Reference Books:**

1. BMS Design Manuals and EV Safety Standards (AIS-156).
2. SAE International EV Standards.
3. MNRE & NITI Aayog EV Policy Documents.

## Module 12:- Automobile Servicing

**Period: 2 weeks (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	IC Engines, Automobile Engineering, Basic Electrical & Electronics Systems.	
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand construction and servicing procedures of major automobile systems.</li> <li>2. To perform preventive maintenance and fault diagnosis using modern tools.</li> <li>3. To evaluate engine performance and emission parameters.</li> <li>4. To gain exposure to authorized service center workflow and documentation practices.</li> <li>5. To develop competency in automotive diagnostics and troubleshooting.</li> </ol>	
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Perform systematic inspection and servicing of SI/CI engines.</li> <li>2. Diagnose transmission, clutch and brake system faults using standard procedures.</li> <li>3. Conduct emission testing and interpret results as per Bharat Stage norms.</li> <li>4. Use automotive diagnostic scan tools to detect and rectify ECU-based faults.</li> <li>5. Carry out preventive maintenance and prepare service checklists.</li> <li>6. Prepare a structured industrial training report detailing workshop layout, service workflow and safety practices.</li> </ol>	
<b>Theory Contents</b>		
	Course Contents	No. of Hours
	Automobile layout and major subsystems overview.	01
	SI and CI engine servicing procedures.	01
	Fuel injection systems and common rail technology.	01
	Clutch, gearbox and transmission systems.	01
	Brake systems (Disc, Drum, ABS fundamentals).	01
	Suspension and steering systems.	01
	Vehicle electrical systems and battery maintenance.	01
	Automotive sensors and ECU basics.	01
	Emission standards (BS-VI) and pollution control systems.	01
	OBD (On Board Diagnostics) fundamentals.	01
	Preventive maintenance scheduling.	01
	Service documentation and warranty procedures.	01
<b>Practical Contents</b>		
	Course Contents	No. of Hours
	Engine oil change and filter replacement procedure.	04
	Valve clearance adjustment and spark plug inspection.	04

Fuel injector cleaning and performance check.	04
Clutch plate inspection and gearbox oil replacement.	04
Brake pad inspection and brake bleeding procedure.	04
Wheel alignment and balancing operation.	04
Battery testing and charging system check.	04
Use of an OBD scanner for fault code identification.	04
Emission testing using an exhaust gas analyzer.	04
Suspension system inspection and shock absorber testing.	04
Preparation of a preventive maintenance checklist.	04
Industrial Training at Authorized Service Center: Live servicing observation, job card preparation, safety compliance; Submission of service report.	04
<p>Mini Project</p> <p>Comprehensive servicing and diagnostic evaluation of a selected vehicle, including fault identification, emission measurement and cost estimation of maintenance.</p>	
<p>Textbooks:</p> <ol style="list-style-type: none"> <li>1. Kirpal Singh, Automobile Engineering, Standard Publishers.</li> <li>2. K.K. Jain &amp; R.B. Asthana, Automobile Engineering, Tata McGraw-Hill.</li> </ol>	
<p>Reference Books:</p> <ol style="list-style-type: none"> <li>1. Bosch Automotive Handbook.</li> <li>2. AIS &amp; Bharat Stage Emission Norms Documentation.</li> <li>3. OEM Service Manuals (Maruti, Tata, Mahindra, etc.).</li> </ol>	

## Module 13- HVAC System Servicing

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Basic knowledge of Thermodynamics, Refrigeration & Air Conditioning, Heat Transfer, and Fluid Mechanics.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To understand the operation and servicing of refrigeration and air-conditioning systems.</li> <li>2. To evaluate HVAC system performance using psychrometric analysis.</li> <li>3. To perform troubleshooting and preventive maintenance of HVAC equipment.</li> <li>4. To study industrial and commercial HVAC plant layout and energy efficiency practices.</li> </ol>
<b>Course Outcomes:-</b>	<p>Upon completion of this module, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Analyze the vapor compression refrigeration cycle and determine COP experimentally.</li> <li>2. Perform psychrometric calculations for air-conditioning processes.</li> <li>3. Diagnose faults in compressors, condensers, and evaporators.</li> <li>4. Conduct refrigerant charging and leak detection procedures safely.</li> <li>5. Evaluate HVAC system energy consumption and suggest efficiency improvements.</li> <li>6. Prepare an industrial HVAC plant visit report, including system configuration and safety standards.</li> </ol>

### Theory Contents

Course Contents	No. of Hours
Vapor compression refrigeration cycle and performance parameters.	01
Refrigerants (R134a, R410A, R32), environmental impact, and safety standards.	01
Psychrometry: Psychrometric chart, sensible & latent heat processes	01
HVAC components: Compressor, condenser, evaporator, expansion devices	01
Duct design basics, airflow measurement, and ventilation standards.	01
Energy efficiency in HVAC systems and green building considerations	01

### Practical Contents

Course Contents	No. of Hours
Refrigeration test rig experiment: Determination of COP and system efficiency.	04
Psychrometric experiment: Determination of relative humidity and enthalpy.	04
Refrigerant charging and leak detection using a manifold gauge set.	04
Airflow measurement using an anemometer and duct inspection.	04
Compressor fault diagnosis and preventive maintenance checklist preparation	04
Industrial Visit / Training at Commercial HVAC Plant: Study of chiller plant, AHU, cooling tower, BMS integration; Submission	04

### Mini Project

Energy performance evaluation of a classroom HVAC system and proposal of energy-saving measures with estimated annual savings.

### Textbooks:

1. C.P. Arora, Refrigeration and Air Conditioning, McGraw-Hill.
2. Manohar Prasad, Refrigeration and Air Conditioning, New Age International.

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**Reference Books:**

1. ASHRAE Handbook – HVAC Systems and Equipment.
2. ISHRAE Standards and Guidelines.
3. Bureau of Energy Efficiency (BEE) HVAC Audit Manuals.

## Module 14-Drone Technology (UAV Design & Application)

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Engineering Mechanics, Basic Aerodynamics, Electrical Machines, and Embedded Systems fundamentals.
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1.To introduce students to the fundamentals of UAV (Unmanned Aerial Vehicle) systems.</li> <li>2.To analyze aerodynamics and propulsion requirements of multirotor drones.</li> <li>3.To assemble and configure drone components, including the flight controller and ESC.</li> <li>4.To provide hands-on experience in drone assembly, calibration, and flight operation.</li> <li>5.To explore real-world applications and safety regulations in India.</li> </ol>
<b>Course Outcomes:-</b>	<p>After completion of the internship, students will be able to:</p> <ol style="list-style-type: none"> <li>1.Understand drone classification, components, and working principles.</li> <li>2.Explain flight dynamics, propulsion systems, and control mechanisms.</li> <li>3.Assemble drone hardware, including ESC, flight controller, GPS, and telemetry module.</li> <li>4.Calibrate sensors and perform safe flight operations.</li> <li>5.Apply drone technology in agriculture, surveillance, mapping, and industrial inspection.</li> <li>6.Understand DGCA regulations and safety standards in India.</li> </ol>

### Theory Contents

Course Contents	No. of Hours
History and evolution of UAVs, Types of drones: Fixed Wing, Multi-rotor, Hybrid, Drone classification (Nano, Micro, Small, Medium, Large), Civil and defense applications	01
Frame structure and materials, Motors (BLDC), ESC (Electronic Speed Controller), Propellers (types and selection), Flight Controller (overview of popular controllers like Pixhawk, KK2.1.5), Battery (Li-Po), and Power Distribution Board	01
Basics of aerodynamics, Thrust, Lift, Drag, Weight, Roll, Pitch, Yaw, PID Control concept, Sensors used in drones: Gyroscope, Accelerometer, Magnetometer, Barometer, GPS	01
RF communication basics, Transmitter and Receiver, GPS-based navigation, Telemetry systems, Ground Control Station (GCS) software	01
Drone Rules 2021 (India), Role of Directorate General of Civil Aviation (DGCA), UIN & UAOP basics, No-fly zones, Safety checklist & risk assessment	01
Drone Rules 2021 (India), Role of Directorate General of Civil Aviation (DGCA), UIN & UAOP basics, No-fly zones, Safety checklist & risk assessment	01

### Practical Contents

Course Contents	No. of
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	Hours
Identification of Drone Components- Physical identification of motors, ESC, propellers, FC, battery, Wiring and connection understanding	04
Quadcopter Frame Assembly- Frame building, Motor mounting, Propeller selection and mounting	04
ESC & Flight Controller Configuration- ESC calibration, Flight controller setup, Firmware flashing, Parameter tuning basics	04
Sensor Calibration & Testing- Accelerometer calibration, Compass calibration, Radio calibration, Pre-flight checklist	04
Flight Simulation Training-Drone flight simulator practice, Basic maneuvers: Take-off, Hovering, Landing, Direction control	04
Live Drone Flying Session- Safe take-off and landing, Stable hovering, Emergency procedures, Battery management	04
<b>Mini Project</b>	
<ol style="list-style-type: none"> <li>1. Basic Drone Build &amp; Flight Demonstration</li> <li>2. Application-based task (e.g., Aerial mapping demo)</li> </ol>	
<b>Textbooks:</b>	
<ol style="list-style-type: none"> <li>1. Austin, Unmanned Aircraft Systems: UAV Design, Development and Deployment, Wiley.</li> <li>2. Beard &amp; McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press.</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. DGCA India Civil Aviation Requirements for Drones.</li> <li>2. BLDC Motor &amp; Flight Controller Technical Manuals.</li> <li>3. Research Articles on UAV Applications and Control Systems.</li> </ol>	

## Module 15-Mechanical Engineering Sales

**Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)**

<b>Course Prerequisites:-</b>	Basic understanding of engineering concepts, Interest in innovation and entrepreneurship Basic knowledge of product design/problem solving, Willingness to work in teams, and develop practical solutions	
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To introduce students to the fundamentals of technical sales in mechanical engineering industries</li> <li>2. To develop the ability to understand customer requirements and propose suitable engineering solutions</li> <li>3. To provide hands-on exposure to sales processes, including product demonstration, costing, and quotations</li> <li>4. To develop communication, negotiation, and presentation skills required for technical sales roles</li> </ol>	
<b>Course Outcomes:-</b>	After completion of the internship, students will be able to: <ol style="list-style-type: none"> <li>1. Understand the role of sales engineers in the mechanical industries</li> <li>2. Interpret technical specifications and match them with suitable engineering products</li> <li>3. Prepare basic product quotations and cost estimates</li> <li>4. Demonstrate effective technical communication and sales presentation skills</li> </ol>	
<b>Theory Contents</b>		
	Course Contents	No. of Hours
	Introduction to Industrial Marketing and Role of Sales Engineer in the Mechanical Industry	01
	Understanding Customer Requirements and Technical Specifications	01
	Technical Product Demonstration and Presentation Skills	01
	Costing, Pricing, and Quotation Preparation	01
	Sales Negotiation and Customer Interaction	01
	Sales Process, CRM Basics, and After-Sales Service	01
<b>Practical Contents</b>		
	Course Contents	No. of Hours
	Study of mechanical products (pumps, compressors, machine tools, HVAC equipment). Product feature analysis.	04
	Case study: analyzing customer requirement documents and selecting suitable mechanical equipment.	04
	Prepare and demonstrate product presentation using catalogues and technical datasheets.	04
	Hands-on activity: preparing quotation, cost estimation, and comparison of vendor specifications.	04
	Role-play activity: simulated sales meeting with a customer, handling objections and negotiation.	04
	Preparation and delivery of final product sales pitch and solution presentation.	04
<b>Mini Project</b>		
	<ol style="list-style-type: none"> <li>1. Recommending a CNC Machine to a Manufacturing Startup</li> <li>2. Technical Sales Proposal for an Industrial Pumping Solution</li> </ol>	
<b>Reference Books:</b>		
	1. Care, John & Bohlig, Aron, Mastering Technical Sales: The Sales Engineer's Handbook,	

Artech House.

(Gold-standard book for sales engineers, covering technical sales, demos, RFPs, and objection handling.)

2. Clifton, M. Bradford; Townsend, Wesley P.; Bird, Henry M.B.; Albano, Robert E., Target Costing:

<b>Module 16: Entrepreneurship Development</b>	
<b>Period: 1 Week (Theory: 06 Hours/Week; Practical: 24 Hours/ Week)</b>	
<b>Course Prerequisites:-</b>	Basic understanding of engineering concepts, Interest in innovation and entrepreneurship Basic knowledge of product design/problem solving, Willingness to work in teams, and develop practical solutions
<b>Course Objectives:-</b>	1. To introduce students to the fundamentals of entrepreneurship and startup development 2. To develop problem-solving and opportunity identification skills 3. To provide hands-on experience in idea generation, product development, and business model creation 4. To expose students to real-world entrepreneurial practices and the startup ecosystem
<b>Course Outcomes:-</b>	1. Identify entrepreneurial opportunities in engineering domains 2. Develop innovative product or service concepts 3. Prepare a basic business model and startup plan 4. Demonstrate teamwork, leadership, and problem-solving skills
<b>Theory Contents</b>	
Course Contents	No. of Hours
Introduction to Entrepreneurship, Startup Ecosystem, Role of Engineers in Entrepreneurship	01
Idea Generation Techniques, Design Thinking for Innovation	01
Business Model Basics, Value Proposition	01
Product Development and Prototyping Basics	01
Marketing, Costing, and Financial Basics for Startups	01
Pitching and Startup Presentation	01
<b>Practical Contents</b>	
Course Contents	No. of Hours
session, team formation, Problem identification in engineering and society, brainstorming	04
Idea generation workshop, idea screening, and selection of feasible project ideas	04
Prepare a value proposition, identify customer segments, and conduct competitor analysis	04
Prototype development using lab facilities/simulation / conceptual design	04
Market survey, pricing strategy, cost estimation, break-even analysis	04
Preparation of business pitch, presentation rehearsal, final pitch presentation, and evaluation	04
<b>Mini Project:</b>	
1) Business Pitch Preparation, which includes Problem, Solution, and Market opportunity Prototype, Business model, Revenue plan, Financials, Competitive advantage. 2) Final Pitch Presentation & Evaluation: Team presentation before evaluation panel, Assessment based on innovation, feasibility, business potential, and communication	
<b>Reference Books:</b>	
1. Kuratko, Donald F., Entrepreneurship: Theory, Process and Practice, 9 <sup>th</sup> Edition, Cengage Learning, 2014. 2. Khanka, S.S., Entrepreneurial Development, S. Chand & Co., 2013	

## Power Plant Technologies (Course Code- MJ1111801)

Designation of Course	Power Plant Technologies		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: 04 Hours/ Week	Semester End Examination	60 Marks	Theory: 04
Practical: - - - Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/ Week	Term Work	-- Marks	Practical: 00
	Oral	-- Marks	
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites:-</b>	<ol style="list-style-type: none"> <li>1. Mechanical Engineering System.</li> <li>2. Thermodynamic Principles</li> <li>3. Thermodynamic Applications</li> </ol>
<b>Course Objectives:-</b>	<p>To explain the concepts of different types of Power Plants</p> <p>To study and analyze different types of Steam Condensers, Cooling Towers, Steam Nozzle and Steam Turbine.</p>
<b>Course Outcomes:-</b>	<p>On completion of the course, students will be able to–</p> <ol style="list-style-type: none"> <li>1. <b>Analyze</b> different types of power plants and <b>compare</b> their suitability based on technical, environmental, and Indian energy scenario considerations.</li> <li>2. <b>Evaluate</b> the thermodynamic performance of thermal power plants using Rankine, reheat, and regenerative cycles, including numerical analysis.</li> <li>3. <b>Analyze</b> the performance of gas turbine and combined cycle power plants and <b>explain</b> the working principles of nuclear reactors.</li> <li>4. <b>Calculate and assess</b> the performance of steam condensers and cooling towers using efficiency and vacuum analysis.</li> <li>5. <b>Analyze and compute</b> steam nozzle flow parameters and turbine performance using velocity diagrams and efficiency relations.</li> <li>6. <b>Evaluate</b> the economic performance of power plants using cost and load curve analysis and <b>apply</b> safety and maintenance principles in power plant operation.</li> </ol>

### Course Content

<b>Unit No. -I</b>	<b>Introduction to Power Plants</b>	<b>(8 Hrs.)</b>
<p>Overview of steam, hydel, diesel, gas turbine, and nuclear power plants. Rankine cycle review. Comparison and selection of power plants. Indian energy scenario (brief) and environmental considerations. Issues in Power Plants. Resources and development of power in India, NTPC, NHPC, and their role in Power development in India. Power generation in the private sector, Power distribution, National Grid, Indian Electricity Grid Code. Regulation Structure of IEGC, Operating Policies and Procedures, Present Power position in India.</p>		
<b>Unit No.-II</b>	<b>Thermal Power Plant-Operation and Thermodynamic Analysis</b>	<b>(8 Hrs.)</b>

<p>Role of thermal power plant in the current power generation scenario. General layout of a thermal power plant, Fuels used in thermal power plant- Fuel handling layout and its methods, stages in coal handling storage, Fuel burning-Stoker firing, Pulverized fuel burning- Pulverization of coal, Ash handling system, Ash disposal management and its utilization, Feed water treatment. Ideal Rankine Cycle, Reheat cycle, Regenerative feed heating, Open and closed feed heaters. Numerical problems on cycle performance.</p>		
<b>Unit No. -III</b>	<b>Gas Turbine and Nuclear Power Plant</b>	<b>(8 Hrs.)</b>
<p>Gas turbine power plant-Schematic diagram, components, and its working. Combined cycle power generation- Combined gas and steam turbine power plant operation. Gas turbine cycle with reheat, regeneration, and intercooling. Numerical based on the syllabus contents. Nuclear power, Radioactivity, Radioactive charge, types of reactions, Working of a nuclear power plant, making of nuclear fuel, Thermal fission Reactors- PWR, BWR and gas cooled reactors, Advantages and Disadvantages of Nuclear power plant.</p>		
<b>Unit No.-IV</b>	<b>Steam Condenser and Cooling Tower</b>	<b>(8 Hrs.)</b>
<p>Necessity of steam condenser, elements of steam condensing plant, classification, cooling water requirements, condenser efficiency, vacuum efficiency (Numerical Treatment). Cooling towers, Types of cooling towers, air leakage and its effects on condenser performance, air pumps (Numerical Treatment for Air Pump capacity)</p>		
<b>Unit No. -V</b>	<b>Steam Nozzle and Steam Turbine</b>	<b>(8 Hrs.)</b>
<p>General forms of nozzles: Flow through steam nozzles, critical pressure ratio, and mass flow rate. Energy losses in the nozzle. Working principle of steam turbine, classification, Simple impulse turbine, Compounding of Impulse turbine, Reaction turbine, Velocity diagram, Blade efficiency, Stage efficiency, Net efficiency, Comparison between Impulse and Reaction turbines.</p>		
<b>Unit No.-VI</b>	<b>Power Plant Economics, Plant Safety, and Maintenance</b>	<b>(8 Hrs.)</b>
<p>Power Plant Economics -Cost of electric energy, fixed and operating costs, energy rates, types of tariffs, economics of load sharing, Load Curves, comparison of various power plants. Energy, Economic, and Environmental issues of Power plants. Plant Safety and Maintenance: Operation and Maintenance procedures of power plants, Operator training, Safety during selection of power plant equipment –safety in commissioning of thermal power plant equipment, hydrostatic and air leakage test. Safety in auxiliary plants. Cooling water system, Safety in maintenance of power plants.</p>		

**Practical's (Any 8 with compulsorily one plant visit):**

1. Study of National & International Grid, Indian Electricity Grid Code
2. Study of a combined cycle gas-based and coal based Power plant.
3. To perform an analysis of a thermal power plant.
4. To perform an analysis of the gas turbine/ diesel power system.
5. Study of Power Plant Instrumentation.
6. Study of Heat Exchangers used in Power Plant
7. To study different types of hybrid power plants.
8. Visit to a thermal power plant.
9. Visit to a Hydro Electric Power Plant

## 10. Case Study on Plant Safety and Maintenance

### **Project-Based Learning**

Following is the list of Topics for project-based learning (Not Limited to) based on the syllabus Contents:

1. To prepare a chart on the National & International Grid, the Indian Electricity Grid Code
2. To prepare a chart on a thermal power plant
3. To prepare a chart on Hydro Electric Power Plants
4. To prepare a chart on Steam Condenser and Cooling Towers
5. To prepare a chart on the Steam Nozzle and the Steam Turbine
6. To prepare a chart on Energy Storage Technologies
7. To prepare a demonstration model of a thermal power plant
8. To prepare a demonstration model of Hydro Electric Power Plants
9. To prepare a demonstration model of the Steam Condenser
10. To prepare a demonstration model of Cooling Towers
11. To prepare a demonstration model of the Steam Nozzle
12. To prepare a demonstration model of a steam turbine
13. Case study on Thermal Power Plant
14. Case study on Hydro Electric Power Plants
15. Case study on Steam Nozzle and Steam Turbine

### **Text Books**

1. Domkundwar and Arora, Power Plant Engineering, Dhanpatrai and Sons.
2. P. K. Nag, Power Plant Engineering, TMH, 3<sup>rd</sup> Edition, 2002

### **Reference Books**

1. Modern Power Station Practice, Vol. 6, Instrumentation, Controls and Testing, Pergamon Press, Oxford, 1971.
2. John V Grimaldi and Rollin H Simonds, Safety Management
3. M. M. El Wakil, Power Plant Technology –McGraw-Hill. Int. Edition.
4. C. A. Gross, Power System Analysis, John Wiley and Sons, Inc., 1986.
5. John Weisman & L.E. Eckart, Modern Power Engineering, Prentice Hall, 1985

## Industrial Product Design (Course Code-MJ1111802)

Designation of Course	Industrial Product Design		
Teaching Scheme	Examination Scheme		Credits Allotted
Theory: 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical: 00 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	00 Marks	00
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites :-</b>	<ol style="list-style-type: none"> <li>1. Machine Drawing</li> <li>2. Machine Design</li> <li>3. Any CAD software</li> </ol>
<b>Course Objectives: -</b>	<p>To enable students to understand</p> <ol style="list-style-type: none"> <li>1. Various aspects of product design and development, concept generation, and selection</li> <li>2. Aesthetic and Ergonomic considerations in product design</li> </ol>
<b>Course Outcomes: -</b>	<p>On completion of the course, students will be able to–</p> <ol style="list-style-type: none"> <li>1. <i>Explain</i> the fundamentals of product design and development, including customer needs identification, product planning processes, product architecture, and challenges in developing successful products.</li> <li>2. <i>Apply</i> systematic product design methods such as objective tree method, function analysis, QFD, morphological charts, and value engineering to develop and evaluate alternative product design solutions.</li> <li>3. <i>Analyze</i> product specifications and concept generation techniques to develop, screen, and select suitable product design concepts.</li> <li>4. <i>Evaluate</i> the role of industrial design and prototyping techniques, including rapid prototyping technologies, in the development and management of innovative product designs.</li> <li>5. <i>Analyze</i> ergonomic principles, human–machine interaction, and industrial safety standards for designing safe, efficient, and user-friendly products and work systems.</li> <li>6. <i>Evaluate</i> design for manufacturing and assembly principles, cost estimation methods, and innovation strategies to improve manufacturability and sustainability of products.</li> </ol>

Unit-I	Introduction to Product Design and Development	(8 Hrs.)
<p>Market survey. Identify customer needs and product planning processes. Product architecture: Implication of architecture, establishing architecture, and related system-level design issues. Overview of industrial design, Successful product, development of quality aspect of product design, Challenges of product development.</p>		

<b>Unit-II</b>	<b>Product Design Methods</b>	<b>(8 Hrs.)</b>
Creative and rational, clarifying objectives - the objective tree method, establishing functions- the function analysis method, setting requirements–the performance specification method, determining characteristics–the QFD method, generating alternatives – the morphological chart method, evaluating alternatives – the weighted objective method, improving details – the value engineering method, and design strategies.		
<b>Unit-III</b>	<b>Product Specifications and Concept Generation</b>	<b>(8 Hrs.)</b>
Product specification, steps to establish the target specifications, Concept generation, five-step concept generation method, concept selection, concept screening, concept testing, product architecture		
<b>Unit-IV</b>	<b>Industrial Design and Prototyping</b>	<b>(8 Hrs.)</b>
Industrial Design: Need, impact, and quality, industrial design process and its management, legal issues in product design, design resources, economics, and management of product development projects. Prototyping: Basics and principles of prototyping, Rapid prototyping technologies, planning for prototypes.		
<b>Unit-V</b>	<b>Ergonomics and Industrial Safety</b>	<b>(8 Hrs.)</b>
Introduction: General approach to the man-machine relationship, workstation design, working position, and posture. An approach to industrial design - elements of design structure for industrial design in engineering applications in manufacturing systems. Environmental Application of ergonomics in industry for safety, health, and environmental control. Safety and ISO 14000 Systems.		
<b>Unit-VI</b>	<b>Design for Manufacture</b>	<b>(8 Hrs.)</b>
Estimating manufacturing cost, reducing component, assembly, and support costs, design for assembly, design for disassembly, design for the environment, design for graphics and packaging, effective prototyping principles, and planning. Product data management. Innovation and creativity in product design. Product costing, value engineering, aesthetic concepts.		

### **Project-Based Learning**

Following is the list of Topics for project-based learning (Not Limited to) based on the syllabus

1. Design of an ergonomic study table for students
2. Development of a multipurpose portable tool kit for field engineers
3. Design of an eco-friendly water bottle with enhanced usability
4. Redesign of a household product using value engineering
5. Product design using quality function deployment
6. Design and prototype of a foldable bicycle stand
7. Development of an ergonomic hand tool for workshop applications
8. Design of a smart waste segregation bin
9. Design of a portable solar mobile charger stand

10. Development of a low-cost agricultural tool for farmers
11. Redesign of a backpack for improved ergonomics
12. Product design and prototype of a modular storage organizer

**Textbooks:**

1. Product Design and Development: Karl T. Ulrich, Steven G. Eppinger; Irwin McGraw-Hill
2. Product design and Manufacture: A.C. Chitale and R.C. Gupta; PHI
3. Product Development, Tata McGraw-Hill
4. New Product Development: Tim Jones, Butterworth, Heinemann, Oxford, 1997.

**Reference Books:**

1. Product Design for Manufacture and Assembly: Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight.
2. Product Design: Otto and Wood; Pearson Education.
3. Industrial Design for Engineers: Mayall W.H, London, Hiffee books Ltd, 1988
4. Introduction to ergonomics – R.C. Bridger, McGraw-Hill Pub.
5. Product Design – Kevin Otto, Kristin Wood Pierson Education.

## Program Elective-II/III: PROJECT MANAGEMENT & ETHICS

(Course No. PE1111701/803)

Designation of Course	Project Management & Ethics		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory:- 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical:- 00 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	00 Marks	00
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites: -</b>	Basic knowledge of Mathematics & Statistics, Knowledge of Industrial Engineering & Management, Basic knowledge of soft skills, and professional skills
<b>Course Objectives:-</b>	<ol style="list-style-type: none"> <li>1. To create awareness about the concepts of project management and its components</li> <li>2. To apply the techniques specified by the Project Management Body of Knowledge for effective project management.</li> <li>3. To create awareness of social and professional responsibility among stakeholders</li> </ol>
<b>Course Outcomes: -</b>	<p>The students should be able to–</p> <ol style="list-style-type: none"> <li>4. <i>Explain</i> the fundamental concepts of project management, including project lifecycles, project management processes, and the role of a project manager in managing projects effectively.</li> <li>5. <i>Apply</i> feasibility analysis techniques and risk management tools such as financial evaluation models and risk identification methods for decision-making in project management using appropriate software tools.</li> <li>6. <i>Analyze</i> different project cost estimation methods and budgeting techniques to estimate project costs and allocate resources effectively.</li> <li>7. <i>Apply</i> project planning and scheduling techniques such as Work Breakdown Structure (WBS), PERT, and CPM to develop and manage project schedules using project management software.</li> <li>8. <i>Evaluate</i> project performance using monitoring and control techniques, project management information systems, and performance measurement tools to ensure project success.</li> <li>9. <i>Assess</i> ethical responsibilities, stakeholder interactions, and professional conduct required for effective and responsible project management practices.</li> </ol>

### Course Contents

<b>Unit I</b>	Introduction to Project Management	<b>(08 Hrs.)</b>
	Project, Project Management, Management by projects, Project Management Associations, Benefits of Project Management, Project management Process, Role of Project Manager, Project Lifecycle	
<b>Unit II</b>	Project Management Techniques and Risk Management	<b>(08 Hrs.)</b>
	Feasibility Studies, Numerical Models (Payback Period, Return on Investment, Net Present Value, Internal Rate of Return), Scoring Models, Break-Even Analysis, Project Risk Management: Introduction, Risk, Risk Management, Role of Risk Management in Overall Project Management, Steps in Risk Management, Risk Identification, Risk Analysis, Reducing Risks. Use of Excel and MS Project for feasibility studies and risk management.	
<b>Unit III</b>	Project Cost Estimating	<b>(08 Hrs.)</b>

Estimating terminology, Project Costs, Estimating Methods (Jobbing, Factoring, Inflation, Economies of Sales, Unit Rates, Day Work), Analogous Estimating, Parametric Estimating, Bottom-Up Estimating, Three-Point Estimates, Monte Carlo Simulation, Project Budgeting, Resource Allocation, Cost Forecasts. Use of Excel and MS Project for project cost estimating		
<b>Unit IV</b>	<b>Project Planning and Scheduling</b>	<b>(08 Hrs.)</b>
Project Planning: Introduction, Need for Project Planning, Project Life Cycle, Roles, Responsibilities and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Scheduling: Introduction, Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, Measures of variability, CPM Model, Network Cost System Use of MS Project: Project Planning and Scheduling		
<b>Unit V</b>	<b>Project Monitoring and Control</b>	<b>(08 Hrs.)</b>
Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control, Project Management Information System: Introduction, Project Management Information System (PMIS), Planning of PMIS, Design of PMIS, Project Performance Measurement and Evaluation: Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects		
<b>Unit VI</b>	<b>Professional Responsibility (Ethics)</b>	<b>(08 Hrs.)</b>
Ensuring Integrity and Professionalism, Project Management Knowledge Base, Enhancing Individual Competence, Balancing Stakeholder Interests, Interactions with Team Members and Stakeholders, Templates, Tools, and Techniques		

### **Project-Based Learning**

1. Feasibility Study of a Small Renewable Energy Project
2. Project Planning and Scheduling for a New Manufacturing Unit
3. Cost Estimation and Budgeting for a Construction Project
4. Risk Management Plan for a Startup Project
5. Project Scheduling and Critical Path Analysis for a College Event
6. Development of a Project Management Information System (PMIS) Model
7. Financial Evaluation of a Product Development Project
8. Monte Carlo Simulation for Project Cost and Time Estimation
9. Project Performance Evaluation Using Earned Value Analysis
10. Ethical Decision-Making in Project Management
11. Resource Optimization for Multi-Project Management
12. Project Planning for Smart City Infrastructure Development

### **Text Books & Reference Books**

1. Panneerselvam R; “Project Management”; Prentice Hall India Learning Pvt. Ltd. (2009)
2. Samuel J. Mantel, Jack R. Meredith; “Project Management: A Managerial Approach”; Wiley; Eighth edition (6 August 2012)
3. Gupta R; “Project Management”; Prentice Hall India Learning Private Limited; Second edition (2014)
4. Project Management Institute; “A Guide to the Project Management Body of Knowledge (PMBOK Guide)”; 5th Revised edition (1 January 2013)
5. Harold Kerzner; “Project Management: A Systems Approach to Planning, Scheduling and Controlling Paperback”; Wiley; tenth edition (20 November 2012)
6. Erik Larson, Clifford Gray; “Project Management: The Managerial Process”; McGraw-Hill Education; Sixth edition (1 July 2014).

**Program Elective II/ III: ARGUMENTED AND VIRTUAL REALITY**  
(Course Code-PE1111701/803)

<b>Designation of Course</b>	<b>Augmented and Virtual Reality</b>		
<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>		<b>Credits Allotted</b>
Theory: - 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical: - 00 Hours/ Week	Internal Assessment	40 Marks	
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites: -</b>	Artificial Intelligence, Image Processing
<b>Course Objectives:-</b>	This course is designed to give historical and modern overviews and perspectives on virtual reality. It describes the fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems.
<b>Course Outcomes: -</b>	The students should be able to– <ol style="list-style-type: none"> <li>1. Describe how VR systems work and list the applications of VR.</li> <li>2. Understand the design and implementation of the hardware that enables VR systems to be built.</li> <li>3. Understand the Geometry of Virtual Worlds &amp; The Physiology of Human Vision.</li> <li>4. Understand the system of human vision and its implication on perception and rendering.</li> <li>5. Explain the concepts of motion and tracking in VR systems.</li> <li>6. Describe the importance of interaction and audio in VR systems.</li> </ol>

**Course Contents**

<b>Unit I</b>	<b>Introduction to Virtual Reality</b>	<b>(08 Hrs.)</b>
Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality.		
<b>Unit II</b>	<b>Representing the Virtual World</b>	<b>(08 Hrs.)</b>
Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR		
<b>Unit III</b>	<b>The Geometry of Virtual Worlds &amp; The Physiology of Human Vision</b>	<b>(08 Hrs.)</b>
Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.		
<b>Unit IV</b>	<b>Visual Perception &amp; Rendering</b>	<b>(08 Hrs.)</b>
Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information. Visual Rendering -Ray Tracing and Shading Models, Rasterization,		

Correcting Optical Distortions, Improving Latency and Frame Rates.		
<b>Unit V</b>	<b>Motion &amp; Tracking</b>	<b>(08 Hrs.)</b>
Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies		
<b>Unit VI</b>	<b>Interaction &amp; Audio</b>	<b>(08 Hrs.)</b>
Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio -The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering.		

### **Project-Based Learning**

1. Study the use of Virtual Reality at NASA
2. GHOST (General Haptics Open Software Toolkit) software development toolkit.
3. Sweeping coverage of eye movements
4. Automatic stitching of panoramas in Virtual Reality
5. A virtual Study Use Case- NICE, An Educational Experience
6. Side effects of using VR systems/ VR sickness.

### **Text Books**

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
2. Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002
3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.

### **Reference Books**

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Merging Real and Virtual Worlds", 2005.
4. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003

**Program Elective: II/III -MOBILE ROBOTS & DRONE TECHNOLOGY**  
(Course Code - PE111701/803)

Designation of Course	Mobile Robots & Drone Technology		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: 04 Hours/ Week	Semester End Examination	60	04
Practical: -- Hours/ Week	Internal Assessment	40	
	Term Work	--	00
	Oral/Practical	--	
	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites: -</b>	The students should have knowledge of <ol style="list-style-type: none"> <li>1. Robotics Simulation softwares</li> <li>2. Robotic Control Systems</li> <li>3. Artificial Intelligence in Robotics.</li> </ol>
<b>Course Objectives: -</b>	<ol style="list-style-type: none"> <li>1. To recognize and describe the role of Mobile Robots &amp; Drone Technology (MRDT) in past, present, and future society.</li> <li>2. To comprehend and explain various components of MRDT.</li> <li>3. To comprehend and explain basics of flight and flight control systems.</li> <li>4. To understand and describe basics of underwater robots.</li> </ol>
<b>Course Outcomes: -</b>	The students should be able to– <ol style="list-style-type: none"> <li>1. Understand the challenges in developing autonomous mobile Robots.</li> <li>2. Abstract kinematic control of wheeled mobile Robots.</li> <li>3. Understand the challenges involved in sensory perception for mobile Robots.</li> <li>4. Ability to design UAV drone system.</li> <li>5. To understand working of different types of engines and its area of applications.</li> <li>6. To understand static and dynamic stability dynamic instability and control concepts.</li> <li>7. To know the loads taken by aircraft and type of construction and also construction materials in them.</li> </ol>

**Course Contents**

<b>Unit I</b>	<b>Introduction to mobile robots</b>	<b>(08 Hrs.)</b>
Introduction to Mobile robots, Locomotion, Classification -Legged, hopping, Wheeled, Aerial, Key issues in locomotion , Degree of mobility and steerability, robot maneuverability, kinematic modelling of Mobile robot, Wheel kinematic constraints Motion control, Kinematic models of simple car and legged robots.		
<b>Unit II</b>	<b>Control of Mobile Robots</b>	<b>(08 Hrs.)</b>
Control theory, Control design basics, Cruise-Controllers, Performance Objectives, State space modelling of mobile robots, Linearization, LTI system, Stability, PID control, basic control algorithms, Low-level, control. State space control, back stepping control.		
<b>Unit III</b>	<b>Perception and Actuation</b>	<b>(08 Hrs.)</b>
Sensors for mobile robots, Classification, performance, uncertainty in sensors , Wheel sensor, Heading sensor, Accelerometer, Inertial measurement, Motion sensor, range sensors, Global positioning system (GPS), Doppler effect-based sensors, Vision sensor , Basics of computer vision, Image processing techniques, Feature extraction – image, Range data location recognition, Actuator systems: Types of motors, DC, AC servo systems, Linear actuation systems.		

<b>Unit IV</b>	<b>Introduction and Design of UAV Drone Systems</b>	<b>(08 Hrs.)</b>
Introduction to Unmanned Aircraft Systems, History of UAV drones, classification of drones, System Composition, Applications. Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards and Regulatory Aspects-India Specific, Design for Stealth.		
<b>Unit V</b>	<b>Avionics Hardware of Drones</b>	<b>(08 Hrs.)</b>
Autopilot, AGL-pressure sensors-servos-accelerometer - gyros-actuators - power supply-processor, integration, installation, configuration.		
<b>Unit VI</b>	<b>Payloads, Controls, Navigation and Testing</b>	<b>(08 Hrs.)</b>
Payloads, Telemetry, Tracking, controls-PID feedback, radio control frequency range, modems, memory system, simulation, ground test-analysis-trouble shooting. Waypoints navigation, ground control software, System Ground Testing, System In-flight Testing, Future Prospects and Challenges.		

### Textbooks

1. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed MartinAeronautics.
2. Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2011.
3. Thrun, Burgard, Fox, "Probabilistic Robotics", MIT Press, 2005.
4. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006.
5. Howie M. Choset, Kevin M. Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, Sebastian Thrun, Ronald C Arkin · 2005 "Principles of Robot Motion: Theory, Algorithm & Implementations", MIT Press, 2005.
6. Roland Siegwant & Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2004.
7. ASA Test Prep. Remote Pilot Test Prep — UAS: Study & Prepare. Wellfleet Press, 2016. 978-1577151326
8. Austin, Unmanned Aircraft Systems: UAVS Design, Development and Deployment. Wiley,2010. 978-0-470-05819-0
9. Baichtal, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs. QuePublishing, 2016. 978-0789755988
10. Beard & McLain, Small Unmanned Aircraft: Theory and Practice. Princeton University Press, 2012. 978-0691149219
11. Cares & Dickmann, Operations Research for Unmanned Systems. Wiley, 2016. 978-1-118-91894-4.

### Reference Books

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley,2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Roadto Autonomy", Springer, 2007
4. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc,1998.

**Program Elective- II/III: ADVANCED AUTOMOTIVE TECHNOLOGY**  
(Course Code -PE1111701/803)

Designation of Course	Advanced Automotive Technology		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: - 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical: - 00 Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/ Week	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites: -</b>	Students should have studied: <ol style="list-style-type: none"> <li>1. Thermodynamics Applications</li> <li>2. Thermodynamics Principles</li> <li>3. Fluid Mechanics</li> <li>4. Basic Electrical &amp; Electronics Engineering</li> <li>5. Industrial Automation</li> </ol>
<b>Course Objectives: -</b>	<ol style="list-style-type: none"> <li>1. To understand advanced developments in modern automotive engine technologies.</li> <li>2. To study electric and hybrid vehicle architecture and propulsion systems.</li> <li>3. To analyze automotive electronic control and embedded systems.</li> <li>4. To explore alternative fuels and emission control technologies as per current norms.</li> <li>5. To examine advanced transmission and driveline systems used in modern vehicles.</li> <li>6. To introduce intelligent transportation and autonomous vehicle technologies.</li> </ol>
<b>Course Outcomes: -</b>	The students should be able to– <ol style="list-style-type: none"> <li>1. Explain modern IC engine advancements and advanced combustion techniques.</li> <li>2. Analyze electric and hybrid vehicle configurations and their components.</li> <li>3. Illustrate automotive electronics, sensors, actuators, and control systems.</li> <li>4. Evaluate alternative fuel systems and emission control technologies.</li> <li>5. Differentiate advanced transmission and driveline systems.</li> <li>6. Describe intelligent transportation systems and autonomous vehicle technologies</li> </ol>

**Course Contents**

<b>Unit I</b>	<b>Modern Automotive Engines &amp; Advanced Combustion Technologies</b>	<b>(08 Hrs.)</b>
Review of SI and CI Engines, Gasoline Direct Injection (GDI), Common Rail Direct Injection (CRDI), Turbocharging and Supercharging, Variable Valve Timing (VVT), Homogeneous Charge Compression Ignition (HCCI), Engine Downsizing & Efficiency Improvement.		
<b>Unit II</b>	<b>Electric &amp; Hybrid Vehicle Technology</b>	<b>(08 Hrs.)</b>
Introduction to Electric Vehicles (EVs), Battery Electric Vehicle (BEV) Architecture, Hybrid Electric Vehicles (Series, Parallel, Series-Parallel), Plug-in Hybrid Electric Vehicles (PHEV), Electric Motors (BLDC, PMSM, Induction Motor), Regenerative Braking, EV Charging Standards.		
<b>Unit III</b>	<b>Automotive Electronics &amp; Control Systems</b>	<b>(08 Hrs.)</b>
Electronic Control Unit (ECU), Sensors and Actuators, Engine Management System, Transmission Control, Anti-lock Braking System (ABS), Electronic Stability Control (ESC), CAN Protocol.		
<b>Unit IV</b>	<b>Alternative Fuels &amp; Emission Control Technologies</b>	<b>(08 Hrs.)</b>

CNG, LPG, Biofuels, Hydrogen, Fuel Cell Technology, Emission Formation in Engines, Bharat Stage (BS-VI) Norms, Catalytic Converter, EGR, DPF, SCR Systems.		
<b>Unit V</b>	<b>Advanced Automotive Transmission &amp; Driveline Systems</b>	<b>(08 Hrs.)</b>
Automated Manual Transmission (AMT), Continuously Variable Transmission (CVT), Dual Clutch Transmission (DCT), Torque Converter, AWD & 4WD Systems, Electronic Differential.		
<b>Unit VI</b>	<b>Intelligent &amp; Autonomous Vehicle Technologies</b>	<b>(08 Hrs.)</b>
Advanced Driver Assistance Systems (ADAS), Adaptive Cruise Control, Lane Departure Warning, Collision Avoidance Systems, V2V & V2I Communication, SAE Autonomous Levels (0–5), Connected Cars & Telematics.		

### **Textbooks**

1. William B. Ribbens, Understanding Automotive Electronics, 8th Edition, Butterworth-Heinemann (Elsevier), 2017.
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition, CRC Press, 2011.
3. James D. Halderman, Automotive Technology: Principles, Diagnosis and Service, 6th Edition, Pearson Education, 2016.

### **Reference Books**

1. Robert Bosch GmbH, Automotive Handbook, 10th Edition, SAE International / Wiley, 2018.
2. K. K. Ramalingam, Automobile Engineering, Scitech Publications, Chennai.
3. Kirpal Singh, Automobile Engineering (Vol. 1 & 2), Standard Publishers Distributors.
4. T. K. Garrett, K. Newton & W. Steeds, The Motor Vehicle, 13th Edition, Butterworth-Heinemann.
5. Mehrdad Ehsani, Yimin Gao & Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles, CRC Press.

**Program Elective-II/III: ENERGY AUDIT AND MANAGEMENT**  
(Course Code-MD1111701/803)

Designation of Course	Energy Audit & Management		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: - 04 Hours/ Week	Semester End Examination	60 Marks	04
Practical: - 00 Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 00 Hours/ Week	<b>Total</b>	<b>100 Marks</b>	<b>04</b>

<b>Course Prerequisites: -</b>	The student should know of - 1. Basic Physics; 2. Basic Electrical Engineering 3. Basic Thermal Engineering; 4. Mathematics
<b>Course Objectives: -</b>	The course aims to: 1. Provide knowledge of the global and national energy scenario and the importance of energy conservation and sustainable energy management. 2. Develop the ability to conduct energy audits and evaluate energy performance in industrial and building systems. 3. Introduce economic evaluation techniques for assessing the feasibility of energy conservation measures. 4. Enable students to identify energy conservation opportunities in electrical and thermal systems used in industries. 5. Develop analytical skills for energy and material balance calculations for improving process efficiency. 6. Familiarize students with modern energy management strategies and policies for sustainable industrial operations.
<b>Course Outcomes: -</b>	The students should be able to-- 1. Explain and analyze the global and national energy scenario, energy policies, environmental impacts, and the importance of energy conservation, including the provisions of the Energy Conservation Act of 2001. 2. Apply energy audit methodologies and tools to evaluate energy consumption patterns, identify energy saving opportunities, and prepare energy audit reports for industrial or building systems. 3. Analyze and evaluate the economic feasibility of energy conservation projects using financial appraisal techniques such as NPV, IRR, payback period, and life-cycle cost analysis. 4. Analyze energy consumption in electrical systems and apply techniques for improving efficiency through load management, power factor correction, efficient motors, and optimized lighting systems. 5. Evaluate energy conservation opportunities in thermal systems such as boilers, steam systems, heat exchangers, and cogeneration units for improving overall thermal efficiency. 6. Apply the principles of material and energy balance to industrial processes and analyze energy flows using process flow charts and Sankey diagrams for identifying energy losses.

**Course Contents**

Unit I	Energy Scenario	(08 Hrs.)
Energy needs of a growing economy, Long-term energy scenario, Energy pricing, Energy sector reforms, Energy and Environment: Air pollution, Climate change, Energy Security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features		

<b>Unit II</b>	<b>Energy Audit</b>	<b>(08 Hrs.)</b>
Energy Audit: Types and Methodology; Scope of Energy Audit, Energy Audit Reporting Format; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximizing System Efficiency, Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors. Energy Management of Building and Energy audit of Building- Energy management matrix monitoring and targeting Case Studies		
<b>Unit III</b>	<b>Economic Analysis of Energy Conservation Measures</b>	<b>(08 Hrs.)</b>
Economics: Fundamentals: Cash flows, Inflation Rates, Time Points and Periods, Discount Rates, Cost of Capital, Present value, Taxes, Uncertainty and Risk Economic Measures: Net Present Value, Total Life-Cycle Cost, Revenue Requirements, Internal Rate of Return, Modified Internal Rate of Return, Simple Payback Period, Discounted Payback Period, Benefit-to-Cost Ratios, Savings-to-Investment Ratios, Profitability Index Estimation.		
<b>Unit IV</b>	<b>Electrical Energy Management</b>	<b>(08 Hrs.)</b>
Electricity tariff, Load management and maximum demand control, Power factor improvement, Distribution, and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, energy-efficient motors, Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues. Case Studies		
<b>Unit V</b>	<b>Thermal Energy Management</b>	<b>(08 Hrs.)</b>
Energy conservation in boilers, steam turbines, and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management. Case Studies on Thermal Energy Management. Case Studies.		
<b>Unit VI</b>	<b>Material and Energy Balance</b>	<b>(08 Hrs.)</b>
Basic Principles, Sankey diagrams, Material balances for different processes, Energy balances, heat balances, Methods for preparing process flow chart, Procedures to carry out the material and energy balance in different processes.		

### Textbooks

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. Energy management by Paul O'Callaghan, McGraw-Hill Book Company-1st edition, 1998.
3. Energy management handbook by W. C. Turner, John Wiley and Sons.
4. Energy management and conservation -K V Sharma and Venkata Shariyah-I K International Publishing House Pvt ltd, 2011.

### Reference Books

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Seventh Edition, The Fairmont Press Inc., 2012.
2. Albert Thomann, "Handbook of Energy Audits", Sixth Edition, The Fairmount Press, 2003.
3. G. G. Rajang, "Optimizing Energy Efficiencies in Industry", Tata McGraw-Hill, 2001
4. Wayne C. Turner, "Energy Management Handbook", The Fairmount Press, Inc., 2001.
5. Charles M. Gottschalk, "Industrial Energy Conservation", John Wiley and Sons, 1996.
6. Craig B. Smith, "Energy Management Principles", Pergamon Press, 2015.
7. Hamis, "Energy Auditing and Conservation; Methods, Measurements, Management and Case Study", Hemisphere Publishers, Washington, 1980.
8. C.W. Gelling's and J.H. Chamberlin, "Demand-Side Management Planning", Fairmount Press, 1993.

**PROJECT WORK**  
(Course Code- RP1111804)

Designation of Course	Project Work		
Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: --- Hours/ Week	Semester End Examination	-- Marks	--
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 16 Hours/ Week	Term Work	100 Marks	08
	Oral/Practical	50 Marks	
	<b>Total</b>	<b>150 Marks</b>	<b>08</b>

<b>Course Prerequisites: -</b>	<p>The students should know of</p> <ol style="list-style-type: none"> <li>1. Knowledge of Mathematics &amp; Science</li> <li>2. Knowledge of basic concepts in heat transfer.</li> <li>3. Basic information on thermodynamics.</li> <li>4. Basic knowledge of design</li> <li>5. Knowledge of basic concepts in mechanical engineering.</li> </ol>
<b>Course Objectives: -</b>	<ol style="list-style-type: none"> <li>1. To identify the problem for a specific need of an organization</li> <li>2. To review literature on a specific research topic</li> <li>3. To make feasible, sustainable design</li> <li>4. To work sincerely as a member of a team</li> <li>5. To communicate ideas to supervisors as well as subordinates</li> <li>6. To develop new equipment or make modifications to existing equipment</li> </ol>
<b>Course Outcomes: -</b>	<p>The students should be able to–</p> <ol style="list-style-type: none"> <li>1. Understand the latest changes in the technological world and apply fundamental principles of science and engineering.</li> <li>2. Create the ability to identify, formulate, and model problems and apply them to find engineering solutions based on a system approach.</li> <li>3. Understand the importance of sustainability and cost-effectiveness in the design and development of engineering solutions.</li> <li>4. To fabricate the designed equipment</li> <li>5. To conduct laboratory and field testing of the new equipment</li> <li>6. Create awareness of social, Create ability to communicate efficiently.</li> </ol>

**Course Contents**

Details of the major project
<p><b>Project Planning and Team Formation</b></p> <p>Formation of a project team based on common technical interests</p> <p>Identification of project domain</p> <p>Selection of the project guide with HOD approval</p> <p>Preparation of project proposal</p> <p>Literature survey and problem definition</p> <p><b>Project Selection and Feasibility Study</b></p> <p>Selection of project (new equipment development / industry-sponsored / research-oriented)</p> <p>Feasibility analysis based on:</p> <ul style="list-style-type: none"> <li>• Availability of laboratory resources</li> <li>• Design and fabrication scope</li> <li>• Time and cost constraints</li> </ul> <p>Finalization of project objectives and methodology</p> <p><b>Design and Fabrication</b></p> <p>Engineering design calculations</p> <p>Preparation of drawings and layouts</p>

Material selection  
Hardware fabrication and assembly  
Implementation based on industrial training experience

### **Testing and Performance Evaluation**

Experimental setup  
Testing procedures  
Data collection  
Performance analysis  
Troubleshooting and modifications

### **Documentation and Presentation**

Preparation of a detailed project report

- Abstract
- Literature review
- Methodology
- Results and discussion
- Conclusions and future scope

Preparation of technical drawings and charts  
Presentation skills development

### **Weekly activities done by students are as follows,**

Week 1: Team Formation & Domain Selection

Week 2: Problem Identification

Week 3: Literature Survey

Week 4: Project Proposal Preparation

Week 5: Feasibility Study

Week 6: Design Calculations

Week 7: CAD Modeling & Drawings

Week 8–10: Fabrication & Assembly

Week 11-13: Testing & Data Collection

Week 14-15: Documentation