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:

- *Recruiting experienced 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 interpretation 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 Interpreting and respect, and of inclusive attitudes.

PROGRAM OUTCOMES

PO1: Engineering Knowledge: *Use 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 use 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: *Use 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: *Use knowledge and interpretation of engineering management principles and economic decision-making, and use these in 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) Sem.-VII

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hrs./Week)			Examination Scheme (Marks)						Credits			
			L	P	T	ESE	IA	TW	OR	PR	Total	L	P	T	Total
1	C401	Industrial Automation	3	2	-	60	40	25	25	--	150	3	1	-	4
2	C402	Elective-I	3	2	-	60	40	25	-	--	125	3	1	-	4
3	C403	Production Planning & Control[@]	4	-	-	60	40	-	-	-	100	4	-	-	4
4	C404	Power Plant Technology	3	2	1	60	40	25	-	-	125	3	1	1	5
5	C405	Measurement & Metrology Techniques	-	2	-	-	-	25	25	-	50	-	1	-	1
6	C406	Machine Learning	-	2	-	-	-	25	25	-	50	-	1	-	1
7	C407	Project Stage-I	-	2	-	-	-	50	50	-	100	-	3	-	3
8	C408	Internship***	-	-	-	-	-	25	25	-	50	-	3	-	3
		Total	**13**	**12**	**1**	**240**	**160**	**200**	**150**	**-**	**750**	**13**	**11**	**1**	**25**

[@]Industry Taught Course-V

B. Tech. (Mechanical) Sem.-VIII

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hrs./Week)			Examination Scheme (Marks)						Credits			
			L	P	T	ESE	IA	TW	OR	PR	Total	L	P	T	Total
1	C409	Renewable Energy Technologies	3	2	-	60	40	25	-	-	125	3	1	-	4
2	C410	Elective-II	3	2	-	60	40	25	-	-	125	3	1	-	4
3	C411	Energy Audit & Management[@]	4	-	-	60	40	-	-	-	100	4	-	-	4
4	C412	Reliability & Machine Condition Monitoring	3	2	1	60	40	25	25	-	150	3	1	1	5
5	C413	Project Stage-II	-	4	-	-	-	100	100	-	200	-	6	-	6
6	C414	Operations Research Practices		2	-	-	-	25#	-	-	25	-	1	-	1
7	C415	Robot Movement Systems		2	-	-	-	25#	-	-	25	-	1	-	1
		Total	**13**	**14**	**1**	**240**	**160**	**225**	**125**	**-**	**750**	**13**	**11**	**1**	**25**
8	C416	Research Paper Publication**						-			-		-		2

[@]Industry Taught Course-VI; #: Based on TW & internal oral examination; **Add-on Course; ***Period of 60 days

Elective-I	Six Sigma, Lean & Agile Manufacturing, Waste to Energy Conversion, Jig, Fixture & Die Design, Artificial Intelligence, Principles of Aircraft & Submarine Design
Elective -II	Industrial Product Design, Engineering Economics, Project Management & Ethics, Virtual Reality, Additive Manufacturing & Rapid Prototyping

INDUSTRIAL AUTOMATION
(Course Code C401)

Designation of Course	**Industrial Automation**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - --Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	25 Marks	
	Total	**150 Marks**	**04**

Course Prerequisites: -	The students should know of 1. Knowledge of Mathematics & Theory of Machines, Mechanical Engineering Systems 2. Knowledge of Properties of Fluid, Turbomachinery 3. Knowledge of Basic Electrical and Electronics
Course Objectives: -	1. Interpret automation technologies and identify advantages, limitations, and applications of the same. 2. Develop the ability to recognize, articulate, and solve industrial problems using automation technologies. 3. To provide students with knowledge of the applications of fluid power systems in process, construction, robotics, and manufacturing industries and enable them to design and implement automated systems using pneumatics. 4. To make the students acquainted with the conceptual as well as practical knowledge of the PLC programming & latest technologies being used to achieve PLC Industrial Automation.
Course Outcomes: -	On completion of the course, students will be able to: 1. Apply the fundamentals of industrial automation to solve practical problems in industrial processes. 2. Analyze control system concepts and implement them for automation applications. 3. Explain and apply concepts related to fluid power systems, power units, and their accessories in industrial scenarios. 4. Analyze fluid power control mechanisms and select appropriate control valves for specific applications. 5. Design and implement hydraulic and pneumatic circuits, including actuators, for practical industrial applications. 6. Develop and test PLC-based ladder logic diagrams for industrial automation tasks.

Course Contents

Unit I	**Introduction to Industrial Automation and Robotics**	**(06 Hrs.)**
Introduction of Automation and Robotics, Historical Development, three laws of robotics by Isaac Asimov, Broad classes of industrial automation-Fixed, flexible, and programmable, and their comparative study, Automation Principles and Strategies, USA Principle, Ten Strategies for Automation and production systems, Automation Migration Strategy-Manual Production, Automated Production, Automated integrated production.		
Unit II	**Automatic Control Systems and Control Actions**	**(06 Hrs.)**

Introduction to control systems: mechatronics system & its examples, mechatronics system components. Open loop and closed loop systems, effects of feedback, basic characteristics of feedback control systems, and classification of control systems.

Introduction to Controllers: Control System Parameters, Controller Modes, Control Actions, Types of Controllers-ON-OFF Controller, Proportional Controller (P-Controller), Proportional + Integral Controller (P-I Controller), Proportional + Derivative Controller (P-D Controller), Proportional + Integral + Derivative Controller (P-I-D Controller), Effect of Proportional, Integral, and Derivative Control on the Time Response of the System

Control System Components: Elements of a Data Acquisition and Control System, Overview of the Input/Output Process, Data Acquisition Case Studies. Variable Frequency Drive, Servomotor, switches, Relays, and Contactors.

Unit III	**Fundamentals of Industrial Fluid Power Systems**	**(06 Hrs.)**

Fluid Power System: Components of the fluid power system, advantages, and limitations. Difference between electrical, pneumatic, and fluid power systems. Seals, sealing materials. Types of pipes, hoses, and materials. Fluid conditioning through filters, strainers, sources of contamination, and contamination control.

Power units and accessories: Types of power units, reservoir assembly, sizing of reservoirs, constructional details, pressure switches, temperature switches. Accumulators: Types, selection procedure, and applications of accumulators. ISO symbols for hydraulic and pneumatic Components

Unit IV	**Fluid Power Control**	**(06 Hrs.)**

Necessity of fluid control through pressure control, directional control, and flow control valves. Control valves: i) Principle of pressure control valves, direct operated and pilot operated pressure relief valves, pressure reducing valve, sequence valve. ii) Principle of flow control valves, pressure-compensated and non-compensated flow control valves. iii) Principle of directional control valves, types of directional control valves, two-way, three-way, four-way valves, check valve, and shuttle valve. Open centre, close centre, tandem centre valves. Actuating devices-manually operated, mechanically operated, solenoid operated, pilot operated, lever operated.

Unit V	**Hydraulic & Pneumatic Circuits**	**(06 Hrs.)**

Linear and rotary actuators: Types, construction, and characteristics. Cylinder mountings, cushioning of cylinders.

Hydraulic & Pneumatic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, automatic reciprocating, fail-safe circuit, counterbalance circuit, actuator locking, unloading circuit, motor breaking circuit, etc. Types of filters, pressure regulators, lubricators, mufflers, dryers, direction control valves, pneumatic actuators, shuttle valve, two-pressure valve, quick exhaust valve, and time delay valves. Speed regulating methods, pneumatic circuits, reciprocating, cascading time delay, etc. Application of pneumatics in low-cost automation and in industrial automation. Development of Electro-hydraulic Circuits and Electro-pneumatic Circuits.

Unit VI	**Programmable Logic Controller**	**(06 Hrs.)**

Introduction to PLCs, Basic Structure of a PLC, Principles of Operation, PLC Programming Languages, Ladder diagram, Latching and internal relays, Timers and Counters, Selection of a PLC for Control System, Application of PLCs for Automatic Control System. Concept of SCADA and its Applications,

Term Work

(Term work shall consist of a minimum of 8 experiments from the following)

1. Study of P, P+I, P+D, P+I+D control actions using any trainer kit / simulation software.
2. To study the working of the servomotor and its applications in industrial automation.
3. To study the working of variable frequency drives and their applications in industrial automation.
4. Study of flow control valves (Meter in, Meter out Circuits).
5. Study of directional control valves.
6. Study of pressure control valves.
7. Study of ISO/JIC Symbols for hydraulic and pneumatic systems.
8. Following experiments to be done on hydraulic trainers: a) Regenerative circuit, b) Speed control circuit, c) Sequencing circuit, d) Traverse and feed circuit, etc.

9. Following experiments to be done on pneumatic trainer: a) Automatic reciprocating circuit, b) Speed control circuit, c) Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve.
10. Design of simple hydraulic/pneumatic systems used in practice, such as hydraulic clamp, jacks, dumper, forklift, etc., by using fluid simulation software such as LVSIM®-HYD & PNEU, Automation Studio.
11. Study of PLC, SCADA, and development of ladder logic for various industrial applications.
12. Industrial visit to study Hydraulic / Pneumatic-based Automation systems.
13. Study of an industrial pick and place robot and integrated automation.

Project-Based Learning

The following is the list for project-based learning topics (Not limited to)

1. To prepare a demonstration model of a PID Controller with any application.
2. To prepare a demonstration model of control system applications.
3. To prepare a demonstration model of applications of Fluid power systems.
4. To prepare a demonstration model of applications of electro-hydraulic and electro-pneumatic systems.
5. To prepare a demonstration model of a pick-and-place robot for any application.
6. Preparing a demonstration model of any industrial automation system with PLC programming.

Textbooks

1. Automation, Production Systems and Computer Integrated Manufacturing M. P. Groover, Pearson Education, 5th edition, 2009.
2. Majumdar S.R., Pneumatics Systems Principles and Maintenance, Tata McGraw-Hill.
3. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Majumdar S.R., Oil Hydraulic system- Principle and maintenance, Tata McGraw-Hill.
5. Esposito Anthony, Fluid Power with Application, Prentice Hall.
6. Stewart H. L., Hydraulics and Pneumatics, Taraporewala Publication.
7. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw-Hill Book Company.
8. Pipenger J.J., Industrial Hydraulics, McGraw-Hill.

Reference Books

1. Automation, Production Systems and Computer-Integrated Manufacturing M. P. Groover, Pearson Education. 5th edition, 2009.
2. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010

Unit Tests

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

ELECTIVE-I: SIX SIGMA, LEAN & AGILE MANUFACTURING
(Course Code C402.1)

Designation of Course	**Six Sigma, Lean & Agile Manufacturing**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - --Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Total	**125 Marks**	**04**

Course Prerequisites: -	Students should know of 1. Students should have Basic knowledge of Industrial Engineering. 2. Students should have Basic knowledge of Statistics
Course Objectives: -	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
Course Outcomes: -	On completion of the course, students will be able to: 1. Apply the fundamentals of industrial automation to solve practical problems in industrial processes. 2. Analyze control system concepts and implement them for automation applications. 3. Explain and apply concepts related to fluid power systems, power units, and their accessories in industrial scenarios. 4. Analyze fluid power control mechanisms and select appropriate control valves for specific applications. 5. Design and implement hydraulic and pneumatic circuits, including actuators, for practical industrial applications. 6. Develop and test PLC-based ladder logic diagrams for industrial automation tasks.

Course Contents

Unit 1	**Lean Manufacturing**	**06 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.		
Unit 2	**Agile Production System and Practices**	**06 Hrs.**
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.		
Unit 3	**Management in the Agile Organization**	**06 Hrs.**

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.		
Unit 4	**Statistics and probability distribution**	**06 Hrs.**
Basic statistics, probability distributions, normal distribution, central limit theorem, measurement system analysis – precision, accuracy, bias, linearity, gage repeatability & reproducibility. Process capability analysis.		
Multi-Variate analysis, sampling techniques, Hypothesis testing, testing with normal data, One Way ANOVA, and nonparametric tests for non-normal data. Chi-square tests		
Unit 5	**Introduction to Six Sigma**	**06 Hrs.**
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		
Unit 6	**Six Sigma in manufacturing**	**06 Hrs.**
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		

Term Work:

1. Case study on Just-in-Time system
2. Case study on the Toyota production system
3. Case study on Kanban and Kaizen production system
4. Case study on Management in the Agile Organization
5. To find the Process capability.
6. Application of Chi-square tests
7. Case study on Sigma level calculations.
8. Case study on the design of the Experiment.

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.

Reference Book:

1. Productions and Operations Management - Chasel Aquilino - Dreamtech latest edition.
2. Toyota Production System -An integrated approach to Just in Time - Yasuhiro Monden – Engineering and Management Press -Institute of Industrial Engineers, Norcross, Georgia- 1983.
3. The Machine that Changed the World. The Story of Lean Production - James P Womack, Daniel T Jones, and Daniel Roos -Harper Perennial - edition published 1991.
4. Lean Thinking - James Womack – ISBN 0743249275 – 2003.
5. Japanese Manufacturing Techniques. The Nine Hidden Lessons by simplicity - Richard Stumberger - ASQC Press 1991.
6. Quality Function Development - James Bossert - ASQC Press 1991.

Unit Test -

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

ELECTIVE-I: WASTE TO ENERGY CONVERSION
(Course Code C402.2)

Designation of Course	**Waste to Energy Conversion**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - -- Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites:-	The students should know of - 1. Mechanical Engineering System. 2. Thermodynamic principles 3. Thermodynamic Applications 4. Power Plant Technology
Course Objectives:-	1. To enable students to interpret the concept of Waste to Energy. 2. Learning about the best available technologies for Waste to Energy Conversion
Course Outcomes:-	On completion of the course, students will be able to: 1. Explain and classify the fundamentals of waste and waste processing. 2. Assess and evaluate the environmental and social impacts of waste-to-energy conversion plants. 3. Apply and analyze the principles of pyrolysis and combustion technologies to evaluate their performance. 4. Compare and analyze different gasification technologies and assess their operational performance. 5. Explain and design basic anaerobic digestion systems for waste treatment. 6. Select and evaluate air quality equipment and systems for waste-to-energy conversion plants.

Course Contents

Unit I	**Introduction to Waste and Waste Processing**	**(06Hrs.)**
Solid waste sources, types, composition, properties, global warming; Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, segregation of waste, size reduction, managing waste, status of technologies for generation of energy from waste treatment and disposal aerobic composting, incineration, furnace type and design, medical waste / pharmaceutical waste treatment technologies incineration, environmental impacts, measures to mitigate environmental effects due to incineration.		
Unit II	**Environmental and social impacts of waste-to-energy conversion plants**	**(06 Hrs.)**

Contributions of WTE conversion to waste reduction and energy generation, Air quality and residue management considerations of WTE conversion, Greenhouse gas profile of WTE, Compatibility of WTE with recycling, Health and safety aspects of WTE, Integrated planning for WTE plants, Future trends.		
Unit III	**Pyrolysis and Combustion Technology**	**(06 Hrs.)**
Pyrolysis - Introduction, Pyrolysis, Pyrolysis reactors, Investigations on pyrolysis of MSW, Plusses and minuses of the process, Utilization of the process products, Commercial scale pyrolysis plants. Combustion technology - Introduction, Benefits & issues, Chemistry of combustion, Efficiency of combustion, Process stabilization & combustion control, MSW incinerator systems, Grate technology, Fluidized bed combustion technology, Refuse-derived fuel combustion.		
Unit IV	**Gasification technologies**	**(06 Hrs.)**
Gasification, Conventional gasification, Chemical reactions in gasification, Key factors for gasification of waste, Gasifier configurations, Fixed bed gasifiers, Fluidized bed gasifiers, Slagging gasification, Plasma gasification, Plasma arc gasifier, Plasma technology for treatment of incinerator residues & hazardous waste, Issues with plasma arc gasification, Gasification plants in operation, Energy recovery from plastics, Recycling of plastic waste, Technologies for energy recovery from plastic waste, Demonstration-level liquid fuels production from plastic Pyrolysis, Production of gaseous fuel, Commercial systems, Fuel properties of pyrolytic oils.		
Unit V	**Anaerobic Digestion**	**(06 Hrs.)**
Anaerobic food web, Bioreactor configurations, Experiences in different countries, Fundamentals behind anaerobic digestion, Thermophilic anaerobic digestion, Power-to-gas concept to store electric power in the natural gas grid, Electrolysis, Bio-methanation at thermophilic conditions, Microbial electrochemical systems, Bioreactor configurations.		
Unit VI	**Air quality equipment and systems for waste-to-energy conversion plants**	**(06 Hrs.)**
Air quality considerations and regulations for municipal waste combustors, Acid gas scrubbing in municipal waste combustors, Particulate control devices utilized at waste combustion facilities, Control of nitrogen oxide emissions and hazardous air pollutants from waste combustors, Air pollution control cost–benefit analysis, Air quality technology innovations for municipal waste combustors		

Term Work

1. Market survey on municipal Waste and Waste Processing.
2. Study of Pyrolysis technology.
3. Study of Combustion technology.
4. Study of Gasification technologies.
5. Study of Anaerobic Digestion.
6. Visit to Biogas Power Plant.
7. Visit to Pyrolysis reactors or Gasifier.
8. Case study on Environmental and social impacts of waste-to-energy conversion plants.
9. Case study on Air quality equipment and systems for waste-to-energy conversion plants.

Project-Based Learning

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

1. Preparing a chart: Waste and Waste Processing
2. To prepare a chart on the Environmental and social impacts of waste-to-energy conversion plants
3. Preparing a chart on the Pyrolysis Process.
4. To prepare a chart on Combustion technology for waste energy conversion.
5. To prepare a chart on Gasification technologies.
6. To prepare a chart on Anaerobic Digester.
7. Preparing a demonstration model of the Pyrolysis Process
8. To prepare a demonstration model of fixed-bed gasifiers
9. Preparing a demonstration model of Fluidized bed gasifiers
10. To prepare a demonstration model of a Plasma arc gasifier
11. To prepare a demonstration model of Anaerobic Digestion
12. Case study on Pyrolysis technology
13. Case study on Combustion technology
14. Case study on Gasification technologies
15. Case study on Anaerobic Digestion

Textbooks:

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, 2nd 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.

Unit Test –

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

ELECTIVE-I: JIG FIXTURE AND DIE DESIGN
(Course Code C402.3)

Designation of Course	**Jig Fixture and Die Design**		
Teaching Scheme:	End Semester Examination		**Credits Allotted**
Theory: - 03 Hours/ Week	Internal Assessment	60 Marks	03
Tutorial: - --Hours/ Week	Term Work	40 Marks	
Practical: - 02 Hours/ Week	Oral/Practical	25 Mark	01
	Total	125 Marks	04

Course Prerequisites: -	The student should have. 1. Basic knowledge of conventional and non-conventional manufacturing processes. 2. Knowledge of casting processes. 3. Knowledge of plastic processes and methods
Course Objectives: -	1. To design jigs. 2. To design fixtures. 3. To design dies for the manufacturing system.
Course Outcomes: -	On completion of the course, students will be able to: 1. Explain the concepts of jigs and fixtures and their underlying principles. 2. Design jigs using standard components for various manufacturing operations. 3. Design fixtures employing standard components to meet specific machining requirements. 4. Analyze and select suitable plastic processing methods for given applications. 5. Design injection molding dies and apply injection molding techniques effectively. 6. Develop die designs for pressure die casting and evaluate their suitability for manufacturing.

Course Contents

Unit I	**Fundamentals of Jigs and Fixtures**	**(6 Hrs.)**
Significance and purpose of jigs and fixtures, and their functions in manufacturing processes. Classifications of Jigs and Fixtures. Design features of the main elements of Jigs and Fixtures, such as locating, clamping, and guiding elements, and their integrations. Indexing, locking, and auxiliary elements. Bodies and bases or frames of Jigs and fixtures. Economics of Jigs and Fixtures, Pneumatics & Hydraulics for Jig & Fixtures.		
Unit II	**Design of Jigs**	**(6 Hrs.)**
General guidelines & procedures for the design of Jigs. Design & selection of standard elements, Analysis of clamping force required & their magnitude, Design of drilling jigs.		
Unit III	**Design of Fixtures**	**(6 Hrs.)**
General guidelines & procedures for design of fixtures. Design & selection of standard elements, Analysis of clamping force required & their magnitude, concept of modular fixtures & tool presetting fixtures. Design of milling, turning fixture, and fixture for assembly. Economic analysis.		
Unit IV	**Plastics Processing**	**(6 Hrs.)**
Materials used for plastic processing, Compression, transfer, injection & blow moulding processes - their working, construction, types & advantages, and limitations.		

Unit V	Design of Injection Molds	(6 Hrs.)
Specifications and elements of the injection molding machine, Injection molding feed system: runner and gates, ejection methods, ejection force calculation, parting surface selection, cooling systems, Defects & remedies.		
Unit VI	**Design of Die Castings Dies**	**(6 Hrs.)**
Die casting machines-Hot & cold chamber, metals for die casting, die locking methods, interlocks & safety devices, specific details of die constructions, casting, ejection, cores, slides, loose die pieces, types of cores, directional solidification, types of feeders, die venting, water cooling, classification of dies- single, combination, multi-impression. General details of die design, Gating system, inserted impressions, die casting defects and remedies, die lubrication & rules for die lubrication.		

Term Work: (Any Eight)

1. Design & working drawing of a simple blanking die.
2. Design & working drawing of progressive die.
3. Design & working drawing of compound die.
4. Design & working drawing of the combination die.
5. Design & working drawing of a deep drawing die.
6. Injection molding process.
7. Injection Mold Design
8. Blow Molding process.
9. Hot & cold chamber die casting.
10. Design a gating system in die casting.
11. A report on factory visits, comprising product range, processes, plant layout, Auxiliary equipment, process parameters, etc.

Project-Based Learning:

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

1. Fabrication of a simple blanking die.
2. Automatic blanking Machine
3. Fabrication of a progressive die.
4. Fabrication of compound die.
5. Automatic Pneumatic Punching Machine
6. Tool and die design for Progressive tools.
7. Tool and die design for trimming tools.
8. Pneumatic drill jig
9. Fabrication of a combination die.
10. Fabrication of a deep drawing die.
11. Tool and die design for Blanking.
12. Fabrication of Sandwich Jig.
13. Fabrication of a universal Fixture
14. Indexing drill jig by using a bevel Gear
15. Fabrication of an Injection mold.
16. Fabrication of Blow Mold.
17. Automatic multi-spindle drilling machine

Textbooks:

1. P. N. Rao, “Manufacturing Technology”, Tata McGraw-Hill
2. M. H. A. Kempster, “Introduction to Jigs and Fixtures Design”
3. P. H. Joshi, “Press Tools”, A.H. Wheeler
4. P. C. Sharma, “Production Engineering”, S. Chand

Reference Books:

1. Donaldson, Lecain & Goold, “Tool Design”, Tata McGraw-Hill PRODUCTION
2. Doebler H. H., “Die Casting”, McGraw-Hill
3. “Tool Engineering Handbook”, A. S. T. M. E.
4. Wilson, “Fundamentals of Tool Design”, A. S. T. M. E.
5. Richard Kibbe, John E. Neely, Meyer, White, “Machine Tool Practices”

Unit Test -

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

ELECTIVE-I: ARTIFICIAL INTELLIGENCE
(Course Code C402.4)

Designation of Course	**Artificial Intelligence**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: - 3 Hrs./Week	End Semester Examination	60	03
Practical: - 2 Hrs. /Week	Internal Assessment	40	
	Term Work	25	01
	Total	125	04

Course Prerequisite: -	1. Engineering mathematics-III, Statistics and Numerical Methods, Sensors Technology
Course Objective: -	To provide Knowledge about 1. To interpret the artificial intelligence algorithms for robotics problems. 2. To interpret the performance of AI algorithms 3. To compute complex problems in flexible automation
Course Outcomes: -	On completion of the course, students will be able to 1. Explain the evolution, goals, and tools of Artificial Intelligence and apply search algorithms, optimization methods, and AI programming to develop basic AI systems. 2. Analyze fuzzy set theory and design fuzzy inference and rule-based systems for industrial decision-making applications. 3. Demonstrate knowledge of neural network architectures and implement supervised and unsupervised learning algorithms for problem-solving. 4. Apply probabilistic methods and statistical learning techniques to reason under uncertainty. 5. Develop intelligent systems for accurate control of autonomous robots. 6. Evaluate and implement advanced AI techniques for design, manufacturing, and industrial problem-solving.

Course Content

Unit I	**Introduction to artificial intelligence techniques**	**(06 Hrs.)**
Evolutionary computation, Goals of AI in manufacturing, tools for AI, such as Search algorithms, Mathematical optimization, programming in an AI environment, developing an artificial intelligence system, and natural language processing.		
Unit II	**Introduction to fuzzy logic**	**(06 Hrs.)**
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.		
Unit III	**Introduction to artificial neural networks**	**(06 Hrs.)**
Fundamentals of neural networks, neural network architectures, Neural Learning, Supervised Learning, Unsupervised Learning, taxonomy of neural network architectures, and standard back propagation algorithms.		
Unit IV	**Handling uncertainty**	**(06 Hrs.)**
Probabilistic methods for uncertain reasoning, such as Bayesian networks, Hidden Markov		

models, Kalman filter, Decision theory and Utility theory, statistical learning methods, support vector machines, expert systems.		
Unit V	**Intelligent systems**	**(06 Hrs.)**
Robotic vision systems, image processing techniques, application to object recognition, and inspection, automatic speech recognition, Path Planning Robot Control in Dynamic Environments, Accurate Motion Control of Fast Mobile Robots.		
Unit VI	**Industrial application of AI and expert systems**	**(06 Hrs.)**
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.		

List of Practical /Term work: -

Term work shall consist of the programs listed below, based on the syllabus

1. Fuzzy logic sets.
2. Fuzzy logic relation.
3. A* algorithm.
4. AO* algorithm.
5. Searching algorithms.
6. Min/MAX search procedure for game Playing.
7. Variants of the Min/ Max search procedure.
8. Implementation of a mini-project using the concepts studied in the AI course.

Project-based learning:-

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

Create a demo model/ chart/ Working Block diagram for any application of the following topics using any programming language:

1. Search algorithm
2. Fuzzy set theory
3. Fuzzy decision making
4. Neural Learning
5. Supervised Learning,
6. Unsupervised Learning
7. Robotic vision systems
8. Path Planning Robot Control
9. Genetic algorithms

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

Reference Book:-

1. Russell, Stuart and Norvig, Peter, Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.
2. Aleksander, Igor, and Burnett, Piers, Thinking Machines, Oxford, 1987.
3. Bench-Capon, T. J. M., Knowledge Representation: An approach to artificial

intelligence, Academic Press, 1990.
4. Gennesaret, Michael R. and Nilsson, Nils J, Logical Foundations of Artificial Intelligence, Morgan Kaufmann,1987.
2. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition)
3. Vinod Chandra S.S., Anand Hareendran S, " Artificial Intelligence and Machine Learning"
4. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
5. Jacek M. Zurada, Introduction to Artificial Neural Systems, PWS Publishing Company, 1995.
6. Simon Haykin, Neural Networks: A Comprehensive Foundation, Macmillan College Publishing Company, 1994.

Unit Test:

Unit Test 1	Unit I, II, III
Unit Test 2	Unit IV, V, VI

ELECTIVE-I: PRINCIPLES OF AIRCRAFT & SUBMARINE DESIGN

(Course No.C402.5)

Designation of Course	**Principles of Aircraft & Submarine Design**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial:- --Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Theory of Machine 2. Machine Design and Analysis I and II
Course Objectives: -	1. To make the student interpret the choice of the selection of design parameters, fix the geometry, and investigate the performance and stability characteristics of airplanes. 2. To make the student interpret the basic concepts of submarine design, various systems in submarines, dynamics, and control of submarines.
Course Outcomes: -	On completion of the course, students will be able to: 1. Design the preliminary configuration of an aircraft, from data collection to satisfying mission specifications. 2. Analyze and estimate geometric and design parameters of an airplane. 3. Develop and evaluate a system, component, or process to meet requirements for aircraft systems. 4. Explain the principles of submarine design and the associated development process. 5. Analyze and describe the operation of various systems used in a submarine. 6. Apply principles of dynamics and control to model and assess the behavior of a submarine.

Course Contents

Unit I	**Introduction to Aircraft Design**	**(06 Hrs.)**
State of the art in airplane design, Purpose and scope of airplane design, Classification of airplanes based on purpose and configuration. Factors affecting configuration, Merits of different plane layouts. Stages in Airplane design. Designing for manufacturability, Maintenance, Operational costs, and Interactive designs.		
Unit II	**Preliminary Design Procedure**	**(06 Hrs.)**
Data collection and 3-view drawings, their purpose, weight estimation, Weight equation method – Development & procedures for evaluation of component weights. Weight fractions for various segments of the mission. Choice of wind loading and thrust. Loading.		
Unit III	**Design of Wing, Fuselage, and Empennage**	**(06 Hrs.)**
Selection of an airfoil. Selection of Wing parameters, selection of sweep, Effect of Aspect ratio, Wing Design and Airworthiness requirements, V-n diagram, loads, Structural features. Elements of fuselage design, Loads on fuselage, Fuselage Design. Fuselage and tail sizing. Determination of Tail surface areas, Tail design, Structural features, and check for nose wheel lift off.		
Unit IV	**Introduction to Submarine Design**	**(06 Hrs.)**
Introduction, Design Objectives, Design Progression, Basic principles of submarine design in a complex modern multi-platform system. Operational requirements for submarines, Architecture,		

and technologies can deliver the capability. Submarine design and development process and all its phases, the platform and combat systems, pressure hull design considerations, and Balancing of a submarine design (e.g., weight and buoyancy relations, overall submarine performance).		
Unit V	**Submarine Systems**	**(06 Hrs.)**
Introduction, Hydraulic system, High-Pressure Air systems, water systems, System for hydrostatic Control, Environmental control system, Provision for escape, Electrical System.		
Unit VI	**Dynamics and Control**	**(06 Hrs.)**
Introduction, Some Basic Concepts, Operational Requirement, Equation of motion of a submarine, Hydrodynamic derivatives, Stability, and control in the horizontal and vertical plane, Steering and depth control system, Impact on design.		

Term Work

Any four case studies from the following:

1. Aircraft Conceptual Design Practices & Case Studies
2. Study of brake systems of various aircraft.
3. Study of pneumatic systems of various aircraft.
4. Study of hydraulic systems of various aircraft.
5. Case study on: Submarine Design in a Changing World.
6. The Submarine as a Case Study in Transformation: Implications for Future Investment
7. Interpreting the Structure Design of a Submarine.

Project-Based Learning

Anyone from the following:

1. One design project on various components of an aircraft.
2. One design project on various components of a submarine.
3. CAD detailed drawing of any one component of the aircraft.
4. CAD detailed drawing of any one component of the submarine.
5. Detailed drawing of a submarine system using any CAD software.

Textbooks

1. Raymer, D.P. Aircraft conceptual Design, AIAA series, 5th edition, 2012.
2. Torenbeck, E. Synthesis of Subsonic Airplane Design, Delft University Press, U.K. 1986.

Reference Books

1. Kuechemann, D., The Aerodynamic Design of Aircraft, American Institute of Aeronautics Publishers, 2012
2. Harrington, R. L. (1992). Marine Engineering (Revised, Subsequent ed.). Revised, Penyunt.) Jersey City, United States: *The Society of Naval Architects and Marine Engineers.*
3. Burcher, R., & Rydill, L. J. (1995). Concepts in submarine design (Vol. 2). Cambridge University Press.

Unit Tests

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

PRODUCTION PLANNING AND CONTROL

(Course Code C403)

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

Course Prerequisites:-	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 Material.
Course Objectives: -	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.
Course Outcomes:-	On completion of the course, students will be able to: 1. Explain the significance of Production Planning and Control (PPC) in industrial operations. 2. Apply various forecasting techniques to predict sales effectively. 3. Propose innovative ideas and strategies to enhance PPC in industry. 4. Implement material requirement planning methods for efficient production management. 5. Compare and categorize different techniques used for PPC in industrial settings. 6. Analyze recent trends and developments in PPC.

Course Contents

Unit I	**Introduction**	**(8 Hrs.)**
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.		
Unit II	**Forecasting and Capacity Planning**	**(8 Hrs.)**
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.		
Unit III	**Planning Materials and Purchasing**	**(8 Hrs.)**

Scope and requirement of MRP, MRP I and MRP II, Master Production Schedule, Bill of Materials, Capacity Requirement Planning. Purchasing - Documentation, Make or Buy decisions, Vendor Development.		
Unit IV	**Techniques And Production Control**	**(8 Hrs.)**
Process planning, route sheet, and factors 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		
Unit V	**Inventory Control and Store Control**	**(8 Hrs.)**
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.		
Unit VI	**Recent Trends in PPC**	**(8 Hrs.)**
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 problems in the automobile industry and the best ways of solving them.
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 defense.

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 Charry, 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

Unit Test -

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

POWER PLANT TECHNOLOGY

(Course Code C404)

Designation of Course	**Power Plant Technology**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: 03 Hours/ Week	End Semester Examination	60 Marks	04
Practical: - 02 Hours/ Week	Internal Assessment	40 Marks	
Tutorial: 1 Hour/ Week	Term Work	25 Marks	01
	Total	**125 Marks**	**05**

Course Prerequisites:-	The student should have 1. Mechanical Engineering System. 2. Thermodynamic principles 3. Thermodynamic Applications
Course Objectives:-	To explain the concepts of different types of Power Plants To study and analyze different types of Steam Condensers, Cooling Towers, Steam Nozzles, and Steam Turbines.
Course Outcomes:-	On completion of the course, students will be able to: 1. Explain and analyze the fundamental concepts of power plants and their operations. 2. Evaluate and compare the performance of Thermal and Nuclear Power Plants. 3. Assess and optimize the operational performance of Thermal Power Plants. 4. Analyze and evaluate the construction and functioning of Steam Condensers and Cooling Towers to improve efficiency. 5. Examine and optimize the design and performance of Steam Nozzles and Steam Turbine Plants. 6. Analyze and justify the economic aspects of power plant operation and management.

Course Content

Unit No. -I	**Introduction to Power Plants:**	**(8 Hrs.)**

Introduction of steam, hydel, diesel, nuclear, and gas turbine power plants, combined power cycles, comparison and selection, Power and energy, sources of energy, Indian Energy scenario, Conventional & Non-Conventional sources of energy and their availability in India, Power Plants in India, Location of power plant. Issues in Power plants. Resources and development of power in India, NTPC, NHPC, and their role in Power development in India.

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, acid and alkali cleaning, and safety in auxiliary plants. Cooling water system, Safety in maintenance of power plants.

Unit No.-II	**Thermal Power Plant and Nuclear Power Plant:**	**(8 Hrs.)**

Thermal Power Plant - Role of thermal power plant in current power generation scenario, Selection site for thermal power plant, General lay out 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- Gravity system, pneumatic or vacuum system. Ash disposal management and its utilization, Feed water treatment-Mechanical, thermal methods.

Introduction, Nuclear power-Radio Activity-Radioactive charge-types of reactions, Working of a nuclear power plant, Thermal fission Reactors- PWR, BWR, and gas-cooled reactors, Advantages and Disadvantages of Nuclear power plant.

Unit No. -III	Thermodynamic Analysis:	(8 Hrs.)
Review of thermodynamic cycles related to power plants - Rankine cycle, Rankine cycle with reheat, reheat factor, regeneration Rankine cycle, Principle of regeneration, types of feed water heaters, Numerical based on different combinations.		
Unit No.-IV	**Steam Condenser and Cooling Towers:**	**(8 Hrs.)**
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)		
Unit No. -V	**Steam Nozzle and Steam Turbine:**	**(8 Hrs.)**
General forms of nozzles: Flow through steam nozzles, Velocity of steam leaving nozzle, mass of steam discharged, Critical Pressure ratio, Areas of throat and exit for maximum discharge, length of nozzle, efficiency of nozzle, effect of friction in 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, Losses in steam turbine, and Governing of steam turbine.		
Unit No.-VI	**Power Plant Economics**	**(8 Hrs.)**
Power Plant Economics - Cost of electric energy, fixed and operating costs, energy rates, types of tariffs, economics of load sharing, Load Curves, Load duration Curves, types of loads and their characteristics, performance and operational characteristics of power plants, comparison of various power plants, Energy, Economic, and Environmental issues of Power plants.		

Term work:

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 a 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 / Hydro Electric Power Plants
9. 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, Indian Electricity Grid Code
2. Preparing a chart on a Thermal Power Plant
3. Preparing a chart on Hydro Electric Power Plants
4. Preparing a chart on the Steam Condenser and Cooling Towers
5. To prepare a chart on the Steam Nozzle and the Steam Turbine
6. Preparing 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. Preparing a demonstration model of Cooling Towers
11. To prepare a demonstration model of the Steam Nozzle
12. Preparing 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. 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. Domkundwar and Arora, Power Plant Engineering, Dhanpatrai and Sons.

Reference Books

1. Grainger, John J, and Stevenson, Jr., W.D. Power System Analysis, McGraw Hill 1994
2. L. K. Kirchmeyer, Economic Operation of Power Systems, John Wiley and Sons, 1993.
3. C. A. Gross, Power System Analysis, John Wiley and Sons, Inc., 1986.
4. John Weisman & L.E. Eckart, Modern Power Engineering, Prentice Hall, 1985
5. A course on Power Plant Engineering Ramlingam SCITECH Publication
6. S. P. Sukhatme, Solar Energy, Tata McGraw-Hill, 3rd Edition, 1996.
7. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2011
8. P. K. Nag, Power Plant Engineering, TMH, 3rd Edition, 2002

Unit Test –

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

MEASUREMENT AND METROLOGY TECHNIQUES

(Course Code C405)

Designation of Course	**Measurement and Metrology Techniques**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral	25 Marks	
	Total	**50 Marks**	**01**

Course Prerequisites: -	A student should know of 1. Students should have Basic knowledge of Mechanical terms, Force, Pressure, and Temperature, and Electronics terms, like Voltage, Resistance, and Current. 2. Students should have Basic knowledge of Measuring Units, Mathematics, and Various Measurement terms.
Course Objectives: -	Students should be able to 1. Use various precision measuring instruments, *viz.* Vernier caliper, micrometer, *etc.* 2. Acquire knowledge of different sensors and transducers 3. Acquire knowledge of tolerances, gauges, and the measurement of surface finish
Course Outcomes: -	On completion of the course, students will be able to: 1. Analyze static and dynamic characteristics of measurement systems. 2. Identify and classify different devices used for linear and angular measurement. 3. Measure temperature, pressure, strain, and fluid flow using appropriate sensors for various applications. 4. Apply the concepts of limits, fits, and tolerances in designing limit gauges. 5. Select and utilize displacement, velocity, position, force, torque, and level sensors for specific engineering applications. 6. Determine various screw thread and gear tooth parameters using relevant measuring equipment.

Course Contents Term Work: (Any 8 experiments need to be performed during the practical)

1. Study & Calibration of Thermocouples (J & K-Type)/RTD(PT-100)

   Thermocouples & Laws of thermocouples
2. Study & Calibration of Pressure Measurement, & Vacuum Measurement

   Diaphragm Pressure Gauge, Bourdon Tube, Bellows, McLeod Gauge
3. Measurement of Load/Force using Load Cells
4. Displacement & Angle measurement using LVDT & Encoder Sensor
5. Study of Different Switches & Relays
6. Measurement of the roughness surface.

   Surface texture, Meaning of RMS and CLA values, and grades of roughness.
7. Measurement of angle by sine bar/sine center.

   Side bar, Sine center, uses of sine bar, angle gauge, slip gauges.
8. Measurement of optical surface using an Interferometer.

Introduction, flatness testing by interferometry, NPL flatness interferometer.

10. Measurements of screw tread parameters using Floating Carriage Micrometer.
    External screw threads terminologies, floating carriage instruments, pitch, and flank Measurement.
11. Measurement of gear tooth thickness using gear tooth Vernier caliper and span micrometer
    Spur gear parameters, gear tooth thickness measurement, and gear tooth Vernier caliper.
12. Study and experiment on the profile projector/Tool maker's microscope
13. Industrial visit to the Automation Company and the Inspection & Quality control division of any Industry with a detailed report.

Textbooks:

1. Ramchandran K. P., Vijyaraghavan G. K., Balasundaram M. S., "Mechatronics: Integrated Mechanical Electronic Systems", John Wiley & Sons, 2008.
2. Bolton W., "Mechatronics - A Multidisciplinary Approach", 4th Edition, Prentice Hall,2009.
3. Kumar D. S., "Mechanical Measurement & Control", Metropolitan Book Co. Pvt. Ltd., New Delhi,2007
4. Singh M. D. and Joshi J. G., "Mechatronics", 3rd Edition, Prentice Hall, New Delhi,2009.
5. Beckwith T. G., Marangoni R. D., Lienhard J. H., "Mechanical Engineering Measurements", Pearson Prentice Hall, 2007
6. Jain R. K., "Engineering Metrology", Khanna Publishers
7. Hume K. J., "Engineering Metrology", Macdonald, 1950
8. Sharp K. W. B., "Practical Engineering Metrology", Pitman Publication, 1970.

Reference Book:

1. Doebelin Ernesto, "Measurement Systems", McGraw-Hill International Publication Co., New York, 4th Edition,1990.
2. Sawhney A. K. and Sawhney P., "Mechanical Measurement and Control", Dhanpat Rai and Company Pvt. Ltd., New Delhi, 12th Edition, 2010.
4. Figliola R. S., Beasley D. E., "Theory and design for mechanical measurements", Wiley India Edition.
5. Alciatore & Histand, "Introduction to Mechatronics and Measurement Systems", 4th Edition, McGraw-Hill publication, 2011.
6. Bishop (Editor), "Mechatronics – An Introduction", CRC Press, 2006.

Unit Test -

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

MACHINE LEARNING
(Course Code C406)

Designation of Course	**Machine Learning**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: - 00 Hrs./Week	Term Work	25	01
	Oral	25	
Practical: - 02 Hrs. /Week	**Total**	**50**	

Course Prerequisite: -	1. Engineering Mathematics-III, Statistics and Numerical Methods, Introduction to Data Science.
Course Objective: -	To provide Knowledge about 1. To interpret the difference between supervised and unsupervised learning. 2. Use the knowledge of linear regression for different applications. 3. To interpret the knowledge of deep learning.
Course Outcomes:-	On completion of the course, students will be able to: 1. Analyze different machine learning techniques and their applications. 2. Apply principles of probability to solve problems in uncertain environments. 3. Explain the concepts of various processes in machine learning. 4. Implement linear regression techniques for predictive modeling. 5. Apply multiple linear regression methods to real-world datasets. 6. Perform clustering analysis and interpret the results for pattern recognition.

Course Content

List of Practical /Term work: - (Any 6 of the following list)

1. Study and practice of the Linear regression system.
   - ML Techniques overview, Validation Techniques.
2. Study and practice of the logistics regression system
   - Regression basics: Relationship between attributes using Covariance.
3. Study and practice or regularization techniques.
   - ML: Supervised learning, Unsupervised learning, Reinforcement learning
4. Study and practice of KNN systems.
   - K-Nearest Neighbor algorithm
5. Study and practice the decision tree.
   - Wilson editing and triangulations or Decision Trees
6. Study and practice of random forest.
   - Classification & Regression of random forest.
7. Study and practice of K-means clustering.
   - K-Medoids, k-Mode, and density-based clustering.
8. Study and practice Natural Language Programming.
9. Study and practice the deep learning process.
   - Introducing popular architecture, models, and their use in various settings.
10. Implementation of a mini-project or case study using the concepts studied in the ML course.

Textbook

1. Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN: 9788131804896
2. Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN9788121939485
3. Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978 93-85046-52-0
4. Jain N, Artificial Intelligence: making a system intelligent, 2018, ISBN: 978812657994

References Books:

1. Zsolt Nagy, "Artificial Intelligence and Machine Learning Fundamentals", Packt Publishing, 2018, ISBN: 978-1-78980-165-1
2. Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. The elements of statistical learning: data mining, inference, and prediction. Vol. 2. New York: Springer, 2009.
3. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. Data mining and analysis: fundamental concepts and algorithms. Cambridge University Press, 2014.
4. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021

PROJECT STAGE -I
(Course Code
C407)

Designation of Course	**Project Stage -I**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 02 Hours/ Week	End Semester Examination	-- Marks	--
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - -- Hours/ Week	Term Work	50 Marks	03
	Oral/Practical	50 Marks	
	Total	**100 Marks**	**03**

Course Prerequisites: -	The students should know of 1. Knowledge of Mathematics & Science 2. Knowledge of basic concepts in heat transfer. 3. Basic information on thermodynamics. 4. Basic knowledge of design 5. Knowledge of basic concepts in mechanical engineering.
Course Objectives: -	1. To identify the problem for a specific need of an organization 2. To review literature on a specific research topic 3. To make feasible, sustainable design 4. To work sincerely as a member of a team 5. To communicate ideas to supervisors as well as subordinates
Course Outcomes: -	On completion of the course, students will be able to: 1. Formulate a project team by identifying members with complementary skills and aligned technical interests. 2. Collaborate and select project ideas in consultation with faculty and HOD, focusing on new equipment development, industry-sponsored problems, or research-oriented projects. 3. Assess the feasibility of project ideas considering design, fabrication, and available resources. 4. Prepare a preliminary project plan including aim, design alternatives, cost estimation, activities bar chart, and resource requirements. 5. Design equipment with reference materials, develop working drawings, and track progress through activities charts. 6. Present and propose improvements to the completed project based on analysis, feedback, and suggested modifications.

Course Contents

Details of Project Stage -I

1. he formation of a project team with members having similar interests.
2. Discuss the ideas among the team members and choose a faculty member interested in a similar activity with the consent of the HOD. The projects can be on new equipment development, on industry-sponsored problems, or on research-oriented subjects.
3. Discuss the project with the faculty, with the idea that projects selected are suitable for design and fabrication with the available resources.
4. First stage presentation with
    - Project Aim
    - Feasible design and alternatives considered.
    - Estimation of the approximate cost of the project
    - Activities bar chart
    - Internal Lab resources required.
    - External resources required and their availability.
5. Second presentation with
    - Collection of reference material and
    - Design of the equipment with working drawings
    - Stage of work completed through the activities bar chart.
6. Third presentation of complete work with suggested modifications.

INTERNSHIP
(Course Code
C408)

Designation of Course	**Internship**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - -- Hours/ Week	End Semester Examination	-- Marks	--
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - -- Hours/ Week	Term Work	25 Marks	03
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**03**

Course Prerequisites: -	The students should know of 1. All courses up to B. Tech Semester VI.
Course Objectives: -	1. To expose technical students to the industrial environment. 2. To provide possible opportunities to learn, interpret, and sharpen the real-time technical, managerial skills required at the job. 3. To familiarize with various materials, processes, products, and their applications, along with relevant aspects of quality control. 4. To acquaint the social, economic, and administrative considerations that influence the working environment of an industrial organization.
Course Outcomes: -	The students should be able to– 1. Identify and select suitable internship opportunities in industry, research, or entrepreneurship. 2. Plan and initiate internship activities effectively within organizational timelines. 3. Apply technical knowledge to perform tasks in real-world industrial or research settings. 4. Document observations and work systematically in an Internship Diary/Workbook. 5. Analyze and present internship findings through reports and seminars. 6. Demonstrate professional behavior, ethics, teamwork, and societal awareness.

Course Contents

Introduction:

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.

Duration:

Internship to be completed after semester 6 and before commencement of semester VII, of at least 8 weeks (60 Days); and it is to be assessed and evaluated in semester VII.

Internship Work Identification:

Students may choose either to work on innovation or entrepreneurial activities resulting in a start-up or undergo an internship with industry/NGO's/Government organizations/Micro/Small/Medium enterprises to make themselves ready for the industry.

Contacting various companies for Internship and Internship work identification process should be initiated in the 6th semester in coordination with the training and placement cell/ industry institute cell/ internship cell. This will help students to start their internship work on time. Also, it will allow students to work during the vacation period after their 6th semester examination. Students can take internship work in the form of Online/onsite work from any of the following, but not limited to:

- Working on a consultancy/ research project,
- Participation at Events (Technical / Business)/in innovation-related completions like Hackathon,
- Contribution in Incubation/ Innovation/ Entrepreneurship Cell/ Institutional Innovation Council/ startups cells of the institute
- Development of new product/ Business Plan/ registration of start-up,
- Participation in IPR workshop/Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos,
- Industry / Government Organization Internship, Internship through Internshala,
- In-house product development, intercollegiate, interdepartmental research internship under a research lab/group,
- micro/small/medium enterprise/online internship.

Internship Diary/ Internship Workbook:

Students must maintain an Internship Diary/ Internship Workbook. The main purpose of maintaining a diary/workbook is to cultivate the habit of documenting. The students should record in the daily training diary the day-to-day account of the observations, impressions, information gathered, and suggestions given, if any. The training diary/workbook should be signed after every day by the supervisor/ in-charge of the section where the student has been working. Internship Diary/workbook and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.

Internship Diary/workbook may be evaluated based on the following criteria:

• Proper and timely documented entries • Adequacy & quality of information recorded. • Data recorded. • Thought process and recording techniques used. • Organization of the information

Internship Work Evaluation:

The evaluation of these activities will be done by the Cell In-charge/faculty mentor or Industry Supervisor based on the Overall compilation of internship activities, evidence needed to assign the points, and the duration for certain activities. Assessment and Evaluation is to be done in consultation with the internship supervisor (Internal and External – a supervisor from the place of internship.

Recommended evaluation parameters-Post Internship Internal Evaluation -25 Marks + Internship Diary/Workbook and Internship Report - 25 Marks

Evaluation through Seminar Presentation/Viva-Voce at the Institute

The student will give a seminar based on his training report, before an expert committee constituted by the department concerned, as per the norms of the institute. The evaluation will be based on the following criteria:

• Depth of knowledge and skills Communication & Presentation Skills • Teamwork • Creativity • Planning & Organizational skills • Adaptability • Analytical Skills • Attitude & Behavior at work • Societal Interpreting • Ethics • Regularity and punctuality • Attendance record • Logbook • Student's Feedback from External Internship Supervisor.

After completion of the Internship, the student should prepare a comprehensive report to indicate what he/she has observed and learnt in the training period. The student may contact the Industrial Supervisor/

Faculty Mentor for assigning special topics and problems, and should prepare the final report on the student's physical presence. If the student is found absent without prior intimation to the department/institute/concerned authority, the entire training can be cancelled.

The report shall be presented covering the following recommended fields, but not limited to,

• Title/Cover Page • Internship completion certificate • Internship Place Details- Company background-organization and activities/Scope and object of the study / personal observations • Index/Table of Contents • Introduction • Title/Problem statement/objectives • Motivation/Scope and rationale of the study • Methodological details • Results / Analysis /inferences and conclusion • Suggestions / Recommendations for improvement to industry, if any • Attendance Record • Acknowledgement • List of reference (Library books, magazines and other sources)

Feedback from internship supervisor (External and Internal)

Post internship, the faculty coordinator should collect feedback about the student with the following.

Recommended parameters: Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skills, individual work, Teamwork, Leadership, etc.

RENEWABLE ENERGY TECHNOLOGIES

(Course Code C409)

Designation of Course	**Renewable Energy Technologies**		
Teaching Scheme :	**Examination Scheme**		**Credits Allotted**
Theory: 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - -- Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites:-	The students should know of 1. Mechanical Engineering System. 2. Thermodynamic principles 3. Thermodynamic Applications 4. Power Plant Technology
Course Objectives:-	1. To explain the concepts of Non-renewable energy systems 2. To outline the utilization of renewable energy sources for both domestic and industrial applications 3. To analyze the environmental and cost economics of renewable energy sources in comparison with fossil fuels.
Course Outcomes:-	On completion of the course, students will be able to – 1. Explain the fundamentals and principles of solar energy conversion and its potential applications. 2. Analyze the construction, working, and performance characteristics of solar power systems for various operating conditions. 3. Examine the components, operation, and performance of wind energy conversion systems and assess their efficiency. 4. Compare the performance of biogas and biomass energy systems based on their design and operating parameters. 5. Integrate different renewable energy technologies for their techno-economic feasibility in sustainable energy applications. 6. Analyze the construction, working, and efficiency of various energy storage technologies used in renewable energy systems.

Course Contents

Unit I	**Fundamentals of Solar Energy:**	**(06 Hrs.)**
Principle of conversion of solar radiation into heat, Applications of solar energy, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Collection efficiency, Solar Thermal Power Plant, Solar Pond, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.		
Unit II	**Solar Energy Technology :**	**(06 Hrs.)**

Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell, and its working principle, Different types of Solar cells, Series and parallel connections, Photovoltaic applications: Battery chargers, domestic lighting, street lighting, and water pumping		
Unit III	**Wind Energy Technology:**	**(06 Hrs.)**
Power from wind, site selection, characteristics of the wind, wind energy conversion systems and their classification, construction and working of a typical windmill, design considerations for windmills, small wind turbines, performance, blade element theory, social and environmental considerations, present status.		
Unit IV	**Bio-Energy Technology:**	**(06 Hrs.)**
Importance of biogas technology, Different Types of Biogas Plants. Aerobic and anaerobic bioconversion processes, various substrates used to produce Biogas, Individual and community biogas-operated engines, and their use. Removal of CO2 and H2O, Application of Biogas in domestic, industrial, and vehicles. Bio-hydrogen production. Isolation of methane from Biogas and packing and its utilization. Biomass Energy: Introduction, Photosynthesis Process, Biofuels; Biomass Resources, Biomass conversion technologies -fixed dome, Urban waste to energy conversion, Biomass gasification.		
Unit V	**Other Renewable Technologies:**	**(06 Hrs.)**
Ocean Thermal Energy Conversion: Introduction, Working principle, Resource and site requirements, Location of OTEC system, Electricity generation methods from OTEC, open cycle and closed cycle OTEC systems, Advantages and disadvantages, Applications of OTEC. Tidal Energy - Introduction, Origin and nature of tidal energy, Basic principle of tidal power generation, Components of tidal power plants, Tidal energy technology, Tidal range power, Basic modes of operation of tidal systems. Advantages and limitations Introduction to Hydroelectric power plant, Introduction- types - system components of Small Hydro Power Systems, discharge curve, and estimation of power potential - Turbines for SHP.		
Unit VI	**Energy Storage Technologies:**	**(06 Hrs.)**
Pumped Hydroelectric Storage, Compressed Air Energy Storage, Battery Technologies - Traditional and Advanced, Flow Batteries, Flywheels, Fuel Cell: Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems. Superconducting Magnetic Energy Storage, Super-capacitors/Ultra-capacitors, Energy Storage Technology Comparisons, Functional Comparison, Cost Comparison, latest Energy Storage Technologies		

Term Work

1. Study of the national and global renewable energy scenario.
2. To perform an analysis of a solar power system.
3. Case Studies on Solar Power Systems.
4. To perform an analysis of the Wind power system.
5. Determination of characteristics of a wind generator.
6. Performance evaluation of vertical and horizontal-axis wind turbine rotors.
7. Measurement of I-V characteristics of a solar cell.

8. Study the effect of input light intensity on the performance of the solar cell.
9. Study of Energy Storage Technologies
10. Study of Biogas/ Biomass Plant
11. Study of Tidal Power/ Ocean Power Plant
12. Visit to Wind Power/ Solar Power Plant.
13. Visit to Biogas Plant

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 demonstration model of a Solar Power System
2. To prepare a demonstration model of Small Hydro Power Systems
3. To prepare a demonstration model of a Wind power system
4. To prepare a demonstration model of the Biomass Energy system
5. To prepare a demonstration model of the Biogas system
6. To prepare a demonstration model of the Fuel cell system
7. Preparing a demonstration model of Energy Storage Technologies
8. Case study on Small Hydro Power Systems
9. Case study on Solar Power System
10. Case study on Wind power system
11. Case study on Biomass Energy
12. Case study on Biogas system
13. Case study on Fuel cell system
14. Case study on Ocean Thermal Energy
15. Case study on Tidal Energy

Textbooks:

1. Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, John Wiley and Sons, 2006.
2. Solanki: Renewable Energy Technologies: Practical Guide for Beginners, PHI Learning Pvt. Ltd., 2008.

Reference Books:

1. Solar Energy Principles, Thermal Collection & Storage, S. P. Sukhatme: Tata McGraw Hill Pub., New Delhi.
2. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw-Hill Pub., 2009.
3. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India, 2016.
4. Solar Cells: From Materials to Device Technology edited by S. K. Sharma, Khuram Ali, Springer (2020)
5. D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International Publishers, 2007.
6. Remus Teodorescu, Marco Liserre, Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, 2011.
7. Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley and Sons, 2004.
8. Non-Conventional Energy Sources, G. D. Rai, New Delhi.
9. Renewable Energy, Power for a Sustainable Future, Godfrey Boyle,2004,
10. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw-Hill Pub.,2009.
11. Fundamentals of Renewable Energy Resources by G. N. Tiwari, M. K. Ghosal, Narosa Pub., 2007.

12. Rational Design of Solar Cells for Efficient Solar Energy Conversion, edited by Alagarsa My Pandikumar, Ramasamy Ramaraj, Wiley (2018).
13. Energy fables, edited by Jenny Rinkinen, Elizabeth Shove, Jacopo Torriti, Routledge, a T&F group, (2019).

Unit Test –

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

Elective-II: INDUSTRIAL PRODUCT DESIGN
(Course Code C410.1)

Designation of Course	**Industrial Product Design**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	End Semester Examination	60 Marks	03
Practical: 02 Hours/ Week	Internal Evaluation	40 Marks	
	Term Work:	25 Marks	01
	Total	**125 Marks**	**04**

Course Prerequisites:-	A student should have Basic Knowledge of 1. Machine Drawing I & II 2. Industrial Engineering & Management, Manufacturing Process, Advanced Manufacturing Processes 3. CAD software viz. CATIA/ ProE/ SolidWorks/ Uni-Graphics
Course Objectives:-	To study 1. Various aspects of product design and development different product design methods. 2. Concept generation and product specification. 3. Industrial Design and Prototyping. 4. Aesthetic, Environmental, and Ergonomic considerations to develop an industrial product.
Course Outcomes:-	On completion of the course, students will be able to – 1. Explain the fundamental concepts and principles of industrial product design. 2. Apply various product design methods and demonstrate their practical implementation. 3. Formulate concept generation strategies and develop detailed product specifications. 4. Analyze legal and economic considerations and select suitable prototyping methods for industrial products. 5. Evaluate the influence of aesthetics, ergonomics, and safety in industrial product design.) 6. Integrate and modify design aspects for manufacturing, assembly, and environmental sustainability to create improved industrial products.

Course Contents

Unit 1	**Introduction to Product Design and Development**	**(6 Hrs.)**
Overview of industrial design, Successful product, development of quality aspect of product design; Challenges of product development, Market survey. Identify customer needs and product planning processes. Product architecture: Implication of architecture, establishing the architecture, and related system-level design issues.		
Unit 2	**Product Design Methods**	**(6 Hrs.)**
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.		
Unit 3	**Product Specifications and Concept Generation**	**(6 Hrs.)**
Concept generation, five-step concept generation method, concept selection, concept screening, concept testing, Product specification, steps to establish the target specifications.		
Unit 4	**Industrial Design and Prototyping**	**(6 Hrs.)**
It's the need, impact, and quality, the industrial design process and its management, legal issues in product design, IPR, design resources, economics, and management of product development projects. Prototyping: Basics and principles of prototyping, Rapid prototyping technologies, planning for prototypes		

Unit 5	Aesthetics, Ergonomics, and Industrial Safety	(6 Hrs.)
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		
Unit 6	**Design for Manufacture, Assembly, and Environment**	**(6 Hrs.)**
Estimating manufacturing cost, reducing component, assembly, and support costs, design for assembly, design for disassembly, design for environment, design for graphics and packaging, effective prototyping-principle and planning. Product data management. Innovation and creativity in product design. Product costing, value engineering, aesthetic concepts.		

Project-Based Learning:

1. Quality function deployment
2. Aesthetics and ergonomics
3. Design for manufacturing and assembly
4. Design for the environment
5. Rapid prototyping

Term Work: Use of different CAD software, *viz.* CATIA/ ProE/ SolidWorks/ Uni-Graphics while doing the following case studies:

1. A case study on a market study to identify customer needs
2. A case study on the use of morphological analysis
3. A case study on Quality Function Development (QFD)
4. A case study of one aesthetic consideration in product design
5. Failure Modes and Effects Analysis (FMEA) in product design
6. A case study on Design for Manufacturing
7. A case study on Product Lifecycle Management (PLM)
8. A case study of one ergonomic consideration in product design
9. A case study of one industrial safety consideration in product design

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 Chitale & Gupta, "Product Development", Tata McGraw-Hill
3. New Product Development: Tim Jones, Butterworth, Heinemann, Oxford, 1997.
4. Product Design for Manufacture and Assembly: Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight.

Reference Books

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

Unit Tests

Unit Test-I	Unit-I,II,III
Unit Test-II	Unit-IV,V,VI

Elective-II: Engineering Economics

(Course Code C410.2)

Designation of Course	**Engineering Economics**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - --Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of the basics of Mathematics.
Course Objectives: -	Students will be able to interpret the economics behind running a successful engineering project.
Course Outcomes: -	On completion of the course, students will be able to: 1. Explain the fundamental concepts of engineering economics and apply them for effective selection and planning of engineering projects. 2. Analyze the concept of time value of money and compute the equivalent worth of cash flows at any given time for project evaluation. 3. Apply basic methodologies of engineering economic analysis to assess and select suitable project alternatives. 4. Compare alternative project options using appropriate economic evaluation techniques to determine their feasibility and viability. 5. Perform replacement analysis to evaluate and plan for resource substitution or equipment upgradation in projects. 6. Estimate depreciation and analyze the impact of corporate income taxes on project profitability and cash flow planning.

Course Contents

Unit 1	**Introduction to Economics**	**(06 Hrs.)**
Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics – Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis – V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning.		
Unit 2	**Interest and Time Value of Money**	**(06 Hrs.)**
Introduction to Time Value of Money; Simple Interest; Compound Interest; Nominal Interest rate; Effective Interest rate; Continuous Compounding; Economic Equivalence; Development of Interest Formulas; The Five Types of Cash Flows; Single Cash flow Formulas; Uneven Payment Series; Equal Payment Series; Linear Gradient Series; Geometric Gradient Series.		
Unit 3	**Basic Methodologies of Engineering Economic Analysis**	**(06 Hrs.)**

Minimum Attractive (Acceptable) Rate of Return (MARR); Payback Period Method; Equivalent Worth Methods: Present Worth Method, Future Worth Method, Annual Worth Method; Rate of Return Methods: Internal Rate of Return Method; External/Modified Rate of Return Method; Public
Sector Economic Analysis (Benefit Cost Ratio Method); Introduction to Lifecycle Costing; Introduction to Financial and Economic Analysis
Unit 4 | Comparative Analysis of Alternatives | (06 Hrs.)
Comparing Mutually Exclusive Alternatives having the Same useful life by 1. Payback Period Method and Equivalent Worth Method 2. Rate of Return Methods and Benefit-Cost Ratio Method Comparing Mutually Exclusive Alternatives having different useful lives by 1. Repeatability Assumption 2. Co-terminated Assumption 3. Capitalized Worth Method Comparing Mutually Exclusive, Contingent, and Independent Projects in Combination.
Unit 5 | Replacement Analysis | (06 Hrs.)
Fundamentals of Replacement Analysis: Basic Concepts and Terminology; Approaches for Comparing Defender and Challenger; Economic Service Life of Challenger and Defender Replacement Analysis When Required Service Life is Long: Required Assumptions and Decision Framework; Replacement Analysis under the Infinite Planning Horizon; Replacement Analysis under the Finite Planning Horizon
Unit 6 | Depreciation and Corporate Income Taxes | (06 Hrs.)
Concept and Terminology of Depreciation; Basic Methods of Depreciation: Straight line method, Declining Balance Method, Sinking Fund Method, Sum of the Year Digit Method, Modified Accelerated Cost Recovery System (MACRS); Introduction to Corporate Income Tax; After Tax Cash flow Estimate; General Procedure for Making After Tax Economic Analysis.

Term Work

1. Completing a break-even analysis of a company
2. Calculation of the time value of money
3. Calculating the feasibility of a project by economic analysis
4. Comparing Mutually Exclusive Alternatives having the Same useful life by the Payback Period Method and Equivalent Worth Method
5. Comparing Mutually Exclusive Alternatives having the Same useful life by Payback Rate of Return Methods and Benefit Cost Ratio Method
6. Comparing Mutually Exclusive Alternatives having different useful lives
7. Replacement analysis of a machine
8. Calculation of depreciation of a machine
9. Calculation of corporate taxes.

Project-Based Learning

1. Case study on break-even analysis of a company
2. Case study on the Calculation of the time value of money
3. Case study on the feasibility of a project by economic analysis
4. Case study on Comparing Mutually Exclusive Alternatives having the Same useful life by Payback Period Method and Equivalent Worth Method
5. Case study on Comparing Mutually Exclusive Alternatives having the Same useful life by Payback Rate of Return Methods and Benefit Cost Ratio Method
6. Case study on Comparing Mutually Exclusive Alternatives having different useful lives

7. Case study on Replacement analysis of a machine
8. Case study on the Calculation of the depreciation of a machine
9. Case study on the Calculation of corporate taxes.

Textbooks

1. R. Paneerselvem, Engineering Economics, Prentice Hall India.

Reference Books

1. Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc.
2. E. Paul De Garmo, William G. Sullivan, and James A. Bonta Delli, Engineering Economy, McGraw-Hill Publishing Company.
3. James L. Riggs, David D. Bedworth, and Sabah U. Randhawa, Engineering Economics, Tata McGraw-Hill Education Private Limited.

Unit Tests

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

Elective-II: PROJECT MANAGEMENT & ETHICS
(Course Code C410.3)

Designation of Course	**Project Management & Ethics**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - --Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Mathematics & Statistics 2. Industrial engineering & management 3. Soft skills and professional skills
Course Objectives: -	1. To create awareness about the concepts of project management and its components 2. To use the techniques specified by the project management body of knowledge for effective project management. 3. To create awareness of social and professional responsibility among stakeholders
Course Outcomes: -	On completion of the course, students will be able to – 1. Explain the fundamental concepts of project management and apply them across various phases of the project life cycle. 2. Analyze economic models, evaluate project profitability, and **assess** associated risks using suitable risk management techniques. 3. Apply different cost estimating and forecasting methods to prepare and justify project budgets effectively. 4. Develop project plans and schedules using appropriate tools and optimize project duration through suitable techniques. 5. Examine project execution, monitoring, and control processes to evaluate overall project performance. 6. **Assess** professional ethics and integrate ethical principles of project management for sustainable organizational growth.

Course Contents

Unit I	**INTRODUCTION TO PROJECT MANAGEMENT**	**(06 Hrs.)**
Project, Project Management, Management by projects, Project Management Associations, Benefits of Project Management, Project management Process, Role of Project Manager, Project Lifecycle		
Unit II	**PROJECT MANAGEMENT TECHNIQUES AND RISK MANAGEMENT**	**(06 Hrs.)**
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.		
Unit III	**PROJECT COST ESTIMATING**	**(06 Hrs.)**
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.		
Unit IV	**PROJECT PLANNING AND SCHEDULING**	**(06 Hrs.)**

Project Planning: Introduction, Need for Project Planning, Project Life Cycle, Roles, Responsibilities and Teamwork, 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.		
Unit V	**PROJECT MONITORING AND CONTROL**	**(06 Hrs.)**
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		
Unit VI	**PROFESSIONAL RESPONSIBILITY (ETHICS)**	**(06 Hrs.)**
Ensuring Integrity and Professionalism, Project Management Knowledge Base, Enhancing Individual Competence, Balancing Stakeholder Interests, Interactions with Team Members and Stakeholders, Templates, Tools, and Techniques		

Term Work

1. Identifying the Key Components of a Project
2. Create a Project with MS Project
3. Represent Project Resources in MS Project
4. Perform Resource Leveling in MS Project
5. Plan and manage procurement
6. Plan and manage the schedule
7. Develop, execute, and validate a strategy for stakeholder engagement
8. Determine risk management options
9. Displaying Calendar Information in a Gantt Chart

Project-Based Learning

1. Case study involving various aspects of the project
2. Case study involving various techniques used for project selection.
3. Case study of project cost estimation
4. Case study based on project scheduling
5. Industrial case study of project ethics
6. Case study on project risk management

Textbooks

1. Erik Larson, Clifford Gray; “Project Management: The Managerial Process”; McGraw-Hill Education; Sixth edition (1 July 2014)
2. Panneerselvam R; “Project Management”; Prentice Hall India Learning Private Limited; 1 Edition (2009)
3. Samuel J. Mantel, Jack R. Meredith; “Project Management: A Managerial Approach”; Wiley; Eighth edition (6 August 2012)
4. Gupta R; “Project Management”; Prentice Hall India Learning Private Limited; Second edition (2014)

Reference Books

1. Project Management Institute; “A Guide to the Project Management Body of Knowledge (PMBOK Guide)”; 5th Revised edition (1 January 2013)
2. Harold Kerzner; “Project Management: A Systems Approach to Planning, Scheduling and Controlling Paperback”; Wiley; tenth edition (20 November 2012)

Unit Tests

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

Elective-II: VIRTUAL REALITY
(Course Code C410.4)

Designation of Course	**Virtual Reality**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03Hours/ Week	End Semester Examination	60 Marks	03
Practical:- 02 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	25 Marks	01
	Total	**125 Marks**	**04**

Course Prerequisites: -	Companion Course, if there is any: Virtual Reality Lab
Course Objectives:-	This course is designed to give historical and modern overviews and perspectives on virtual reality. It describes the fundamentals of sensation, perception, and technical and engineering aspects of virtual reality systems.
Course Outcomes: -	The students should be able to– 1. Describe how VR systems work and list the applications of VR. 2. Interpret the design and implementation of the hardware that enables VR systems to be built. 3. Interpret the Geometry of Virtual Worlds &The Physiology of Human Vision. 4. Interpret the system of human vision and its implications on perception and rendering. 5. Explain the concepts of motion and tracking in VR systems. 6. Describe the importance of interaction and audio in VR systems.

Course Contents

Unit I	Introduction to Virtual Reality	**(06 Hrs.)**
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.		
Unit II	Representing the Virtual World	**(06 Hrs.)**
Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR, and Haptic Representation in VR		
Unit III	The Geometry of Virtual Worlds &The Physiology of Human Vision	**(06 Hrs.)**
Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.		
Unit IV	Visual Perception & Rendering	**(06 Hrs.)**
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		
Unit V	Motion & Tracking	**(06 Hrs.)**
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		
Unit VI	Interaction & Audio	**(06 Hrs.)**
Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio		

-The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering.

Term Work

1. Installation of Unity and Visual Studio, setting up Unity for VR development, and interpreting the documentation of the same.
2. Study and demonstration of depth perception.
3. Study and demonstration of skeleton tracking for various applications
4. Demonstration of the working of HTC Vivi, Google Cardboard, Google Daydream, and Samsung Gear VR.
5. Develop a scene in Unity that includes a cube and Transformations on the 3 game objects.
6. Develop a scene in Unity that includes a plane and use transformations on the 3 game objects
7. Develop a scene in Unity that includes a sphere and use transformations on the 3 game objects
8. Develop a scene in Unity that includes a video source
9. Develop a scene in Unity with that audio source.

Project-Based Learning

Exemplar/ Case Studies

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.

Textbooks

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
2. Interpreting 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

Unit Tests

Unit Test-I	Unit I, II, III
Unit Test-II	Unit-IV, V, VI

Elective-II: ADDITIVE MANUFACTURING & RAPID PROTOTYPING

(Course Code C410.5)

Designation of Course	**EL II: Additive Manufacturing & Rapid Prototyping**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - --Hours/ Week	Internal Assessment	40 Marks	
Practical: - 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	-- Marks	
	Total	**125 Marks**	**04**

Course Prerequisites: -	The students should know of 1) Solid Modelling, Auto CAD 2) Manufacturing Technology I & II 3) Design & Analysis of Machine Components
Course Objectives: -	1) To interpret the fundamental concepts of Additive Manufacturing (i.e., Rapid Prototyping) and 3-D printing, their advantages, and limitations. 2) To classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations, etc. 3) To have a holistic view of various applications of these technologies in relevant fields such as mechanical, Biomedical, Aerospace, electronics, etc.
Course Outcomes: -	On completion of the course, students will be able to – 1.Explain the importance of additive manufacturing and illustrate the complete AM process chain. 2.Analyze and apply liquid-based and solid-based additive manufacturing processes for specific applications. 3.Compare and implement powder-based additive manufacturing processes for producing functional components. 4.Evaluate and utilize suitable metal additive manufacturing processes for different engineering products. 5.Apply various AM data formatting and data processing techniques for effective product realization. 6.Select appropriate materials and a**ssess** potential applications of additive manufacturing in diverse fields such as automotive, aerospace, and biomedical engineering.

Course Contents

Unit I	**Introduction to Rapid Prototyping**	**(06 Hrs.)**
Introduction: Prototyping fundamentals, Historical development, Fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, commonly used Terms, Classification of RP process, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal, and clean up post-processing		
Unit II	**Liquid-based and Solid-based Rapid Prototyping**	**(06 Hrs.)**
Liquid-based Rapid Prototyping Systems: Stereo lithography Apparatus (SLA), Solid ground curing (SGC). Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. **Solid-based Rapid Prototyping Systems:** Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.		
Unit III	**Powder-Based Rapid Prototyping**	**(06 Hrs.)**

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Indirect and direct SLS, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, post processing, post curing, surface deviation and accuracy, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, Post processing of AM parts

Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations, and applications– Case Studies.

Unit IV	**Design for Additive Manufacturing**	**(06 Hrs.)**

Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers, etc.

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, for example, system for preliminary selection, production planning, and control

Unit V	**AM Data Formatting and Data Processing**	**(06 Hrs.)**

Rapid Prototyping Data Formats: STL Format, STL File Problems, Consequences of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Rapid Prototyping Software's: Features of various RP software's like Magics, Mimics, Solid View, View Expert, 3D View, Velocity 2, Rhino, STL View 3, Data Expert, and 3D doctor.

AM Data Processing: Part Orientation and Support Structure Generation, Model Slicing, and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies, and Tool Path Generation.

Unit VI	**AM Materials and Applications**	**(06 Hrs.)**

3D Printing Materials: properties, characteristics, and application of all types (ABS, PLA, PVA, HDPE, PET, PETG, etc.) Types of Composite Materials, properties, characteristics, and applications of all types. (N6, N12, ABS Carbon Fiber, etc.)

RP Applications: Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture.

RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules.

Term Work

1. Study of 3D Printing Machines
2. Study of different AM Software's
3. Study of AM Data Formatting and Data Processing
4. Study and demonstration of Plastic 3D Printing using FDM-based Rapid Prototyping (Plastic & Composites)
5. Study and demonstration of Plastic 3D Printing using SLS-based Rapid Prototyping (Plastic & Composites)
6. Study and demonstration of Plastic 3D Printing using Liquid-based/solid-based/powder-based Rapid Prototyping (Plastic & Composites)
7. Study and demonstration of Plastic 3D using FDM-based Rapid Prototyping Printing (Metals)
8. Assignment on 3D Printing Applications.
9. Select an appropriate 3D printing material and justify it for the following application: -
   a. Prototyping
   b. medical appliances
   c. Construction.
10. Selection of 3d printing machine specification for the following materials: -

a. Polymers
b. Composites
c. Metals

11. Measures surface quality and mechanical properties of the AM product
12. Study of CAM packages for AM

Project-Based Learning

Students must prepare and submit a demonstration model based on the above syllabus (Not limited to)

1. To prepare a demonstration model/chart of the AM Processes chain
2. To prepare a demonstration model of liquid-based AM technologies
3. To prepare a demonstration model of solid-based AM technologies
4. To prepare a demonstration model of powder-based AM technologies
5. To prepare a 3D printed model for various applications (Biomedical, aerospace, etc.)
6. To prepare a document on data formatting and data processing by selecting one application

Textbooks

1. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer,2006.
2. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
3. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.
4. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles &Applications", 4th Edition, World Scientific, 2015.
5. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley& Sons, 2006.
6. Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.

Reference Books

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World Scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker. "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
4. David F. Rogers, J. A. Adams, "Mathematical Elements for Computer Graphics", TMH,2008.
5. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.

Unit Tests

Unit Test-I	Unit- I, II, III
Unit Test-II	Unit- IV, V, VI

Energy Audit & Management

(Course Code C411)

Designation of Course	**Energy Audit & Management**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: - 4 hrs./Week	End Semester Examination	60 marks	04
	Internal assessment	40 marks	
	Total	100 marks	04

Course Prerequisite	The student should know of - 1. Basic Physics 2. Basic Electrical Engineering 3. Basic Thermal Engineering 4. Mathematics
Course Objective	1. Interpret basic energy conversion, conservation, and management principles. 2. Identify sources of energy loss and target savings. 3. Interpret the design of waste heat recovery systems, efficient power cycle, and power generation systems. 4. To enable students to carry out life cycle cost analysis and budgeting.
Course Outcomes	On completion of the course, students will be able to: 1. Analyze the national and global energy scenario to identify trends, challenges, and opportunities for sustainable development. 2. Apply the principles of material and energy balance to evaluate various industrial and thermal processes. 3. Evaluate the techno-economic feasibility of energy conservation and management measures. 4. Design and assess systems for effective electrical energy management in industrial and commercial sectors. 5. Design and assess systems for efficient thermal energy management in different engineering applications. 6. Conduct comprehensive energy audits and formulate implementable energy conservation strategies for sustainable operations.

Course Content

UNIT I	**Energy Scenario**	**8 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.		
UNIT II	**Energy Audit**	**8 Hrs.**

Energy Audit: Types and Methodology; Scope of Energy Audit, Energy Audit Reporting Format; Interpreting 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		
UNIT III	**Economic Analysis of Energy Conservation Measures**	**8 Hrs.**
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		
UNIT IV	**Electrical energy management**	**8 Hrs.**
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		
UNIT V	**Thermal energy management**	**8 Hrs.**
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.		
UNIT VI	**Material and Energy Balance**	**8 Hrs.**
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.		

Project-based learning:

1. Conduct a preliminary energy audit and prepare a report on the electrical plant.
2. Conduct a preliminary energy audit and prepare a report on the thermal plant.
3. Prepare an energy audit report on a small-scale industry with a payback period.
4. Conduct an energy audit on a residential house/own house with a payback period.
5. Prepare an economic audit sheet of any small-scale industry.
6. Prepare social instructions charts for energy-saving tricks.
7. Write one research paper on an audit carried out in a small-scale industry.
8. Prepare a standard energy-efficient model for a residential house.

Text Books:

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul Callaghan, McGraw–Hill Book Company–1st edition, 1998.
3. Energy management handbook by W. C. Turner, John Wiley & 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. IEEE Recommended “Practice for Energy Management in Industrial and Commercial Facilities”, IEEE std 739 – 1995. (Bronze book).
8. Hamis, “Energy Auditing and Conservation; Methods, Measurements, Management and Case Study”, Hemisphere Publishers, Washington, 1980.
9. C.W. Gelling’s and J.H. Chamberlin, “Demand-Side Management Planning”, Fairmount Press, 1993.
10. Wayne C Turner, “Energy Management Handbook”, The Fairmount Press, 2006.
11. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Papers I to IV.

Unit Tests: -

Unit Test-I	Units- I, II, and III
Unit Test-II	Units IV, V, and VI

Reliability and Machine Condition Monitoring
(Course Code C412)

Designation of Course	**Reliability and Machine Condition Monitoring**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03Hours/ Week	End Semester Examination	60 Marks	03
Practical:- 02 Hours/ Week	Internal Assessment	40 Marks	
Tutorial;- o1 Hours/Week	Term Work	25 Marks	01
	Oral	25 Marks	01
	Total	**150 Marks**	**05**

Course Prerequisites: -	A student should know Engineering Mathematics, Probability, Statistics, and Mechanical Vibration.
Course Objectives:-	1. Interpreting of basic principles of reliability for ensuring sustainable product design. 2. Application to system requirements, design, manufacturing, and testing, with real-world examples 3. Interpret in detail Asset Management, Maintenance, Quality, and Productiveness
Course Outcomes: -	On completion of the course, students will be able to: 1. Explain the fundamental concepts, measures, and characteristics of system reliability and failure behavior. 2. Apply probability concepts and statistical methods to analyze and interpret failure data using standard distributions. 3. Analyze system reliability through redundancy techniques, network methods, and reliability allocation approaches. 4. Evaluate system design for enhanced reliability and maintainability using FMECA and fault/success tree analyses. 5. Apply signal processing techniques, including FFT and time-domain analyses, for machinery condition monitoring. 6. Diagnose machinery faults using vibration, oil, and particle analysis and formulate condition-based maintenance strategies.

Course Contents

Unit I	**Fundamental Concepts of Reliability and Reliability Measures**	**(06Hrs.)**
Brief history, concepts, terms and definitions, applications, the life cycle of a system, concept of failure, typical engineering failures, and their causes **Reliability Measures:** Reliability function–R(t), cumulative distribution function (CDF)– F(t), probability density function (PDF) – f(t), hazard rate function-λ(t), Mean time to failure (MTTF) and Mean time between failures (MTBF), typical forms of hazard rate function, bathtub curve		
Unit II	**Probability Concepts and Failure Data Analysis**	**(06 Hrs.)**
Theory of probability, rules of probability, Introduction to independence, mutually exclusive, conditional probability, random variables, discrete and continuous probability distributions. Binomial, normal Comparison of probability distributions -, lognormal, Weibull, exponential, Standard deviation, variance, mean, mode, and the Central Limit Theorem. **Failure Data Analysis:** Data collection and empirical methods, estimation of performance measures for ungrouped complete data, grouped complete data, analysis of censored data, fitting probability distributions graphically (Exponential and Weibull) and estimation of distribution parameters		
Unit III	**Reliability Evaluation of Systems**	**(06 Hrs.)**

Reliability Improvement Redundancy, element redundancy, unit redundancy, standby redundancy - types of stand-by redundancy, parallel components, single redundancy, multiple redundancies, cut and tie set approach for reliability evaluation. Star and delta method, matrix method (Numerical).		
Introduction to Reliability allocation or apportionment, reliability apportionment techniques- equal apportionment, AGREE, ARINC, Minimum effort method (Numerical)		
Unit IV	**Design for Reliability and Maintainability**	**(06 Hrs.)**
Reliability design process and design methods, reliability allocation, failure modes, effects, and criticality analysis (FMECA), fault tree and success tree methods, symbols used, maintainability design process, quantifiable measures of maintainability, repair versus replacement		
Unit V	**Data Acquisition, Signal Processing, Applications, and Representation:**	**(06 Hrs.)**
Introduction, Collection of vibration signal – vibration transducers, characteristics, and mountings, Conversion of vibrations to an electrical signal. The fast Fourier transform (FFT) analysis, Time waveform analysis, Phase signal analysis, and Spectral signal processes.		
Unit VI	**Machinery Fault Diagnosis Using Vibration Analysis and Oil and Particle Analysis: Oil Fundamentals**	**(06 Hrs.)**
Commonly witnessed machinery faults diagnosed by vibration analysis, correcting faults that cause vibration; Balancing, Alignment, Resonance vibration control with dynamic absorbers. Condition-based maintenance and oil analysis, Setting up an oil analysis program, Oil analysis – Sampling methods, Oil analysis – lubricant properties, Oil analysis – contaminants in lubricants, Particle analysis techniques, Alarm limits for various machines.		

Term Work

The term work shall consist of

1. Data acquisition using a velocity pickup.Data acquisition using an accelerometer.
2. Data acquisition of sound signals.
3. Spectral analysis of velocity, acceleration noise signals.
4. Experiment demonstrating the balancing of a rotating shaft.

Project-Based Learning

Exemplar/ Case Studies

1. Data acquisition using a velocity pickup.
2. Data acquisition using an accelerometer.
3. Data acquisition of sound signals.
4. Spectral analysis of velocity, acceleration noise signals.
5. Experiment demonstrating the balancing of a rotating shaft.

Text Books

1. Ebling C. E., 2004, “An Introduction to Reliability and Maintainability Engineering”, Tata McGraw-Hill Education Private Limited, New Delhi.

2. Srinath L. S., 1991, “Reliability Engineering”, East West Press, New Delhi.

3. Birolini A., 2010, “Reliability Engineering: Theory and Practice”, Springer.

4. Parkhi R. M., “Market Leadership by Quality and Reliability”, Vidyanand Publications 2012.

5. Roy B. and Allan R. N., 1992, “Reliability evaluation of engineering systems: concepts and techniques”, Springer.

6. Thomson, W. T., "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 1990

7. Gupta K., "Introductory Course on Theory and Practice of Mechanical Vibrations", New Age International Ltd., 1984

8. J. S. Rao, “Vibratory Condition Monitoring of Machines”, Narosa Publishing House, New Delhi

Reference Books

1. Patrick D. T. Newton O'Connor, D., Bromley R., 2002, "Practical Reliability Engineering", John Wiley and Sons.

2. Rao S. S., 1992, "Reliability Based Design. McGraw-Hill

Andrew Kennedy, Skilling Jardine, Albert H. C. Tsang, 2006, "Maintenance, Replacement and Reliability: Theory and Applications, CRC/Taylor and Francis.

3. Nachlas Joel A., 2005, "Reliability Engineering: Probabilistic Models and Maintenance Methods," Taylor and Francis.

4. Cyril M. Harris, Allan G. Piersol, "Shock and Vibration Handbook", McGraw-Hill Publishing Co.

5. C. Scheffer, Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", Newnes, an imprint of Elsevier

Unit Tests

Unit Test-I	Unit I, II, III
Unit Test-II	Unit-IV, V, VI

PROJECT STAGE -II
(Course Code C413)

Designation of Course	**Project Stage -II**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - -- Hours/ Week	End Semester Examination	-- Marks	--
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 04 Hours/ Week	Term Work	100 Marks	06
	Oral/Practical	100 Marks	
	Total	**200 Marks**	**06**

Course Prerequisites: -	The students should know of 1. Knowledge of basic concepts in heat transfer. 2. Basic information on thermodynamics 3. Basic knowledge of fluid mechanics. 4. Knowledge of basic concepts in mechanical engineering 5. Basic knowledge of design
Course Objectives: -	1. To fabricate the designed equipment 2. To conduct laboratory and field testing of the new equipment 3. To analyze the performance of the equipment with different performance parameters 4. To make changes in design if necessary, based on the performance analysis 5. To prepare the project report and deliver a presentation. 6. To work sincerely as a member of a team
Course Outcomes: -	On completion of the course, students will be able to: 1. Design and fabricate engineering equipment or systems based on defined specifications and practical constraints. 2. Perform laboratory and field testing to evaluate the functional performance of the developed equipment. 3. Analyze experimental data to assess performance parameters and identify areas for improvement. 4. Modify and optimize the design of equipment based on performance analysis and feedback. 5. Prepare and present a comprehensive project report demonstrating technical content, documentation, and communication skills. 6. Collaborate effectively as a team member, demonstrating professional ethics, responsibility, and project management abilities.

Course Contents

Details of Project Stage -II

1. The project taken in the First semester will be continued as far as possible. In case after the training, the students wish to change their project, the same may be allowed after discussion with the faculty. The new project should be based on the training taken and should utilize the training experience.

   In Semester II concentration will be on

   - Hardware fabrication
   - Testing of equipment
   - Preparing a project report

2. The work will be evaluated through three presentations to watch the progress and suggest modifications for completing the project.

Operations Research Practices
(Course Code C414)

Designation of Course	**Operations Research Practices**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
	End Semester Examination	-	---
Practical: - 02 hours/Week	Internal Assessment	-	
	Term Work	25 Marks	1
	Practical	-	-
	Total	25 Marks	1

Course Prerequisites: -	Good knowledge of mathematics.
Course Objective: -	The students will be able to interpret various models in operations research used in industries to solve problems.
Course Outcomes	On completion of the course, students will be able to: 1. Apply the graphical method to formulate and solve Linear Programming Problems. 2. Analyze and evaluate Linear Programming Problems using the simplex method. 3. Develop solutions for transportation and assignment problems using appropriate optimization techniques. 4. Construct project networks and analyze project schedules using CPM and PERT techniques. 5. Apply queuing theory models to analyze and optimize service systems. 6. Apply and evaluate Inventory Control Models to optimize inventory costs and performance.

Course Contents

Unit 1	**LPP: Graphical Method**	**(04 Hrs.)**
Linear programming – Examples from industrial cases, formulation & definitions, Matrix form. Implicit assumptions of LPP. Graphical Method of solving the LPP.		
Unit 2	**LPP: Simplex Method**	**(04 Hrs.)**
Simplex Algorithm – slack, surplus & artificial variables, computational details, big-M method, 2 phasemethod. Identification and resolution of special cases through simplex iterations.		
Unit 3	**LPP: Special Cases**	**(04 Hrs.)**
Transportation Problems - Examples, Definitions – decision variables, supply & demand constraints, formulation, Balanced & unbalanced situations, Solution methods – NWCR, minimum cost and VAM, test for optimality (MODI method), degeneracy and its resolution. **Assignment Problems** - Examples, Definitions – decision variables, constraints, formulation, Balanced & unbalanced situations, Solution method – Hungarian, test for optimality (MODI method), degeneracy& its resolution.		
Unit 4	**Project Modelling**	**(04 Hrs.)**
Project definition, Project scheduling techniques – Gantt chart, PERT & CPM, Determination of critical paths, Estimation of Project time and its variance in PERT using statistical principles,		
Unit 5	**Inventory Model**	**(04 Hrs.)**
Concept of inventory costs, Basics of inventory policy (order, lead time, types), Fixed order-quantity models – EOQ, POQ & Quantity discount models. EOQ models for discrete units,		
Unit 6	**Queuing Theory**	**(04 Hrs.)**

Definitions – queue (waiting line), waiting costs, characteristics (arrival, queue, service discipline) of queuing system, queue types (channel vs. phase). Kendall's notation, Little's law, steady state behavior. Models with examples - M/M/1 and its performance measures.

Term work

Term work shall consist of any eight practicals described in the syllabus and listed below.

1. Solution of linear programming problem using graphical method
2. Solution of the linear programming problem with the simplex method.
3. Problem-solving using the Big M method.
4. Problem solving using the phase method.
5. Solution of the transportation problem.
6. Solution of the assignment problem.
7. Identification of project duration using CPM
8. Finding probabilities of project completions using PERT
9. Performance measures for M/M/1 queuing model.
10. Determination of various inventory costs using the inventory model.

Textbooks:

1. Operations Research: An Introduction. H.A. Taha.

Reference Books:

1. Linear Programming. K.G. Murthy.
2. Linear Programming. G. Hadley.
3. Principles of OR with Application to Managerial Decisions. H.M. Wagner.
4. Introduction to Operations Research. F.S. Hiller and G.J. Lieberman.
5. Elements of Queuing Theory. Thomas L. Saaty.
6. Operations Research and Management Science, Handbook: Edited by A. Ravi Ravindran.
7. Management Guide to PERT/CPM. Wiest& Levy.
8. Modern Inventory Management. J.W. Prichard and R.H. Eagle.

Robot Movement System
(Course Code C415)

Designation of Course	**Robot Movement System**		
Teaching Scheme:	**Examination Scheme**		**Credits Allotted**
Theory: -	End Semester Examination	--	01
Practical: 02 Hours/Week	Internal Assessment	--	
	Term Work	25 Marks	
	Total	**25 Marks**	**01**

Course Prerequisites: -	The students should know of 1. Mechanism and Mechanics 2. Basic Electrical Engineering. 3. Engineering Mathematics
Course Objectives: -	To provide knowledge about 1. Robot Movement System Components 2. Robot Motion control techniques 3.Mechanics of a robot manipulator
Course Outcomes: -	On completion of the course, students will be able to– 1. Describe the different types of robot movement systems and their applications. 2. Analyze the robot drive systems to determine their suitability for specific tasks. 3. Examine various robot end effectors and justify their selection for particular operations. 4. Select and recommend appropriate robot sensors for given applications based on functional requirements. 5. Evaluate and compare robot motion control techniques to optimize performance. 6. Develop and assess the kinematic models of robots for position and motion analysis.

Course Contents

Unit-I	**Introduction to Robot Movement System**	**04 Hrs.**
Introduction to robot movement system, Components of robot movement system, working of robot motion system, Robot configurations, Work volume and work envelope, Robot Joints and symbols, Robot Coordinates, Robot Reference Frames, Resolution, accuracy, and precision of Robot, Work cell control, Robot locomotive system, and its types.		
Unit-II	**Robot Drive Systems**	**04 Hrs.**
Pneumatic Drives, Hydraulic Drives, Mechanical Drives, Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors, BLDC-Salient Features, Applications and Comparison of all these Drives, Micro actuators, selection of drive, Power transmission systems for robot, Motion conversion, Determination of HP of motor, Types of Gearboxes: - Planetary, Harmonic, Cycloidal gearbox and gear Ratio, variable speed arrangements.		
Unit-III	**End Effectors**	**04 Hrs.**

Grippers, Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two-Fingered and Three-Fingered Grippers; Internal Grippers and External Grippers; Advanced Grippers- Adaptive grippers, Soft Robotics Grippers, Tactile Sensor Grippers; Various process tools as end effectors; Robot end effectors interface, Active and passive compliance, Selection and Design Considerations.

Unit-IV	**Robot Sensor**	**04 Hrs.**

Position sensors – Piezo Electric Sensor, LVDT, Resolvers. Proximity Sensor – Optical, Inductive, and capacitive, Encoders: Absolute and Incremental: - Optical, Magnetic, Capacitive, pneumatic Position Sensors Range Sensors: Range Finders, Laser Range Meters, Touch Sensors,
Force and torque sensors. Safety Sensor: Light Curtain, Laser Area Scanner, Safety Switches; Machine vision

Unit-V	**Robot motion control technique**	**04 Hrs.**

Introduction to robot motion control, Point to Point (PTP) control, Continuous path control (CP), controlled path, stop-to-stop control, Trajectory planning, Joint and Cartesian space trajectory

Unit-VI	**Mechanics of Robot Manipulator Movement**	**04 Hrs.**

Coordinate and vector transformation using matrices, Rotation matrix, homogeneous transformations H parameter, Forward and Inverse kinematics of 2 and 3 Link robots manipulator

Term Work:

Term work shall consist of a record of a minimum of 8 experiments from the following.

1. Study of different types of robot locomotive mechanisms.
2. Study of different robot drives for the Pick and place application
3. Demonstration of different types of robot grippers.
4. Study of robotics sensors used in AI AI-based object sorting system
5. Demonstration of a robot motion control system for an object sorting system by a robotic arm
6. Study and create a robot joint trajectory by using any robotic simulation software
7. Analysis of the Forward Kinematics of a 2-2-link manipulator
8. Analysis of Inverse Kinematics of a 2 2-link manipulator
9. Operation and troubleshooting of the robot motion control system

Textbooks:

1. M.P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012.
2. M.P. Groover, M. Naegel, "Industrial Robotics, Technology, Programming & Applications", TMH,2nd Edition, 2012.

References Books:

1. J. G. Keramas, "Robotics Technology Fundamentals", Thompson Learning, 2nd Edition, 2002.
2. J. J. Craig, "Introduction to Robotics Mechanics & Control", Pearson Education, 3rd Edition,2004.
3. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw-Hill Book co, 1987.
4. S.R. Deb, "Robotics Technology and Flexible Automation", TMH, 2nd Edition, 2010.
5. Mike Wilson, "Implementation of Robotic Systems"

Rules and Regulations

- **Rules regarding the conduction of Internal Assessment (IE):**
  Internal Assessment (IA) will comprise 40 marks. Out of this, 20 marks will be for Unit Tests, and 20 marks will be for Project-Based Learning. Two Unit Tests, each of 20 marks, will be conducted: The average of marks obtained in these two-unit tests will be considered as UT marks. Roll numbers allotted to the students shall be the examination numbers for the conduct of unit tests.

- **Rules Regarding ATKT, Standard of Passing and Award of Class of Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune**

  A.T. K. T.

  1. A candidate who is granted a term for B.Tech. Semester I, III, V, VII will be allowed to keep the term for his/her B.Tech. Semester-II, IV, VI, VIII examinations respectively, even if he/she appears and fails or does not appear at the B.Tech. Semester I, III, V, VII examinations respectively.
  2. A candidate shall be allowed to keep the term for the B.Tech. Semester-III course if he/she has a backlog of any number of Heads of passing at B.Tech. Semester I & II taken together.
  3. A student shall be allowed to keep the term for the B.Tech. Semester-V of the respective course if he/she has no backlog of B. Tech. Semester I & II, and he/she has a backlog of any number of Heads of passing at B. Tech. Semester-III & IV taken together.
  4. A student shall be allowed to keep the term for the B. Tech. Semester-VII of the respective course if he/she has no backlog of B. Tech. Semester I, II, III, IV, and he/she has a backlog of any number of Heads of passing at B. Tech. Semester V & VI taken together.

Standard of Passing:

1. Internal Assessment (IE):

- ✓ There will not be a separate passing head of 16 marks out of 40 marks for Internal Assessment (IA; the overall passing of 40% marks for the combined 100 marks will be imposed. However, the End Semester University Examination of 60 marks should have a separate passing of 40% marks.
- ✓ To grant the term, it is mandatory to appear for all the Unit tests conducted each semester.

2. Overall Passing:

- ✓ The candidate must obtain a minimum Grade Point of 5.0 (40% marks) in the End.
- ✓ Semester University Examinations, and in the combined End Semester + Internal Assessment
- ✓ A student who fails in the End Semester Examinations of a course must reappear only in the End Semester Examinations as a backlog candidate and clear that hurdle to pass.
- ✓ **Award of the Class for the Degree, considering CGPA:**

- ✓ A student who has completed the minimum credits specified for the programme shall be declared to have passed the programme. The result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The Criteria for the Award of Honors at the end of the Programme are as follows. (Same as CBCS 2014 Course Curriculum).

Range of CGPA	**Final Grade**	**Performance Descriptor**	**Equivalent range of Marks (%)**
9.50 ≤ CGPA ≤ 10.00	O	Outstanding	80 ≤ Marks ≤ 100
9.00 ≤ CGPA ≤ 9.49	A+	Excellent	70 ≤ Marks < 80
8.00 ≤ CGPA ≤ 8.99	A	Very Good	60 ≤ Marks < 70
7.00 ≤ CGPA ≤ 7.99	B+	Good	55 ≤ Marks < 60
6.00 ≤ CGPA ≤ 6.99	B	Average	50 ≤ Marks < 55
5.00 ≤ CGPA ≤ 5.99	C	Satisfactory	40 ≤ Marks < 50
CGPA below 5.00	F	Fail	Marks Below 40

Rules for Credits of MOOC courses, Social Activities, and Publication of Research Paper:

1. If a candidate completes a **MOOC/NPTEL course** in a particular semester **relevant to the courses in that semester**, he/ she will be allotted **TWO** credits after producing the certificate of completion of the respective course.

   Students shall register to MOOCs which are offered by any of the following agencies:

   a. SWAYAM: www.swayam.gov.in

   b. NPTEL: www.onlinecourse.nptel.ac.in

   c. Course Era: www.coursera.org

   d. edX online learning: www.edx.org

   e. MIT Open Course ware: www.ocw.mit.edu

   f. Udemy: www.udemy.com

   g. Spoken tutorial: www.spoken-tutorial.org

2. If a candidate completes his/her duties in NSS/Social Activities, he/she will be allotted **TWO** credits after producing the certificate of completion of the respective course/ activity from the relevant authorities.
3. If a candidate publishes a research paper in UGC approved CARE journals, he/she will be allotted **TWO** credits after producing the certificate of publication of the respective paper.
4. These credits will be given only after the authentic document is verified by the Head of the Department, and a separate marksheet is submitted by the Head of the Department along with the subject examiner.