ANNEXURE I

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, infrastructure to meet needs of profession & society.*
- *To provide an environment conducive to innovation, creativity, research and entrepreneurial leadership.*
- *To practice and promote professional ethics, transparency and accountability for 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 &up gradation of curricula.*
- *Up gradation of laboratories, library & communication facilities.*
- *Collaboration with industry and research & development organizations.*
- *Sharing of knowledge, infra-structure and resources.*
- *Training, extension, testing and consultancy services.*
- *Promoting interdisciplinary research.*

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 working environment.*

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

Graduates will be able,

- *To fulfill need 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.*

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. ***Engineering knowledge****: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.*

2. ***Problem analysis****: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.*

3. ***Design/development of solutions****: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.*

4. ***Conduct investigations of complex problems****: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.*

5. ***Modern tool usage****: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.*

6. ***The engineer and society****: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.*

7. ***Environment and sustainability****: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.*

8. ***Ethics****: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.*

9. ***Individual and team work****: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.*

10. ***Communication****: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.*

11. ***Project management and finance****: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.*

12. ***Life-long learning****: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.*

Statements of Programme Specific Outcomes (PSOs)

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

PSO2: Apply Mechanical Engineering principles for research, innovation and develop entrepreneurial skills.

PSO3: Apply concepts of mechanical engineering to asses' societal, environmental, health and safety issues with professional ethics.

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 Air Craft & 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 have knowledge 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. Understand automation technologies and identify advantages, limitations and applications of the same. 2. Develop 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 able 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: -	The students should be able to– 1. Understand & apply fundamentals of industrial automation. 2. Understand concepts of control system and apply it for automation. 3. Understand concepts related to fluid power system, Power units and its accessories. 4. Understand concepts related to Control of fluid power and Control valves. 5. Understand concepts related to Hydraulics and Pneumatics – Actuators and Circuits and its application. 6. Understand concepts of PLC and Develop ladder diagram for industrial applications.

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 system, effects of feedback and basic characteristic of feedback control systems, 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 fluid power system, advantages and limitations. Difference between electrical, pneumatic and fluid power systems. Seals, sealing materials. Types of pipes, hoses, material. 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, 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, counter balance 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 PLCs for Control System, Application of PLCs for Automatic Control System. Concept of SCADA and its Applications,

Term Work

(Term work shall consists of minimum 8 experiments from following)

1. Study of P, P+I, P+D, P+I+D control actions using any trainer kit / simulation software.
2. To study working of servomotor and its applications in industrial automation.
3. To study working of variable frequency drive and its 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 trainer 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's 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 industrial pick and place robot and integrated automation.

Project Based Learning

Following are list for project-based learning (Not limited to)

1. . To prepare a demonstration model of 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 pick and place robot with any application.
6. To prepare 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: -	Student should have knowledge of 1. Students should have Basic knowledge of Industrial Engineering. 2. Students should have Basic knowledge of Statistics
Course Objectives: -	Student should be able to 1. Use of six sigma technique to reduce variation 2. Use of Lean manufacturing for process improvement 3. Use of Agile manufacturing
Course Outcomes: -	Learner will be able to… 1. Understand and work with the Lean manufacturing process 2. Understand and work with the Agile Production System 3. Management in the Agile Organization. 4. Understand basic statistical processes. 5. Understand and calculate the six sigma levels 6. Understand and work with the DMAIC process

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, 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, Flexible work force.		
Unit 2	**Agile Production system and Practices**	**06 Hrs.**
Agile production system-the task 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, understanding 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, 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 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 design of Experiment.

Project Based Learning

1. Chart preparation showing different methods of waste elimination.
2. Chart preparation for showing the various elements of JIT system.
3. Study of a system based on value stream mapping.
4. Demonstration of elimination of waste using 5S system.
5. Demonstration of Cause and effect diagram for a system.
6. Demonstration of control charts for a system.
7. Study of 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 have knowledge of - 1. Mechanical Engineering System. 2. Thermodynamic principals 3. Thermodynamic Applications 4. Power Plant Technology
Course Objectives:-	1. To enable students to understand of the concept of Waste to Energy. 2. To learn about the best available technologies for Waste to Energy Conversion
Course Outcomes:-	On completion of the course, students will be able to– 1. **Understand** fundamentals of waste and waste Processing. 2. **Understand** Environmental and social impacts of waste to energy conversion plants 3. **Understand** fundamentals Pyrolysis and Combustion technology and **analyze** their performance 4. **Understand** Gasification technologies and **analysis** their performance. 5. **Understand** fundamentals of Anaerobic Digestion. 6. **Understand** 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 minusses 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; Biomethanation 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. To prepare a chart Waste and Waste Processing
2. To prepare a chart on Environmental and social impacts of waste to energy conversion plants
3. To prepare a chart on 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. To prepare demonstration model of Pyrolysis Process
8. To prepare demonstration model of Fixed bed gasifiers
9. To prepare demonstration model of Fluidized bed gasifiers
10. To prepare demonstration model of Plasma arc gasifier
11. To prepare 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

Text Books:

1. Nicholas P Cheremisinoff, ―Handbook of Solid Waste Management and Waste Minimization Technologies‖, An Imprint of Elsevier, New Delhi, 2003.
2. P AarneVesilind, 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 Backhusrt, 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 plastic processes methods
Course Objectives: -	1. To design jigs. 2. To design fixtures. 3. To design dies for manufacturing system.
Course Outcomes: -	The students should be able to– 1. To understand the concept of jigs and fixture and its principles. 2. To design jigs with use of standard components. 3. To design fixture with use of standard components. 4. To select plastic processes methods. 5. To understand the concept of injection moulding and able to design the injection molding die. 6. To design dies for the pressure die casting.

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 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 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 - its working, construction, types & advantages and limitations.		
Unit V	**Design of Injection Molds**	**(6 Hrs.)**
Specifications and elements of 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 simple blanking die.
2. Design & working drawing of progressive die.
3. Design & working drawing of compound die.
4. Design & working drawing of 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 gating system in die casting.
11. A report on factory visit, comprising of product range, processes, plant layout, AuxilIary equipment, process parameters etc.

Project Based Learning:

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

1. Fabrication of simple blanking die.
2. Automatic blanking Machine
3. Fabrication of 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 combination die.
10. Fabrication of a deep drawing die.
11. Tool and die design for Blanking.
12. Fabrication of Sandwich Jig.
13. Fabrication of universal Fixture
14. Indexing drill jig by using bevel Gear
15. Fabrication of 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 McGrw 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 understand the artificial intelligence algorithms to robotics problems. 2. To understand the performance of AI algorithms 3. To compute the complex problems in flexible automation
Course Outcomes: -	On completion of the course, students will be able to 1. Use different machine learning techniques. 2. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning. 4. Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents, artificial neural networks. 5. Demonstrate proficiency in developing applications in AI and Machine Learning. 6. Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

Course Content

Unit I	**Introduction to artificial intelligence techniques**	**(06 Hrs)**
Evolutionary computation, Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, programming in AI environment, developing artificial intelligence system, 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, 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, standard back propagation algorithms.		
Unit IV	**Handling uncertainty**	**(06 Hrs)**
Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, 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 programs listed below based on 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 Min/ Max search procedure.
8. Implementation of mini-Project using the concepts studied in the AI course.

Project based learning:-

Following is the list of topic 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 programing 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. Genesereth, 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 understand the choice of the selection of design parameters, Fixing the geometry and to investigate the performance and stability characteristics of airplanes. 2. To make the student understand the basic concepts of submarine design, various systems in submarine, dynamics and control of submarine.
Course Outcomes: -	The students should be able to– 1. Initiate the preliminary design of an aircraft starting from data collection to satisfy mission specifications. 2. Understand the estimation of geometric and design parameters of an airplane. 3. Understand the design of a system, component, or process to meet requirements for aircraft systems. 4. Understand the concepts of submarine design and development process. 5. Understand the various system used in the submarine. 6. Understand the dynamics and control system of submarine.

Course Contents

Unit I	**Introduction to Aircraft Design**	**(06 Hrs.)**
State of 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, 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 mission. Choice of wind loading and thrust. Loading.		
Unit III	**Design of Wing, Fuselage and Emphanage**	**(06 Hrs.)**
Selection of aero foil. 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, 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, 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 Concept, 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. Understanding Structure Design of a Submarine.

Project Based Learning

Any One from the following:

1. One design project on various components of aircraft.
2. One design project on various component of submarine.
3. CAD detailed drawing of any one component of aircraft.
4. CAD detailed drawing of any one component of 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 scope, objective and application of Production Planning and Control 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:-	The students should be able to– 1. Understand the importance of PPC in industry. 2. Understand the different techniques of forecasting and apply them in sales forecasting. 3. Understand different ideas and concept to improve PPC in industry. 4. Understand different techniques for material requirement planning. 5. Understand different techniques used for PPC in industry. 6. Understand Recent trends 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, factor 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, factor influencing process planning. Line Balancing-Heuristic Method, Rank Position Weightage Method. Scheduling-procedure of scheduling, scheduling devices, Gantt Chart, loading devices, Machine Loading Chart, Scheduling and loading techniques, Sequencing of operations - Johnson's rule, Loading, Dispatching, Follow- up, Evaluation, PERT, CPM		
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, Replenishment Systems. Stores Management: Function of store keeping, Types of stores, Store layout and storage systems, Stores Documentations, 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 computer in production planning and control, Enterprise Resource Planning (ERP), Automation of repetitive process, Customer Relationship Management (CRM), Advanced Planning and Scheduling (APS), MRP software, JIT- elements of Just in Time Systems, Kanban System, Kaizen Strategy.		

Project Based Learning:

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

1. Basic production control problem in automobile industry and 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 manufacturing company.
5. The effect of material management technique 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 operational cost of the manufacturing industry.
10. Minimizing defective product through effective production planning and control.
11. Effect of manpower planning on organization performance.
12. The impact of quality control technique on the profitability in manufacturing organizations.
13. An assessment of the impact of marketing segmentation on production planning in an organization.
14. An optimal inventory control of raw materials and network analysis of production planning.
15. Minimizing defective products through effective production planning and control in defence.

Textbooks:

1. “Production Systems - Planning Analysis and Control”, J. L. Riggs, “, Jhon 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 Hours/ Week	Term Work	25 Marks	01
	Total	**125 Marks**	**05**

Course Prerequisites:-	The student should have 1. Mechanical Engineering System. 2. Thermodynamic principals 3. Thermodynamic Applications
Course Objectives:-	To explain the concepts of different types of Power Plants To study and analyze different types of Steam Condenser, Cooling Towers, Steam Nozzle and Steam Turbine.
Course Outcomes:-	On completion of the course, students will be able to– 1. **Understand** fundamentals of Power Plants **2. Understand** Thermal Power Plant and Nuclear Power Plant and **analysis** their performance. 3. **Understand** fundamentals of Thermal power plant and **analysis** their performance. 4. **Understand** construction and working of Steam Condenser and Cooling Towers and **analysis** their performance. 5. **Understand** construction and working of Steam Nozzle and Steam Turbine Plants and **analysis** their performance. 6. **Understand** study fundamentals of Power Plant Economics.

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 equipments, hydrostatic and air leakage test, acid and alkali cleaning, 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, Principal 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 tariffs, economics of load sharing, Load Curves, Load duration Curves, types of load 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 combined cycle gas based and coal based Power plant.
3. To perform analysis of a thermal power plant.
4. To perform analysis of 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 National & International Grid, Indian Electricity Grid Code
2. To prepare a chart on Thermal Power Plant
3. To prepare a chart on Hydro Electric Power Plants
4. To prepare a chart on Steam Condenser and Cooling Towers
5. To prepare a chart on Steam Nozzle and Steam Turbine
6. To prepare a chart on Energy Storage Technologies
7. To prepare demonstration model of Thermal Power Plant
8. To prepare demonstration model of Hydro Electric Power Plants
9. To prepare demonstration model of Steam Condenser
10. To prepare demonstration model of Cooling Towers
11. To prepare demonstration model of Steam Nozzle
12. To prepare demonstration model of 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 –Mc Graw 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, 3rdEdition 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: -	Student should have knowledge of 1. Students should have Basic knowledge of Mechanical terms Force, Pressure, Temperature, and Electronics terms like as Voltage, Resistance and Current. 2. Students should have Basic knowledge of Measuring Units, Mathematics, and Various Measurement terms.
Course Objectives: -	Student 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 measurement of surface finish
Course Outcomes: -	Learner will be able to… 1. Understand static and dynamic characteristics of measurement systems. 2. Know different devices used for linear and angular measurement. 3. Measure temperature, pressure, strain and fluid flow using different sensors for various applications. 4. Using of concepts like limits, fits and tolerances for designing the limit gauges. 5. Use displacement, velocity, position, force, torque, level sensors for specific applications. 6. Measure various screw thread or gear tooth parameters using specific equipment.

Course Contents

Term Work: (Any 8 experiments need perform during practical's)

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 surface roughness.

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

   Sine bar, Sine center, uses of sine bar, angle gauge, slip gauges.
8. Measurement of optical surface using 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, gear tooth Vernier caliper.
12. Study and experiment on profile projector/Tool makers microscope
13. Industrial visit to Automation Company and Inspection & Quality control division of any Industry with detail report.

Text Books:

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", 4thEdition, 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 System", 4th Edition, Mc-Graw 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 understand the difference of supervised and unsupervised learning. 2. Apply the knowledge of linear regression for different applications. 3. To understand the knowledge of deep learning.
Course Outcomes:-	On completion of the course, students will be able to 1. Understand the different machine learning techniques. 2. Apply the knowledge of probability for uncertain methods. 3. Understand the concept of various processes in machine learning. 4. Apply the knowledge of linear regression process. 5. Apply the knowledge of Multiple linear regression process. 6. Apply the knowledge of clustering method.

Course Content

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

1. Study and practice of Linear regression system.
   - ML Techniques overview, Validation Techniques.
2. Study and practice of logistics regression system
   - Regression basics: Relationship between attributes using Covariance.
3. Study and practice or regularization technics.
   - ML: Supervised learning, Unsupervised learning, Reinforcement learning
4. Study and practice of KNN systems.
   - K-Nearest Neighbor algorithm
5. Study and practice of 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-mean clustering.
   - K-Medoids, k-Mode and density-based clustering.
8. Study and practice of Natural Language Programing.
9. Study and practice of deep learning process.
   - Introduce popular architectures, models, and the use of it in various settings.
10. Implementation of mini-Project or case study using the concepts studied in the ML course.

Text Book

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 have knowledge of 1. Knowledge of Mathematics & Science 2. Knowledge of basic concepts in heat transfer. 3. Basic information of thermodynamics. 4. Basic knowledge of design 5. Knowledge of basic concepts in mechanical engineering.
Course Objectives: -	1. To identify problem for a specific need of an organization 2. To review literature on 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 6. To develop new equipment or make modifications in existing one
Course Outcomes: -	The students should be able to–

Course Contents

Details of Project Stage -I

1. The formation of a project team with members having similar interest.
2. Discuss the ideas within the team members and choosing a faculty member interested in 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 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 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 have knowledge of 1. All courses up to B. Tech Semester VI.
Course Objectives: -	1. To expose technical student to the industrial environment. 2. To provide possible opportunities to learn, understand, 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 industrial organization.
Course Outcomes: -	The students should be able to– 1. Understand the latest changes in technological world and apply fundamental principles of science and engineering. 2. Create ability to identify, formulate and model problems and apply it to find engineering solutions based on a system approach. 3. Understand importance of sustainability and cost-effectiveness in design and development of engineering solution. 4. Create ability to be multi skilled engineer with a good technical knowledge, management, leadership, entrepreneurship skills. 5. Create awareness of social, cultural, global, and environmental responsibility as an engineer. 6. Create ability to communicate efficiently.

Course Contents

Introduction:
Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as the employers are looking for employees who are properly skilled and having awareness about industry environment, practices, and culture. Internship is structured, short-term, supervised training often focused on tasks or projects with defined time scales. Core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom and hence creating competent professionals in the industry and to understand 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 7 of at least 8 weeks (60 Days); and it is to be assessed and evaluated in semester 7.
Internship work Identification:
Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo 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 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 in vacation period after their 6th semester examination. Student can take internship work in the form of Online/onsite work from any of the following but not limited to:

- Working for 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 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, inter department research internship under research lab/group,
- micro/small/medium enterprise/online internship.

[1] https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf

Internship Diary/ Internship Workbook:

Students must maintain Internship Diary/ Internship Workbook. The main purpose of maintaining 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 Cell In-charge/faculty mentor or Industry Supervisor based on 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 internship supervisor (Internal and External – a supervisor from 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 concerned department as per 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 Understanding • Ethics • Regularity and punctuality • Attendance record • Logbook • Student's Feedback from External Internship Supervisor.

After completion of 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 Industrial Supervisor/

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

The report shall be presented covering 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, faculty coordinator should collect feedback about student with following recommended parameters: Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skill, 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 have knowledge of 1. Mechanical Engineering System. 2. Thermodynamic principals 3. Thermodynamic Applications 4. Power Plant Technology
Course Objectives:-	1. To explain the concepts of Non-renewable energy systems 2. To outline 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. **Understand** Fundamentals of Solar Energy. 2. **Understand** construction working of solar power system and **analysis** their performance. 3. **Understand** Wind Energy Technology and **analysis** their performance. 4. **Understand** fundamentals of Biogas and Biomass Energy and **analysis** their performance. 5. **Understand** different Renewable Technologies and **analysis** their performance. 6. **Understand** construction and working Energy Storage Technologies

Course Contents

Unit I	**Fundamentals of Solar Energy:**	**(06Hrs.)**
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 typical wind mill, design considerations for wind mills, 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, industry 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 national and global renewable energy scenario.
2. To perform analysis of solar power system.
3. Case Studies on solar power system.
4. To perform analysis of Wind power system.
5. Determination of characteristics of a wind generator.
6. Performance evaluation of vertical and horizontal axes wind turbine rotors.
7. Measurement of I-V characteristics of solar cell.
8. Study the effect of input light intensity on the performance of 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 demonstration model of Solar Power System
2. To prepare demonstration model of Small Hydro Power Systems
3. To prepare demonstration model of Wind power system
4. To prepare demonstration model of Biomass Energy system
5. To prepare demonstration model of Biogas system
6. To prepare demonstration model of Fuel cell system
7. To prepare 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

Text Books:

1. Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, John Wileyand 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, NewDelhi.

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 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:-	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, Environment and Ergonomic considerations to develop an industrial product.
Course Outcomes:-	Students should be able to 1. Understand fundamental concept of industrial product design 2. Understand and apply different product design methods 3. Understand the concept generation and develop the product specifications 4. Evaluate legal economic issues and select a prototyping method for industrial product 5. Evaluate the approaches of Aesthetic, Ergonomics and safety in industrial product 6. Understand design for manufacturing, assembly and environment and apply for industrial product

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, related system level design issue.		
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 – 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)**
Its need, impact and quality, 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 environment 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 environment
5. Rapid prototyping

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

1. A case study on market study to identify costumer needs
2. A case study on use of morphological analysis
3. A case study on Quality Function Development (QFD)
4. A case study of one aesthetic considerations 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 considerations in product design
9. A case study of one industrial safety considerations in product design

Text Books:

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	**Name of the subject**		
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 Basic of Mathematics
Course Objectives: -	Students will be able to understand the economics behind running a successful engineering project
Course Outcomes: -	Student should be able to 1. Understand the basic concepts of economics any apply them for selection and planning 2. Understand time value of money and calculate the value of money at any given time in a project 3. Understand Basic Methodologies of Engineering Economic Analysis and use them to for selection of project 4. Use various methods to compare two different projects to check their viability 5. Use replacement analysis for panning and changing of resources in a project 6. Plan for Depreciation and Corporate Income Taxes

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 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 time value of money
3. Calculating the feasibility of a project by economic analysis
4. Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
5. Comparing Mutually Exclusive Alternatives having 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 Calculation of time value of money
3. Case study on feasibility of a project by economic analysis
4. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
5. Case study on Comparing Mutually Exclusive Alternatives having 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 Calculation of depreciation of a machine
9. Case study on 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, MCMilan Publishing Company.
3. James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Engineering Economics, TataMCGraw 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 apply the techniques specified by project management body of knowledge for effective project management. 3. To create awareness of social and professional responsibility among stakeholders
Course Outcomes: -	The students should be able to– 1. Understand concepts of project management and apply it to various phases in project life cycle 2. Understand economic models, evaluate project profitability and analyze risk management 3. Understand different cost estimating & forecasting methods to apply in project budgeting 4. Understand the methods of project planning, scheduling and apply it to reduce project duration 5. Understand the project execution, monitoring, control process and evaluate the performance of the project 6. Understand professional ethics of project management and apply it for organizational benefits

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 of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Scheduling: Introduction, Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, Measures of variability, CPM Model, Network Cost System.		
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. Identify 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 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 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 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, 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. Understand the design and implementation of the hardware that enables VR systems to be built. 3. Understand the Geometry of Virtual Worlds &The Physiology of Human Vision. 4. Understand the system of human vision and its implication 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	**(06Hrs.)**
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, understanding documentation of the same.
2. Study and demonstration of depth perception.
3. Study and demonstration of skeleton tracking for various application
4. Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
5. Develop a scene in Unity that includes a cube and apply transformations on the 3 game objects.
6. Develop a scene in Unity that includes a plane and apply transformations on the 3 game objects
7. Develop a scene in Unity that includes a sphere and apply transformations on the 3 game objects
8. Develop a scene in Unity that includes a video source
9. Develop a scene in Unity 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.

Text Books

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

Reference Books

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging 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 have knowledge of 1) Solid Modelling, Auto CAD 2) Manufacturing Technology I & II 3) Design & Analysis of Machine Components
Course Objectives: -	1) To understand the fundamental concepts of Additive Manufacturing (i.e., Rapid Prototyping) and 3-D printing, its 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, Bio-medical, Aerospace, electronics etc.
Course Outcomes: -	The students should be able to– 1. Understand the importance of additive manufacturing process and AM process chain 2. Understand and apply Liquid-based and Solid Based additive manufacturing processes. 3. Understand and apply powder based additive manufacturing processes. 4. Understand and apply various Metal Additive Manufacturing process for different products 5. Apply various AM data formatting and data processing techniques for different products 6. Select suitable material for AM process and explore different applications of AM parts from various fields like Automobile, Aerospace, Bio-medical etc.

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, 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, Consequence 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, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D 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 Composites Materials, properties, characteristics, and application of all types. (N6, N12, ABS Carban 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 appropriate 3D printing material and justify it for following application: -
   a. Prototyping
   b. medical appliances
   c. Construction.
10. Selection of 3d printing machine specification for following materials: -

a. Polymers
b. Composites
c. Metals

11. To measure surface quality and mechanical properties of AM product
12. Study of CAM packages for AM

Project Based Learning

Students have to prepare and submit a demonstration models based on above syllabus (Not limited to)

1. To prepare a demonstration model/chart of 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 (Bio-medical, aerospace etc.)
6. To prepare a document on data formatting and data process 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 OtherTechnologies", 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", Worldscientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: RapidPrototyping to Direct Digital Manufacturing", Springer, 2010
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of RapidPrototyping 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 have knowledge of - 1. Basic Physics 2. Basic Electrical Engineering 3. Basic Thermal Engineering 4. Mathematics
Course Objective	1. Understand basic energy conversion, conservation, and management principles. 2. Identify sources of energy loss and target savings. 3. Understand design of waste heat recovery systems, efficient power cycle, and power generation systems. 4. To enable students in carrying out life cycle cost analysis and budgeting.
Course Outcomes	1. Analyze about energy scenario nationwide and worldwide 2. To know the procedure for the balance of energy and material in different processes 3. To conduct an economic analysis of energy conservation measures 4. To understand a system of electrical energy management 5. To understand a system of thermal energy management 6. Conduct energy audits and formulate & implement energy conservation strategies.

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; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximizing System Efficiency Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors. Energy Management of Building and Energy audit of Building- Energy management matrix monitoring and targeting Case Studies		
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 preliminary energy audit and prepare report on electrical plant.
2. Conduct preliminary energy audit and prepare report on thermal plant.
3. Prepare energy audit report on small scale industry with payback period.
4. Conduct energy audit on residential house/own house with payback period.
5. Prepare economical audit sheet of any small scale industry.
6. Prepare social instructions charts for energy saving tricks.
7. Write one research paper on audit carried out in small scale industry.
8. Prepare standard energy efficient model for 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 o' Callaghan, Mc–Graw Hill Book company–1st edition, 1998.
3. Energy management handbook by W. C. Turner, John Wiley, and sons.
4. Energy management and conservation –k v Sharma and Venkata shariah-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 Hand Book", 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: Paper I to IV.

Unit Tests: -

Unit Test-I	Unit- I, II and III
Unit Test-II	Unit- 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: -	Student should have knowledge of Engineering Mathematics, Probability, Statistics and Mechanical Vibration
Course Objectives:-	1. Understanding of basic principles of reliability for ensuring sustainable product design. 2. Application to system requirements, design, manufacturing and testing, with real world examples 3. Understand in detail Asset Management, Maintenance, Quality and Productiveness
Course Outcomes: -	Student should be able to 1. Understand different measures of reliability 2. Know different probability methods used in reliability engineering 3. Calculate MTTF, MTBF, failure rate and hazard rate. 4. To acquire knowledge of methods for evaluation of reliability of different systems. 5. Understand the concepts of maintainability and availability in reliability engineering 6. Understand the reliability design procedure 7. Know different methods to test reliability of the system.

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 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 electrical signal. The fast Fourier transform (FFT) analysis, Time waveform analysis, Phase signal analysis, 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

Term work shall consists 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 balancing of rotating shaft 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 balancing of rotating shaft 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’Conner, D., Bromley R., 2002, “Practical Reliability Engineering”, John Wiley and Sons.
2. Rao S. S., 1992, “Reliability Based Design. McGraw-Hill
3. Andrew Kennedy, Skilling Jardine, Albert H. C. Tsang, 2006, “Maintenance, Replacement and

Reliability: Theory and Applications", CRC/Taylor and Francis.
4. Nachlas Joel A., 2005, "Reliability Engineering: Probabilistic Models and Maintenance Methods" Taylor and Francis.
5. Cyril M. Harris, Allan G. Piersol, "Shock and Vibration Handbook", McGraw-Hill Publishing Co.
6. C. Scheffer, Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", Newnes an imprint of Elsevie

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 have knowledge of 1. Knowledge of basic concepts in heat transfer. 2. Basic information of 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 performance of the equipment with different performance parameters 4. To make changes in design if necessary, based on the performance analysis 5. To prepare project report and deliver presentation. 6. To work sincerely as a member of team
Course Outcomes: -	The students should be able to– 1. Understand the latest changes in technological world and apply fundamental principles of science and engineering. 2. Create ability to identify, formulate and model problems 3. Understand importance of sustainability and cost-effectiveness in design and development of engineering solution. 4. Create ability to be multi skilled engineer with a good technical knowledge, management, leadership, entrepreneurship skills. 5. Create awareness of social, 6. Create ability to communicate efficiently.

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 with aim of watching the progress and suggesting 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 understand various models in operations research used in industries to solve problems
Course Outcomes	As a part of this course, students will: 1. Understand graphical method of solving Linear ProgrammingProblems. 2. Understand simplex method of solving Linear ProgrammingProblems. 3. Understand transportation and assignment problems. 4. Use CPM and PERT for modelling. 5. Apply queuing theory to optimize queues. 6. Use Inventory Control System to optimize inventory costs.

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 syllabus and listed below.

1. Solution of linear programming problem using graphical method
2. Solution of linear programming problem with simplex method.
3. Problem solving using Big M method.
4. Problem solving using two phase method.
5. Solution of transportation problem.
6. Solution of 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 cost using 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 have knowledge 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 robot manipulator
Course Outcomes: -	The students should be able to 1. To Identify robot movement system 2. To Understand robot drive system 3. To Understand robot end effector 4. To Select robot sensor as per application 5. To Understand robot motion control technique 6.To Evaluate Kinematics Model of Robot

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; Advance 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.**
Co-ordinate and vector transformation using matrices, Rotation matrix, Homogenous Transformations-H Parameter, Forward and Inverse kinematics of 2 and 3 Link robot manipulator		

Term Work:

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

1.Study of different type of robot locomotive mechanism.
2.Study of different robot drive for Pick and place application
3.Demonstration of different type of robot gripper .
4. Study of robotics sensor used in AI based object sorting system
5.Demonstration of robot motion control system for object sorting system by robotic arm
6. Study and create robot joint trajectory by using any robotic simulation software
7. Analysis of Forward kinematics of 2 link manipulator
8. Analysis of Inverse kinematics of 2 link manipulator
9.Operation and troubleshooting of robot motion control system

Text Books :

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"

B. TECH. & ROBOTICS& AUTOMATION: COURSE STRUCTURE CBCS-2021

B. Tech. (Robotics &Automation) Sem.-I

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	C101	Linear Algebra, Calculus & Complex Variables	4	-	1	60	40	-	-	-	100	4	-	1	5
2	C102	Waves & Solid State Physics	3	2	-	60	40	25	-	-	125	3	1	-	4
3	C103	Electrical Engineering Systems	4	2	-	60	40	25	-	-	125	4	1	-	5
4	C104	Mechanical Engineering Systems	3	2	-	60	40	50	-	-	150	3	1	-	4
5	C105	Computer Aided Drafting & Visualization*	3	4	-	60	40	25	-	25	150	3	2	-	5
6	C106	Computer Programming: Fundamentals (Using C/C++)	-	4	-	-	-	50	-	50	100	-	2	-	2
	Total		**17**	**14**	**1**	**300**	**200**	**175**	**-**	**75**	**750**	**17**	**7**	**1**	**25**

*End Sem. Examination of 4 Hrs.; #: Based on TW & internal oral examination

B. Tech. (Robotics &Automation) Sem.-II

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	C107	Differential Equations, Probability & Statistics	4	-	1	60	40	-	-	-	100	4	-	1	5
2	C108	Chemistry of Engineering Materials	3	2	-	60	40	25#	-	-	125	3	1	-	4
3	C109	Electronics Engineering Systems	4	2	-	60	40	25#	-	-	125	4	1	-	5
4	C110	Fundamentals of Robotics	4	2	-	60	40	25	-	25	150	4	1	-	5
5	C111	Engineering Mechanics	3	-	-	60	40	-	-	-	100	3	-	-	3
6	C112	Basics of PLC	-	2	-	-	-	50#	-	-	50	-	1	-	1
7	C113	Object Oriented Programming (Using Python)	-	4	-	-	-	50	-	50	100	-	2	-	2
	Total		**18**	**12**	**1**	**300**	**200**	**175**	**-**	**75**	**750**	**18**	**6**	**1**	**25**

#: Based on TW & internal oral examination

B. Tech. (Robotics &Automation) Sem.-III

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	C201	Hydraulics & Pneumatics: Principals	4	2	-	60	40	25	25	-	150	4	1	-	5
2	C202	Theory of Machines	4	2	-	60	40	25	25	-	150	4	1	-	5
3	C203	Strength of Machine Components	4	0	1	60	40	-	-	-	100	4	-	1	5
4	C204	Electronic Circuits	3	0	-	60	40	-	-	-	100	3	-	-	3
5	C205	Embedded Systems[@]	3	2	-	60	40	25#	-	-	125	3	1	-	4
6	C206	Data Structures and Algorithms	-	2	-	-	-	25#			25		1	-	1
7	C207	MATLAB Programming	-	2	-	-	-	25	-	25	50	-	1	-	1
8	C208	Vocational Course-I [$]	-	2	-		-	25	25	-	50	-	1	-	1
	Total		**18**	**12**	**1**	**300**	**200**	**150**	**75**	**25**	**750**	**18**	**6**	**1**	**25**
9	C209	Social Activity-I [**]	-	-	-	--	-	-	-	-	-	-	-	-	2

#: Based on TW & internal oral examination; [@]Industry Taught Course-I; $ Sensors, PLC & HMI: Basic Training;** Add on Course,

B. Tech. (Robotics &Automation) Sem.-IV

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	C210	Digital Electronics[@]	4	-	-	60	40	-	-	-	100	4	-	-	4
2	C211	Power Electronics & Drives	3	2	1	60	40	25	25	-	150	3	1	1	5
3	C212	Manufacturing Technology-I	3	2	-	60	40	25	-	-	125	3	1	-	4
4	C213	Automatic Control Systems	4	2	-	60	40	25	25	-	150	4	1	-	5
5	C214	Design & Analysis of Machine Components*	4	2	-	60	40	25	25	-	150	4	1	-	5
6	C215	Solid Modelling	-	2	-	-	-	25	-	-	25		1	-	1
7	C216	Vocational Course-II [$]	-	2	-	-	-	25	25	-	50	-	1	-	1
	Total		**18**	**12**	**1**	**300**	**200**	**150**	**100**	**00**	**750**	**18**	**6**	**1**	**25**
8	C217	MOOC-I**	-	-	-	-	-	-	-	-	-	-	-	-	2

#: Based on TW & internal oral examination; [@]Industry Taught Course-II; $ PLC, HMI & Automation: Advanced Training; ** Add on Course

B. Tech. (Robotics &Automation) Sem.-V

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	C301	Signals and Systems[@]	4	2	-	60	40	25#	-	--	125	4	1	-	5
2	C302	Robot Kinematics & Dynamics	3	2	1	60	40	25	25	-	150	3	1	1	5
3	C303	Manufacturing Technology-II	4	2	-	60	40	25	25	-	150	4	1	-	5
4	C304	Electrical Control Systems	3	2	-	60	40	25#	-	-	125	3	1	-	4
5	C305	Introduction to Finite Element Analysis*	4	2	-	60	40	25	-	25	150	4	1	-	5
6	C306	Vocational Course-III[$]	-	2	-	-	-	25	25	-	50	-	1	-	1
	Total		**18**	**12**	**1**	**300**	**200**	**150**	**75**	**25**	**750**	**18**	**6**	**1**	**25**
7	C307	Environmental Study+	2	-	-	50	-	-	-	-	50	-	-	-	-
8	C308	Social Activity-II [**]	-	-	-	--	-	-	-	-	-	-	-	-	2

#: Based on TW & internal oral examination ; [@]Industry Taught Course-III; $ Mounting and Communication of Sensors; +Mandatory Audit course; ** Add on Course

B. Tech. (Robotics &Automation) Sem.-VI

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	C309	Electro Hydraulics and Pneumatics[@]	4	2	-	60	40	25	25	-	150	4	1	-	5
2	C310	Robotic Simulation	3	2	-	60	40	25#	-	-	125	3	1	-	4
3	C311	Instrumentation for Robotics & Automation	4	2	-	60	40	25	25	-	150	4	1	-	5
4	C312	Quantitative Techniques, Communication and Values	3	-	-	60	40	-	-	-	100	3	-	-	3
5	C313	Artificial Intelligence and Neural network for Robots	3	-	1	60	40	25#	-	-	125	3	-	1	4
6	C314	Vocational Course-IV[$]	-	2	-	-	-	25	25	-	50	-	1	-	1
7	C315	Robotic Programming-I	2	2	-	-	-	25	-	25	50	2	1	-	3
	Total		**19**	**10**	**1**	**300**	**200**	**150**	**75**	**25**	**750**	**19**	**5**	**1**	**25**
8	C316	MOOC-II**	-	-	-	-	-	-	-	-	-	-	-	-	2

#: Based on TW & internal oral examination ; [@]Industry Taught Course-IV; $ Troubleshooting and Maintenance of Robots; ** Add on Course

B. Tech. (Robotics &Automation) 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	Advanced Robotics	3	2	1	60	40	25	25	-	150	3	1	1	5
2	C402	Elective-I	3	2	-	60	40	25	-	-	125	3	1	-	4
3	C403	Industrial Internet of Things	4	2	-	60	40	25	25	-	150	4	1	-	5
4	C404	Future Factory (FMS)@	3	2	-	60	40	25#	-	-	125	3	1	-	4
5	C405	Robotic Programming-II		2	-	-	-	25	25	-	50	-	1	-	1
6	C406	Project Stage-I	-	2	-	-	-	50	50	-	100	-	3	-	3
7	C407	Internship***	-	-	-	-	-	25	25	-	50	-	3	-	3
	Total		**13**	**12**	**1**	**240**	**160**	**200**	**150**	**-**	**750**	**13**	**11**	**1**	**25**

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

B. Tech. (Robotics & Automation) 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	C408	Totally Integrated Automation	4	2	-	60	40	25	-	-	125	4	1	-	5
2	C409	Elective-II	3	2	-	60	40	25	-	-	125	3	1	-	4
3	C410	Industrial Engineering & Management	3	-	-	60	40	-	-	-	100	3	-	-	3
4	C411	Field & Service Robots@	3	-	1	60	40	-	-	-	100	3	-	1	4
5	C412	Mobile Robots & Drone Technology	-	2	-	-	-	25	25	-	50	-	1	-	1
6	C413	Design of Integrated Robotic Cells	-	4	-	-	-	25	25	-	50	-	2	-	2
7	C414	Project Stage-II	-	4	-	-	-	100	100	-	200	-	6	-	6
	Total		**13**	**14**	**1**	**240**	**160**	**200**	**150**	**-**	**750**	**13**	**11**	**1**	**25**
8	C415	Research Paper Publication**	-	-	-	-	-	-	-	-	-	-	-	-	2

#: Based on TW & internal oral examination ; @Industry Taught Course-VI, Social Activities-Additional Credit Course; ** Add on Course

Elective-I: Six Sigma, Lean & Agile Manufacturing, Engineering Economics, Augmented Reality & Virtual Reality, Operations Research Elective-II: Industrial Product Design, Project Management & Ethics, Additive Manufacturing & Rapid Prototyping, Image Processing

Sem VII

ADVANCED ROBOTICS

(Course No. C 401)

Designation of Course	**Advanced Robotics**		
Teaching Scheme:	**Examination Scheme**		**Credits Allotted**
Theory: - 03 Hours/Week	End Semester Examination	60	03
Practical: 02 Hours/Week	Internal Assessment	40	01
Tutorial : 01 Hours/Week	Term Work	25 Marks	01
	Oral	25 Marks	
	Total	**150 Marks**	**05**

Course Prerequisites: -	1. Basics of Robotics 2. Data Storage System 3. Applied Mechanics
Course Objectives: -	To provide knowledge about 1.Robotic machine used in smart manufacturing 2.Data storage and capturing techniques 3. Robotics application in Smart manufacturing
Course Outcomes: -	The students should be able to 1. To Understand Smart Material Handling Technologies 2. To Understand Data Storage and Capturing system 3. To Select Industrial Manipulator for application 4. To Design Robot End Effector 5. To Understand robot application in Manufacturing 6.To Understand Advanced robot application

Course Contents

Unit-I	**Introduction to Smart Material handling Techniques**	**08 Hrs.**
Principles of Smart Material Handling, Design consideration for smart storage system, Unit load concept, Material Handling equipment, Material transport systems: AGVs, Monorails, Conveyor systems, Cranes and hoists, Analysis of material transport systems: Charting technique, analysis of vehicle-based systems, Conveyor analysis		
Unit-II	**Storage and Data Capturing Systems**	**08 Hrs.**
Conventional storage methods and equipment's Storage system performance, Analysis of Automated storage/retrieval systems (ASRS) and Carousel Storage system. Automatic data capturing system (ADC), Bar coding, Radio frequency identification (RFID), Optical character recognition, Magnetic stripes		
Unit-III	**Industrial Robot**	**08 Hrs.**
Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot cantered cell.		
Unit-IV	**End Effector Design**	**08 Hrs.**
Classification, Design consideration, Materials for hostile operation. Cylindrical Cam type; Grippers using pneumatic, hydraulic, and electrical motor for transmission; Vacuum Grippers, Ultrasonic grippers. Gripper force analysis and gripper design, design of multiple degrees of		

freedom, active and passive grippers. Selection of Robot: Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.		
Unit-V	**Application of Robots in Smart Manufacturing**	**08 Hrs.**
Pick and place Robot, Application of Robots in Arc Welding Robots, Assembly and mega-assembly Robots continuous arc welding, Spot welding, Spray painting, assembly operation, Other industrial applications: Coating, Deburring, cleaning, Die Casting, Molding, Material handling, Picking, Palletizing, Packaging Robots For Inspection: Robotic vision systems, image representation, object recognition and categorization, depth measurement		
Unit-VI	**Advanced Application of Robots**	**08 Hrs.**
Military and medical applications, robot for underwater applications Robots, Climbing Robots, Machine mounted Robots. Interfacing Robots with computers. Obstacle Avoidance: Lee's Algorithm; Counter Path Defining using 'via' point, blending.		

Term Work:

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

1. Study of Smart Material handling systems with any Simulation tool
2. Demonstration of Flexible Manufacturing System for various application
3. Study and analysis of Storage and Data capturing systems
4. Study of different Industrial Robot application with any Simulation tool
5. Demonstration of pick and place application by industrial robot
6. Study and analysis of robot grippers (includes the problems based on gripper force)
7. Case Study on advanced industrial applications of robots
8. Case Study of Medical robot
9. Case Study of robot for any Military application

Project Based Learning: -

1. To Prepare prototype of smart manufacturing for various machining operation
2. To prepare prototype of FMS
3. To prepare chart/poster of Flexible Manufacturing system
4. To prepare chart/poster of data storage and capturing system
5. To prepare Barcode reader robotic manipulator
6. To prepare model of robot manipulator interfacing with prototype of CNC
7. To design and prepare protype of robot manipulator with any type of gripper
8. To prepare prototype model of robot for any military application

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.

3. S.K.Saha "Introduction to Robotics", The McGraw Hills company.

References Books:

1. Deb S.R., “Robotics”, Tata McGraw Hill Publications, New Delhi. ISBN 13: 9780070077911
2. Yoram Koren, & quot; Robotics for Engineers", McGraw Hill Book Co. ISBN-10: 0070353999
3. Fu K.S., Gonzalex R.C., Lee C.S.G., "Robotics Control Sensing, Vision and intelligence", McGraw Hill Book Co. ISBN 10: 0070226253 / ISBN 13: 9780070226258
4. Todd D.J., “Fundamentals of Robot Technology”, Wiley Publications, ISBN:978-0-470-20301-9

Unit Test

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

El-I SIX SIGMA, LEAN & AGILE MANUFACTURING
(Course No. C 402.1)

Designation of Course	**Six sigma, Lean & Agile Manufacturing**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: - 3 Hours/ Week	End Semester Examination	60	03
Practical: - 02 Hours/ Week	Internal Assessment	40	01
	Term Work	25 Marks	
	Total	**125 Marks**	**04**

Course Prerequisites: -	Student should have knowledge of 1. Students should have Basic knowledge of Industrial Engineering. 2. Students should have Basic knowledge of Statistics
Course Objectives: -	Student should be able to 1. Use of six sigma technique to reduce variation 2. Use of Lean manufacturing for process improvement 3. Use of Agile manufacturing
Course Outcomes: -	Learner will be able to… 1. Understand and work with the Lean manufacturing process 2. Understand and work with the Agile Production System 3. Management in the Agile Organization. 4. Understand basic statistical processes. 5. Understand and calculate the six sigma levels 6. Understand and work with the DMAIC process

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, 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, Flexible work force.

Unit 2	**Agile Production system and Practices**	**06 Hrs.**

Agile production system-the task 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, understanding 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, 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 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 design of Experiment.

Project Based Learning

1. Chart preparation showing different methods of waste elimination.
2. Chart preparation for showing the various elements of JIT system.
3. Study of a system based on value stream mapping.
4. Demonstration of elimination of waste using 5S system.
5. Demonstration of Cause and effect diagram for a system.
6. Demonstration of control charts for a system.
7. Study of 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

El-I Engineering Economics

(Course No. C 402.2)

Designation of Course	**Engineering Economics (Elective -I)**		
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 Basic of Mathematics
Course Objectives: -	Students will be able to understand the economics behind running a successful engineering project
Course Outcomes: -	Student should be able to 1. Understand the basic concepts of economics any apply them for selection and planning 2. Understand time value of money and calculate the value of money at any given time in a project 3. Understand Basic Methodologies of Engineering Economic Analysis and use them to for selection of project 4. Use various methods to compare two different projects to check their viability 5. Use replacement analysis for panning and changing of resources in a project 6. Plan for Depreciation and Corporate Income Taxes

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 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 time value of money
3. Calculating the feasibility of a project by economic analysis
4. Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
5. Comparing Mutually Exclusive Alternatives having 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 Calculation of time value of money
3. Case study on feasibility of a project by economic analysis
4. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
5. Case study on Comparing Mutually Exclusive Alternatives having 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 Calculation of depreciation of a machine
9. Case study on Calulation of corporate taxes.

Textbooks

1. R. Paneerselvem, Engineering Economics, Prentice Hall India.
2. M.P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012.

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, MC Milan 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

El-I ARGUMENTED AND VIRTUAL REALITY

(Course No. C 402.3)

Designation of Course	**Augmented and 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 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, 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. Understand the design and implementation of the hardware that enables VR systems to be built. 3. Understand the Geometry of Virtual Worlds &The Physiology of Human Vision. 4. Understand the system of human vision and its implication 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**	**(06Hrs.)**
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, understanding documentation of the same.
2. Study and demonstration of depth perception.
3. Study and demonstration of skeleton tracking for various application
4. Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
5. Develop a scene in Unity that includes a cube and apply transformations on the 3 game objects.
6. Develop a scene in Unity that includes a plane and apply transformations on the 3 game objects
7. Develop a scene in Unity that includes a sphere and apply transformations on the 3 game objects
8. Develop a scene in Unity that includes a video source
9. Develop a scene in Unity that audio source.

Project Based Learning

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

Text Books

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

Reference Books

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging 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

El-I OPERATIONS RESEARCH
(Course No. C 402.4)

Designation of Course	**Operations Research**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Lectures: - 03 hours/Week	End Semester Examination	60 Marks	3
Practical: - 02 hours/Week	Internal Assessment	40 Marks	
	Term Work	25 Marks	1
	Practical	-	-
	Total	**125 Marks**	**4**

Course Prerequisites:	Good knowledge of mathematics.
Course Objective: -	The students will be able to understand various models in operations research used in industries to solve problems
Course Outcomes	As a part of this course, students will: 1. Understand OR problem and associated models. 2. Understand Linear Algebra. 3. Use transportation and assignment problems. 4. Use PERT for modelling. 5. Use Inventory Control System. 6. Apply queuing theory and modulation techniques.

Course Contents

Unit 1	**Introduction to Operation Research**	**(06 Hrs.)**
Origin of OR and its definition. Concept of optimizing performance measure, Types of OR problems, Deterministic vs. Stochastic optimization, Phases of OR problem approach – problem formulation, building mathematical model, deriving solutions, validating model, controlling, and implementing solution.		
Unit 2	**Linear Programming:**	**(06 Hrs.)**
Linear programming – Examples from industrial cases, formulation & definitions, Matrix form. Implicit assumptions of LPP. Some basic concepts and results of linear algebra – Vectors, Matrices, Linear Independence/Dependence of vectors, Rank, Basis, System of linear eqns., Hyperplane, Convex set, convex polyhedron, Extreme points, Basic feasible solutions. Geometric method: 2-variable case, Special cases – infeasibility, unboundedness, redundancy & degeneracy, Sensitivity analysis. Simplex Algorithm – slack, surplus & artificial variables, computational details, big-M method, identification, and resolution of special cases through simplex iterations. Duality – formulation, results, fundamental theorem of duality, dual-simplex and primal-dual algorithms.		
Unit 3	**Transportation and Assignment problems:**	**(06 Hrs.)**
TP - 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. AP - Examples, Definitions – decision variables, constraints, formulation, Balanced &unbalanced situations,		

Solution method – Hungarian, test for optimality (MODI method), degeneracy & its resolution.		
Unit 4	**PERT – CPM:**	**(06 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, Concept of project crashing/time-cost trade-off.		
Unit 5	**Inventory Control**	**(06 Hrs.)**
Functions of inventory and its disadvantages, ABC analysis, 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, sensitivity analysis and Robustness, Special cases of EOQ models for safety stock with known/unknown stock out situations, models under prescribed policy, Probabilistic situations.		
Unit 6	**Queuing Theory**	**(06 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, Poisson's Process & queue, Models with examples - M/M/1 and its performance measures; M/M/m and its performance measures; brief description about some special models. **Simulation Methodology:** Definition and steps of simulation, random number, random number generator, Discrete Event System Simulation – clock, event list, Application in Scheduling, Queuing systems and Inventory systems.		

Term work

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

1. Solution of linear programming problem using graphical method
2. Solution of linear programming problem with simplex method.
3. Problem solving using Big M method.
4. Problem solving using two phase method.
5. Solution of transportation problem.
6. Solution of 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 cost using inventory model.

List of Project Based Learning Topics:

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

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

Textbooks:

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

Reference Books:

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

Unit Tests:

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

INDUSTRIAL INTRNET OF THINGS

(Course No. C 403)

Designation of Course	**Industrial Internet of Things**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 4 Hours/ Week	End Semester Examination	60 Marks	4
Practical: - 2 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	25Marks	1
	Oral/Practical	25 Marks	
	Total	**150 Marks**	**5**

Course Prerequisites: -	Systems in Mechanical Engineering, Programming and Problem Solving, Basic Electronics Engineering, Solid Mechanics, Solid Modeling and Drafting, Electrical and Electronics Engineering, Mechatronics, Measurement Laboratory, Fluid Power & Control Laboratory
Course Objectives: -	1. Introduction to IoT, Overview of IoT Building Blocks 2. Build small applications in IoT for Mechanical Engineering Applications using Sensors, Actuators, Microcontrollers and Cloud 3. Learn commonly used IoT Simulation Hardware platforms 4. Understand different Communication Technologies used in IoT 5. Development of application-level protocol and Security of IoT Ecosystem 6. Understand IoT applications in different domains
Course Outcomes: -	On completion of the course the learner will be able to; 1. EXPLAIN the Applications/Devices, Protocols and Communication Models of IoT 2. DEMONSTARTE small Mechanical Engineering IoT oriented applications using Sensors, Actuators, Microcontrollers and Cloud 3. SELECT commonly used IoT Simulation Hardware platforms 4. APPLICATION of Interfacing and Communication Technologies for IoT 5. ILLUSTRATE IoT Application Development and Security of IoT Ecosystem 6. EVALUATE Present and Future Domain specific Applications of IoT Ecosystem

Course Contents

Unit I	**Introduction to Industrial Internet of Things Systems**	**(08Hrs.)**
The Various Industrial Revolutions, Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, Support System for Industry 4.0, Smart Factories.		
Unit II	**Implementation System for IIoT**	**(08 Hrs.)**
Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes with Bluetooth, WiFi, and LoRa Protocols and IoT Hub systems.		

Unit III	IIoT Data Monitoring & Control	(08 Hrs.)
IoT Gate way, IoT Edge Systems and It's Programming, PLC and Wi-Fi enabled system, Cloud computing, Real Time Dashboard for Data Monitoring, Data Analytics and Predictive Maintenance with IIoT technology.		
Unit IV	**Cyber Physical Systems**	**(08 Hrs.)**
Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis		
Unit V	**Industrial IoT- Applications**	**(08 Hrs.)**
Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management.		
Unit VI	**Case Studies of IIoT Systems**	**(08 Hrs.)**
IIoT application development with Embedded PC based development boards, Development of mini-Project on new version of Operating systems and Edge development board. That project should also address to the current societal needs		

Term Work

1. Study of various application of internet on things in industry
2. Demonstration of Electro-Hydraulic system for Data storage and optimization using IoT
3. Demonstration of Electro-Pneumatic system for Data storage and optimization using IoT
4. Demonstration of PLC based Traffic light control system for Data storage and optimization using IoT
5. Development of IoT Cloud for classroom monitoring and generation of graphical result
6. Demonstration of any health monitoring application using IoT tools
7. Demonstration of automated toll collection system (using FASTTAG).
8. Industrial visit to any relevant organization where IoT based tool is implemented.

Project Based Learning

Students have to prepare and submit a demonstration models based on above syllabus.

Prepare a model/a chart/a case study based on following topic (Not limited to this)

1. Industrial Internet of Things in industry
2. Industrial Internet of Things system implementation element
3. IoT data Monitoring and control by PLC/Wi-Fi
4. Preductive maintenance in IIoT
5. Cyber physical system
6. IoT application for health care /Power plant/Quality control system

Text Books

1. daCosta, F., (2013), "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, ISBN: 9781430257417
2. Waher, P., (2015), "Learning Internet of Things," Packt Publishing, ISBN: 9781783553532
3. Ovidiu, V. and Friess, P., (2014), "Internet of Things - From Research and Innovation to Market Deployment," River Publishers, ISBN: 9788793102941,

4. Ida, N., (2020), “Sensors, Actuators and Their Interfaces,” SciTech Publishers, ISBN: 9781785618352
5. Pfister, C., (2011), “Getting Started with the Internet of Things,” O’Reilly Media, ISBN: 9781449393571

Reference Books

1. Bahga, A. and Madisetti, V., (2015), “Internet of Things - A Hands-on Approach,” Universities Press, ISBN: 9788173719547
2. Hajjaj, S S H. and Gsangaya, K. R., (2022), “The Internet of Mechanical Things: The IoT Framework for Mechanical Engineers,” CRC Press, ISBN: 9781032110950
3. Raj, P. and Raman, A. C., (2017), “The Internet of Things: Enabling Technologies, Platforms, and Use Cases,” Auerbach Publications/CRC Press, ISBN: 9781498761284
4. Adrian McEwen, A. and Cassimally, H., (2013), “Designing the Internet of Things,” John Wiley and Sons, ISBN:
5. Veneri, G., Capasso, A., (2018), “Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0,” Packt Publishing, ISBN: 9781789537222
6. Hersent, O, Boswarthick, D., Elloumi, O., (2012), “The Internet of Things: Key Applications and Protocols”, Wiley, ISBN: 9781119994350 7. Uckelmann, D., Harrison, M., Michahelles, F., (2011), “Architecting the Internet of Things,” Springer, ISBN: 9781119994350

Unit Tests

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

FUTUTE FACTORY

(Course No. C 404)

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

Course Prerequisites: -	The students should have knowledge of 1) Manufacturing Technology-I, II 2) Automatic Control System 3) Electro-Hydraulic and Pneumatics 4) Power Electronics & Drives 5) Object Oriented Programming (Using Python) 6) Programmable Logic Controller
Course Objectives: -	To provide Knowledge about 1. Modern manufacturing systems 2. To understand the concepts and applications of flexible manufacturing systems 3. To introduce the concept of smart factories, especially the various technologies involved within the smart manufacturing. 4. To introduce the applications and scope for technology involved in Industry 4.0.
Course Outcomes: -	The students should be able to– 1. Recognize the recent manufacturing trends related to Industry 4.0, FMS, and its implementation in manufacturing 2. Perform Planning, Scheduling, and control of Flexible Manufacturing systems 3. Identify the role of cloud manufacturing for smart factories, challenges, and scope 4. Understand and apply the concept of agile manufacturing and cyber security in future factory 5. Identify applications of AR and VR in smart manufacturing. 6. Understand and apply the concept of digital twins in future factory

Course Contents

Unit I	**Introduction to smart manufacturing technologies**	**(06 Hrs.)**
Introduction to Industry 4.0, Smart manufacturing, Related technologies, Traditional Factory and Smart Factory, The Smart Factory Opportunity, CIM wheel, CIMS Structure and Functions, Future Trends of smart Factory and applications. Introduction & composition of FMS, hierarchy of computer control, computer control of work center and assembly lines, FMS supervisory computer control, types of software specification and selection.		
Unit II	**Applications of FMS and factory of the future**	**(06 Hrs.)**
FMS application in machining, sheet metal fabrication, prismatic component production, aerospace application, FMS development towards factories of the future. Flexibility rules, Sustainability, Man in the factory, building blocks for the factory of the future, Building architecture and factory planning, IT Infrastructure and cyber security, Data Management, Machines and manufacturing systems.		

Unit III	Cloud Manufacturing and connected factory	(06 Hrs.)
Introduction to Cloud computing, Industrial Internet of Things, supply chain management, Big Data and Analytics, Big Data decision-making, , Automotive Cloud, warehouse operations, Augmented reality. Virtualization, Cloud Platforms, Big data in production, Cloud-based ERP and MES solutions, Connected factory applications, IT security for cloud applications.		
Unit IV	**Agile Manufacturing and Safety with Future Factory**	**(06 Hrs.)**
Agile Manufacturing: Introduction to Agile Manufacturing, Agile Manufacturing Principles, Implement Agile Manufacturing, Applications of Agile Manufacturing, Real-Time Data to Guide Iteration, Computer Vision to Augment Operators, Manufacturing Apps to Amplify Training Programs, Mass Customization. **Safety with Future Factory**: Introduction to cybersecurity, security principles, risk and opportunities in cybersecurity technology,		
Unit V	**Virtual and Augmented Reality, Machine Learning in Industry 4.0**	**(06 Hrs.)**
Introduction, Difference in AR and VR, Hardware and Software Technology, Industrial Applications of Augmented reality and Virtual reality. Basics of Machine Learning, The Machine Learning Process, Into Machine Learning working cycle, Preparing Data, Running Experiments, Finding the Model, Training the Model, Deploying and using a Model, Machine Learning in practice (examples of existing or future applications in the field of manufacturing)		
Unit VI	**Digital Twins**	**(06 Hrs.)**
Introduction to Digital Twins, Benefits, impact and challenges, Features and Implementation of Digital Twins, Computational tools, Types of Digital Twins, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing), digital twin in dynamical systems, Data-driven digital twins, methods in digital twin technology, Deep learning in digital twin technology.		

Term Work

List of Practical /Term work: -

(Term work shall consists of minimum 8 experiments based on above syllabus)

1. Study of FMS/CIM/Industry 4.0 technology in smart manufacturing applications.
2. Study of different applications of FMS and factory of future
3. Case studied on cloud manufacturing
4. Study of Cloud-based ERP.
5. Study of Agile manufacturing in smart manufacturing applications
6. Study of cyber security and its different applications in future factory
7. Design and Simulation of process automation using simulation software
8. Study of integration of robotics system with CNC Machine
9. Study of factory simulation using simulation software
10. Industrial visit to Automation Factory

Project Based Learning

Students have to prepare and submit a demonstration models based on above syllabus.

Prepare a model/a chart/a case study based on following topic (Not limited to this)

1. FMS/CIM/Industry 4.0 technology
2. Smart manufacturing
3. Cloud-based ERP
4. Agile Manufacturing
5. Safety with Future Factory
6. Use of Virtual and Augmented Reality for industrial applications.
7. Machine Learning working cycle

8. Digital Twins
9. Cyber security for mechanical industry.

Textbooks

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press,2020
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003
5. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.
6. Kalpakjian, "Manufacturing Engineering and Technology", Addison-Wesley Publishsing Co., 1995.
7. Taiichi Ohno, "Toyota Production System: Beyond large-scale Production", Productivity Press (India) Pvt. Ltd. 1992.
8. Smid P., CNC Programming Handbook, Industrial Press, 2005

Reference Books

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMHWeb
6. Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New AgeInternational Ltd., 1994.
7. Raouf, A. and Ben-Daya, M., Editors, "Flexible manufacturing systems: recent development", Elsevier Science, 1995.

Unit Tests

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

Robotic Programming -II
(Course No. C 405)

Designation of Course	**Robotic Programming -II**		
Teaching Scheme:	**Examination Scheme**		**Credits Allotted**
Theory: - ----	End Semester Examination		
Practical: 02 Hours/Week	Internal Assessment		
	Term Work	25 Marks	01
	Oral	25 Marks	
	Total	**50 Marks**	**01**

Course Prerequisites: -	1. C/C++ Programming 2. Python Programming 3. Robot fundamentals 4. VAL/VAL-II Robot Programming
Course Objectives: -	To provide knowledge about 1.Robot operating system 2 2.Robot Simulation Engines 3. Programming for path and motion planning
Course Outcomes: -	The students should be able to 1. To Understand the basic principles of Robotics programming and development. 2. To Learn Robot Simulation Engines 3. Design real world applications using available software. 4. Understand integration technologies and its applications 5. To Understand Mapping and SLAM 6. Identify problems in integrating the system / simulations / programming.

Course Contents

Unit-I	**Introduction to Robot Operating System 2 (RoS 2)**	**04 Hrs.**
Architectural overview of the Robot Operating System, Framework and setup with ROS2 environment, ROS2 workspace structure, essential command line utilities. ROS2 nodes, topics, services, parameters, actions and launch files.		
Unit-II	**Robot Simulation Engines**	**04 Hrs.**
Physics simulations of Robots with Gazebo, Mujoco and Pybullet C++/Python APIs. Programming nodes, topics, services, actions with C/C++/Python. Real time programming with ROS2.		
Unit-III	**Programming for Path Planning**	**04 Hrs.**
Intro to Path Planning and Navigation, Classic Path Planning, Number of classic path planning approaches that can be applied to low-dimensional robotic systems. Coding the BFS and algorithms in C++. Sample-Based and Probabilistic Path Planning and improvement using the classic approach. Programming in Move it framework.		
Unit-IV	**Programming for Motion Planning**	**04 Hrs.**
Use of EKF ROS package to a robot to estimate its pose. Monte Carlo Localization:- The Monte Carlo Localization algorithm which uses particle filters to estimate a robot's pose. Build MCL in C++ :- Coding the Monte Carlo Localization algorithm in C++. Simultaneous Localization and Mapping (SLAM) implementation with ROS2 packages and C++. Combining mapping algorithms with the localization concepts.		

Unit-V	Mapping and SLAM	04 Hrs.
Introduction to the Mapping and SLAM concepts and algorithms. Occupancy Grid Mapping:- Mapping an environment with the Occupancy Grid Mapping algorithm. Grid-based FastSLAM:- Simultaneous mapping an environment and localize a robot relative to the map with the Grid-based FastSLAM algorithm.		
Unit-VI	**Introduction to Microros**	**04 Hrs.**
Concepts of microros, Client library, features of microros, real time operating systems (RTOS- Free RTOS, Zephyr), implementation of microros on ARM/ESP32 based microcontrollers.		

Term Work:

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

1. Study of Nodes and Robot Operating system 2 (ROS 2) topic
2. Study of Services, actions in Robot Operating system 2 (ROS 2)
3. Mujoco and Gazebo Simulations through (ROS 2) programming
4. Simulation of 6-dof manipulator through program in ROS2
5. Simulation of autonomous vehicle (Mobile and field robots) through program in ROS2
6. Microros implementation on ESP32
7. Microros implementation on STM32L4
8. Motion planning with Moveit2 Discovery kit IoT

Textbooks:

1. Programming Robots with ROS, Morgan Quigley, Brian Gerkey, & William D Smart, SPD Shroff Publishers and Distributors Pvt Ltd., 2016

2.S.K. Saha "Introduction to Robotics", The McGraw Hills company.

References Books:

1. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernandez, PACKT publishing, 2013
2. Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System, Lentin Joseph, PACKT publishing, 2015

INTERNSHIP

(Course No. C 407)

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 have knowledge of 1. All courses up to B. Tech Semester VI.
Course Objectives: -	1. To expose technical student to the industrial environment. 2. To provide possible opportunities to learn, understand, 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 industrial organization.
Course Outcomes: -	The students should be able to– 1. Understand the latest changes in technological world and apply fundamental principles of science and engineering. 2. Create ability to identify, formulate and model problems and apply it to find engineering solutions based on a system approach. 3. Understand importance of sustainability and cost-effectiveness in design and development of engineering solution. 4. Create ability to be multi skilled engineer with a good technical knowledge, management, leadership, entrepreneurship skills. 5. Create awareness of social, cultural, global, and environmental responsibility as an engineer. 6. Create ability to communicate efficiently.

Course Contents

Introduction:

Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as the employers are looking for employees who are properly skilled and having awareness about industry environment, practices, and culture. Internship is structured, short-term, supervised training often focused on tasks or projects with defined time scales. Core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom and hence creating competent professionals in the industry and to understand 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 7 of at least 8 weeks (60 Days); and it is to be assessed and evaluated in semester 7.

Internship work Identification:

Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo 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 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 in vacation period after their 6th semester examination. Student can take internship work in the form of Online/onsite work from any of the following but not limited to:

- Working for 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 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, inter department research internship under research lab/group,
- micro/small/medium enterprise/online internship.

[1] https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf

Internship Diary/ Internship Workbook:

Students must maintain Internship Diary/ Internship Workbook. The main purpose of maintaining 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 Cell In-charge/faculty mentor or Industry Supervisor based on 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 internship supervisor (Internal and External – a supervisor from 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 concerned department as per 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 Understanding • Ethics • Regularity and punctuality • Attendance record • Logbook • Student's Feedback from External Internship Supervisor.

After completion of 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 Industrial Supervisor/

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

The report shall be presented covering 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, faculty coordinator should collect feedback about student with following recommended parameters: Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skill, individual work, Teamwork, Leadership, etc.

PROJECT STAGE -I

(Course No. C 406)

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

Course Prerequisites: -	The students should have knowledge of 1. Knowledge of basic concepts in Robot Programing. 2. Basic information of fundamentals of robotics. 3. Basic knowledge of Data Structures and Algorithm. 4. Knowledge of basic concepts in Robotics & Automation Engineering. 5. Basic knowledge of robot design.
Course Objectives: -	1. To identify problem for a specific need of an organization 2. To review literature on 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 6. To develop new equipment or make modifications in existing one

Course Contents

Details of Project Stage -I

1. The formation of a project team with members having similar interest.
2. Discuss the ideas within the team members and choosing a faculty member interested in 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 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 activities bar chart.
6. Third presentation of complete work with suggested modifications.

TOTALLY INTEGRATED AUTOMATION

(Course No. 408)

Designation of Course	**Totally Integrated Automation**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	60 Marks	04
Practical: - 02 Hours / Week	Internal Assessment	40 Marks	
	Term Work	25 Marks	01
	Total	**125 Marks**	**05**

Course Prerequisites: -	The students should have knowledge of 1. Knowledge of Signals and Systems, Instrumentation for Robotics & Automation 2. Knowledge of Basics of Sensors, PLC & HMI, Future Factory (FMS) 3. Knowledge of Digital Electronics, Automatic Control Systems and computer networking
Course Objectives: -	To impart knowledge on 1. Various automation needs of the industries. 2. Fundamental concepts of SCADA Systems 3. The utility of Distributed Control Systems and applications of DCS in Process Automation 4. Fundamentals of PAC 5. Concepts of HMI and SCADA 6. To gain knowledge in communication protocols in an integrated system
Course Outcomes: -	At the end of this course, students will demonstrate the ability to – 1. Outline the selection, and application of various TIA control elements 2. Discuss the configuration of SCADA functionalities with Tags, Screens, and Trends 3. Compare various communication protocols for automation system 4. Identify and differentiate various sub systems of DCS 5. Describe various functions of Interfaces in DCS. 6. Analyze and design an appropriate system for the industrial applications.

Course Contents

Unit I	**Introduction to Totally Integrated Automation (TIA)**	**(08 Hrs.)**
Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure. Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI.		
Unit II	**Supervisory Control and Data Acquisition (SCADA)**	**(08 Hrs.)**
Overview Developer and runtime packages, architecture, Tools, Tag, Internal & External graphics, Alarm logging, Tag logging, structured tags, Trends, history, Report generation, SCADA industrial applications and other sector viz; defence, agriculture and medical.		
Unit III	**Communication Protocols of SCADA**	**(08 Hrs.)**
Proprietary and open Protocols, OLE/OPC, DDE, Server/Client Configuration, Messaging, Recipe, User administration, Interfacing of SCADA with PLC, drive, and other field device.		
Unit IV	**Distributed Control Systems (DCS)**	**(08 Hrs.)**
Introduction : DCS Evolution, DCS Architecture, Comparison, Local Control unit, Process Interfacing Issues, Redundancy concept, Communication facilities, Case studies of Machine automation, Process automation, Comparison between SCADA and DCS.		

Unit V	Interfaces in DCS	(08 Hrs.)
Operator interfaces: low level, high level, Operator Displays, Engineering Interfaces: Low level, high level, General purpose computers in DCS, Interfacing between two industrial grade equipment's through PLC.		
Unit VI	**Industrial Plant Design**	**(08 Hrs.)**
Design criteria, Process sequencing, Plant layout modelling, Selection of industrial power and automation cables, Overview of plant simulation software. **Totally Integrated Automation in Digital Enterprise**- Automated engineering, Intelligent data management, Virtual commissioning, Cloud-based engineering, Preventive maintenance, Individualized mass production, Integrated energy management.		

Term Work

(Term work shall consists of minimum 8 experiments based on above syllabus)

Hands-on Experiments related to Course Contents in Totally Integrated Automation

1. Study of conveyor automation system using PLC, SCADA and Electrical drive.
2. Design of inspection automation system using sensors, PLC, HMI/SCADA.
3. Sizing and Selection of industrial power and automation cable for a typical application.
4. Design of simple water management system using PLC, SCADA and Electrical drive.
5. Design and Simulation of process automation using simulation software Viz. AUTOMATION STUDIO/ CIROS
6. Design and Simulation of robotic system using simulation software Viz. AUTOMATION STUDIO/ CIROS
7. Study of integration of robotics system with CNC Machine
8. Study of SIMATIC S7-1500, S7-1200, HMI PANEL and software SIMATIC STEP 7 based on TIA portal of Siemens.
9. Graphic image creation for operator control and monitoring
10. To prepare graphic object dynamic through programming for real time monitoring with an HMI
11. Troubleshooting and alarms with an HMI device
12. Industrial visit to automation industry
13. Interfacing between two industrial grade equipment's through PLC

Project Based Learning

Students have to prepare and submit a demonstration models/charts based on above syllabus
Following are the list of project-based learning (Not limited to)

1. To prepare a demonstration model/chart based on totally integrated automation.
2. To prepare a demonstration model/chart based on SCADA System.
3. To prepare a demonstration model/chart based on Communication system for SCADA
4. To prepare a demonstration model/chart based on DCS
5. To prepare a demonstration model/chart based on interfaces in DCS
6. To prepare a demonstration model/chart based on Industrial Plant Design

Text books

1. Kelly, John. W. Webb & Ronald A. Reis, "Programmable logic controllers: Principles and Applications", Prentice Hall India, 2003.
2. Michael P. Lukas, Distributed Control systems, Van Nostrand Reinfold Company1995
3. David Bailey, Edwin Bright, "Practical SCADA for industry", Newnes, Burlington, 2003.
4. Gordon Clarke, Deon Reyneders, Edwin Wright, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related systems", Newnes Publishing, 2004.

5. Win C C Software Manual, Siemens, 2003
6. RS VIEW 32 Software Manual, Allen Bradly, 2005
7. CIMPLICITY SCADA Packages Manual, Fanuc India Ltd, 2004
8. William T Shaw, "Cybersecurity for SCADA systems", PennWell, 2006.
9. Stuart G McCrady, "Designing SCADA Application Software", Elsevier, 2013.

Reference Books

1. SIMATIC STEP 7 in the Totally Integrated Automation Portal", SIEMENS AG, 2012.
2. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995.
3. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010.
4. "Anatomy of Automation"- Amber G.H & P. S. Amber, Prentice Hall. Principles of CIM by Vajpayee, PHI.

Unit Tests

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

El-II INDUSTRIAL PRODUCT DESIGN

(Course No. 409.1)

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:-	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, Environment and Ergonomic considerations to develop an industrial product.
Course Outcomes:-	Students should be able to 1. Understand fundamental concept of industrial product design 2. Understand and apply different product design methods 3. Understand the concept generation and develop the product specifications 4. Evaluate legal economic issues and select a prototyping method for industrial product 5. Evaluate the approaches of Aesthetic, Ergonomics and safety in industrial product 6. Understand design for manufacturing, assembly and environment and apply for industrial product

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, related system level design issue.		
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 – 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)
Its need, impact and quality, 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 environment 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. Live market survey with at least 100 customer for given product.
2. To develop 2D or 3D model of product architecture for selected product.
3. To develop 2D or 3D model by using any prototyping method.
4. Write the patent for given model and file the same.

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

1. A case study on market study to identify costumer needs
2. A case study on use of morphological analysis
3. A case study on Quality Function Development (QFD)
4. A case study of one aesthetic considerations 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 considerations in product design
9. A case study of one industrial safety considerations in product design

Text Books:

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, "ProductDevelopment", 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 WinstonKnight.

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

El-II PROJECT MANAGEMENT & ETHICS

(Course No. 409.2)

Designation of Course	**Project Management & Ethics**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ 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: -	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 apply the techniques specified by project management body of knowledge for effective project management. 3. To create awareness of social and professional responsibility among stakeholders
Course Outcomes: -	The students should be able to– 1. Understand concepts of project management and apply it to various phases in project life cycle 2. Understand economic models, evaluate project profitability and analyze risk management 3. Understand different cost estimating & forecasting methods to apply in project budgeting 4. Understand the methods of project planning, scheduling and apply it to reduce project duration 5. Understand the project execution, monitoring, control process and evaluate the performance of the project 6. Understand professional ethics of project management and apply it for organizational benefits

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 of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Scheduling:		

Introduction, Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, Measures of variability, CPM Model, Network Cost System.		
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. Identify 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 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 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

El-II ADDITIVE MANUFACTURING & RAPID PROTOTYPING

(Course No. 409.3)

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
Practical: - 02 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	25 Marks	01
	Total	**125 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1) Solid Modelling, Auto CAD 2) Manufacturing Technology I & II 3) Design & Analysis of Machine Components
Course Objectives: -	1) To understand the fundamental concepts of Additive Manufacturing (i.e., Rapid Prototyping) and 3-D printing, its 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, Bio-medical, Aerospace, Electronics etc.
Course Outcomes: -	The students should be able to– 1. Understand the importance of additive manufacturing process and AM process chain 2. Understand and apply Liquid-based and Solid Based additive manufacturing processes. 3. Understand and apply powder based additive manufacturing processes. 4. Understand and apply various Metal Additive Manufacturing process for different products 5. Apply various AM data formatting and data processing techniques for different products 6. Select suitable material for AM process and explore different applications of AM parts from various fields like Automobile, Aerospace, Bio-medical etc.

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, 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, Consequence 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, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D 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 Composites Materials, properties, characteristics, and application 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 appropriate 3D printing material and justify it for following application: -
   a. Prototyping
   b. medical appliances
   c. Construction.

10. Selection of 3d printing machine specification for following materials: -
    a. Polymers
    b. Composites
    c. Metals
11. To measure surface quality and mechanical properties of AM product
12. Study of CAM packages for AM

Project Based Learning

Students have to prepare and submit a demonstration models based on above syllabus (Not limited to)

1. To prepare a demonstration model/chart of 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 (Bio-medical, aerospace etc.)
6. To prepare a document on data formatting and data process 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

El-II IMAGE PROCESSING

(Course No. 409.4)

Designation of Course	**Image Processing**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ 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: -	Engineering Graphics, Python programming, AI
Course Objective: -	The students will learn about the basics of image processing in this course
Course Outcomes	Students shall be able to 1. Understand the fundamentals of digital image processing 2. Understand the basics of image enhancement and apply the knowledge in spatial domain. 3. Understand the basics of image enhancement and apply the knowledge in Frequency domain. 4. Apply knowledge of image restoration 5. Apply knowledge of morphing and colour processing to an image 6. Understand Image Compression and Application of IP

Course Contents

Unit I	**Digital Image Fundamentals**	**(06 Hrs.)**
What is Digital Image Processing, Origins of Digital Image Processing, Examples of fields that use DIP, Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Elements of Visual Perception, Image Sensing and Acquisition.		
Unit II	**Image Enhancement in the Spatial Domain**	**(06 Hrs.)**
Image Sampling and Quantization, Some Basic Relationships Between Pixels, Linear and Nonlinear Operations. Some Basic Intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters		
Unit III	**Frequency Domain**	**(06 Hrs.)**
Preliminary Concepts, The Discrete Fourier Transform (DFT) of Two Variables, Properties of the 2-DDFT, Filtering in the Frequency Domain, Image Smoothing and Image Sharpening Using Frequency Domain Filters, Selective Filtering		
Unit IV	**Restoration:**	**(06 Hrs.)**
Noise models, Restoration in the Presence of Noise Only using Spatial Filtering and Frequency Domain Filtering, Linear, Position-Invariant degradations Estimating the		

Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering		
Unit V	**Morphological Image Processing**	**(06 Hrs.)**
Morphological Image Processing: Preliminaries, Erosion and Dilation, Opening and Closing. Image Processing: Color Fundamentals, Color Models, Pseudo color Image Processing.		
Unit VI	**Image Compression and Application of IP**	**(06 Hrs.)**
Image Compression: Fundamentals, Models, Error Free and lossy compressions, Standards Applications of IP: satellite, sonar, radar and medical uses		

Term work

1. Image Printing Program Based on Half toning.
2. Reducing the Number of Intensity Levels in an Image.
3. Zooming and Shrinking Images by Pixel Replication.
4. Zooming and Shrinking Images by Bilinear Interpolation.
5. Arithmetic Operations.
6. Image Enhancement Using Intensity Transformations.
7. Histogram Equalization.
8. Spatial Filtering.
9. Enhancement Using the Laplacian.
10. Unsharp Masking

Text Books:

1. Digital Image Processing by Bhabatosh Chanda and Dwijesh Majumder, PHI
2. Fundamentals of Digital Image Processing by Anil K Jain, PHI
3. Digital Image Processing Using Matlab, Rafel C. Gonzalez and Richard E. Woods, Pearson Education.

Reference Books:

1. Kenneth R. Castleman, Digital Image Processing‘, Pearson, 2006.
2. D,E. Dudgeon and RM. Mersereau, Multidimensional Digital Signal Processing‘, Prentice Hall Professional Technical Reference, 1990.
3. William K. Pratt, Digital Image Processing‘, John Wiley, New York, 2002

Project based learning

Projects related to

1. Image Printing Program Based on Halftoning.
2. Reducing the Number of Intensity Levels in an Image.
3. Zooming and Shrinking Images by Pixel Replication.
4. Zooming and Shrinking Images by Bilinear Interpolation.
5. Arithmetic Operations.
6. Image Enhancement Using Intensity Transformations.
7. Histogram Equalization.
8. Spatial Filtering.
9. Enhancement Using the Laplacian.
10. Unsharp Masking

INDUSTRIAL ENGINEERING & MANAGEMENT

(Course No. 410)

Designation of Course	**Industrial Engineering & Management**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
	Internal Assessment	40 Marks	
	Total	**100 Marks**	**03**

Course Prerequisites: -	The students should have knowledge of 1. Fundamentals of Mechanical Engineering 2. Manufacturing Process 3. Advanced Manufacturing Processes
Course Objectives: -	To impart knowledge on 1. The fundamentals of management 2. Types of business organization and its structure 3. Fundamentals of main four departments of an organization i.e. finance, production, marketing and personnel 4. Details of method study tool of industrial engineering 5. Details of work measurement tool of industrial engineering 6. Details of ergonomics and industrial safety tool of industrial engineering
Course Outcomes: -	At the end of this course, students will demonstrate the ability to – 1. **Understand** fundamentals of management 2. **Understand** and select different types of business organizations and it's structure 3. **Evaluate** fundamentals of main four departments of an organization i.e. finance, production, marketing and personnel 4. **Understand** and **Analyze** the details of method study tool used in industrial engineering 5. **Understand** and **Analyze** the details of work measurement tool used in industrial engineering 6. **Understand** and **Analyze** the details of ergonomics and industrial safety tool used in industrial engineering

Course Contents

Unit I	**Management-An Introduction**	**(08 Hrs.)**
Management- Meaning and Definitions, Management, Administration, and Organization concepts, Management as an Art and Science and a profession, contribution of various thinkers to management thought, Types and Functions of Management. Different approaches to management – scientific, operational, human and system approach		
Unit II	**Organization**	**(08 Hrs.)**
Different forms of business Organization – Individual proprietorship, Partnership, Joint stock company, Co-Operative enterprise, Public Sector, Undertakings, organizational structures in Industries, Line, Functional, Line and functional, Project, Matrix Organization and Committees		
Unit III	**Financial, Marketing and Personnel Management**	**(08 Hrs.)**
Personnel Management-Definitions Recruitment, Selection and training of the employees, Job valuation and Merit rating, wage administration different methods of wage payments, incentives. Marketing Management-Definitions, Marketing and Selling concept, market segmentation, distribution channels, Market Research, Advertising and sales promotion and Sales forecasting. Financial Management-Capital structure, Fixed capital, working capital, sources of finance, cost analysis, Break even analysis, Depreciation and Financial statement.		

Unit IV	Method Study	(08 Hrs.)
Steps in method study, tools and techniques used, process chart symbols, flow diagrams, two handed chart, multiple activity chart, use of motion pictures and its analysis. SIMO charts, chorno & cycle graph, developing, presentation, installation and maintenance of improved methods.		
Unit V	**Work Measurement**	**(08 Hrs.)**
Time Study: Aim and objectives , terminology and tools, use of stop watch procedure in making a time study, elements, selection of operations time study forms, handling of foreign elements. Performance rating. **Allowances**: Personal, Fatigue and other allowances. Analysis and calculation of Standard Time. Determination of number of cycle's time study for indirect functions such as Maintenance, Marketing etc., MOST Technique. **Works Sampling**: Definition, Objectives, theory of Work Sampling. Other applications of work sampling, errors in work sampling study. **Synthetic and Standard data Methods**: Concepts, introduction to PMTS, MTM-1, WF, Basic motion time, MTM-2, and other second – generation methods timing of group operations		
Unit VI	**Ergonomics and Industrial Safety**	**(08 Hrs.)**
Definitions, importance in industry, basic anatomy of human body, anthropometrics, measurement of physical work and its techniques, work and rest cycles, bio mechanical factors environment effects. Importance of safety, planning, training, safety precautions, safety Equipment's, Government regulations on safety.		

Project Based Learning

Students have to prepare and submit a demonstration models/charts based on above syllabus
Following are the list of project-based learning (Not limited to)

1. Management: Types, Functions, Principles
2. Study of organization Structure
3. Study of Business organizations
4. Study of Financial, Marketing and Management
5. Study of Personnel Management
6. Study of Method Study methods and procedure
7. Study of Method Study charts
8. Study of Work Measurement methods and procedure
9. Study of Time study procedure and problems
10. Study of Work sampling and problems
11. Study of Ergonomics
12. Study of Industrial Safety

Text Books:

1. O. P. Khanna, Industrial Engineering & Management, Dhanapat Rai & Sons.
2. M. C. Shukla, Business Organization and Management, S. Chand & Co. Ltd, New Delhi.
3. Harold Koontz & Heinz Enrich, Essentials of Management, McGraw Hill International.
4. M. N. Mishra, Organizational Behavior, Vikas publishing New Delhi.
5. Dale Yoder, Personnel Management.
6. Work Study, ILO.

Reference Books:

1. S. S. Patil, Industrial Engineering & Management, Electro tech Publication.
2. Mansoor Ali &Dalela, Industrial Engineering & Management System, Standard Publisher distributions.

3. R. M. Currie, Work Study, ELBS.
4. Management by James A. F. Stoner, R. Edward Freeman, PHI
5. Management Today: Principles and Practice by Gene Burton and Manab Thakur, TMH
6. Organizational Behavior by Keith Davis, TMH
7. Management (Tasks, responsibilities and Practices) by Peter Drucker, Harper Business
8. Production Management by Lockyer, ELBS
9. Modern Production Management by E. S. Buffa (John Wiley)
10. Financial Management by Vanhorne, PHI
11. Financial Management (Theory and Practice) by Prasanna Chandra, TMH
12. Marketing Management by Philip Kotler, Pearson Edition
13. Marketing Management by Rajan Saxena, TMH
14. Personnel Management by Edward Flippo, TMH
15. Industrial Engineering and PPC" by A.K Bewwor and V.A.Kulkarni.

Unit Tests

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

FIELD & SERVICE ROBOTS

(Course No. 411)

Designation of Course	**Field & Service Robots**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 03 Hours/ Week	End Semester Examination	60 Marks	03
Tutorial: - 01 Hours/ Week	Internal Assessment	40 Marks	
	Tutorial		01
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Sensor technology 2. Artificial Intelligence for robotics 3. Robot programming
Course Objectives: -	To impart knowledge on 1. The applications and current trend in field and service robot (FSR) 2. Path planning algorithms inside a field/service robot for navigation 3. Interaction interface concepts for humanoid robot
Course Outcomes: -	The students should be able to– 1. Describe the applications and current trend in field and service robot 2. Explain about the kinematic modeling of mobile robots 3. Identify, formulate and solve algorithm related to localization, obstacle avoidance, and mapping 4. Apply and program robot for reactive concepts for robot interaction with human, between machines and among robots 5. Analyze the concepts of balancing legged robots and interaction interface concepts for humanoid robot 6. Implement path planning algorithms inside a field/service robot for navigation.

Course Contents

Unit I	**Introduction**	**(08 Hrs.)**
History of service robotics, Present status and future trends, Need for service robots, applications examples and Specifications of service and field Robots. Non-conventional Industrial robots.		
Unit II	**Localization**	**(08 Hrs.)**
Introduction-Challenges of Localization, Map Representation, Probabilistic Map based Localization, Monte Carlo localization, Landmark based navigation, Globally unique localization, Positioning beacon systems, Route based localization.		
Unit III	**Planning and Navigation**	**(08 Hrs.)**
Introduction-Path planning overview, Road map path planning, Cell decomposition path planning, Potential field path planning, Obstacle avoidance, Case studies: Tiered robot architectures.		
Unit IV	**Field Robots**	**(08 Hrs.)**
Ariel robots, Collision avoidance, Robots for agriculture, mining, exploration, underwater, Civilian and military applications, Nuclear applications, Space applications.		
Unit V	**Humanoids**	**(08 Hrs.)**
Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration.		
Unit VI	**Human Recognition and Application of FSR**	**(08 Hrs.)**

Image Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications - Case studies.

Project Based Learning

1. Need for service robot.
2. Experiment on robot kinematics.
3. Probabilistic Map based Localization-Monte carlo localization
4. Global & Local path planning in robotics.
5. Assignment on Metrical maps - Grid maps - Sector maps – Hybrid Maps.
6. Case study on Human activity recognition using vision, touch, sound etc.
7. Use of PUDU Bot mobile robot for office work.

Text books

1. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer, 2011.
2. Sebastian Thrun, Wolfram Burgard, Dieter Fox, “Probabilistic Robotics”, MIT Press, 2005.
3. Karsten Berns, Ewald Von Puttkamer, “Autonomous L and Vehicles Steps towards Service Robots”, Vieweg Teubner Springer, 2009.
4. Bruno Siciliano, Oussama Khatib, Springer Hand book of Robotics, Springer, 2008.

Reference Books

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, „Introduction to Autonomous Mobile Robots‖, Bradford Company Scituate, USA, 2004
2. Riadh Siaer, „The future of Humanoid Robots- Research and applications‟, Intech Publications, 2012.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2005.

Unit Tests

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

MOBILE ROBOTS & DRONE TECHNOLOGY

(Course No. 412)

Designation of Course	**Mobile Robots & Drone Technology**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory------- Hours/ Week	End Semester Examination	---	---
Practical: - 02 Hours/ Week	Internal Assessment	---	
	Term Work	25 Marks	01
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**01**

Course Prerequisites: -	The students should have knowledge of 1. Robotics Simulation softwares 2. Robotic Control Systems 3. Artificial Intelligence in Robotics.
Course Objectives: -	1. To recognize and describe the role of Mobile Robots & Drone Technology (MRDT) in past, present, and future society. 2. To comprehend and explain various components of MRDT. 3. To comprehend and explain basics of flight and flight control systems. 4. To understand and describe basics of underwater robots.
Course Outcomes: -	The students should be able to– 1. Understand the challenges in developing autonomous mobile Robots. 2. Abstract kinematic control of wheeled mobile Robots. 3. Understand the challenges involved in sensory perception for mobile Robots. 4. Ability to design UAV drone system. 5. To understand working of different types of engines and its area of applications. 6. To understand static and dynamic stability dynamic instability and control concepts. 7. To know the loads taken by aircraft and type of construction and also construction materials in them.

Course Contents

Unit I	**Introduction to mobile robots**	**(04 Hrs.)**
Introduction to Mobile robots, Locomotion, Classification -Legged, hopping, Wheeled, Aerial, Key issues in locomotion , Degree of mobility and steerability, robot maneuverability, kinematic modelling of Mobile robot, Wheel kinematic constraints Motion control, Kinematic models of simple car and legged robots.		
Unit II	**Control of Mobile Robots**	**(04 Hrs.)**
Control theory, Control design basics, Cruise-Controllers, Performance Objectives, State space modelling of mobile robots, Linearization, LTI system , Stability, PID control, basic control algorithms, Low-level, control. State space control, backstepping control.		
Unit III	**Perception and Actuation**	**(04 Hrs.)**
Sensors for mobile robots, Classification, performance, uncertainty in sensors , Wheel sensor, Heading sensor, Accelerometer, Inertial measurement, Motion sensor, range sensors, Global positioning system (GPS), Doppler effect-based sensors, Vision sensor , Basics of computer vision, Image processing techniques, Feature extraction – image, Range data location recognition, Actuator systems: Types of motors, DC, AC servo systems, Linear actuation systems.		

Unit IV	Introduction and Design of UAV Drone Systems	(04 Hrs.)
Introduction to Unmanned Aircraft Systems, History of UAV drones, classification of drones, System Composition, Applications. Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards and Regulatory Aspects-India Specific, Design for Stealth.		
Unit V	**Avionics Hardware of Drones**	**(04 Hrs.)**
Autopilot, AGL-pressure sensors-servos-accelerometer - gyros-actuators - power supply-processor, integration, installation, configuration.		
Unit VI	**Payloads, Controls, Navigation and Testing**	**(04 Hrs.)**
Payloads, Telemetry, Tracking, controls-PID feedback, radio control frequency range, modems, memory system, simulation, ground test-analysis-trouble shooting. Waypoints navigation, ground control software, System Ground Testing, System In-flight Testing, Future Prospects and Challenges.		

Term Work

1. Calculation of steerability, mobility and maneuverability of various mobile robot wheel configurations
2. Designing of kinematic models of wheels.
3. Interfacing and speed control of Robot wheel using PWM signal
4. Tuning PID controller using ZN method and estimation of speed
5. Backstepping control of linear path.
6. Interfacing a GPS module to a mobile robot.
7. Range data detection using a LIDAR module and ultrasonic module.
8. To demonstrate speed control of BLDC Motor using PWM technique.
9. To measure the frequency and level of RF signals using of spectrum analyzer.
10. To configure, test and perform communication of FCB with motor, GPS, ESC and sensors.
11. To write technical specification sheet for different types of the drone and for it's application.
12. To identify different features of controls of HD and thermal image of camera used in drone.
13. To identify of different types of SMD IC packages.
14. To identify different types of ports and connectors.
15. To study and sketch various frame structure viz. quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa+ and hexa S).
16. Practices on various drone assembly materials.

Textbooks

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

2012. 978-0691149219
11. Cares & Dickmann, Operations Research for Unmanned Systems. Wiley, 2016. 978-1-118-91894-4.

Reference Books

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

Unit Tests

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

DESIGN OF INTEGRATED ROBOTIC CELLS

(Course No. 413)

Designation of Course	**Design of Integrated Robotic Cells**		
Teaching Scheme:	**Examination Scheme**		**Credits Allotted**
Theory: --- Hours/Week	End Semester Examination		
Practical: 04 Hours/Week	Internal Assessment		
	Term Work	25 Marks	02
	Oral/Practical	25 Mark	
	Total	**50 Marks**	**02**

Course Prerequisites: -	1. Drafting Software like Auto-CAD, CATIA 2. Robotic Simulation Software 3. Engineering Mathematics
Course Objectives: -	To provide knowledge about 1. Robot Cell Design 2. Robotic Design optimization techniques 3. Robotic Cell design in Manufacturing
Course Outcomes: -	The students should be able to 1. To Understand Robot cell design 2. To Understand robot control system design 3. To Design robot drive system 4. To Estimate robotic design optimization technique 5. To Design robot in Manufacturing 6. To Design mobile Robot

Course Contents

Unit-I	**Introduction to Robotic Cell Design Concept**	**04 Hrs.**
Principle of Robotic Cell Design, Robot Cell design outlet, Robotic cell design concept and process, objective tree in design, Function analysis, grant chart, Purpose of Experiment and test in design, design consideration for ocean robot.		
Unit-II	**Robot Control system design**	**04 Hrs.**
Feedback control system design, types of control systems, open and closed loop control systems, and state-space models, MATLAB SISO design tool.		
Unit-III	**Robot Drive Train Design**	**04 Hrs.**
Characteristics of servomotors and gearboxes in industrial robots, Trajectory generator, Design method - Motor model and Gear box model.		
Unit-IV	**Design Optimization Technique**	**04 Hrs.**
Characteristics of objective functions for design optimization based on robot simulations, Optimization algorithms - Gradient based algorithms, Genetic algorithms, The Complex algorithm, The Complex-RF, Complex-RD – A modified version for discrete variables, Complex-RFD – An optimization algorithm for mixed variables, Adaptive Complex method.		

Unit-V	Robotic Cell design and Manufacturing	04 Hrs.
Introduction, Application of Robotics cell in manufacturing, Inline Mechanical Assembly cell, Electronic Sensor assembly cell.		
Unit-VI	**Design of Mobile Robot**	**04 Hrs.**
The design criteria of mobile robot structure, movement type and wheel selection, material selection, Design calculation, Structural simulation by any analysis software.		

Term Work:

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

1. Case Study of Robotic Cell Design Concept
2. Case Study of Robot Control system design
3. Case Study of Robot Drive Train Design
4. Case Study of Robotic cell Design Optimization Technique
5. Case Study of Robotic Cell design and Manufacturing
6. Case Study of Design of Mobile Robot
7. Case Study of Design of Agricultural application robot
8. Case Study of Design of Field and service robot
9. Case Study of Design of Bomb diffusing robot

Text Books:

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.
3. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.

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. S.R. Deb, "Robotics Technology and Flexible Automation", TMH, 2nd Edition, 2010.
4. Mike Wilson, "Implementation of Robotic Systems"

PROJECT STAGE -II

(Course No. 414)

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 have knowledge of 1. Knowledge of basic concepts in Robot Programing. 2. Basic information of fundamentals of robotics. 3. Basic knowledge of Data Structures and Algorithm. 4. Knowledge of basic concepts in Robotics & Automation Engineering 5. Basic knowledge of robot design
Course Objectives: -	1. To fabricate the designed equipment 2. To conduct laboratory and field testing of the new equipment 3. To analyze performance of the equipment with different performance parameters 4. To make changes in design if necessary, based on the performance analysis 5. To prepare project report and deliver presentation. 6. To work sincerely as a member of team
Course Outcomes: -	The students should be able to– 1. Understand the latest changes in technological world and apply fundamental principles of science and engineering. 2. Create ability to identify, formulate and model problems 3. Understand importance of sustainability and cost-effectiveness in design and development of engineering solution. 4. Create ability to be multi skilled engineer with a good technical knowledge, management, leadership, entrepreneurship skills. 5. Create awareness of social, 6. Create ability to communicate efficiently.

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

   - Experimentation work
   - Testing of equipment's
   - Preparing a project report

2. The work will be evaluated through three presentations with aim of observing the progress and suggesting modifications for completing the project.