FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(CBCS Curriculum for the Academic Year 2019-2020)

and

Syllabi

B.E. VII and VIII Semester

of

Four Year Degree Programme

In

Mechanical Engineering

(With effect from the academic year 2019– 2020)
(As approved in the faculty meeting held on 25-06-2019)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2019

SCHEME OF INSTRUCTION & EXAMINATION
B.E. VII - Semester
(MECHANICAL ENGINEERING)

S. No.	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1	**PC 701 ME**	Thermal Turbo Machines	3	1	-	4	30	70	3	3
2	**PC 702 ME**	Finite Element Analysis	3	1	-	4	30	70	3	3
3	**PC 703 ME**	Industrial Engineering	3	-	-	3	30	70	3	3
4	**PC 704 ME**	Production And Operations Management	3	-	-	3	30	70	3	3
5	**HS 901 MB**	Managerial Economics and Accountancy	3	-	-	3	30	70	3	3
6		Open Elective-II								
7		Open Elective-III	3	-	-	3	30	70	3	3
Practical/ Laboratory Courses										
8	**PC 751 ME**	Thermal Engineering Lab	-	-	2	2	25	50	3	1
9	**PC 752 ME**	CAE Lab	-	-	2	2	25	50	3	1
10	**PW 761 ME**	Project Work – I	-	-	4	4	50	-	-	2
11	**SI 762 ME**	Summer Internship	`	-	-	-	50	-	-	2
			21	**02**	**08**	**31**	**360**	**590**		**27**

Open Elective – II			**Open Elective – III**		
S. No.	Course Code	Course Title	S. No.	Course Code	Course Title
1	**OE 771 CE**	Green Building Technologies	1	**OE 781 CE**	Road Safety Engineering
2	**OE 772 CS**	Data Science Using R Programming	2	**OE 782 IT**	Software Engineering
3	**OE 773 EC**	Fundamentals of IoT	3	**OE 783 EC**	Principles of Electronic Communications
4	**OE 774 EE**	Non-Conventional Energy Sources	4	**OE 784 EE**	Illumination and Electric Traction systems
5	**OE 775 ME****	Entrepreneurship	5	**OE 785 ME****	Mechatronics

PC: Professional Course PE: Professional Elective
L: Lectures T: Tutorials P: Practical D: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note: 1) Each contact hour is a Clock Hour
2) The practical class can be of two and half hour (clock hours) duration as per the requirement of a particular laboratory.

Note-2: * The students have to undergo a Summer Internship of four weeks' duration after VI semester and credits will be awarded in VII semester after evaluation.
** Subject is not offered to the students of Mechanical Engineering Department.

Course Code	Course Title						Core / Elective
PC 701 ME	**Thermal Turbo Machines**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Thermal Engineering	**3**	**1**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn about formulation of governing equations for compressible fluid flows
- To understand the design concepts of mechanical devices handling compressible fluids
- To learn about the functioning of turbomachines and related performance parameters.

Course Outcomes

After completing this course, the student will be able to

1. Formulate the problems related to fluid flow
2. Explain the working principle of mechanical devices handling compressible fluids
3. Analyse the turbomachines for its performance parameters

UNIT-1

Introduction to compressible flows: Speed of propagation of pressure waves, Mach number, Acoustic velocity and Mach cone, limits of compressibility, pressure field due to a moving source of disturbance, one dimensional compressible flow.

Isentropic flow with variable area, Mach number variation, Area ratio as function of Mach number, flow through nozzles and diffusers.

Flow in constant area ducts with friction-Fanno flow, variation of flow properties, variation of Mach number with duct length, isothermal flow with friction

UNIT-II

Flow in constant area duct with Heat Transfer, -The Rayleigh liner, Rayleigh flow relations, variation of flow properties, Maximum heat transfer.

Flow with Shock Waves-Development of Normal Shock waves, governing equations, Prandtl -Meyer relation, Rankine-Hugoniot equations, Stagnation pressure ratio across shock.

UNIT-III

Blade nomenclature of an aerofoil, Rotodynamic compressors: Introduction and general classification, Comparison of Reciprocating and Rotary compressors, Positive displacement Rotary compressors, Flow through rotary compressors. Static and total head quantities, Thermodynamic cycles and work done, calculation of various efficiencies. Velocity diagrams and prewhirl. Euler equation for energy transfer between fluid and rotor, Analysis of Centrifugal compressors and analysis of axial flow compressors, Chocking, Surging and Stalling.

UNIT-IV

Steam Turbines: Classification, flow over blades, pressure velocity variations, Compounding of steam turbines- pressure compounding, velocity compounding and pressure-velocity compounding, Impulse turbine with several blade rings, Nozzle efficiency, Blade efficiency and Gross stage efficiency of Impulse turbine, Velocity diagrams for Impulse turbine-De Laval Turbine, blade efficiency of Impulse turbine, Optimum blade speed ratio, Maximum work done and blade efficiency of Impulse turbine, Degree of reaction of Reaction turbine, Parson Reaction turbine, Velocity diagram for Parson Reaction turbine, blade efficiency of Parson Reaction turbine, Maximum work done and blade efficiency of Parson Reaction turbine, Height of blades of Reaction turbine, Balancing of End thrust.

UNIT-V

Gas Turbines: Applications and Classification of Gas Turbines- constant pressure and constant volume gas turbines, Joule cycle-configuration diagram and temp-entropy diagram, Thermal efficiency of Joules cycle, Maximum pressure ratio in terms of temperature ratio, optimum pressure ratio for maximum work output with and without considering machine efficiencies, Improvement of gas turbine plant performance- Inter-cooling, Reheating and Regeneration. Simple Problems on Joule cycle.

Air Craft Propulsion: Air craft engine types, air craft propulsion theory, Turbo jet engines, Ramjet engines, Pulse jet engines, Rocket Propulsion: Types of Propellants, Types of Rocket engines, Rocket propulsion Theory-Rocket applications.

Suggested Readings:

1. Yahya S M, *Fundamentals of Compressible Flow,* New Age International Publishers, Third Edition, 2007.
2. Mathur ML, & Mehta F S, *Thermal Engineering,* Jain Brothers, New Delhi, 2003.
3. Dennis G Shepherd, *Aerospace Propulsion,* Elsevier Publishing Company, New York, 1995.
4. Cohen H Rogers G F C, SaravanaMutto H I H, *Gas Turbine Theory,* Longman 5th Edition, New York, 2004.
5. Ganeshan V, *Gas Turbines,* Tata Me Graw Hills, New Delhi, 2003
6. Yadav, R *Steam and Gas Turbines,* Central Publishing House Ltd, Alllahabad, 2003.

Course Code	Course Title						Core / Elective
PC 702 ME	**Finite Element Analysis**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
EM, MOM, FM, HT	**3**	**1**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand the theory and application of the finite element method for analysing structural systems.
- To learn Approximation theory for structural problems as the basis for finite element methods
- To learn formulations for a variety of elements in one, two, and three dimensions. Implementations of element formulations will be examined using Matlab.
- To understand modelling and analysis of structures using planar, solid, and plate elements

Course Outcomes

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

1. Summarize basic equations of elasticity and formulate finite element modelling of one dimensional element using Potential energy approach.
2. Formulate finite element modelling of truss and frame elements along with the concepts of transformation from local to global matrices.
3. Interpolate Hermitian shape function of beam element in natural coordinate system.
4. Develop stiffness matrix for a plane stress & plane strain conditions on a CST, Axisymmetric elements by interpolating shape functions in natural coordinate system.
5. Interpolate the shape functions of Isoparametric elements and to present the use of numerical integration to evaluate the element matrices in typical 2D problems. Formulate finite element model to steady state heat transfer analysis using one & two dimensional elements.
6. Formulate mass and stiffness matrices of 1D & beam elements to establish Eigen values &Eigen vectors using Lagrangian and Hamilton principles. Develop finite element model for 3D problems in stress analysis and explain the concepts of convergence criteria.

UNIT-I

Introduction: Introduction to Finite Element Method for solving field problems, Stress and Equilibrium, Boundary conditions, Strain, Displacement, Stress-Strain relations.

One dimensional problems: Finite element modelling coordinates and shapes functions, Potential Energy approach: Assembly of Global stiffness matrix and load vector, Finite element equations, Treatment of boundary conditions, Galerkin's approach, Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Element stiffness matrix for a truss member, Analysis of plane truss with two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node, Analysis of Beams: Element stiffness matrix for two nodes (two degrees of freedom per node).

UNIT-III

Finite element modelling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Finite element modelling of axi-symmetric solids subjected to axi-symmetric loading with triangular elements.

UNIT-IV

Two dimensional four noded iso-parametric elements and numerical integration. Steady state heat transfer analysis: One dimensional analysis of a fin and two dimensional analysis of thin plate, Analysis of circular shaft subjected to torsion.

UNIT-V

Dynamic Analysis: Formulation of finite element model, element matrices, Evaluation of Eigen values and Eigen vectors for a stepped bar and a beam, Time dependent field problems: Application to one dimensional heat flow in a rod. Introduction to finite element formulation of three dimensional problems in stress analysis, Convergence requirements. Introduction to Finite Element Analysis Software.

Suggested Readings:

1. G. Ramamurthy, Applied Finite Element Analysis, I.K. International Publishing House Pvt.Ltd., New Delhi, 2009.
2. Tirupathi R, Chandraputla and Ashok D Belagundu, Introduction to Finite Elements in Engineering, PHI,1997.
3. Rao S S, The Finite Element Method in Engineering, Pergamon Press, 1989.
4. Segerlind L J, Applied Finite Element Analysis, Wiley Eastern, 1984.
5. Reddy JN, An Introduction to Finite Element Method, McGraw-Hill, 1984.

Course Code	Course Title						Core / Elective
PC 703 ME	**Industrial Engineering**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn the concept of Management.
- To understand role of Production Planning and Control in Industry.
- To learn various material procurement policies.
- To understand importance of quality control and various methods.
- To interpret the role of Decision theory in Industry.

Course Outcomes

After completing this course, the student will be able to

1. Explain various approaches for industrial management. Able to infer concept of management in human resource domain
2. Apply Philosophy of Production Planning and Control in Industry and control the activities in delivering the products in time
3. Determine the optimum requirement of inventory by developing the various quantitative models.
4. Develop various models or methods for ensuring the required quality of the products or processes.
5. Elaborate the role of Decision theory and apply various approaches under Uncertainty and Risk conditions

UNIT-I

Management: Introduction to Management, Scientific Management, Systems approach to Management, MBO, and Decision Making Process.

Personnel Management: Functions of personnel management, types of training, Job evaluation and Merit rating, Collective bargaining and labour participation in management.

UNIT-II

Production Planning & Control: Definition, Objectives, Importance and Functions of Production Planning & Control.

Production Control: Routing, Scheduling, Dispatching, Follow-up and progress Report.

UNIT-III

Inventory Control: Importance of inventory control, types of inventory models Inventory costs deterministic inventory models Basic EOQ models, production model without shortages, Purchase model with instantaneous replenishment and with shortages production model with shortages Inventory model with price breaks, Fixed order quality system, periodic review system Inventory model with probabilistic demand

UNIT-IV

Quality Control: Concept of quality, evolution of quality control, assignable and chance causes of variation, Variable Control charts (X and R charts)

Attributes control charts: P chart and C chart

Acceptance Sampling – Single Sampling, Double Sampling and Multi sampling plans – OC curves of single sampling plans

UNIT-V

Decision Theory: Introduction, Decision, Decision Making & Decision Theory, Types of Decisions, decision making process, Types of Decision making Environment:

Decision making under Uncertainty- Criterion of Optimism or Maximax, Criterion of Pessimism or Maximin, Minimax decision criteria

Decision making under Risk: Expected Monetary Value(EMV), Expected Opportunity Loss (EOL) Criterion & Expected Value of Perfect Information(EVPI) Criterion

Decision Trees

Suggested Readings:

1. M.Mahajan, *"Industrial Engineering and Production Management"*, Dhanpatrai& sons, New Delhi
2. S.K. Sharma and Savitasarma, *"Industrial Engineering and Organization Management"*, SK Kataria& Sons, New Delhi.
3. S.D. Sharma, "*Operations Research*", Kedarnnath, Ramnath& Co., Meerut, 2009
4. S Kalavathi, "*Operations Research"*, Vikas Publishing House Pvt. Ltd, 2009
5. V. K. Kapoor, "*Operations Research"*, S. Chand, New Delhi.
6. SK Sharma &Savita Sharma," A course in Industrial Engineering & Operations Management", S K Kataria& Sons, 2008.

Course Code	Course Title						Core / Elective
PC 704 ME	**Production and Operations Management**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand the concept of Production & Operations Management.
- To understand role of work study and work measurement in Industry.
- To learn use of forecasting and various methods of it.
- To understand importance Aggregate planning, Materials Requirement Planning for Industry.
- To understand Project Management approaches in completion of Project.

Course Outcomes

1. Explain various types of Production Systems, develop suitable layout for a given plant
2. Develop various methods for work study and apply suitable Recording techniques. Develop standard procedures and time for the operations.
3. Explain necessity of Forecasting and various methods of it. Develop suitable quantitative forecasting technique for the given past data. Compare accuracy of models in connection with forecast errors.
4. Explain Aggregate planning & Mater scheduling, Materials Requirement Planning Processes. Develop quantitative models for Material requirement and resources based on time span.
5. Elaborate the usages of PERT/CPM techniques for a give project and develop suitable quantitative model for the project in successful competition by identifying the time constraints for start and end of process activities.

UNIT-I

Production & Operations Management: Introduction, Types of production Systems. Job shop, Batch, Flow shop.

Plant location and layout: Factors affecting plant location, Break even analysis, plant layout objectives, Types of layouts, merits and demerits.

UNIT-II

Work Study: Introduction to method study, Steps in method study, Recording techniques- Flow process chart, String diagram, Therbligs, Principles of motion economy.

Work measurement: Stop watch time study, Standard time calculation. Work sampling- procedure, applications, advantages and disadvantages, Wages and incentives, types of incentive plans.

UNIT-III

Forecasting: Introduction, Forecasting objectives and uses, demand patterns, Qualitative models Market survey, Delphi Tech, Quantitative models, Moving average, Weighted moving average, Simple exponential smoothing, trend adjusted exponential smoothing, Least square method, Simple regression, multiple regression.

Forecast errors: Mean absolute Deviation (MAD), Mean Square Error (MSE), Mean Forecast Error(MFE), Mean absolute percentage error (MAPE).

UNIT-IV

Aggregate Planning and Master Scheduling: Introduction, objectives of aggregate planning, Cost in aggregate planning, Strategies in aggregate planning, Master production scheduling.

Materials Requirement Planning MRP 1: Importance of MRP, MRP system inputs and outputs, MRP calculations

Manufacturing Resource Planning MRP 2 & Enterprise Resource Planning (ERP): Features of ERP packages like SAP, BANN, People soft etc.,

UNIT-V

Project Management: Project management: Network fundamentals, difference between PERT/CPM Scheduling the activities. Fulkerson's rule. Earliest and latest times. Determination of ES and EF in the forward path. LS and LF in backward path. Determination of critical path. Free float, independent float, Total float, Program evaluation and review technique, crashing of network.

Suggested Readings:

1. Joseph Monk, *Operations Management*, TMH Publishers, New Delhi, 2004.
2. Buffa Elwood S, *Modern Production / Operations Management,* John Wiley Publishers, Singapore, 2002.
3. Everett E Adam, Jr and Ronald J. Ebert, *Production and Operations Management – Concepts, Models and Behaviour,* 5th Ed. 1998, (EEE), Prentice Hall of India(P) Ltd., New Delhi.
4. Panneer Selvam R, "*Operations Research*", Second Edition, PHI Learning Pvt. Ltd. New Delhi, 2006.
5. S.D. Sharma, "*Operations Research*", Kedarnnath, Ramnath & Co., Meerut, 2009.

Course Code	Course Title						Core / Elective
HS 901 MB	**Managerial Economics and Accountancy**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand responsibilities of a manager of a business undertaking.
- To analyse various factors influencing demand elasticity
- To Forecast & compute the future sales level.
- To determine Break Even Point (BEP) of an enterprise
- To understand the features, steps, merits, uses & limitations of Pay Back, ARR, NPV, PI & IRR methods of Capital Budgeting
- To understand the principles of accounting and prepare Journal, Ledger, Trial Balance, Manufacturing A/c, Trading A/c., Profit & Loss A/c. and Balance Sheet of an enterprise.

Course Outcomes

1. Determine the responsibilities of a manager of a business undertaking.
2. Assess various factors influencing demand elasticity
3. Able to Forecast & compute the future sales level.
4. Determine Break Even Point (BEP) of an enterprise Outline the features, steps, merits, uses & limitations of Pay Back, ARR, NPV, PI & IRR methods of Capital Budgeting
5. Understands the principles of accounting and prepare Journal, Ledger, Trial Balance, Manufacturing A/c, Trading A/c., Profit & Loss A/c. and Balance Sheet of an enterprise.

UNIT-I

Introduction to economics and its evolution: Managerial Economics its Scope, Importance and relation to other sciences, its usefulness to Engineers-Basic concepts of Managerial Economics.

UNIT-II

Demands: Analysis-concept of demand, determinants, law of demand, its assumptions, elasticity of demand, price, income and cross elasticity, demand forecasting-markets competitive structure, price- output determination under perfect competition and Monopoly.

UNIT-III

Theory of Production: Firm and industry-production function-input-output relations-laws of returns- internal and external economics of scale. Cost Analysis-Cost concepts-fixed and variable costs-explicitly and implicitly costs-out pocket of costs and imputed costs-opportunity cost-cost output relation- ship-break even analysis.

UNIT-IV

Capital management: Significance, determinates and estimation of fixed and working capital requirements, sources of capital. Introduction to capital budgeting, methods of payback and discounted cash flow methods with problems.

UNIT-V

Book-keeping: Principles and significance of double entry book keeping, journal, subsidiary books, ledger accounts, trial balance concepts and preparation of final accounts with simple adjustments- analysis and interpretation of financial statements through ratios.

Suggested Readings:

1. Varshney RL and KI Maheswari, Managerial Economics, Sultan Chand.
2. JC Pappas and EF Grigham, Managerial Economics.
3. Grawal T.S. Introduction to Accountancv.
4. Maheswari S.N. Introduction to Accountancy.
5. Panday I.M. Financial Management.

Course Code	Course Title						Core / Elective
OE 771 CE	**Green Building Technologies**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To impart knowledge of the principles behind the green building technologies.
- To know the importance of sustainable use of natural resources and energy.
- To understand the principles of effective energy and resources management in buildings.
- To bring awareness of the basic criteria in the green building rating systems.
- To understand the methodologies to reduce, recycle and reuse towards sustainability.

Course Outcomes

After completing this course, the student will be able to

1. Define a green building, along with its features, benefits and rating systems.
2. Describe the criteria used for site selection and water efficiency methods.
3. Explain the energy efficiency terms and methods used in green building practices.
4. Select materials for sustainable built environment & adopt waste management methods.
5. Describe the methods used to maintain indoor environmental quality.

UNIT-I

Introduction to Green Buildings: Definition of green buildings and sustainable development, typical features of green buildings, benefits of green buildings towards sustainable development. Green building rating systems – GRIHA, IGBC and LEED, overview of the criteria as per these rating systems.

UNIT- II

Site selection and planning: Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect, maximize comfort by proper orientation of building facades, day lighting, ventilation, etc.

Water conservation and efficiency: Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, water efficient plumbing systems, water metering, waste water treatment, recycle and reuse systems.

UNIT-III

Energy Efficiency: Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy. Methods to reduce operational energy: Energy efficient building envelopes, efficient lighting technologies, energy efficient appliances for heating and air-conditioning systems in buildings, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.

UNIT-IV

Building materials: Methods to reduce embodied energy in building materials: (a) Use of local building materials (b) Use of natural and renewable materials like bamboo, timber, rammed earth, stabilized mud blocks, (c) use of materials with recycled content such as blended cements, pozzolana cements, fly ash bricks, vitrified tiles, materials from agro and industrial waste. (d) reuse of waste and salvaged materials

Waste Management: Handling of construction waste materials, separation of household waste, on-site and off-site organic waste management

UNIT-V

Indoor Environmental Quality for Occupant Comfort and Wellbeing: Daylighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics. Codes related to green buildings: NBC, ECBC, ASHRAE, UPC etc.

Suggested Readings:

1. IGBC Green Homes Rating System, Version 2.0., Abridged reference guide, 2013, Indian Green Building Council Publishers.
2. GRIHA version 2015, GRIHA rating system, Green Rating for Integrated Habitat Assessment.
3. *Alternative building materials and technologies* by K.S. Jagadish, B.V. Venkatarama Reddy and K.S. Nanjunda Rao.
4. *Non-Conventional Energy Resources* by G. D. Rai, Khanna Publishers.
5. *Sustainable Building Design Manual*, Vol.1 and 2, TERI, New Delhi 2004.
6. Mike Montoya, *Green Building Fundamentals*, Pearson, USA, 2010.
7. Charles J. Kibert*, Sustainable Construction - Green Building Design and Delivery*, John Wiley & Sons, New York, 2008.
8. Regina Leffers*, Sustainable Construction and Design*, Pearson / Prentice Hall, USA, 2009.

Course Code	Course Title						Core / Elective
OE 772 CS	**Data Science Using R Programming**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn basics of R Programming environment: R language, R- studio and R packages
- To learn various statistical concepts like linear and logistic regression, cluster analysis, time series forecasting
- To learn Decision tree induction, association rule mining and text mining

Course Outcomes

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

1. Use various data structures and packages in R for data visualization and summarization
2. Use linear, non-linear regression models, and classification techniques for data analysis
3. Use clustering methods including K-means and CURE algorithm

UNIT – I

Data Science: Introduction to data science, Linear Algebra for data science, Linear equations, Distance, Hyper planes, Half spaces, Eigen values, Eigenvectors.

UNIT II

Statistical Modelling, Random variables, Probability mass/density functions, sample statistics, hypothesis testing.

UNIT III

Predictive Modelling: Linear Regression, Simple Linear Regression model building, Multiple Linear Regression, Logistic regression

UNIT IV

Introduction to R Programming, getting started with R: Installation of R software and using the interface, Variables and data types, R Objects, Vectors and lists, Operations: Arithmetic, Logical and Matrix operations, Data frames, functions, Control structures, Debugging and Simulation in R.

UNIT V

Classification: performance measures, Logistic regression implementation in R, K-Nearest neighbours (KNN), K-Nearest neighbours implementation in R, Clustering: K-Means Algorithm, K-Means implementation in R.

Suggested Readings:

1. Nina Zumel, Practical Data Science with R, Manning Publications, 2014.
2. Peter Bruce and Andrew Bruce, Practical Statistics for Data Scientists, O'Reilly, 2017.
3. Hadley Wickham and Garrett Grolemund, R for Data Science, O'Reilly, 2017.
4. Roger D Peng, R Programming for Data science, Lean Publishing, 2016.
5. Rafael A Irizarry, Introduction to Data Science, Lean Publishing,2016.

Course Code	Course Title						Core / Elective
OE 773 EC	**Fundamentals of IoT**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Discuss fundamentals of IoT and its applications and requisite infrastructure
- Describe Internet principles and communication technologies relevant to IoT
- Discuss hardware and software aspects of designing an IoT system
- Describe concepts of cloud computing and Data Analytics
- Discuss business models and manufacturing strategies of IoT products

Course Outcomes

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

1. Understand the various applications of IoT and other enabling technologies.
2. Comprehend various protocols and communication technologies used in IoT
3. Design simple IoT systems with requisite hardware and C programming software
4. Understand the relevance of cloud computing and data analytics to IoT
5. Comprehend the business model of IoT from developing a prototype to launching a product.

UNIT - I

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT protocols, Logical Design of IoT: IoT functional Blocks, Communication Models, APIs, IoT enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics (Ref 1)

IoT Applications: Smart Home, Smart Cities, Smart Environment, Smart Energy, Smart Retail and Logistics, Smart Agriculture and Industry, Smart Industry and smart Health (Ref1)

UNIT – II

Internet Principles and communication technology: Internet Communications: An Overview – IP, TCP, IP protocol Suite, UDP. IP addresses – DNS, Static and Dynamic IP addresses, MAC Addresses, TCP and UDP Ports, Application Layer Protocols – HTTP, HTTPS, Cost Vs Ease of Production, Prototypes and Production, Open Source Vs Closed Source. Prototyping Embedded Devices – Sensors, Actuators, Microcontrollers, SoC, Choosing a platform, Prototyping Hardware platforms – Arduino, Raspberry Pi. Prototyping the physical design – Laser Cutting, 3D printing, CNC Milling (Ref 2)

UNIT – III

API Development and Embedded programming: Getting started with API, writing a new API, Real time Reactions, Other Protocols, Techniques for writing embedded code: Memory management, Performance and Battery Life, Libraries, Debugging. (Ref 2)

Developing Internet of Things: IoT design Methodology, Case study on IoT System for weather monitoring (Ref 1)

UNIT – IV

IoT Systems - Logical Design using Python: Introduction to Python, Data Types and Structures, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operations., Classes, Python packages for IoT (Ref 1 and Ref 3) IoT Physical Devices and Endpoints: Raspberry Pi, Interfaces of Pi, Programming pi with Python - Controlling LED and LDR using Pi with python programming.

UNIT – V

Cloud computing and Data analytics and IoT Product Manufacturing: Introduction to Cloud storage models and Communication APIs, Amazon web services for IoT, Skynet IoT Messaging Platform. Introduction to Data Analytics for IoT (Ref 1). Case studies illustrating IoT Design – Smart Lighting, Weather Monitoring, Smart Irrigation. (Ref 1) Business model for IoT product manufacturing, IoT Start-ups, Mass manufacturing, Ethical issues in IoT. (Ref 2)

Suggested Readings:

1. Internet of Things (A Hands-On-Approach), Vijay Madisetti, Arshdeep Bahga, VPT Publisher, 1st Edition, 2014.
2. Designing the Internet of Things, Adrian McEwen (Author), Hakim Cassimally. Wiley India Publishers.
3. Fundamentals of Python, Kenneth A Lambert and B.L. Juneja, Cengage Learning
4. *Internet of Things* - Converging Technologies for smart environments and Integrated ecosystems, River Publishers.
5. *Internet of things* -A hands on Approach, Arshdeep Bahga, Universities press.

Course Code	Course Title						Core / Elective
OE 774 EE	**Non-Conventional Energy Sources**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To impart the knowledge of basics of different non-conventional types of power generation & power plants in detail so that it helps them in understanding the need and role of Non-Conventional Energy sources particularly when the conventional sources are scarce in nature

Course Outcomes

On completion of course the student will be able to:

1. Understand the different nonconventional sources and the power generation techniques to generate electrical power.
2. Understand the Solar energy power development and different applications.
3. Understand different wind energy power generation techniques and applications.
4. Design a prescribed engineering sub-system
5. Recognize the need and ability to engage in lifelong learning for further developments in this field.

UNIT-I

Review of Conventional and Non-Conventional energy sources - Need for non-conventional energy sources Types of Non- conventional energy sources - Fuel Cells - Principle of operation with special reference to H2 °2 Cell - Classification and Block diagram of fuel cell systems - Ion exchange membrane cell - Molten carbonate cells - Solid oxide electrolyte cells - Regenerative system- Regenerative Fuel Cell - Advantages and disadvantages of Fuel Cells-Polarization - Conversion efficiency and Applications of Fuel Cells.

UNIT-II

Solar energy - Solar radiation and its measurements - Solar Energy collectors -Solar Energy storage systems - Solar Pond - Application of Solar Pond - Applications of solar energy.

UNIT-III

Wind energy- Principles of wind energy conversion systems - Nature of wind - Power in the Wind-Basic components of WECS -Classification of WECS -Site selection considerations -Advantages and disadvantages of WECS -Wind energy collectors -Wind electric generating and control systems - Applications of Wind energy -Environmental aspects.

UNIT- IV

Energy from the Oceans - Ocean Thermal Electric Conversion (OTEC) methods - Principles of tidal power generation -Advantages and limitations of tidal power generation -Ocean waves - Wave energy conversion devices -Advantages and disadvantages of wave energy - Geo-Thermal Energy - Types of Geo-Thermal Energy Systems - Applications of Geo-Thermal Energy.

UNIT-V

Energy from Biomass - Biomass conversion technologies / processes - Photosynthesis - Photosynthetic efficiency - Biogas generation - Selection of site for Biogas plant - Classification of Biogas plants - Details of commonly used Biogas plants in India - Advantages and disadvantages of Biogas generation -Thermal gasification of biomass -Biomass gasifiers.

Suggested Readings:

1. Rai G.D, *Non-Conventional Sources of Energy,* Khandala Publishers, New Delhi, 1999.
2. M.M. El-Wakil, Power *Plant Technology.* McGraw Hill, 1984.

Course Code	Course Title						Core / Elective
OE 775 ME	**Entrepreneurship**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioural aspects of entrepreneurs and time management

Course Outcomes

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

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core / Elective
OE 781 CE	**Road Safety Engineering**						**Open Elective-III**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**0**	**0**	**0**	**30**	**70**	**3**

Course Objectives

- Introduction to various factors considered for road safety and management
- Explain the road safety appurtenances and design elements
- Discuss the various traffic management techniques

Course Outcomes

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

1. Prepare accident investigation reports and database
2. Apply design principles for roadway geometrics improvement with various types of traffic safety appurtenances/tools
3. Manage traffic including incident management

UNIT – I

Road Accidents: Causes, scientific investigations and data collection, Analysis of individual accidents to arrive at real causes, statistical methods of analysis of accident data, Basic concepts of Road accident statistics, Safety performance function: The empirical Bayes method Identification of Hazards road location. Application of computer analysis of accident data.

UNIT – II

Safety in Road Design: Operating the road network for safety, highway operation and counter measures, road safety audit, principles-procedures and practice, code of good practice and checklists, vehicle design factors & Driver characteristics influencing road safety.

UNIT – III

Road Signs and Traffic Signals: Classification, Location of Signs, measures of sign effectiveness, Types of visual perception, sign regulations, sign visibility, sign variables, Text versus symbols. Road Marking: Role of Road markings, Classification, visibility. Traffic Signals: Need, Signal face. Illumination and location of Signals, Factors affecting signal design, pedestrians' safety, fixed and vehicle actuated signals. Design of signa1s, Area Traffic control. Delineators, Traffic Impact Attenuators, Road side rest areas, Safety Barriers, Traffic Aid Posts.

UNIT – IV

Traffic Management Techniques: Integrated safety improvement and Traffic Calming Schemes, Speed and load limit, Traffic lights, Safety cameras, Tests on driver and vehicles, pedestrian safety issues, Parking, Parking enforcement and its influence on Accidents. Travel Demand Management; Methods of Traffic management measures: Restriction of Turning Movements, One-way streets, Tidal Flow Operation Methods, Exclusive Bus Lanes and Closing Side-streets; Latest tools and techniques used for Road safety and traffic management. Road safety issues and various measures for road safety; Legislation, Enforcement, Education and Propaganda, Air quality, Noise and Energy Impacts; Cost of Road Accidents.

UNIT – V

Incident Management: Introduction, Characteristics of Traffic Incidents, Types of Incidents, Impacts, Incident management process, Incident traffic management; Applications of ITS: Motorist information, Equipment used; Planning effective Incident management program, Best practice in Incident management

programs. National importance of survival of Transportation systems during and after all natural disasters especially cyclones, earthquakes, floods etc. and manmade disasters like sabotage, terrorism etc.

Suggested Readings:

1. Guidelines on Design and Installation of Road Traffic Signals, IRC:93.
2. Specification for Road Traffic Signals, IS: 7537-1974.
3. Principles and Practice of Highway Engineering by L.R. Kadiyali and N.B. Lal.
4. Hand Book of T.E. Myer Kutz, Editor McGraw Hill, 2004.

Course Code	Course Title						Core / Elective
OE 782 CS	**Software Engineering**						**Open Elective-III**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce the basic concepts of software development- processes from defining a product to shipping and maintaining that product
- To impart knowledge on various phases, methodologies and practices of software development
- To understand importance of software modelling using UML
- To understand the importance of testing in software development and study various testing strategies and software quality metrics.

Course Outcomes

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

1. Acquire knowledge about different software development processes and their usability in different problem domains.
2. Understand the process of requirements collection, analysing, and modelling requirements for effective understanding and communication with stakeholders.
3. Design and develop the architecture of real world problems towards developing a blueprint for implementation.
4. Use the UML language to design various models during software development life cycle.
5. Understand the concepts of software quality, testing and maintenance.

UNIT-I

The software Problem: Cost, Schedule and Quality, Scale and change, Software Processes: - Process and project, Component Software Processes, Software Development Process Models, Project management Process.

UNIT-II

Software Requirements Analysis and Specification: Value of a good SRS, Requirements Process, Requirements Specification, Functional Specification with Use Cases, Other approaches for analysis. Software Architecture: Role of Software Architecture Views, Component and connector view, Architectural styles for C & C view, Documenting Architecture Design, Evaluating Architectures.

UNIT-III

Planning a Software Project: Effort Estimation, Project Schedule and staffing, Quality Planning, Risk Management Planning, Project Monitoring Plan, Detailed Scheduling. Design: Design concepts, Function oriented Design, Object Oriented Design, Detailed Design, Verification, Metrics.

UNIT-IV

Coding and Unit Testing: Programming Principles and Guidelines, incrementally developing code, managing evolving code, unit testing, code inspection, Metrics. Testing: Testing Concepts, Testing Process, Black Box testing, White box testing, Metrics.

UNIT-V

Maintenance and Re-engineering: Software Maintenance, supportability, Reengineering, Business process Reengineering, Software reengineering, Reverse engineering; Restructuring, Forward engineering, Economics of Reengineering. Software Process Improvement: Introduction, SPI process, CMMI, PCMM, Other SPI Frameworks, SPI return on investment, SPI Trends.

Suggested Readings:

1. Pankaj Jalote, "Software Engineering- A Precise Approach", Wiley India, 2010.
2. Roger. S. Pressman, "Software Engineering - A Practitioner's Approach", 7th Edition, McGraw Hill Higher Education, 2010.
3. Deepak Jain, "Software Engineering", Oxford University Press, 2008.
4. Rajib Mall, "Fundamentals of Software Engineering", 4th Edition, PHI Learning, 2014.
5. Ian Sommerville, "Software Engineering", 10th Edition, Addison Wesley, 2015.

Course Code	Course Title						Core / Elective
OE 783 EC	**Principles of Electronic Communications**						**Open Elective-III**
Prerequisite	Contact Hours per Week				CIE	SEE	**Credits**
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Provide an introduction to fundamental concepts in the understanding of communications systems.
- Provide an introduction to network model and some of the network layers including physical layer, data link layer, network layer and transport layer.
- Provide an introduction to the evolution of wireless systems and current wireless technologies.

Course Outcomes

1. Understand the working of analog and digital communication systems
2. Understand the OSI network model and the working of data transmission
3. Understand the evolution of communication technologies from traditional telephony systems to modern wireless communication systems.

UNIT – I

Introduction to communication systems: Electromagnetic Frequency Spectrum, Signal and its representation, Elements of Electronic Communications System, Types of Communication Channels.

Signal Transmission Concepts: Baseband transmission and Broadband transmission,

Communication Parameters: Transmitted power, Channel bandwidth and Noise, Need for modulation

Signal Radiation and Propagation: Principle of electromagnetic radiation, Types of Antennas, Antenna Parameters and Mechanisms of Propagation.

UNIT – II

Analog and Digital Communications: Amplitude modulation and demodulation, FM modulation and demodulation, Digital converters, Digital modulation schemes – ASK, FSK, PSK, QPSK, Digital demodulation.

UNIT – III

Data Communication and Networking: Network Models, OSI Model, Data Link Layer – Media Access control, Ethernet, Network Layer – Internet Protocol (IPv4/IPv6), Transport Layer – TCP, UDP.

UNIT – IV

Telecommunication Systems: Telephones, Telephone system, Paging systems, Internet Telephony.

Optical Communications: Optical Principles, Optical Communication Systems, Fiber –Optic Cables, Optical Transmitters & Receivers, Wavelength Division Multiplexing.

UNIT – V

Wireless Communications: Evolution of Wireless Systems: AMPS, GSM, CDMA, WCDMA, OFDM. Current Wireless Technologies: Wireless LAN, Bluetooth, PAN and ZigBee, Infrared wireless, RFID communication, UWB, Wireless mesh networks, Vehicular adhoc networks.

Suggested Readings:

1. *Principles of Electronic Communication Systems*, Louis E. Frenzel, 3e, McGraw Hill, 2008.
2. *Data Communications and Networking,* Behrouz A. Forouzan, 5e TMH, 2012.
3. Kennady, Davis, *Electronic Communications systems*, 4e, McGraw Hill, 1999.

Course Code	Course Title						Core / Elective
OE 784 EE	**Illumination and Electric Traction Systems**						**Open Elective-III**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce the students and understand Utilization of electrical energy for various applications like industrial heating, welding etc.,
- To understand the concept of illumination, and know the applications of various lamps to factory lighting, street lighting etc.
- To understand the concept of electrification of traction system

Course Outcomes

On successful completion of course, students will be able to:

1. Design the resistive and inductive heating and calculate the requirements of heating power for an industrial need
2. Analyse the type of motor control required and select the type and rating of motor.
3. Understand and Design illumination for different application
4. Understand the traction and use of DC machines
5. Analyse the traction mechanics to arrive at a rating of drive.

UNIT-I

Industrial Heating: Advantages and methods of electric heating. Description, operation and performance of resistance ovens — Design of elements. Core type, Coreless type furnaces, High frequency eddy current heating, Dielectric heating. Arc furnace. Electric welding, Resistance welding, welding transformer and its rating, various types of Electric arc welding and electric resistance welding.

UNIT-II

Schematic Utilization and Connection Diagrams for Motor Control: Two supply sources for 3 phase Induction motors. Direct reversing, remote control operation, and jogging operating of Induction motor. Contactor control circuit. Push button control stations. Over load relays, limit switches, float switches. Interlocking methods for reversing control.

UNIT-III

Illumination: Introduction, nature and production of light, Sensitivity of the eye, Units of light. The inverse square law and cosine law, Solid angle, lighting calculations — Determination of M.S.C.P, Rousseau's construction, Discharge lamps, Sodium vapour lamps, Mercury vapour lamps — Fluorescent lamp, Starting and power factor corrections, Stroboscopic effects — Neon signs, Application to factory lighting, Street lighting and Flood lighting.

UNIT-IV

Electric Traction: System of Electric Traction — Transmission of drive — Systems of track electrification — Traction mechanics — Speed time curves — Tractive effort — Power of Traction motor — Specific energy consumption — Mechanics of train movement— Coefficient of adhesion.

Traction Motors: Desirable characteristics, DC series motors, AC series motors 3-phase induction motors, DC motor series & parallel control, Energy saving.

UNIT-V

Train Lighting: Systems of train lighting — Special requirements of train lighting — Methods of obtaining unidirectional polarity — Methods of obtaining constant output — Single battery system — Double battery parallel block system — Principal equipment of double battery system — Coach wiring — Dynamo.

Batteries: Lead acid batteries, SMF batteries, Construction and maintenance, Charging and rating of batteries.

Suggested Readings:

1. Partab H, Art and Science of Utilization of Electric Power, Dhanpat Rai & Sons, 1997.
2. K.B. Raina & S.K. Bhattacharya, Electrical Design, Estimating and Costing, Wiley Eastern Ltd., 1991.
3. Partab H, Modern Electric Traction, Dhanpat Rai & Sons, 2000.
4. B.L. Theraja, A Text Book of Electrical Technology, S. Chand & Company Ltd, Vol —I.

Course Code	Course Title						Core / Elective
OE 785 ME	**Mechatronics**						**Open Elective-III**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Student has to understand the

- How to identify, formulate, and solve engineering problems
- The design a system, component, or process to meet desired needs within realistic constraints
- The how to use the techniques, skills, and modern engineering tools necessary for engineering practice
- The use of drive mechanisms and fluid power systems
- The use of industrial electronic devices
- The demonstrate the design of modern CNC machines, and Mechatronics elements

Course Outcomes

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

1. Model and analyse electrical and mechanical systems and their interconnection
2. Integrate mechanical, electronics, control and computer engineering in the design of Mechatronics systems
3. Do the complete design, building, interfacing and actuation of a Mechatronics system for a set of specifications
4. Be proficient in the use of fluid power systems in various Mechatronics applications
5. Demonstrate the use of industrial electronic devices
6. Demonstrate the design of modern CNC machines, and Mechatronics elements

UNIT-I

Introduction to mechanization & automation: Need of interface of electrical & electronic devices with mechanical elements, the concept of Mechatronics, Flow chart of Mechatronics system, elements of Mechatronics system, drive mechanisms, actuators, feedback devices and control system, application in industries and systems development

UNIT-II

Drive mechanisms: Feeding and indexing, orientation, escapement and sorting devices, conveyor systems Introduction to electrical actuators: A.C. servomotors, D.C. servomotors, stepper motors

UNIT-III

Introduction to fluid power systems: Industrial Pneumatics and hydraulics, merits of fluid power, pneumatic & hydraulic elements symbols, study of hydraulic control valves, pumps & accessories, hydraulic circuits & mechanical servo control circuits, Electro-hydraulic and Hydro pneumatic circuits

UNIT-IV

Introduction to industrial electronic devices: Diodes, Transistors, Silicon Controlled Rectifiers (SCR), Integrated Circuits (IC), Digital Circuits, Measurement systems & Data acquisition systems: sensors, digital to analog and analog-to-digital conversion, signal processing using operational amplifiers, introduction to microprocessor & micro controller, Temperature measurement interface and LVDT interface, Systems response

UNIT-V

Design of modern CNC machines and Mechatronics elements: machine structures, guide ways, spindles, tool monitoring systems, adaptive control systems, Flexible manufacturing systems, Multipurpose control machines, PLC programming

Suggested Readings:

1. William Bolton, Mechatronics: Electronic control systems in mechanical and electrical engineering, 6th edition, Pearson Education
2. HMT Ltd, Mechatronics, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998
3. Michaels Histand & David G, Alciatore, Introduction to Mechatronics and Measurement Systems, Tata McGraw-Hill International Edition
4. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, Cengage Learning
5. S.R. Majumdar, Oil Hydraulic Systems – Principles & Maintenance, McGraw-Hill Publishing Company Limited, New Delhi
6. Godfrey Onwubolu, Mechatronics: Principles and Applications, Butterworth-Heinemann

Course Code	Course Title						Core / Elective
PC 751 ME	**Thermal Engineering Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- Student will acquire basic knowledge in determining thermal conductivity of an insulating powder in composite slab or cylinder.
- Student will demonstrate basic knowledge in evaluating the heat transfer coefficients under natural convection and forced convection phenomena
- Student will determine the necessary constants pertaining to radiation
- Student will acquire basic knowledge in understanding the working principles of axial flow fan and its overall efficiency.
- Student will come to know in estimating overall efficiency of a centrifugal compressors
- Student will demonstrate basic knowledge the importance of pressure distribution over cylinder and an aerofoil section on turbo machines

Course Outcomes

After completing this course, the student will be able to

1. Interpret the link between refrigeration effects, work done and COP of the system, describe different methods adopted to evaluate COP, list the different psychrometric processes and describe how those processes can be maintained
2. Calculate the overall efficiency of centrifugal blower and axial flow fan at different volume flow rates, show the variation of overall efficiency with load and speed graphically
3. Identify the various components of low speed wind tunnel, plot a graph showing variation of pressure over the entire length of aerofoil blade and also evaluate the lift and drag coefficient values for a given aerofoil blade at different angle of assign
4. Describe the modes of heat transfer, calculate thermal conductivity, heat transfer coefficient subjected to natural and forced convection environment and Stefan Boltzmann constant value of thermal radiation
5. Express the working principle of heat exchangers and its application in real life, calculate the LMTD and effectiveness of a given heat exchanger for both parallel and counter flows

List of experiments

1. Determination of COP of the Air conditioning system
2. Determination of percentage relative humidity and study of humidification and dehumidification process in Air Conditioning systems
3. Determination of COP of refrigeration systems using capillary tube/ thermostatic expansion valve
4. Determination of overall efficiency of centrifugal blower
5. Determination of overall efficiency of axial flow fan
6. Pressure distribution on symmetrical and non-symmetrical specimen in wind tunnel
7. Measurement of lift and drag force of the models in wind tunnel test section
8. Determination of thermal conductivity of metal bar
9. Determination of the efficiency of pin-fin subjected to natural and forced convection
10. Determination of effectiveness of parallel flow and counter flow heat exchanger
11. Determination of emissivity of given test plate
12. Determination of Stefan Boltzmann constant

Course Code	Course Title						Core / Elective
PC 752 ME	**CAE Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To introduce fundamentals of the analysis software, its features and applications.
- To learn the basic element types in Finite Element analysis.
- To know the concept of discretization of continuum, Loading conditions and analyse the structure using pre-processor and postprocessor conditions.

Course Outcomes

After completing this course, the student will be able to

1. Classify the types of Trusses (Plane Truss & Spatial Truss) and Beams (2D & 3D) with various cross sections to determine Stress, Strains and deflections under static, thermal and combined loading
2. Generalize Plane stress, plane strain conditions & axisymmetric loading on inplane members to predicting the failure behavior and finding the SCF
3. Analyse connecting rod with tetrahedron and brick elements, performing static analysis on flat & curved shells to determine stresses, strains with different boundary conditions.
4. Predict the natural frequencies and modes shapes using Modal, Harmonic analysis. Also finding the critical load using Buckling analysis
5. Simulate steady state heat transfer analysis of chimney, Transient heat transfer of castings, Non-linear, Buckling analysis of shells &CFD analysis
6. Evaluate the stiffness matrix, B matrix and loading matrices of beam/in plane/solid elements using MATLAB software

List of experiments

1. Analysis of Plane Truss & Spatial Truss with various cross sections and materials to determine member forces, member strains & stresses, joint deflections under static, thermal and combined loading
2. 2D & 3D beam analysis with different sections, different materials for different loads (forces and moments) with different end supports
3. Static analysis of plate with a hole to determine the deformations, the Stresses to study the failure behavior and SCF.
4. Plane stress, plane strain and axisymmetric loading on the in plane members with in plane loading to study the stresses and strains.
5. Static analysis of connecting rod with tetrahedron and brick elements
6. Static Analysis of flat and curved shell due to internal pressure and moments to estimate the strains, stresses and reactions forces and moments with different boundary conditions
7. Buckling analysis of plates, shells and beams to estimate BF and modes
8. Modal analysis of beams, plates and shells for natural frequencies and mode shapes
9. Harmonic analysis of a Shaft subjected to periodic force and transient analysis of plate subjected to stepped and ramped loading with varying time
10. Steady state heat transfer Analysis Cross section of chimney and transient heat transfer analysis of solidification of castings.
11. Nonlinear analysis of cantilever beam with non-linear materials at tip moment and post Buckling analysis of shells for critical loads
12. Coupled field analysis.
13. Flow analysis of pipe with different fluids/gasses/air for velocity and pressure gradients
14. CFD analysis of aerofoil design

15. CFD analysis of ducts/impeller/fan
16. Use of MATLAB for finding B matrix, stiffness matrix and loading matrices of beam/in plane/solid elements and interfacing with CAE software's

Note: 1. Any of FEA software ANSYS/ABAQUS/NASTRAN/NISA/CAEFEM/ADINA may be used
2. Any 12 experiments to be conducted

Course Code	Course Title						Core / Elective
PW 761 ME	**Project Work - I**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**4**	**50**	**-**	**2**

Course Objectives

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic literature survey and documentation
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to the real-world problems.
2. Evaluate different solutions based on economic and technical feasibility
3. Effectively plan a project and confidently perform all aspects of project management
4. Demonstrate effective written and oral communication skills

The department can initiate the project allotment procedure at the end of VI semester and finalize it in the first two weeks of VII semester.

The department will appoint a project coordinator who will coordinate the following:

- Collection of project topics/ descriptions from faculty members (Problems can also be invited from the industries)
- Grouping of students (max 3 in a group)
- Allotment of project guides

The aim of project work is to develop solutions to realistic problems applying the knowledge and skills obtained in different courses, new technologies and current industry practices. This requires students to understand current problems in their domain and methodologies to solve these problems. To get awareness on current problems and solution techniques, the first 4 weeks of VII semester will be spent on special lectures by faculty members, research scholars, post graduate students of the department and invited lectures by engineers from industries and R&D institutions. After completion of these seminars each group has to formalize the project proposal based on their own ideas or as suggested by the project guide.

Seminar schedule will be prepared by the coordinator for all the students from the 5th week to the last week of the semester which should be strictly adhered to.

Each group will be required to:

1. Submit a one-page synopsis before the seminar for display on notice board.
2. Give a 30 minutes' presentation followed by 10 minutes' discussion.
3. Submit a technical write-up on the talk.

At least two teachers will be associated with the Project Seminar to evaluate students for the award of sessional marks which will be on the basis of performance in all the 3 items stated above.

The seminar presentation should include the following components of the project:

- Problem definition and specification
- Literature survey
- Broad knowledge of available techniques to solve a particular problem.
- Planning of the work, preparation of bar (activity) charts
- Presentation- oral and written.

Course Code	Course Title						Core / Elective
SI 762 ME	**Summer Internship**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**-**	**50**	**-**	**2**

Course Objectives

- Produce an accurate record of work performed during the Internship/Co-op
- Apply engineering knowledge to a problem in industry
- Produce a technical report
- Discuss work in a team environment, if relevant to the project
- Conduct herself/himself responsibly, safely, and ethically in a professional environment

Course Outcomes

After completing this course, the student will be able to

1. Able to design/develop a small and simple product in hardware or software.
2. Able to complete the task or realize a prespecified target, with limited scope, rather than taking up a complex task and leave it.
3. Able to learn to find alternate viable solutions for a given problem and evaluate these alternatives with reference to prespecified criteria.
4. Able to implement the selected solution and document the same.

Summer Internship is introduced as part of the curricula of encouraging students to work on problems of interest to industries. A batch of three students will be attached to a person from the Government or Private Organisations/Computer Industry/Software Companies/R&D Organization for a period of 4-6 weeks. This will be during the summer vacation following the completion of the III-year Course. One faculty coordinator will also be attached to the group of 3 students to monitor the progress and to interact with the industry co-ordinate (person from industry).

The course schedule will depend on the specific internship/training experience. The typical time per topic will vary depending on the internship

- Overview of company/project
- Safety training
- Discussions with project teams
- Background research, review of documents, white papers, and scientific papers
- Planning, designing, and reviewing the planned work
- Executing the plans
- Documenting progress, experiments, and other technical documentation
- Further team discussions to discuss results
- Final report writing and presentation

After the completion of the project, each student will be required to:

1. Submit a brief technical report on the project executed and
2. Present the work through a seminar talk (to be organized by the Department)

Award of sessionals are to be based on the performance of the students at the workplace and awarded by industry guide and internal guide (25 Marks) followed by presentation before the committee constituted by the department (25 Marks). One faculty member will co-ordinate the overall activity of Industry Attachment Program.

Note: Students have to undergo summer internship of 4-6 weeks at the end of semester VI and credits will be awarded after evaluation in VII semester.

SCHEME OF INSTRUCTION & EXAMINATION
B.E. VIII - SEMESTER
(MECHANICAL ENGINEERING)

S. No.	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1		Professional Elective – II	3	-	-	3	30	70	3	3
2		Professional Elective – III	3	-	-	3	30	70	3	3
3		Professional Elective – IV	3	-	-	3	30	70	3	3
4		Professional Elective – V	3	-	-	3	30	70	3	3
Practical/ Laboratory Courses										
5	**PW 961 ME**	Project Work – II	-	-	16	16	50	100	-	8
			12	**-**	**16**	**28**	**170**	**380**		**20**

Professional Elective – II			**Professional Elective – III**		
S. No.	Course Code	Course Title	S. No.	Course Code	Course Title
1	**PE 821 ME**	Design of Solar Energy System	1	**PE 826 ME**	Power Plant Engineering
2	**PE 822 ME**	Mechanical Vibrations	2	**PE 827 ME**	Robotic Engineering
3	**PE 823 ME**	Composite Materials	3	**PE 828 ME**	Tool Design
4	**PE 824 ME**	Non-Destructive Testing	4	**PE 829 ME**	Product Design And Process Planning
Professional Elective – IV			**Professional Elective – V**		
1	**PE 831 ME**	Intellectual Property Rights	1	**PE 841 ME**	Energy Conservation and Management
2	**PE 832 ME**	Additive Manufacturing Technology	2	**PE 842 ME**	Advanced Propulsion and Space Science
3	**PE 833 ME**	Machine Tool Engineering and Design	3	**PE 843 ME**	Waste Heat Recovery and Co-Generation
4	**PE 834 ME**	Entrepreneurship Development	4	**PE 844 ME**	Aerodynamic Design of Thermal Turbines

PC: Professional Course PE: Professional Elective
L: Lectures T: Tutorials P: Practical D: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note: 1) Each contact hour is a Clock Hour
2) The duration of the practical class is two clock hours, however it can be extended wherever necessary, to enable the student to complete the experiment

Course Code	Course Title						Core/Elective
PE 821 ME	**Design of Solar Energy System**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Student will understand

- Understand the design concepts of solar systems.
- Design and development of solar thermal systems.
- Design of photovoltaic system and its components.
- Analyse the performance of solar energy systems.

Course Outcomes

After completing this course, students will be able to:

1. Analyse the design concepts of solar systems.
2. Apply the design concepts of solar systems.
3. Understand various solar components
4. Design and select various solar components
5. Evaluate the performance solar system

UNIT-I

System conceptual design, design of major components, overall system, design of physical principles to the solar system based on application. The process includes idea generation, concepts selection and estimation, design of major components, and overall system design, solar radiation data.

UNIT-II

Design of solar thermal systems for water, space heating, cooling and power generation. f-Chart calculation method for sizing solar water and space heating systems. Design of non-focusing and focusing collectors.

UNIT-III

Design aspects of solar thermal energy storage systems. Selection criteria of storage materials for heating and cooling applications, selection of heat transfer fluid for heating and cooling applications. Design of LHTES for solar process heating and power generation applications.

UNIT-IV

Design of photovoltaic off-grid and grid- connected power systems. Design of system components - PV modules, batteries, charge controllers, inverters, auxiliaries. Performance analysis of a photovoltaic system. Using software codes for design of solar thermal and photovoltaic systems.

UNIT-V

Performance analysis of various solar thermal systems, PV system and evaluation of solar thermal energy storage system, selection of components and materials, estimation of economics. Using software tools for design of solar thermal and photovoltaic systems, case studies.

Suggested Readings:

1. Duffie. J.A and Beckman. W.A, “Solar Engineering of Thermal Process”, Wiley,3rd ed., 2006.
2. Da Rosa. A.V, “Fundamentals of Renewable Energy Processes”, 2nd ed., Academic Press, 2009.
3. Kalogirou. S.A, “Solar Energy Engineering: Processes and Systems”, Academic Press, 2009.
4. Sen. Z, “Solar Energy Fundamentals and Modeling Techniques”, Turkey, 2008.
5. Vogel. W, Kalb .H, “Large- Scale Solar Thermal Power Technologies”, Wiley-VCH, 2010.

6. Dincer. I, Rosen .M, “Thermal Energy Storage”, 2nd ed., Wiley, 2011.
7. Prasad. D, &Snow .M, “Designing with Solar Power”, Earthscan, 2005

Course Code	Course Title						Core/Elective
PE 822 ME	**Mechanical Vibrations**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Student has to understand the

- Explain the concept of vibrations, with single and multi-degree freedom
- Discuss the numerical methods involved in vibrations
- Demonstrate the concept of Transient vibrations and Random vibrations
- Identify various methods of vibration control.
- Describe the concept of Non-Linear vibrations
- Identify various methods of vibration control.

Course Outcomes

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

1. analyse the multi degree of freedom systems vibrations
2. formulate vibration problem using various numerical methods
3. interpret the concept of the Random and Transient vibrations
4. apply various methods for vibration control
5. interpret the non-linear phenomenon of vibrations and their formulation

UNIT-I

Multi Degree Freedom System: Free Vibration equation of motion. Influence Coefficient i) Stiffness Coeff. (ii) Flexibility Coeff. Generalized coordinates, and Coordinate couplings. Langranges Equations Matrix Method Eigen Values Eigen Vector problems. Modal Analysis. Forced Vibrations of undamped system and modal analysis. Multi Degree System Numerical Methods:-(i) Rayleigh`s Method, (ii)Rayleigh-Ritz Method (iii)Holzer`s Method (iv)Methods of Matrix iterations (v) Transfer Matrix Method, Impulse response and frequency response functions.

UNIT-II

Continuous System: Vibrations of String, Bars, Shafts and beams, free and forced vibration of continuous systems.

UNIT-III

Modal Parameter Extraction Methods: Introduction – Preliminary checks of FRF Data – SDOF Modal Analysis-I – Peak-amplitude – SDOF Modal Analysis-II – Circle Fit Method – SDOF Modal Analysis III – Inverse Method – Residuals – MDOF curve-fitting procedures – MDOF curve fitting in the Time Domain – Global or Multi-Curve fitting – Nonlinear systems.

UNIT-IV

Vibration Control: Balancing of rotating machine, In-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation & vibration absorbers.

Vibration Measurement: FFT analyser, vibration exciters, signal analysis. Time domain & Frequency domain analysis of signals. Experimental modal analysis, Machine Conditioning and Monitoring, fault diagnosis.

UNIT-V

Random Vibrations: Expected values auto and cross correlation function, Spectral density, response of linear systems, analysis of narrow band systems.

Nonlinear Vibrations: Systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane technique, Duffing's equation, jump phenomenon, Limit cycle, perturbation method.

Suggested Readings:

1. W T Thomson., "Theory of Vibrations with Applications", CBS Publishers
2. S S Rao, "Mechanical Vibrations", Addison-Wesley Publishing Co.
3. Leonard Meirovitch, "Fundamentals of Vibration", McGraw Hill International Edison.
4. J P Den Hartog, "Mechanical Vibrations", McGraw Hill.
5. Srinivasan, "Mechanical Vibration Analysis", McGraw Hill.
6. Nuno Manuel Mendes Maia et al," Theoretical and Experimental Modal Analysis", Wiley John & sons, 1999

Course Code	Course Title						Core/Elective
PE 823 ME	**Composite Materials**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course are to:

- Discuss the basic structure of composites
- Define Elastic constants and Hygro-thermal stresses
- identify stress-strain relations in composites
- Describe the behaviour and Design with composites
- Demonstrate the basic equations of plate bending

Course Outcomes

On completion of the course the student will be able to:

1. demonstrate knowledge of composites and their structure
2. predict the Elastic constants and Hygrothermal stresses
3. analyse the stress - strain relationship in composites
4. summarise and apply the Design procedure and the failure criteria.
5. formulate Plate bending equations for various Boundary conditions of composite plates.

UNIT-I

Introduction: Fibres, Matrix materials, interfaces, polymer matrix composites, metal matrix composites, ceramic matrix composite, carbon fibre composites.

UNIT-II

Micromechanics of Composites: Mechanical Properties: Prediction of Elastic constant, micromechanical approach, Halpin-Tsai equations, Transverse stresses. Thermal properties: Hygrothermal stresses, mechanics of load transfer from matrix to fibre.

UNIT-III

Macromechanics of Composites: Elastic constants of a lamina, relations between engineering constants and reduced stiffness and compliances, variation of lamina properties with orientation, analysis of laminated composites, stresses and strains with orientation, inter-laminar stresses and edge effects. Simplified composite beam solutions. Bending of laminated beams.

UNIT-IV

Strength, fracture, fatigue and design: Tensile and compressive strength of unidirectional fibre composites, fracture modes in composites: Single and multiple fracture, de-bonding, fibre pullout and de-lamination failure, fatigue of laminate composites, Effect of variability of fibre strength.

Strength of an orthotropic lamina: Max stress theory, max strain criteria, maximum work (Tsai-Hill) criterion, quadratic interaction criteria. Designing with composite materials.

UNIT-V

Analysis of plates and stress: Plate equilibrium equations, Bending of composite plates, Levy and Navier solution for plates of composite material. Analysis of composite cylindrical shells under axially symmetric loads.

Suggested Readings:

1. Jones, R.M., 'Mechanics of Composite Materials', Mc-Graw Hill Co., 1967.

2. Calcote, L.R., 'The Analysis of Laminated Composite Structures', Van Nostrand, 1969.
3. Whitney. I.M., Daniel, R.B. Pipes, 'Experimental Mechanics of Fibre Reinforced Composite Materials', Prentice Hall, 1984.
4. Hyer. M.W., 'Stress Analysis of Fibre-Reinforced Composite Materials', McGraw Hill Co., 1998.
5. Carl. T. Herakovich, 'Mechanics of Fibrous Composites', John Wiley Sons Inc., 1998.

Course Code	Course Title						Core/Elective
PE 824 ME	**Non-Destructive Testing**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Student has to understand the

- Need, basic concepts and technologies of Non-Destructive Testing (NDT)
- Security precautions from Radiography, protection from radiation and measurement of radiation received by personnel.
- Technology of acoustic emission (AE), the associated instrumentation and applications
- Technologies like neutron radiography; laser induced ultrasonics, surface analysis and thermography
- Merits and demerits of the different NDT Technologies
- Latest research and developments in NDT

Course Outcomes

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

1. the knowledge of different NDT techniques.
2. clear understanding of liquid penetrant inspection and magnetic particle inspection.
3. view and interpret radiographs, utilize the various principles of radiography for different components of different shapes.
4. the knowledge of acoustic emission for NDT and the instrumentation used for NDT.
5. the ability to analyse and prepare a technical report.
6. the knowledge of latest research, developments and trends in NDT.

UNIT-I

Liquid penetrate inspection: Principles of penetrate inspection, characteristics of a penetrate, water washable system, post emulsification system, solvent removable system, surface preparation and cleaning, penetrate application, development, advantages limitations, and applications. Magnetic particle instruction: Principle, magnetization methods, continuous and residual methods, sensitivities, demagnetization, magnetic particles, applications advantages and limitations.

UNIT-II

Eddy current testing: Principle, lift-off factor, and edge effect, skin effect, inspection frequency, coil arrangements, inspection probes, types of circuit, reference pieces, phase analysis, display methods and applications.

UNIT-III

Ultrasonic testing: Generation of ultra sound, characteristics of an ultrasonic beam, sound wavesat interfaces, sound attenuation, display systems, probe construction, type of display, inspection techniques, identification of defects, Immersion testing, sensitivity and calibration. Reference standards. Surface condition, Applications.

UNIT-IV

Radiography: Principle and uses of radiography, limitation principle, radiation sources, production of X-Rays, x-ray spectra, attenuation of radiation, radiographic equivalence, shadow formation enlargement and distortion, radio graphic film and paper, Xeroradiography, fluoroscopy, exposure factors, radiographic screens, identification markers and image quality indicators, inspection of simple shapes, inspection of complex shapes, viewing and interpretation of radiographs, radiation hazard, protection against radiation, measurement of radiation received by personnel.

UNIT-V

Acoustic Emission: Physical Principles, Sources of emission, instrumentation and applications, Other NDT Techniques: Neuron radiography, Laser induced ultrasonics, surface analysis, and thermography.

Suggested Readings:

1. Barry Hull & Vernon John, *Non-Destructive Testing*, 1988.
2. H J Frissell (Editorial Coordinator), Non-*Destructive Evaluation and quality control*, ASM Handbook-International Publication USA, 1989.
3. Dove and Adams, *Experimental Stress analysis and Motion Measurement*, Prentice Hall of India, Delhi
4. *Non-Destructive Examination and Quality Control*, ASM International, Vol.17, 9thedition (1989)
5. J. Prasad and C. G. K. Nair, *Non-Destructive Test and Evaluation of Materials*, Tata McGraw-Hill Education, 2nd edition (2011).
6. B. Raj, T. Jayakumar and M. Thavasimuthu, Practical *Non Destructive Testing*, Alpha Science International Limited, 3 rd. edition (2002).
7. T. Rangachari, J. Prasad and B.N.S. Murthy, *Treatise on non-destructive testing and evaluation*, Navbharath Enterprises, Vol.3, (1983).

Course Code	Course Title						Core/Elective
PE 826 ME	**Power Plant Engineering**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Student has to understand the

- Operation of steam turbine and gas turbine power plants
- About hydraulic power plant, hydrology, dams and spillways
- Various types of nuclear power plants including Pressurized water reactor, Boiling water reactor, Liquid metal fast breeder reactor and Gas cooled reactor
- The power plant economics
- The environmental and safety aspects of power plant operation.

Course Outcomes

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

1. Select coal and ash handling methods for a coal fired power plant.
2. Comprehend basic working principle of steam and gas turbine power plant
3. Classify Dams and Spillways.
4. Demonstrate the basic principles of thermal-fission and fast-breeder nuclear power plants, such as pressurized- water, boiling-water, and heavy-water reactors.
5. Analyse load factor, capacity factor, average load and peak load on a power plant.
6. Illustrate the control methods of major pollutants emitted from fossil-fuel power plants.

UNIT-I

Introduction to Sources of Energy-Resources and Development of Power in India. Steam Power Plant: Plant layout, working of different Circuits, Fuel and handling equipment, types of coal, coal handling, choice of handling equipment, coal storage, ash handling systems.

UNIT-II

Combustion Process: Properties of coal- overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and draught system, cyclone furnace, design and construction, Dust collectors, cooling towers, and heat rejection, corrosion and feed water treatment.

Gas Turbine Power Plant: Introduction -Classification-Layout with Auxiliaries-Principles of working of closed and open cycle gas turbines

UNIT-III

Hydro Electric Power Plant: Water Power-Hydrological cycle, flow measurement- drainage area Characteristics-Hydrographs-storage and pondage- classification of dams and spill ways.

UNIT-IV

Nuclear Power Station: Nuclear fuel-breeding and fertile materials -Nuclear reactor-reactor Operation-Pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor, homogeneous reactor, gas-cooled reactor.

Radiation hazards and shielding -radioactive waste disposal.

UNIT-V

Power Plant Economics and Environmental Considerations: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, Load curves, average load and load factor,

delivery factor-related exercises Effluents from power plants and impact on environment -Pollutants and Pollution Standards -Methods of pollution control

Suggested Readings:

1. Rajput, RK, *A Text Book of 'Power Plant Engineering*, 3rd Edition. Laxmi Publications, New Delhi.
2. Arora SC, Domukundwar S, *A Course in Power Plant Engineering,* Dhanpat Rai & Sons, New Delhi.
3. YadavR, *Steam & Gas Turbines and Power Plant Engineering,* 7th Edition, Central Publishing House, Allahabad, 2007.
4. Nag P K, *Power Plant Engineering,* 2nd Edition, Tata McGraw Hills Co. Ltd, New Delhi, 2002.
5. Wakil M M, *Power Plant Technology*, Me Graw Hill Publications, New york, 2005.

Course Code	Course Title						Core/Elective
PE 827 ME	**Robotic Engineering**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Students will understand

- The configuration, work envelop and motion controls and applications
- Familiarities with the kinematics of robots.
- Robot end effectors and their design.
- Familiarities with the dynamics of robots.
- Robot Programming methods & Languages of robot.
- Various Sensors and drives and their applications in robots

Course Outcomes

At the end of the course, the students will be

1. Equipped with robot anatomy, work volume and robot applications
2. Familiarized with the kinematic motions of robot
3. Having good knowledge about robot end effectors and their design concepts
4. Familiarized with the robot dynamics
5. Equipped with the Programming methods & drives used in robots
6. Equipped with the principles of various Sensors and their applications in robots.

UNIT-I

Robots: History and evolution of robots, Laws of Robotics, basic configuration, degree of freedom, work envelope, motion control methods, Application in industry, material handling, loading & unloading, processing, welding & painting applications, assembly and inspection, Robot specification requirements

UNIT-II

Rotation matrix: Homogenous transformation matrix, Denavit-Hartenberg convention, Euler angles, RPY representation, Direct and inverse kinematics for industrial robots for position and orientation, Redundancy

UNIT-III

Manipulator Jacobian: Joint, End effector velocity, direct and inverse velocity analysis, Trajectory Planning, interpolation, cubic polynomial, linear segments with parabolic blending, static force and moment transformation, solvability, stiffness, singularities

UNIT-IV

Robot dynamics: Lagrangian formulation, link inertia tensor and manipulator inertia tensor, Newton-Euler formulation for RR & RP manipulators, Control: Individual joint, computed torque

UNIT-V

End effectors: position and velocity measurement, Sensors: Proximity and range, tactile, force and torque, Drives for Robots: Electrical, Hydraulic and Pneumatic, Robot vision: Introduction to technique, image acquisition and processing, introduction to robot programming languages.

Suggested Readings:

1. Spong and Vidyasagar, *Robot Dynamics and Control*, John Wile and Sons, 1990
2. R.K. Mittal, I.J. Nagrath, *Robotics and control*, Tata McGraw-Hill Publishing Company Ltd. 2003
3. Groover, *Industrial Robotics*, McGraw-Hill Publishing Company Ltd. 2003

4. Asada and Siotine, *Robot analysis and Intelligence*, Wiley Interscience, 1986
5. K.S. Fu GonZalezRC., lEEc.S.G., *Robotics, Control Sensing Vision and Intelligence*, McGraw Hill, Int. Ed., 1987
6. Richard S. Paul, *Robot Manipulators: Mathematics, Programming, and Control*, MIT Press (MA)

Course Code	Course Title						Core/Elective
PE 828 ME	**Tool Design**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Students will understand

- Various forces involved in the machining operations
- heat generation in machining & coolant operation
- tools, jigs and fixture, suitable for a particular machining operation

Course Outcomes

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

1. Calculate the values of various forces involved in the machining operations
2. Design various single and multipoint cutting tools
3. Analyse heat generation in machining & coolant operation
4. Illustrate the properties of various cutting tool materials and hence select an appropriate tool material for particular machining application
5. Identify appropriate combination of tools, jigs and fixture, suitable for a particular machining operation
6. Design assembly of jigs and fixtures on simple work-piece

UNIT-I

Metal Cutting : Classification of metal cutting operations, mechanics of metal cutting, tool signature, built up edge formation, mechanism of chip formation, types of chips, oblique and orthogonal cutting - Merchant's force diagram, two component tool dynamometer, Merchant's theory of metal cutting, Lee and Schaffler's theory of metal cutting.

UNIT-II

Tool Wear and Tool Life : Sources of heat in metal cutting, heat dissipation and distribution to chip, tool and work piece, methods of evaluating temperature at tool-chip interface. Machinability, factors affecting machinability, Taylor's tool life equation, crater wear and flank wear, mechanics of tool wear and various types of tool failure. Effects of tool geometry, feed, depth of cut, cutting speed on tool wear.

UNIT- III

Cutting Tool Materials: Essential requirements of a tool material, tool materials - HCS, HSS, Cast alloys, Carbides, Ceramic tools, Diamond tool bits. Essential requirements of a good cutting fluid, types of cutting fluids and their relative applications. Economics of machining - introduction, economic tool life, optimal cutting speed to maximum production and maximum profit.

Unit – IV

Press Tools : Press tool design - press operations, press working terminology, working of cutting die press operations - strip layout, punching, blanking-center of pressure, drawing and deep drawing, bending dies and forging - forging die design.

Unit – V

Jigs and Fixtures: Design of jigs and fixtures. Locating devices, clamping devices, principles of design of jigs and fixtures, some examples

Design of Cutting Tools: Broach design, elements of twist drill, HSS twist drill design, design of rotary milling cutter. Design of single point cutting tool.

Suggested Readings:

1. Donaldson [2001], Tool Design, TMH Publishers, New Delhi.
2. Roy A. Lindberg [2002], Processes and Materials of Manufacture, PHI Publishers, New Delhi.
3. G. R. Nagpal [2004], Tool Engineering & Design, Khanna Publishers, New Delhi.
4. ASTME [1987], Fundamentals of Tool Design, PHI Publishers, New Delhi.
5. Amitha Ghose and Mallik [2004], Manufacturing Science, EWP Publishers, New Delhi.

Course Code	Course Title						Core/Elective
PE 829 ME	**Product Design and Process Planning**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

A student shall understand

- The Product Design and Process Functions
- The essence of innovation in product development
- The Human Machine Interactions (ergonomics)
- The various Intellectual Property Rights
- The interaction between Design, Manufacturing, Quality and Marketing
- The awareness about overall view of Process Planning

Course Outcomes

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

1. Identify the functions of design of a product in a system in a given situation and select a suitable product; identify the procedure for technological innovation of a product; explain the importance of brainstorming and Delphi techniques in innovation
2. Explain the importance of design, human machine interaction in project selection and evaluation methods including ergonomic considerations
3. Explain the importance of research in new product development; describe the process of patenting including search of patents, patent laws and international code and discriminate the scope of IPR for a product patent.
4. Discuss the features of design of a new product with respect to manufacture, quality testing and marketing; and steps to evaluate a new product for introduction;
5. Develop process planning including creating process sheets; explain value engineering, group technology and concurrent engineering in the selection of manufacturing process.

UNIT-I

Product Design and Process Design functions. Selection of right product. Systematic procedure of product innovation. Factors contributing to successful technological innovation - need for creativity and innovation. Techniques of innovation like brain storming and Delphi techniques.

UNIT-II

Project Selection and Evaluation: Function of design - Design with Human Machine Interaction (HMI). Collection of ideas and purpose of project. Selection criteria - screening ideas for new products using evaluation techniques. Principles of ergonomics.

UNIT-III

New Product Development: Research and new product development. Patents, definitions, patent search, patent laws, international code for patents -Intellectual Property Rights (IPR).

UNIT-IV

New **Product Planning**: Interaction between the functions of design, manufacture, quality, testing and marketing. Steps for introducing new products after evaluation.

UNIT-V

Process Planning: Process planning, process sheets, selection of manufacturing process, estimation of machining time in various cutting operations - estimation of costs for manufacture. Value engineering in product design, group technology, concepts of concurrent engineering.

Suggested Readings:

1. Niebel BW & Draper AB: *Production Design & Process Engg,* McGraw Hill, Kogakusha, 1974.
2. Harry Nystrom, *Creativity and Innovation,* John Wiley & Sons,
3. BrainTwiss, *Managing Technological Innovation,* Pittrnan Publications, 1992.
4. Harry, B.Waton, *New Product Planning,* Prentice Hall Inc., 1992.
5. Chitale, A. K. & Gupta RC., *Product Design & Manufacturing,* PHI, 1997.

Course Code	Course Title						Core/Elective
PE 831 ME	**Intellectual Property Rights**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Students will understand

- Fundamental aspects of IP
- Aspects of IPR acts.
- Awareness of multi-disciplinary audience
- Awareness for innovation and its importance
- The changes in IPR culture
- About techno-business aspects of IPR

Course Outcomes

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

1. Will respect intellectual property of others
2. Learn the art of understanding IPR
3. Develop the capability of searching the stage of innovations.
4. Capable of filing a patent document independently.
5. Completely understand the techno-legal business angle of IP.
6. Capable of converting creativity into IP and effectively protect it.

UNIT-I

Overview of Intellectual Property: Introduction and the need for intellectual property right(IPR), IPR in India – Genesis and Development, IPR abroad, Some important examples of IPR. Importance of WTO, TRIPS agreement, International Conventions and PCT

Patents: Macro economic impact of the patent system, Patent and kind of inventions protected by a patent, Patent document, how to protect your inventions. Granting of patent, Rights of patent, how extensive is patent protection. Why protect inventions by patents. Searching a patent, Drafting of a patent, Filing of a patent, the different layers of the international patent system, (national, regional and international options), compulsory licensing and licensers of right & revocation, Utility models, Differences between a utility model and a patent. Trade secrets and know-how agreements

UNIT-II

Industrial Designs: What is an industrial design. How can industrial designs be protected? What kind of protection is provided by industrial designs? How long does the protection last? Why protect industrial designs?

UNIT-III

Trademarks: What is a trademark, Rights of trademark? What kind of signs can be used as trademarks? Types of trademark, function does a trademark perform, how is a trademark protected? How is a trademark registered? How long is a registered trademark protected for? How extensive is trademark protection? What are well-known marks and how are they protected? Domain name and how does it relate to trademarks? Trademark infringement and passing off.

UNIT-IV

Copyright: What is copyright. What is covered by copyright. How long does copyright last? Why protect copyright? Related Rights: what are related rights. Distinction between related rights and copyright. Rights covered by copyright? Copy rights in computer programming.

UNIT-V

Enforcement of Intellectual Property Rights: Infringement of intellectual property rights Enforcement Measures Emerging issues in Intellectual property protection. Case studies of patents and IP Protection.

Unfair Competition: What is unfair competition. Relationship between unfair competition and intellectual property laws.

Suggested Readings:

1. Ajit Parulekar and Sarita D' Souza, *Indian Patents Law – Legal & Business Implications*; Macmillan India ltd, 2006
2. B. L. Wadehra; *Law Relating to Patents, Trade Marks*, *Copyright*, *Designs &Geographical Indications*; Universal law Publishing Pvt. Ltd., India 2000
3. P. Narayanan*; Law of Copyright and Industrial Designs*; Eastern law House, Delhi 2010
4. Cronish W. R1 *Intellectual Property; Patents, copyright, Trad and Allied rights*, Sweet &Maxwell, 1993.
5. P. Narayanan, *Intellectual Property Law*, Eastern Law Edn., 1997.
6. Robin Jacob and Daniel Alexander, *A Guide Book to Intellectual Property Patents, Trademarks, Copy rights and designs*, Sweet, Maxwell 4th Edition.

Course Code	Course Title						Core/Elective
PE 832 ME	**Additive Manufacturing Technology**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Students will understand

- the importance of RPT
- Apply various liquid and solid based RPT Systems
- Apply various powder based RPT systems and rapid tooling
- Recognize various STL formats and slicing methods and tessellation
- Application of RPT in Engineering, Jewellery and Bio medical etc.

Course Outcomes

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

1. understand the developments of RPT and its terminology, Advantages and limitations of RPT
2. understand mechanism involved in stereo lithography apparatus system, and terminated object manufacturing, fused deposition modelling and their applications.
3. understand mechanism in selective laser interims and its application. Understand the importance of Rapid tooling
4. recognize various types of file format and slicing methods in RP and various software available to convert 3D models.
5. apply RPT in various fields of Engineering

UNIT-I

Introduction: Prototyping fundamentals, Historical development, fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, commonly used terms, classification of RP process, Rapid prototyping process chain: Fundamental Automated processes, process chain.

UNIT-II

Liquid based rapid prototyping systems: Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. 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): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT-III

Powder Based Rapid Prototyping Systems: Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling VsRt, need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods: Spray Metal Deposition, RTV Epoxy Tools, Ceramic tools, investment casting, spin casting, diecsting, sand casting, 3D Keltool process. Direct Rapid Tooling: Direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP

UNIT-IV

Rapid Prototyping Data Formats: STL Format, STL File Problems, Consequence of Building Valid and invalid tressellated 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

UNIT-V

RP Applications: Application – Material Relationship, application in design, application in engineering, Analysis and planning, aerospace industry, automatic industry, Jewellery industry, coin industry, GIS application, Arts and Architecture.

RP Medical and Bioengineering Application: Planning and simulation of complex surgery, customized implant and prosthesis, design and production of medical devices, forensic science and anthropology, visualization of biomolecules.

Suggested Readings:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rd Ed., 2010
2. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001
3. Terry Wohlers, "Wholers Report 2000", Wohlers Associates, 2000
4. Paul F. Jacobs, "Rapid Prototyping and Manufacturing"–, ASME Press, 1996
5. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed, 2014

Course Code	Course Title						Core/Elective
PE 833 ME	**Machine Tool Engineering and Design**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

Students will understand

- Types of tools for heavy machining processes
- Design elements in sheet metal operation
- Use of jigs and fixtures for automation in industries

Course Outcomes

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

1. Understand basic motions involved in a machine tool.
2. Design machine tool structures
3. Design and analyse systems for specified speeds and feeds
4. Understand control strategies for machine tool operations
5. Apply appropriate quality tests for quality assurance

UNIT-I

Classification of Machine Tools: General purpose, Special purpose, Automatic, Semi-Automatic machine tools, Transfer lines. Kinematics of Machine Tools: Shaping of geometrical and real surfaces, Developing and designing of kinematics schemes of machine tools, Kinematic structures of lathe, drilling, milling, relieving lathe, grinding, gear shaping and gear hobbing machining. Kinematic design and speed and feed boxes. Productivity loss. Stepped and stepless regulation.

UNIT-II

Strength and Rigidity of Machine Tool Structures: Basic principles of design for strength. Different types of structures. General design procedures. Effect of materials and shape factors on the rigidity of structure, overall compliance of machine tool. Design of beds, bases columns, tables, cross rails for various machines. Effect of wear of guide ways on the performance. Various types of guide ways, their relative advantages. Materials for machine tool components including plastic guide ways (PTFE).

UNIT-III

Analysis of Spindles, Bearing and Power Screws: Design of spindles subjected to combined bending and torsion. Layout of bearings. Pre-loading. Anti-friction slide ways. Rolling contact, hydrodynamic, hydrostatic, aerostatics and magnetic bearings, their relative performance. Power Screws, Recirculating ball screws. Hydrodynamic design of journal bearings.

UNIT-IV

Machine Tool Vibrations: Effect of vibration on machine tool; Forced vibrations. Machine tool chatter. Self-excited vibration and dynamic stability single and two-degree freedom analysis. Comply coefficient. Elimination of vibration. Vibration analysis of machine tool structures.

UNIT-V

Hydraulic Systems: General principles, hydraulic fluid power lines. Properties of hydraulic fluid. Various positive displacement pumps, their characteristics and operation. Design of hydraulic tanks and other systems. Various valves used in hydraulic systems. Design and application of various hydraulic circuits. One position and multi-position scheme. Single and multi-pump screws. Electrical analogy. Pneumatic circuits.

Hydro copying system. Evaluation of machine tools with regard to accuracies, sound and vibration. Machine tool testing.

Suggested Readings:

1. Sen and Bhattacharya, Principles of Machine Tools, New Central Book Agency, Calcutta, 1975.
2. S.K. Basu, Design of Machine Tools, Allied Publishers, India, 1961.
3. Acharkan, Machine Tool Design (vol. 1,2 & 3), MIR Publishers, Moscow, 1973.

Course Code	Course Title						Core/Elective
PE 834 ME	**Entrepreneurship Development**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioral aspects of entrepreneurs and time management

Course Outcomes

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997.
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core/Elective
PE 841 ME	**Energy Conservation and Management**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn about energy conservation
- To understand sources of loss of power in energy conversion
- To understand Procedure for Comprehensive Energy Conservation Planning
- To understand Industrial energy conservation methods

Course Outcomes

On successful completion of this course, the student will be able to

1. Understand different forms of energy
2. Calculate the amount of heat energy available
3. Understand the industry energy conservation modelling
4. Understand methodology for forecasting industrial energy supply and demand.

UNIT-I

Definition, Principles of Energy Conservation - Maximum Thermodynamic efficiency. Maximum Cost - effectiveness in energy use. Various forms of energy - Heat Mechanical. Electrical energy and Chemical energy. Identification of potential sources of energy losses - Transportation, operation and conversion from one from to another.

UNIT-II

Heat energy and storage - Media of transport of heat energy - steam, oil and flue gases. Calculation of steam quality. Calculation of amount of heat energy available. Recuperators. Constructional details, Selection of materials to store heat energy. Concept of power. Modes of mechanical energy transport - Gears, pulleys, belts, shafts etc., Calculation of power. Sources of loss of power in energy conversion into electricity, potential energy (i.e., pumps).

UNIT-III

Chemical energy - combustion of fuels - petrol, diesel and coal. Loss due to quality of fuel, conversion into other form of energy - boilers, I.C. engines. Calculation related to losses. Electrical energy - Working principle of motors and generators. Calculation of efficiency of generators. Losses during transmission and energy conversion - into mechanical energy, thermal energy. Calculation of effecting parameters.

UNIT-IV

Procedure for Comprehensive Energy Conservation Planning (CECP) -Specifying targets, identifying energy in-efficient facilities. Synthesize evaluation and optimization of alternative conservation measures in view of organization costs. Flow chart of organization's functions. Collection of accountable data. Application of CECP method. An example.

UNIT-V

Industrial energy conservation modeling - Methodology - Definition of production system - A primary copper production system, Model construction - Mathematical Programming. Market penetration, Structure of energy conservation model. Data preparation - coefficients needed in a model, Unit production cost and unit energy requirements. Model exercise, verification and validation. Methodology for forecasting Industrial Energy Supply and Demand.

Suggested Readings:

1. Gottschalk C.M., "Industrial Energy Conservation", John Wiley & Sons, 1996.
2. Chaturvedi P., and Joshi S., "Strategy for Energy Conservation in India", Concept PublishingCo., New Delhi, 1997.

Course Code	Course Title						Core/Elective
PE 842 ME	**Advanced Propulsion and Space Science**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn about gas dynamic concepts of rocket propulsion system
- To learn rocket engine system.
- To learn celestial sphere and its parameters
- To learn about Satellites & Remote Sensing

Course Outcomes

Student will be able to

1. Classify different rocket propulsion systems and understand the concept of gas dynamics
2. understand the working principle of rocket engine system
3. understand celestial sphere and its parameters

UNIT-I

Advanced Gas Dynamics: Normal shock waves, pitot tubes, moving shock waves, oblique shock waves, reflected shock waves, conical shock waves, hypersonic flow, Newtonian theory, high temperature flows, low density flows.

UNIT-II

Advanced Propulsion: Rocket engines - Operation and performance of rocket engines, design and operating parameters - total impulse, thrust, energy and efficiencies, Typical performance values, overview of monopropellant, bipropellant liquid, solid and hybrid rocket propulsion systems, combined cycle propulsion, Electric / Ion propulsion.

UNIT-III

Rocket Technology: Flight mechanics, application thrust profiles. Acceleration -staging of rockets, feed systems, injectors and expansion nozzles, typical nozzle designs (cone, bell, plug). Rocket heat transfer and ablative cooling. Testing and Instrumentation. Nuclear thermal rockets, pulsed detonation engines, Solar sails.

UNIT-IV

Celestial Sphere: Spherical trigonometry, celestial coordinate systems, Astronomical triangle, Time-Sidereal, apparent and mean solar time. Equation of Time.

Two Body Problem: Formulation, relative motion and solution, Kepler's equation, motions of rockets and artificial satellites, transfer orbits, minimum energy interplanetary transfer orbits, use of parking orbits, Perturbations of artificial satellites due to atmospheric drag and flattening of earth.

UNIT-V

Nuclear Processes in the Sun, Solar wind, interaction of solar Wind and Earth's magnetic field, Van Allen radiation belts.

Satellites & Remote Sensing: Orbits, earth segment, space segment, earth station, satellite subsystems, working details of communication and navigational satellites - components, operation and maintenance, meteorological satellites. Principles of remote sensing.

Suggested Readings:

1. Shapiro, "The dynamics and thermodynamics of compressible flow", 1953.
2. Thomas, D. Daman, "Introduction to space: The Science of space flight", Orbit book Co., 3rd ed., Malabar, FL, 2001.
3. K.D. Abhyankar, "Astrophysics of the solar systems", University Press (India) Ltd., 1999.
4. Timothy Pratt and Charles, W. Bostian, "Satellite Communications", John Wiley, 1986.

Course Code	Course Title						Core/Elective
PE 843 ME	**Waste Heat Recovery and Co-Generation**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn concepts of waste heat recovery
- To learn the applications of heat exchangers & recuperators in heat recovery
- To understand cogeneration methods

Course Outcomes

Student will be

1. Understand the concept of waste heat recovery
2. Distinguish heat exchangers and recuperators
3. Acquire knowledge about various cogeneration methods

UNIT-I

Definition, Sources, Quantity and quality of waste heat. Technologies for waste heat recovery and utilization. Need of storage systems for waste heat.

Utilization of Waste Heat - Continuous and Intermittent. Energy requirements of industry. Various forms of waste heat available.

UNIT-II

Overview of heat exchangers. Gas to gas. Gas to liquid and liquid to liquid heat exchangers. Calculation of effectiveness and design of heat exchanger for number of tubes. Pressure drop considerations LMTD and effectiveness -NTU methods.

UNIT-III

First and Second law of thermodynamics, and its effect on design of recuperators. Recuperators-Ceramic, metallic and reradiant recuperators, high temperature recuperators. Concept of porosity, Peclet number superficial velocity, pressure drop, and selection of material for heat storage and recovery.

UNIT-IV

Cogeneration - Definition, Two basic cogeneration concepts, thermodynamic advantage, Cogeneration efficiency, potential benefits and costs of cogeneration. Cogeneration-Over view, Industrial application of cogeneration.

UNIT-V

Source of waste heat and methods of utilization. Application of Cogeneration to a steam power plant. Identifying the possibilities of extracting energy to run a gas turbine. Integration of Steam turbine and Gas turbine - Power calculations, various types and their applications towards power generation. Quality of steam and its effect on performance. Legislation - Power plant and Industrial fuel use act (FUA) Potential nationwide benefits of Cogeneration, Impact of Cogeneration on fuel use patterns. Legislative, Environment and Institutional Constraints for use of waste heat.

Suggested Readings:

1. Donald Q. Kern, "Process Heat Transfer", McGraw Hill International Editions, Chemical Engineering Series, 1965.
2. Wylen V. and Sonntag, "Fundamentals of Classical Thermodynamics" - SI Version, Wiley Eastern Ltd., 1993.
3. David Hu S., "Handbook of Industrial Energy Conservation", Van Nostrand Reinhold Co., 1983.

Course Code	Course Title						Core/Elective
PE 844 ME	**Aerodynamic Design of Thermal Turbines**						**Elective**
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn design concepts of thermal turbines
- To understand the analysis of flow past a turbine cascade
- To understand turbine blade design methods

Course Outcomes

The student will be able to

1. explain the concepts of thermal turbines
2. analyze the flow past a turbine cascade
3. design the turbine blade

UNIT-I

Introduction: Definition of a turbine stage. Enthalpy - Entropy diagram for a Turbine stage. Definition of Euler work, specific work and isentropic work. Euler's turbine equation and Energy transfer equation. Definitions of shape No, stage efficiency, stage reaction, work done factor, utilization factor and coupling power.

Concepts of ID, 2D and 3D flows; Vortices; Circulation; Potential and Viscous flow theories. Definitions of subsonic, transonic and supersonic flows. Single Aerofoil theory and its limitations. Boundary layer parameters and flow separation.

UNIT-II

Aerodynamics of turbine cascades: Definition of a cascade. Classification of turbine Cascades. Blade and cascade geometric parameters. Blade and cascade angles and relationships. Flow parameters and their significance. Cascade flow model for turbines. Wake flow NACA and other cascade blade data specification methods.

1D Analysis: Cascade aerofoil blade forces. Force coefficients Lift and Drag Coefficients. Equations for blade forces with cascade blade parameters and angles. Stagnation pressure loss for a turbine cascade. Cascade efficiency.

UNIT-III

1D and 2D Blade Design Methods:

1D methods: Pitch-line design method. Velocity diagrams at hub, tip and mean radii. Definition of mean flow terms. Kulta condition and Zweifel's criterion for axial turbine cascade design. Problems on axial turbine stage cascades.

2D methods: Concepts of singularities, simple relations. Schlichting Method - equations for induced velocity,

Camber line and thickness distribution for an arbitrary aerofoil shape - Direct and indirect design problems. Channel flow approach - Stanitz I and I approximation methods.

UNIT-IV

3D Blading Design Methods:

Radial Equilibrium theory: Fundamental equation and approaches for the vortex design of axial turbine cascades; Simple problems on Radial equilibrium theory.

Actuator Disc theory: Concept and application to simple design problems on axial flow turbine cascades.

UNIT-V

Performance Evaluation:

Dimensionless groups and performance maps for axial turbines. Distribution of static pressure over blade profile losses in turbine cascades. Profile, Annulus, Secondary, Tip clearance and over all loss estimation - Soderberg and Ainley - Malhieson methods. Loss model for a turbine
cascade.

Description of wind tunnel test rig for experimental investigations of turbine cascades. Types of pressure probes, Hotwire anemometer, LDV principles and their calibration techniques. Concepts of flow visualization and its significance.

Suggested Readings:

1. J.P. Gostelow, " Cascade Aerodynamics" -, Pergamoa Press, USA.
2. S.M. Yahya, " Fans, Turbines and Compressors", Tata Mc-Graw Hill Pub; Delhi.
3. S.L. Dixon, "Fluid Mechanics and Thermodynamics of Turbomachinary" Pergamon Press, USA.
4. Gopalakrishnan G, Prithvi Raj D, "A treatise on Turboniachincs?', Scitech Publications. Chennai, 2002

Course Code	Course Title						Core / Elective
PW 961 ME	**Project Work - II**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**16**	**50**	**100**	**8**

Course Objectives

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic literature survey and documentation
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to the real-world problems.
2. Evaluate different solutions based on economic and technical feasibility
3. Effectively plan a project and confidently perform all aspects of project management
4. Demonstrate effective written and oral communication skills

The aim of Project work –II is to implement and evaluate the proposal made as part of Project Work - I. Students can also be encouraged to do full time internship as part of project work-II based on the common guidelines for all the departments. The students placed in internships need to write the new proposal in consultation with industry coordinator and project guide within two weeks from the commencement of instruction.

The department will appoint a project coordinator who will coordinate the following:

1. Re-grouping of students - deletion of internship candidates from groups made as part of project Work-I
2. Re-Allotment of internship students to project guides
3. Project monitoring at regular intervals

All re-grouping/re-allotment has to be completed by the 1st week of VIII semester so that students get sufficient time for completion of the project.

All projects (internship and departmental) will be monitored at least twice in a semester through student presentation for the award of sessional marks. Sessional marks are awarded by a monitoring committee comprising of faculty members as well as by the supervisor. The first review of projects for25 marks can be conducted after completion of five weeks. The second review for another 25 marks can be conducted after 12 weeks of instruction.

Common norms will be established for the final documentation of the project report by the respective departments. The students are required to submit draft copies of their project report within one week after completion of instruction.

Note: Three periods of contact load will be assigned to each project guide.