BHARATI VIDYAPEETH DEEMED UNIVERSITY COLLEGE OF ENGINEERING, PUNE

COURSE STRUCTURE 2014 CBCS

B. Tech. Mechanical Sem.- VII

Sr. No.	Course	Teaching Scheme (Contact Hrs./Week)			Examination Scheme (Marks)							Total Credits		
		L	P/D	T	End Sem. Exam	Continuous Assessment					Total	TH	TW	Total
						Unit Test	Attend ance	Assign ments	TW/ OR	TW/ PR				
1	Mechanical Vibration	3	2	--	60	20	10	10	50	--	150	3	1	4
2	Automatic Control System	3	2	--	60	20	10	10	50	--	150	3	1	4
3	Automobile Engineering	3	--	--	60	20	10	10	--	--	100	3	--	3
4	Industrial Fluid Power	3	--	--	60	20	10	10	--	--	100	3	--	3
5	Elective - II	3	-	--	60	20	10	10	--	--	100	3	--	3
6	Inplant Training	-	--	--	--	--	--	--	50	--	50	--	4	4
7	Project Stage -I	--	2		--	--	--	--	100	--	100	--	4	4
	Total	15	06	00	300	100	50	50	250	--	750	15	10	25

Elective-II Courses: a) Computational Fluid Dynamics; b) Industrial Engineering & Management; c) Nanotechnology; d) Production Planning & Control
e) Experimental Methods in Mechanical Engineering

B. Tech. Mechanical Sem.- VIII

Sr. No.	Course	Teaching Scheme (Contact Hrs./Week)			Examination Scheme (Marks)							Total Credits		
		L	P/D	T	End Sem. Exam	Continuous Assessment					Total	TH	TW	Total
						Unit Test	Attend ance	Assign ments	TW/ OR	TW/ PR				
8	Power Plant Engineering	4	2	--	60	20	10	10	50	--	150	4	1	5
9	Industrial Product Design	3	2	--	60	20	10	10	50	--	150	3	1	4
10	Optimum Design*	4	2	--	60	20	10	10	50	--	150	4	1	5
11	Elective-III	3	--	--	60	20	10	10	--	--	100	3	--	3
12	Project Stage –II	-	4	--	--	--	--	--	200	--	200	--	8	8
13	Environmental Sciences	3	--	--	100	--	--	--	--	--	100	3	--	3
	Total	14	10	00	240	80	40	40	350	--	750	14	11	25

* End Sem. examination of duration 4 hours

Elective – III Courses: a) Industrial Automation & Robotics; b) Cryogenics; c) Project Management & Ethics; d) Total Quality Management;
e) Finite Element Analysis

1. MECHANICAL VIBRATION

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week Practical: 02 Hours / Week	End Semester Examination: 60 Marks	Theory: 03 Practical: 01
	Continuous Assessment: 40 Marks	Total: 04
	Term Work/ Oral: 50 Marks	

Course Pre-requisites:

1.	Student should have knowledge of Fundamentals of Engineering Mechanics
2.	Student should have knowledge of Engineering Mathematics
3.	Student should have knowledge of Machine Design and Computer Aided Drafting
4.	Student should have knowledge of Machine Design –I & II
5.	Student should have knowledge of Theory of Machine

Course Objectives:

1.	To study basic concepts of vibration analysis
2.	To acquaint with the principles of vibration measuring instruments
3.	To study balancing of mechanical systems

Course Outcomes:

Students will be able to understand

1.	Develop mathematical model to represent dynamic system
2.	Estimate natural frequency of mechanical element/system
3.	Analyze vibratory response of mechanical element/system
4.	Estimate the parameters of vibration isolation system

UNIT - I	**Basic Concepts of Vibration** Vibration and oscillation, causes and effects of vibrations, Vibration parameters –spring, mass, damper, Damper models, Motion – periodic, non-periodic, harmonic, non- harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis.	**(06 Hours)**
UNIT - II	**Free Undamped Single Degree of Freedom Vibration System** Longitudinal, transverse, torsion vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's Method.	**(06 Hours)**
UNIT - III	**3.1 Free Damped Single Degree of Freedom Vibration System** Viscous damped system – under damped, critically damped, over damped; Logarithmic decrement; Coulomb's damping; Combined	**(06 Hours)**

	viscous and coulomb's damping. **3.2 Equivalent Single Degree of Freedom Vibration System** Conversion of multi-springs, multi masses, multi – dampers into a single spring and damper with linear or rotational co-ordinate system	
UNIT - IV	**4.1 Forced Single Degree of Freedom Vibratory System** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) **4.2 Vibration Isolation and Transmissibility** Force Transmissibility, Motion Transmissibility Typical isolators& Mounts **4.3 Rotor Dynamics:** Critical speed of single rotor, undamped and damped	**(06 Hours)**
UNIT - V	**5.1 Free Undamped Multi Degree of Freedom Vibration System** Eigen values and Eigen vectors for linear system and torsional two degree of freedom; Holzer method for linear and torsional unbranched system; Two rotors, Three rotors and geared system; Dunkerley's and Rayleigh's method for transverse vibratory system	**(06 Hours)**
UNIT - VI	**Vibration Measurement** -Introduction -Vibration measuring parameters- Displacement, Velocity and acceleration -Vibration measuring devices: Accelerometers, Vibration exciters, FFT analyzer, -Introduction to signal analysis: Time domain & Frequency domain analysis of signals. - Noise measurement	**(06 Hours)**

Term Work/Practicals:
1. To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient
2. To obtain frequency response curves of single degree freedom system of vibration for different amount of damping.
3.Free vibration of simply supported beam
4. Free Vibration of a Two-DOF System
5. Forced vibration of SDOF system
6. To determine critical speed of shaft with single rotor.

7. To verify natural frequency of torsional vibration of two rotor system and position of node.	
8. Noise measurement and analysis using vibration Analyzer	
9. To determine natural frequency of vibration of beam using vibration analyzer.	
10. Vibration analysis of mechanical system using MATLAB	
Assignments:	
1. Use and study MATLAB Code for fundamentals of vibration.	
2. Use MATLAB program for vibration analysis with suitable example.	
3. Longitudinal, transverse, torsion vibration system program in MATLAB.	
4. MATLAB Program for Vibration calculations by Using of differential equations in MATLAB.	
5. Study of Free Damped Single Degree of Freedom Vibration System.	
6. Study of Equivalent Single Degree of Freedom Vibration System.	
7. Study of Forced Single Degree of Freedom Vibratory System	
8. Study of Vibration Isolation and Transmissibility	
9. Finding of Eigen values and Eigen vectors for linear system and torsional two degree of freedom by MATLAB program.	
10. Use FFT Analyzer for lathe machine vibration analysis	
11. Study of Noise measurement	
12. Theoretical study of vibration signal analysis.	
Text Books/Reference Books:	
1	Mechanical Vibrations - G. K. Grover Nem Chand & Bros.
2	Mechanical Vibrations 4th edition- S. S. Rao - *Pearson Education*
3	Fundamentals of Mechanical Vibration - S.Graham Kelly - *Tata McGraw Hill* 4.
4	Vibration Analysis - P. Srineevasan - Tata McGraw Hill
5	Mechanical Vibrations - Schaum's outline series - S.Graham Kelly- *McGraw Hill*
6	Theory and Practice of mechanical vibrations - J. S. Rao, K. Gupta - *New Age*
7	Mechanical Vibrations, J.P. Den Hartog, Mc Graw Hill Book Company Inc.
8	Leonard Meirovitch, Introduction to Dynamics and Conti'oJ. *Wiley, New York*
9	Benson H. Tongue, Principles of Vibration. *Oxford University Press.*
10	W. Thomson, Theory of Vibrations with Applications, Second Edition, *Pearson Education*

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

2. AUTOMATIC CONTROL SYSTEM

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	Theory: 03
Practical: 02 Hours / Week	Continuous Assessment: 40 Marks	Practical: 01
	Term Work/ Oral: 50 Marks	**Total : 04**

Course Pre-requisites:

The Students should have

1.	Knowledge of Mathematics & Science
2.	Knowledge of Basic Electrical Engineering.
3.	Knowledge of Sensors and Measurement System.

Course Objectives:

1.	Familiarization with Control System Principles and Applications of Control System.
2.	Calculate and Estimate the Stability Measures, Time Response Measures from the Analysis of Mathematical Models of Some Simple Engineering Systems.
3.	Develop Ladder Diagrams using PLC and Apply It for Industrial Automation.

Course Outcomes:

Students should be able to,

1.	Determine the (absolute) stability of a closed-loop control system using Routh-Hurwitz's stability criterion.
2.	Obtain an overall transfer function of control system by using block diagram algebra methods.
3.	Determine the time response specifications of a control system.
4.	Use analog and digital signal processing for mechatronics applications.
5.	Use Fundamentals of control systems, mechatronics system and able to improve an existing system's performance by using controller action such as PID controllers.
6.	Develop ladder diagram and select PLCs for industrial applications.

Course Contents

UNIT I	**Frequency Domain Modelling and Analysis**	**(06 Hrs)**
	Transfer Function based modeling of Mechanical, Thermal and Fluid System; Concept of Poles & Zeros; Absolute vs Relative Stability; Stability Analysis using Routh Hurwitz Criterion; Mapping of Pole Zero Plot with Damping Factor, Natural Frequency and Unit Step Response.	
UNIT II	**Block Diagram Algebra**	**(06 Hrs)**
	Block Diagram Fundamentals, Canonical Form, Rules for Block Diagram Reduction, Reduction of Block Diagram, Reducing to Unity Feedback Systems, Examples on Block Diagram Reduction.	
UNIT - III	**System Response**	**(06 Hrs)**
	Introduction of Time Response of Control System, Standard Test Signals, Input-Output Model Equation, Instantaneous, Lagging and Delay Response, Transient Specifications for Unit Step Response,	

	Concept of State, State Variable, State Vector, State Space and State Model.	
UNIT - IV	**Signal Conditioning**	**(06 Hrs)**
	Necessity of Signal Conditioning, Passive Circuits, Analog Signal Processing: Operational Amplifiers, Inverting and Non-inverting, Summing, Subtractor, Instrumentation. Digital Signal Processing: Timing Diagrams, Sequential Logic, Flip-Flops, Successive Approximation (SAR) type ADC and R-2R ladder DAC.	
UNIT V	**Automatic Control System**	**(06 Hrs)**
	Concept of Automatic Control Systems, Mechatronics System & Its Examples, Mechatronics System Components, Open Loop and Closed Loop System, Effects of Feedback and Basic Characteristic of Feedback Control Systems. Applications of Feedback and Feed-Forward Control System. Basic Control Action and Controllers:-On-Off Control, Proportional, Integral, Derivative and PID.	
UNIT VI	**Programmable Logic Controller**	**(06 Hrs)**
	Introduction to PLCs, Basic Structure of a PLC, Principles of Operation, PLC Programming Languages, Ladder diagram, Latching and internal relays, Timers and Counters, Selection of a PLCs for Control System, Application of PLCs for Automatic Control System. Concept of SCADA and its Applications.	

Term Work:

Term work shall consist record of minimum 8 experiments from the following; Out of which Experiment no. 1, Experiment no. 3 and Experiment no. 9 are compulsory.

1. Analysis of following control system parameters using software like MATLAB/SIMULINK
    a. Plot the pole-zero configuration in s-plane for the given transfer function
    b. Stability analysis of given control system using Routh-Hurwitz's criterion
    c. Determine the transfer function for given closed loop system in block diagram representation.
    d. Plot unit step response of given transfer function and find peak overshoot, peak time, rise time and delay time.
2. Study of applications of Op-Amp Circuits.
3. Study of P, P+I, P+D, P+I+D control actions using any trainer kit / simulation software.
4. Study of XY position control systems.
5. Stabilizing Inverted Pendulum.
6. Study of A/D and D/A Converters.
7. Study the functions and applications of variable frequency drive(VFD).
8. To study AC servomotor and plot its Torque Speed characteristics.
9. Development of applications by using following instructions of the PLC
    a. Latching
    b. Timers

c. Counters
d. Logic Gates

10. Sequencing of pick and place robot using PLC programming.
11. Identification of different control system components in PLC based mini assembly cell.
12. Development of applications using SCADA system for any automation application.

Assignments:

Assignments will be based on above syllabus

Unit I	1. Numerical based on finding stability of control systems.
	2. Explain the Transfer function based modeling of Mechanical System
	3. Explain the Transfer function based modeling of Thermal System
	4. Explain the Transfer function based modeling of Fluid System
	5. Explain concept of poles and zeros and its importance in stability analysis.
	6. MATLAB based assignments on Routh-Hurwitz's stability criterion
Unit II	1. At least five questions on finding an overall transfer function of control system by using block diagram algebra method.
Unit III	1. What is the meaning of system response?
	2. What do you understand by input-output model equation?
	3. Define instantaneous response, lagging response and delayed response.
	4. Write notes on transient response specifications.
	5. What types of test signals are usually considered for testing a system response.
	6. Define state, state variable, state vector, state space and state model.
Unit IV	1. Why signal conditioning elements are necessary? Explain. What are the applications of signal conditioning elements?
	2. Define an op-amp. Explain with a neat block diagram. List the characteristics of an ideal op-amp.
	3. Write short notes on Inverting and Non-Inverting amplifier.
	4. Describe the significance of an instrumentation amplifier. Explain the operation of an instrumentation amplifier with the help of a circuit diagram.
	5. Define terms timing diagram, sequential logic and flip-flop
	6. Describe the operations of J-K FF with truth table.
	7. Explain working of SAR type ADC
	8. Explain working of R-2R ladder type DAC
Unit V	1. Define mechatronics and appreciate its relevance to contemporary engineering design
	2. Identify five mechatronic systems and its primary elements
	3. Describe the various forms and elements of open-loop and closed-loop control system
	4. Differentiate between feedback and feedforward control system
	5. Explain working of control actions- P, PI, PD and PID
	6. MATLAB based assignments on PID Controller
Unit VI	1. Draw block diagram of PLC and explain working of each block in brief.
	2. What is mean by ladder diagram? State difference between ladder and relay logic
	3. With the help suitable example explain working of latch

	4. Explain working of timer and counter with ladder diagram.
	5. State the criteria for selection of PLCs.
	6. Write five ladder logics for industrial applications.
	7. Write a short note on SCADA System & its use in automation
	8. Mini project based on PLC Programming.

Text Books/Reference Books:

1.	Control System Engineering: Nagrath L.T. and Gopal. M., Wiley Eastern Lid.
2.	Alciatore and Histand, "Introduction to Measurement and Mechatronics Systems", McGraw Hill.
3.	W. Bolton, "Mechatronics", Pearson Education.
4.	M D Singh and J G Joshi, "Mechatronics", PHI
5.	Gary Dunning, "Programmable Logic Controllers", Cengage Learning.
6.	Mechatronics-Principles, Concepts and Application: Mahalik, McGraw Hill Education Pvt Ltd;
7.	Process Control Instrumentation Technology, 8th Edition Curtis D. Johnson, University of Houston
8.	Ogata, Katsuhiko: "Modern Control Engineering (5th Edition)", Prentice-Hall, Inc., 2009 (ISBN: 0-13-615673-8)
9.	Madan Gopal, Control Systems Principles and Design, Tata McGraw Hill, seventh edition, 1997.
10.	Nise, Control System Engineering, John Wiley & sons, 3rd Edition.
11.	Norman Nise, "Control System Engineering", Prentice Hall India, Fourth Edition .
12.	Anand Kumar, "Control System Theory", Prentice Hall India.
13.	F. H. Raven, "Automatic Control Engineering", Third edition, McGraw Hill, 1983.
14.	Dr. N. K. Jain, "Automatic Control Systems Engineering", Dhanpat Rai Publishing Company.

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

3. AUTOMOBILE ENGINEERING

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
	Continuous Assessment: 40 Marks	**Total : 03** Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:

The Students should have basic knowledge of

1.	The Students should have basic knowledge of Elements of Mechanical engineering
2.	The Students should have basic knowledge of Machine Tools
3.	The Students should have basic knowledge of Internal Combustion Engine
4.	The Students should have basic knowledge of Theory of Machine

Course Objectives:

	1. Study basic principles of actual automobile systems 2. Study important systems in an automobile 3. Study recent and modern trends in automobile sector

Course Outcomes:

Students will be able to understand

1.	various systems in an automobile
2.	Importance and features of different systems like steering axle, differential.
3.	Importance and features of different systems like Transmission, braking System
4.	Importance and features tyres, wheel and balancing etc.
5.	Importance of electrical, starting and generating system etc.
6.	Principle of operation, construction and applications of various sensors used in modern automobile

UNIT - I	**Classification of Automobiles** Broad classification of Automobiles, Major components & their functions, Types of vehicle layouts, Types of bodies, Body construction & materials, All wheel drive, Types of chassis & their construction.	**(06 Hours)**

UNIT - II	**Steering System** Function of steering, Steering system layout, Automotive steering mechanism Ackerman & Davis, Types of steering gear boxes, Condition for true rolling, Steering geometry Camber, Caster, King pin inclination, included angle, Toe-in & Toe-out, Wheel alignment, Under steer & Over steer, Types & working of power steering. **Transmissions:** Necessity of gear box, Sliding mesh, Constant mesh, Synchromesh and epicyclic gear box, Overdrives and hydrodynamic torque converter, Trouble shooting and remedies. **Live axle and differential**: Final drive, spiral, bevel, Hypoid and worm drives, Types of live axles, semi, three quarter and full floating axles. Necessity of differential, Conventional and non-slip differential, Trouble shooting and remedies.	**(06 Hours)**
UNIT - III	**Clutch Braking System** Requirement of clutch, Types & functions, Single plate, Multiplate, Centrifugal, Cone clutch, Electromagnetic & Fluid clutches, Troubleshooting & automobile clutch. **Braking System** Function of automotive brake system, Types of braking mechanism Internal, Expanding & Disc brake, Mechanical, Hydraulic & Air brake system, Servo & power brakes, Antiskid braking, Calculation of braking force required, Stopping distance & dynamic weight transfer.	**(06 Hours)**
UNIT - IV	**Suspension** Object of suspension, Basic requirement, Air suspension and its features, Independent suspension, Spring & unspring mass, Types of spring, Shock absorber, Torsion bars, Air suspension, Hydro pneumatic suspension, Pitching, rolling and bouncing. **Wheels and Tyres** Requirements of wheels and tyres, Constructional features, Types of tyres, Types of rim , Inflation Pressure and its importance, Application to ride and stability, Trouble shooting and remedies.	**(06 Hours)**
UNIT - V	**Electrical system** Battery: Types of battery, Lead-Acid, Alkaline, ZEBRA, Sodium Sulphur and Swing, Ratings, charging, Maintenance and testing of Lead-Acid battery. **Starting system**: Requirements, Various torque terms used, Starter motor drives; Bendix, Follo through, Barrel, Rubber compression, Compression Spring, Friction Clutch, Overrunning Clutch, Dyer.	**(06 Hours)**

	Starter motor solenoids and switches, Glow plugs. **Alternator:** Principle of operation, Construction, Working, Rectification from AC to DC.	
UNIT - VI	**Recent trends in Automobiles** Electronic Control module (ECM), operating modes of ECM (closed loop and open loop) Inputs required and output signals from ECM, Electronic Spark control, Air Management system, Idle speed control. Construction, working & application of temperature sensors, inductive sensors, Position sensors (rotary, linear). Hot wire and thin film air flow sensors, vortex flow/turbine fluid sensors, Optical sensor, Oxygen sensors, Light sensors, methanol sensors ,Rain sensor, New developments in the sensor technology.	**(06 Hours)**

Any Six Assignments from the following:

1. Study of types of bodies and chassis of automobile.
2. Report on dismantling and assembly of steering mechanisms.
3. Report on dismantling and assembly of brakes.
4. Report on dismantling and assembly of rear axle and differential.
5. Report on dismantling and assembly of suspension systems.
6. Study of types of tyres and rims.
7. Report on battery charging and starting systems.
8. Study and understanding of different types of sensors used in automobile.
9. Report on industrial visit to any automobile Manufacturer.
10. Report on industrial visit to any Two wheeler/ Four Wheeler service station

Text Books/Reference Books:

1	Automotive Mechanics, William Cruose & Donald L. Anglin, Tata Mcgraw Hill
2	Automotive Mechanics , Joseph Heitner, East-West press pvt .Ltd
3	The Automobile Engineering, T. R. Banga & Nathu Singh, Khanna Publishers
4	The Automobile, Harbans Singh Reyat, S. Chand & Co.
5	Automobile Engineering, R. K. Rajput, Laxmi Publication
6	Basic Automobile Engineering, C.P.Nakra, Dhanpat Rai Publishing CO
7	Automobile Engineering, Kirpal Singh Vol I & II, Standard publishers Distributors ,Delhi
8	Automobile Engineering, K. K. Jain & R.B. Asthana, Tata Mcgraw Hill
9	Automotive Mechanics, S. Srinivasan, Tata Mcgraw Hill

10	Automobile Engineering, Vol I & II, R.K. Mohanty, Standard Book House

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

4. INDUSTRIAL FLUID POWER		
Teaching Scheme:	**Examination Scheme:**	**Credits Allotted**
Theory: -03Hours/ Week	End Semester Examination: 60 Marks	Theory: 03
	Continuous Assessment: 40 Marks	**Total :03**
	Term Work/ Oral: -- Marks	

Course Prerequisites: -	The Students should have 1. Knowledge of fluid mechanics, turbomachinery. 2. Knowledge of mechanical measurement. 3. Knowledge of Theory of Machine
Course Objective: -	1. Familiarization with fluid power principles and the fluid power industry. 2. To analyse specific problems, design solutions and evaluate fluid power systems in industrial applications. 3. To instil within students a positive safety attitude with regard to the design, construction, operation, and maintenance of fluid power systems. 4. To provide students with knowledge of the applications of fluid power systems in process, construction, robotics and manufacturing industries. 5. To develop within each student a measurable degree of competence in the design, construction, operation and maintenance of fluid power systems. 6. To provide students with an understanding of the properties of hydraulic and pneumatic fluids, as well as components utilized in industrial fluid power systems.
Course Outcomes: -	Students should be able to 1. Identify fluid power system and its basic components for practical applications. 2. Select suitable pump, reservoir and accumulators for various industrial applications. 3. Use specific pressure, flow and direction control valves based on applications. 4. Select actuator and develop a simple hydraulic circuit to accomplish the task. 5. Understand basic components of the pneumatic& electro-pneumatic systems and develop pneumatic circuits for industrial automation. 6. Design hydraulic & pneumatic circuit for industrial applications.

Course Contents

Unit 1	Introduction to Fluid Power	(06Hrs)
Fluid power system: Components of fluid power system, advantages and limitations. Difference between electrical, pneumatic and fluid power systems. Applications in the fields of machine tools, material handling, aerospace, mobile and stationary machines, clamping devices and more applications of fluid power. **Types of hydraulic fluids, Seals, Conductors**: Petroleum based, synthetic and water based. Properties of fluids, Pascal's Law, selection of fluids, additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials. Types of pipes, hoses, material. Fluid conditioning through filters, strainers, sources of contamination and contamination control.		
Unit 2	**Source of Power**	**(06 Hrs)**
Pumps: Types, classification, principle of working and constructional details of gear pumps, vane pump, piston pump, power and efficiency calculations, characteristics curves, selection of pumps for hydraulic power transmission (Numerical Treatment). **Power units and accessories**: Types of power units, reservoir assembly, sizing of reservoirs, constructional details, pressure switches, temperature switches. Accumulators: Types, selection procedure, applications of accumulators. ISO symbols for hydraulic and pneumatic Components		
Unit 3	**Fluid Power Control**	**(06 Hrs)**
Control of fluid power: Necessity of fluid control through pressure control, directional control and flow control valves. **Control valves:** i) Principle of pressure control valves, direct operated and pilot operated pressure relief valves, pressure reducing valve, sequence valve. ii) Principle of flow control valves, pressure compensated and non-compensated flow control valves.iii) Principle of directional control valves, types of directional control valves, two-way, three-way, four-way valves, check valve and shuttle valve. Open centre, close centre, tandem centre valves. Actuating devices- manually operated, mechanically operated, solenoid operated, pilot operated, lever operated.		
Unit 4	**Actuators and Industrial Circuits**	**(06 Hrs)**
Actuators: (i) Linear and Rotary actuators (ii) Types of cylinders and mountings, Design considerations for cylinders (iii) Types of hydraulic motors- gear, vane & piston. (iv) Methods of control of acceleration, deceleration. (v) Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads (Numerical Treatment). **Industrial circuits**: Simple reciprocating, Regenerative, Speed control (Meter in, meter out & bleed off), Sequencing, Synchronization, transverse & feed, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, circuit for hydraulic press, unloading circuit, motor breaking circuit.		
Unit 5	**Pneumatics**	**(06 Hrs)**
Principle of Pneumatics: (i) Laws of compression, types of compressors, selection of compressors. Pneumatic actuators-rotary, reciprocating (ii) Comparison of pneumatics with hydraulic power transmissions. (iii) Types of filters, regulators, lubricators, mufflers, dryers. (iv) Pressure regulating valves, (v) Direction control valves (vi) Speed regulating methods		

used in Pneumatics.(vii)Basic pneumatic circuits (viii) Introduction to electro-pneumatics. Application of pneumatics in industrial automation. **Introduction to vacuum**: Vacuum measurement, vacuum pumps, introduction to vacuum sensors and valves. Industrial applications of vacuum.		
Unit 6	**System Design**	**(06 Hrs)**
Design of hydraulic/ pneumatic circuit for practical application, Selection of different components such as reservoir, various valves, actuators, filters, pumps based on design. (Students are advised to refer manufacturer's catalogues.)		

Term work

Term work shall consist record of minimum 10 experiments from following; Out of which Experiment no.7, Experiment no. 9 and Experiment no. 13 are compulsory.

1. Study of ISO/JIC Symbols for hydraulic and pneumatic systems.
2. Study of positive displacement pumps and determination of performance characteristics.
3. Study of filters and determination of filtration ratings.
4. Study of pressure control valves and circuits.
5. Study of flow control valves (Meter in, Meter out Circuits).
6. Study of direction control valves and circuits.
7. Following experiments to be done on pneumatic trainer:
   a) Automatic reciprocating circuit.
   b) Speed control circuit.
   c) Pneumatic circuit involving shuttle valve/quick exhaust valve.
   d) Sequencing circuit.
   e) Circuits by using logic gates.
8. Following experiments to be done on hydraulic trainer:
   a) Regenerative circuit.
   b) Speed control circuit.
   c) Sequencing circuit.
   e) Transverse and feed circuit.
9. Design of circuits by using fluid simulation software's such as LVSIM®-HYD & PNEU, AUTOMATION STUDIO.
10. Study of Logic for DELAY Circuit using signal Input device unit & Indicator unit.
11. Design of compressed air distribution in pneumatic systems.
12. Design of simple hydraulic systems used in practice such as hydraulic clamp, jacks, dumper, forklift etc.
13. Industrial visits for applications of hydraulic and pneumatic system and their reports.
14. Study of accumulators/actuators/intensifiers/hydraulic and pneumatic power brakes.

Assignments

Assignments will be based on above syllabus

1. Theory questions based on hydraulic fluids, seal, strainer, conductor and filters.
2. At least five numerical/theory questions on sources of power.
3. Theory questions based on selection of pressure control, flow control and directional control valve for specific application.
4. Develop at least five hydraulic circuits using simulation software like Automation Studio.
5. Develop at least five pneumatic circuits for low cost industrial automation using simulation software like Automation Studio, Fluid SIM®.
6. Design of at least five hydraulic/pneumatic systems which includes components such as reservoir, various valves, actuators, filters, pumps based on design.
7. Theory questions based on sources of contamination, and its control.
8. Theory questions based on fluid power control.
9. Theory questions based on pneumatics and its applications
10. Identify at least five fluid power applications and enlist the fluid power components used in each of these applications.
11. Design of hydraulic/pneumatic circuit for practical application and selection of fluid power components.

Text Books

1. Anthony Esposito, Fluid Power with Applications, Pearson.
2. S.R. Majumdar, Oil Hydraulic systems- Principle and maintenance, Tata McGraw Hill.
3. S. R. Majumdar, Pneumatics Systems Principles and Maintenance, Tata McGraw Hill.
4. H. L. Stewart, Hydraulics and Pneumatics, Taraporewala Publication.
5. Jagadeesha T. and Tahammaiah Gowda, Fluid Power, Generation, Transmission and Control Wiley Publication.

Reference Books

1. J. J. Pipenger "Industrial Hydraulics", McGraw Hill
2. Pinches "Industrial Fluid Power", Prentice hall.
3. D.A. Pease "Basic Fluid Power'‘, Prentice hall.
4. B. Lall "Oil Hydraulics”, International Literature Association.
5. Yeaple "Fluid Power Design Handbook".
6. ISO - 1219, Fluid Systems and components, Graphic Symbols
7. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
8. Product Manuals and books from Vickers/ Eaton, FESTO, SMC pneumatics
9. Dr. R K Bansal, Fluid Mechanics, Laxmi Publications (P) Ltd.

Unit Tests-

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

Elective II: 5.1 COMPUTATIONAL FLUID DYNAMICS

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH:03 Credits
Practical: - Hours / Week	Continuous Assessment: 40 Marks	Total:03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:

The Students should have

1.	Knowledge of Mathematics & Science
2.	Knowledge of fluid mechanics and heat transfer

Course Objectives:

1.	To introduce Governing Equations of vicious fluid flows
2.	To introduce numerical modeling and its role in the field of fluid flow and heat transfer
3.	To enable the students to understand the various discretization methods

Course Outcomes:

Students will be able to understand

1.	Student should able to understand types of flow
2.	Student should able to understand CFD Analysis
3.	Student should able to understand numerical methods used in CFD
4.	Student should able to understand Generate mesh
5.	Student should able to understand conjugate heat transfer
6.	Student should able to understand turbulence modeling

Course Contents

UNIT - I	**Introduction to fluid Dynamics**	**(06 Hrs)**
	Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and	

	Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies.	
UNIT - II	**Mesh Generation**	**(06 Hrs)**
	Surface mesh generation Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination	
UNIT - III	**Basic Discretization Techniques**	**(06 Hrs)**
	Need to discretization the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation) and second order (based on 3 node, 4 node and 5 node points),explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation using FTCS and Crank Nicholson‘s Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver.	
UNIT - IV	**Two Dimensional Steady and unsteady heat conduction**	**(06 Hrs)**
	Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems	
UNIT - V	**Application of Numerical Methods to Convection – Diffusion System**	**(06 Hrs)**
	Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation Convection –Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system	
UNIT - VI	**CFD as Practical Approach**	**(06 Hrs)**
	Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initialising and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), k-ϵ , k- . Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle	
Assignments:		

Assignments will be based on above syllabus	
1.	Reynolds transport theorem, Integral form of conservation equations
2.	Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations
3.	Surface mesh generation Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms
4.	Grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids
5.	Finite difference approximation using Taylor series, for first order
6.	Explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation using FTCS and Crank Nicholson‘s Method
7.	Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann,
8.	Robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems
9.	Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept
10.	Selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness
Text Books/Reference Books:	
1.	Versteeg, H.K., and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The finite volume Method, Longman, 1998.
2.	Ghoshdastidar , P.S., computer Simulation of flow and heat transfer, Tata McGraw Hill Publishing Company Ltd., 1998.
3.	Patankar, S.V. Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 2004.
4.	Muralidhar, K., and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, NewDelhi, 1995.
5.	Prodip Niyogi, Chakrabarty .S.K., Laha .M.K. Introduction to Computational Fluid Dynamics, Pearson Education, 2005
6.	Introduction to Computational Fluid Dynamics Anil W. Date Cambridge University Press, 2005.

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective II: 5.2 INDUSTRIAL ENGINEERING & MANAGEMENT		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH:03 Credits
Tutorial: 00 Hours / Week	Continuous Assessment: 40 Marks	Total: 03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:		
The Students should have		
1.	Knowledge of basic concept of Management	
2.	Basic information of Industrial engineering.	
3.	Basic knowledge of human considerations in manufacturing.	
Course Objectives:		
	The student should understand the scope, objective and application of industrial engineering tools and management practices in manufacturing.	
Course Outcomes:		
Students will be able to understand		
1.	Definition, principles and functions of management.	
2.	Types and selection of business organizations.	
3.	Functioning of Personnel, Marketing and Finance Department.	
4.	Method Study tool for standardizing the method.	
5.	Work Measurement tool for standardizing the time.	
6.	Ergonomically accepts in manufacturing.	
UNIT - I	**Management-An Introduction:** Management- Meaning and Definitions, Management, Administration, and Organization concepts, Management as an Art and Science and a profession, contribution of various thinkers to management thought, Types and Functions of Management. Different approaches to management – scientific, operational, human and system approach.	**(06 Hours)**
UNIT - II	**Organization:** Different forms of business Organization –Individual proprietorship, Partnership, Joint stock company, Co-Operative enterprise, Public Sector, Undertakings, organizational structures in Industries, Line,	**(06 Hours)**

	Functional ,Line and functional , Project, Matrix Organization and Committees	
UNIT - III	**Financial, Marketing and Personnel Management:** Personnel Management-Definitions Recruitment, Selection and training of the employees, Job valuation and Merit rating, wage administration different methods of wage payments, incentives. Marketing Management-Definitions, Marketing and Selling concept, market segmentation, distribution channels, Market Research, Advertising and sales promotion and Sales forecasting. Financial Management-Capital structure, Fixed capital, working capital, sources of finance, cost analysis, Break even analysis, Depreciation and Financial statement.	**(06 Hours)**
UNIT - IV	**Method Study:** Steps in method study, tools and techniques used, process chart symbols, flow diagrams, two handed chart, multiple activity chart, use of motion pictures and its analysis. SIMO charts, chorno & cycle graph, developing, presentation, installation and maintenance of improved methods.	**(06 Hours)**
UNIT - V	**Work Measurement :** Time Study: Aim and objectives , terminology and tools, use of stop watch procedure in making a time study, elements, selection of operations time study forms, handling of foreign elements. Performance rating. Allowances: Personal, Fatigue and other allowances. Analysis and calculation of Standard Time. Determination of number of cycles time study for indirect functions such as Maintenance , Marketing etc., MOST Technique. Works Sampling: Definition, Objectives, theory of Work Sampling. Other applications of work sampling, errors in work sampling study. Synthetic and Standard data Methods: Concepts, introduction to PMTS, MTM-1, WF, Basic motion time, MTM-2, and other second – generation methods timing of group operations.	**(06 Hours)**
UNIT - VI	**Ergonomics and Industrial Safety:** Definitions, importance in industry, basic anatomy of human body, anthropometrics, measurement of physical work and its techniques, work and rest cycles, bio mechanical factors environment effects. Importance of safety, planning, training, safety precautions, safety	**(06 Hours)**

	Equipments, Government regulations on safety.	

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

Text Books/	
1.	O. P. Khanna, Industrial Engineering & Management, Dhanapat Rai & Sons.
2.	M. C. Shukla, Business Organization and Management, S. Chand & Co. Ltd, New Delhi.
3.	Harold Koontz & Heinz Enrich, Essentials of Management, McGraw Hill International.
4.	M. N. Mishra, Organizational Behavior, Vikas publishing New Delhi.
5.	Dale Yoder, Personnel Management.
6.	Work Study, ILO.
7.	S. S. Patil, Industrial Engineering & Management, Electro tech Publication.
8.	Mansoor Ali & Dalela, Industrial Engineering & Management System, Standard Publisher distributions.
9.	R. M. Currie, Work Study, ELBS.
10.	Management by James A. F. Stoner, R. Edward Freeman, PHI
11.	Management Today: Principles and Practice by Gene Burton and Manab Thakur, TMH
12.	Organizational Behavior by Keith Davis, TMH
13.	Management (Tasks, responsibilities and Practices) by Peter Drucker, Harper Business
14.	Production Management by Lockyer, ELBS
15.	Modern Production Management by E. S. Buffa (John Wiley)
16.	Financial Management by Vanhorne, PHI
17.	Financial Management (Theory and Practice) by Prasanna Chandra, TMH
18.	Marketing Management by Philip Kotler, Pearson Edition

19.	Marketing Management by Rajan Saxena, TMH
20.	Personnel Management by Edward Flippo, TMH
21.	Industrial Engineering and PPC" by A.K Bewwor and V.A.Kulkarni.

Syllabus for Unit Test:	
Unit Test -1	Unit I ,II and III
Unit Test -2	Unit IV,V and VI

ELECTIVE II: 5.3 NANOTECHNOLOGY		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical: 00 Hours / Week	Continuous Assessment: 40 Marks	Total: 03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:	
The Students should have	
1.	Material Science
2.	Physical properties of Material
3.	Chemical properties of Material
Course Objectives:	
	To know the history, synthesis, characterization and application of Nanotechnology
Course Outcomes:	
Students will be able to understand	
1.	The basic of nano science and nanotechnology
2.	Properties of nanomaterials
3.	Synthesis process of the nanomaterials
4.	Characterization tools of nanomaterial
5.	Applications of nano science e and nanotechnology
6.	Safety parameters while implementing nanotechnology

UNIT - I	**Basics of Nanoscience**	**(06 Hours)**
	Introduction, length scale of different structures, definition of nanoscience and nanotechnology, fullerenes, CNTs, graphenes and inorganic nanostructures, the evolution of Nanoscience, quantum dots and electronic structure of various nanophase materials.	
UNIT - II	**Properties of Nano materials**	**(06 Hours)**

	Mechanical, Thermal, Electrical, Optical, Magnetic and Structural properties. Carbon nanostructures -Fabrication, structure, electrical properties and mechanical properties	
UNIT - III	**Synthesis of Nonmaterial's**	**(06 Hours)**
	Bottom up-Ball Milling, Melt mixing, Physical vapour deposition, Ionized cluster beam deposition, Laser pyrolysis, Sputter deposition, Electric arc deposition, Gas evaporation. Chemical methods: Hydrothermal combustion, bath deposition with capping techniques and top down, Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Microemulsions, Sol-gel method, Combustion method, Wet chemical method	
UNIT - IV	**Nanomaterials characterization**	**(06 Hours)**
	Nanomaterials characterization XRD, UV-VIS spectroscopy, X-ray fluorence, X-ray photon emission spectroscopy, Scanning electon microscopy, Transmision electron microscophy, Scanning tunneling microscopy, Atomic force microscopy, Nuclear magnetic resonance spectroscopy, Electron spin resonance spectroscopy, Raman spectroscopy	
UNIT - V	**Applications of Nanotechnology**	**(06 Hours)**
	Industrial applications of nanomaterials, in the areas of electronics, photonics, biology, nano biomaterials, health and environment, medicine, defence, chemicals, catalysts, textiles, etc. Application of nanotechnology in remediation of pollution, photocatalysis and other nanocatalysts, greenhouse gases, global warming. Monitoring nanoparticles at work place and sensors used for this.	
UNIT - VI	**Nanotechnology and Safety**	**(06 Hours)**
	Assessment of human health risks associated with the use of nanotechnologies and nanomaterials in the food **and** agriculture sectors, safety, current risk assessment approaches used by FAO/WHO, environmental, ethical, policy and regulatory issues. Toxicity of nanoparticles, exposure to nanoparticles and CNTs and influence on respiratory systems.	
Term Work/Practical's:		
1. Study of nanoscienece and nanotechnology structures		
2. Synthesis of nanofibers by electrospinning processes		
3. Synthesis of nonmaterial's by sol gel process		

4. Study of Atomic Force Microscope	
5. Study of nano particle analyzer	
6. Study of Electrospinning Process	
7. Study of FTIR	
Assignments:	
1. Study of nano science and nanotechnology structures	
2. Properties :Mechanical, Thermal, Electrical, Optical, Magnetic and Structural	
3. Properties: Carbon nanostructures	
4. Synthesis of Nonmaterial's: Bottom up	
5. Synthesis of Nonmaterial's: Chemical methods	
6. Surface electon microscopy, Transmision electron microscophy, Scanning tunneling microscopy	
7. UV-VIS spectroscopy, X-ray fluorence, Atomic force Microscope, Raman spectroscopy	
8. Applications in electronics, photonics, biology, health and environment, medicine, defence, chemicals, catalysts, textiles	
9. Application of nanotechnology in remediation of pollution, photocatalysis and other nanocatalysts, greenhouse gases, global warming	
10. Nanotechnology and Safety	
Text Books/Reference Books:	
1	Edward L. Wolf (2nd Ed.), Nanophysics & Nanotechnology: An Introduction to Modern Concepts in Nanoscience, WILEYVCH, 2006
2	H.S.Nalwa, Hand book of Nanostructure materials and nanotechnology; (Vol.1-5), Acad. Press, Boston, 2000
3	C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
4	C. Furetta, Hand book of thermoluminescence; World Scientific Publ.
5	5.T.J.Deming, Nanotechnology; Springer Verrlag, Berlin, 1999
6	C. Delerue, M.Lannoo; Nanostructures theory and Modelling
7	Fausto, Fiorillo, Measurement and Characterization of Magnetic materials
8	Janos H, Fendler; Nanoparticles and Nanostructured Films

9	Liu,Hand Book of Advanced Magnetic Materials (4 Vol.)
10	Banwong, Anurag Mittal; Nano CMOS Circuit and Physical Design
11	S. Sakka,Sol-gel science and technology processing, characterization and applications; Kluwer Acad. Publ.
12	Goser et al, “Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices”
13	A. A. Balandin and K. L. Wang, “Handbook of Semiconductor Nanostructures & Nanodevices”
14	Cao Guozhong, “Nanostructures &Nanomaterials -Synthesis, Properties & Application

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective II: 5.4 PRODUCTION PLANING AND CONTROL		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical: - Hours / Week	Continuous Assessment: 40 Marks	Total: 03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:	
The Students should have	
1.	Knowledge of basic concept of Industrial Engineering &Management
2.	Knowledge of statistics.
3.	Basic knowledge of resources of production Man, Machine Material.
Course Objectives:	
1.	The student should understand the scope, objective and application of Production Planning And Control manufacturing Industries.
Course Outcomes:	
Students will be able to understand	
1.	The importance of PPC in industry.
2.	The Forecasting by using different techniques.
3.	Different ideas and concept to improve PPC in industry.
4.	Different techniques for material requirement planning
5.	Different techniques used for PPC in industry.
6.	Computer Aided Process Planning.

Course Contents		
UNIT I	**Introduction to PPC** : Role and stages of PPC, PPC as an integrated function, Product Life Cycle Analysis, Types of Production systems.	**(06 Hrs)**

UNIT II	**Forecasting Techniques:** Use and types of forecasting, Methods of forecasting and comparison, Verification and control.(Numerical Treatment)	**(06 Hrs)**
UNIT - III	**Techniques And Production Control:** Process sheet, Routing, Scheduling- Gantt Chart, Machine Loading Chart, Line of Balance, Line Balancing, Dispatching rules, Sequencing - Johnson's rule, Loading, Follow- up, Evaluation, PERT, CPM. .(Numerical Treatment)	
		(06 Hrs)
UNIT - IV	**Materials Planning And Purchasing:** Scope and requirement of MRP, MRP I and MRP II, Master Production Schedule, Bill of Materials, Capacity Requirement Planning, Introduction to ERP, Purchasing - Documentation, Make or Buy decisions, Vendor Development.	
		(06 Hrs)
UNIT - V	**a) Inventory Control:** Types of Inventory Cost of Inventory, EOQ, Selective Inventory Control, Replenishment Systems. **b) Stores Management:** Types of stores, Storage layout and storage systems, Stores Documentations, Stores Control and Control of Wastage and surplus, JIT, KANBAN, KAIZEN, Value Stream Mapping	
UNIT - VI	**Computer aided production planning and control applied to :** a) Machine capacity planning and utilization. b) Productivity measurement. c) Material Requirement Planning. d) Scheduling Techniques. Hands on experience of Computer aided Production Planning and Control. Case studies from Industries.	**(06 Hrs)**

Assignments:	
1.	Introduction of PPC
2.	Techniques of Forecasting used in PPC
3.	Different Techniques used in PPC to improve the production and to reduce the cost of production
4.	Use and application applications of material planning and purchasing
5.	Use of inventory control

6.	Computer aided production planning and control (CAPP)
Text Books/Reference Books:	
1.	J.L. Riggs, "Production Systems - Planning Analysis and Control ", JhonWiley & Sons.
2.	J.B. Dilworth, "Operations Management - Design, Planning & Control for Manufacturing and Services ", McGraw Hill.
3.	S N Charry, "Production and Operation Management" Tata McGraw- Hill
4.	Samuel Elion, Elements of PPC ", Universal Book Company.
5.	Martand Telsang, "Industrial Engineering and Production Management" S. Chand and Co. Ltd.
6.	Moore, "Production Control ".
7.	Mager and Boodman," Production Planning And Inventory Control"
8.	Martin Star, “Production Management ".
9.	Erry Johnson, “Process Engineering ".
10.	E. EL. Buffa, “Production Management ".
11	A.K. Bewoor and V.A. Kulkarni “Production planning and Control”

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective II: 5.5 Experimental Methods in Mechanical Engineering		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory:-03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical:--- Hours / Week	Continuous Assessment: 40 Marks	PR: -- Credits
	Term Work/ Oral: -- Marks	**Total: 03 Credits**

Course Prerequisite:-	Student should have knowledge of: 1. Basic concepts in core courses in Mechanical Engineering. 2. Basic concepts in Engineering Mathematics. 3. Mechanical Measurements.
Course Objective:-	The student must be able to: 1. Understand the concepts of probability and statistics. 2. Understand application of curve fitting techniques in engineering. 3. Understand methods of design of experiments. 4. Understand need of uncertainty analysis 5. Understand advanced measurement techniques. 6. Select a data acquisition system for a given application.
Course Outcomes:-	Learner will be able to- 1. Understand characteristics of measurement system 2. Apply various techniques of curve fitting. 3. Apply basic concepts of design of experiments. 4. Use techniques of uncertainty analysis. 5. Use advanced measurement techniques in experimentation 6. Use data acquisition system (DAS) in experimentation.

Course Contents

Unit 1	**Introduction to Experimental methods**	**(06 Hrs.)**

Probability and Statistics: Statistical Measurement Theory, Mean Value and Uncertainty, Probability-Density Function, Histogram-Frequency distribution, Mean value and Variance, Infinite Statistics, Normal-Gaussian distribution, Normal-Gaussian distribution,

Characteristics of measurement systems: Dynamic characteristics of first order (liquid in glass thermometer) and second order instruments (U tube manometer). Response of first order and second order systems.

Unit 2	**Curve Fitting**	**(06 Hrs.)**

Engineering application of curve fitting. Least squares approach, Polynomial curve fitting, Overfit and underfit. Multivariable regression analysis. Correlation coefficient. Power law and exponential curve fitting. Numericals based on practical engineering problems.

Unit 3	Planning of Experiments	(06 Hrs.)
Planning of experiments, various stages in experimental investigations; preliminary, intermediate and final, steady state and transient techniques, Need for design of experiments (DOE). Guidelines for performing DOE. Factorial design: Full factorial design and Fractional factorial design. 2^K factorial design. Taguchi method. Response surface methodology.		
Unit 4	**Uncertainty in Measurements**	**(06 Hrs.)**
Errors in instruments, Analysis of experimental data and determination of overall uncertainties in experimental investigation, uncertainties in measurement of parameters like pressure, temperature, flow etc. under various conditions. Estimation of uncertainty by Partial Differentiation Method (PDM), Combining uncertainty components. Student's t-test method.		
Unit 5	**Advanced Measurement Techniques**	**(06 Hrs.)**
Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Telemetry in measurement, Orsat apparatus, Gas Analyzers, Smoke meters, gas chromatography, spectrometry, FFT analyzer.		
Unit 6	**Data Acquisition System (DAS)**	**(06 Hrs.)**
Data Acquisition Systems: Basic and automated versions of DAS. Characteristics of DAS: analogous input, sample speed, accuracy, linearity and resolution. A/D and D/A converters, Signal conditioning equipments. Case studies on selection of DAS for different experimentations. Introduction to data acquisition softwares.		

Reference Books

1. Coleman H. W. and Steele W. G., Experimentation, Validation, and Uncertainty Analysis for Engineers, 3rd ed.: John Wiley & Sons Inc., New Jersey, 2009.
2. Grewal, B. S. Higher engineering mathematics. Khanna Publisher, New Delhi, 1996.
3. Montgomery, Douglas C. Design and analysis of experiments. Vol. 6. New York: Wiley, 2002.
4. Kumar D. S., Mechanical Measurement & Control, Metropolitan Book Co. Pvt. Ltd. New Delhi, 2007.
5. Beckwith T. G., Marangoni R. D., Lienhard J. H., Mechanical Engineering Measurements, Pearson Prentice Hall, 2007

Assignments-

1. Problems on uncertainty analysis
2. Theory questions on introduction to experimental methods
3. Problems on practical engineering based on curve fitting
4. Theory questions on curve fitting
5. Theory questions on design of experiments
6. Practical engineering problems based on design of experiments
7. Questions based on transducers, sensors and actuators

8. Questions based on static and dynamic characteristics of instruments
9. Questions based on data acquisition system
10. Two practical oriented problems using any coding language.

Unit Tests-

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

6. INPLANT TRAINING		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: -- Hrs. / Week	End Semester Examination: -- Marks	TH: -- Credits
Practical: -- Hrs. / Week	Continuous Assessment: -- Marks	TW/OR: 04 Credits
	Term Work/ Oral: 50 Marks	Total: 04 Credits

Course Prerequisites:-	1. Students should have basic idea about engineering fundamentals
Course Objective: -	1. Able to understand company organization and products manufactured. 2. Able to understand economic considerations for a specific product 3. Able to understand safe working environment in the company. 4. Able to communicate with workers and supervisors. 5. Able to understand various aspects of industrial practices and ethics. 6. Able to understand exposure for real life work and internships, carrier options with different work environments.
Course Outcomes: -	1. Factory layout and workflow 2. List of in-house manufactured and bought out parts and the economic considerations for a specific product. 3. Component wise product manufacturing process chart. 4. Your training learning, deficiencies and lapses and suggestions for improvements

In plant training for 45 days:

Before the VII semester, students are required go through in-plant training for 45 days in a manufacturing company. The students will show their interest of training to the faculty coordinator who will arrange their training. In case a student wishes to undergo training in a specific company, he will indicate the same to the training coordinator who after ensuring the suitability of the company will take suitable action. During the training period student will be required to strictly follow the company rules and regulations about timings and other matters will work on the assigned project. During training period the students are required to go the company daily. Their attendance record verified by the factory training in charge of the factory will be part of their project report.

Report:

On completion of training, students are required to write a technical report about their training. In general the report should not exceed 50 pages of typed material. The report should cover following: Introduction-organization, its short history, products manufactured, competitors and organization's position in the market and its growth potential, production planning & control, material management, delivery of orders, off loading of work to third party cost saving or energy saving proposals, qualitative feedback from expert, study of tool room .

7. PROJECT STAGE -I		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 00 Hrs. / Week	End Semester Examination: -- Marks	TH: -- Credits
Practical: 02 Hrs. / Week	Continuous Assessment: -- Marks	TW/OR: 04 Credits
	Term Work/ Oral: 100 Marks	**Total: 04 Credits**

Course Pre-requisites:	
The Students should have	
1.	Knowledge of Mathematics & Science
2.	Knowledge of basic concepts in heat transfer.
3	Basic information of thermodynamics.
4	Basic knowledge of design
5	Knowledge of basic concepts in mechanical engineering.
Course Objectives:	
1.	To identify problem for a specific need of an organization
2.	To review literature on specific research topic
3.	To make feasible, sustainable design
4.	To work sincerely as a member of a team
5.	.To communicate ideas to supervisors as well as subordinates
6.	To develop new equipment or make modifications in existing one
Course Contents	
1	The formation of a project team with members having similar interest.
2	Discuss the ideas within the team members and choosing a faculty member interested in similar activity with the consent of the HOD. The projects can be on new equipment development, on industry sponsored problems or on research oriented subjects.
3	Discuss the project with the Faculty with the idea that projects selected are suitable for design and fabrication with the available resources.
4	First presentation must include following points: • Project Aim • Feasible design and alternatives considered • Estimation of approximate cost of the project • Activities bar chart • Internal Lab resources required External resources required and their availability.
5	Second presentation consists of: • Collection of reference material and • Design of the equipment with working drawings

	Stage of work completed through activities bar chart.
6	Third presentation includes complete work with suggested modifications.

8. Power Plant Engineering

Teaching Scheme:	Examination Scheme:	Credits Allotted
Theory:-04 Hrs. / Week	End Semester Examination: 60 Marks	TH: 04 Credits
Practical:- 02 Hrs. / Week	Continuous Assessment: 40 Marks	PR: 01 Credit
	Term Work/ Oral: 50 Marks	**Total : 05 Credits**

Course Prerequisite:-	Student should have knowledge of: 1. Basic concepts in Fluid Mechanics, Engineering Thermodynamics and Turbo-machinery. 2. Basic concepts in Engineering Mathematics.
Course Objective:-	The student must be able to: 1. Understand present status of power generation in India. 2. Understand various aspects of steam power plant. 3. Understand details of steam condensers, cooling towers and noozels. 4. Understand details of renewable and hybrid power systems. 5. Perform analysis of power plant for specific application 6. Understand various energy storage techniques.
Course Outcomes:-	Learner will be able to understand- 1. Brief overview of different types of power plants 2. Details of non-renewable power systems. 3. Performance of condensers, cooling towers and nozzles. 4. Performance of renewable and hybrid power systems. 5. Economics of power generation. 6. Procedures for safe operation and maintenance of power plants.

Course Contents

Unit 1	**Introduction to Power Engineering**	**(08 Hrs.)**

Different types of power plants–Thermal, Hydro, IC Engine, Gas Turbine, Nuclear and their characteristics, Combined Cycle, Pumped storage,

Compressed air storage power plants and their characteristics. Comparison of Power plants with respect to various parameters.

Issues in Power plants. Resources and development of power in India, NTPC, NHPC and their role in Power development in India.

Power generation in Private sector, Power distribution, National Grid, Indian Electricity Grid Code. Regulation Structure of IEGC, Operating Policies and Procedures, Present Power position in India.

Unit 2	Non-Renewable Power Systems	(08 Hrs.)

High pressure and Super Critical Boilers – Fluidised bed boilers.

Steam power cycles- Rankin cycle with reheat, regeneration. Numerical based on different combinations. Performance of boilers.

Fuel and ash handling, Combustion equipment for burning coal, Mechanical Stokers. Pulveriser, Electrostatic Precipitator, Draught- Different types

Gas Turbine Power Plants: Fuels, Gas turbine material, open and closed cycles, reheating, Regeneration and intercooling, combined cycle. Turbojet, Ramjet, Turboprop, Rocket engine.

Diesel Power Plants: Types of diesel plants, components, Selection of Engine type, applications.

Nuclear Power Plants: Nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled. Advantages and limitations, nuclear power station, waste disposal.

Unit 3	Condensers, Cooling Towers and Steam Nozzles	(08 Hrs.)

Steam Condensers: Function of condenser in thermal power plant, Classification of condensers: Jet, Surface and Evaporative. Air leakage in condenser: sources and its effects. Condenser vacuum, Estimation of quantity of cooling water, Dalton's law of partial pressure, Vacuum efficiency, Condenser efficiency.

Cooling Towers: Cooling water system, types of cooling towers. Performance assessment of cooling towers, Energy saving opportunities.

Steam nozzles: General forms of nozzles, Flow through steam nozzles, Velocity of steam leaving nozzle. Mass of steam discharged, Critical pressure ratio, Areas of throat and exit for maximum discharge, Length of nozzle. Efficiency of a nozzle. Effect of friction in a nozzle.

Unit 4	Renewable and Hybrid Power Systems	(08 Hrs.)

Solar Power System: Types of Solar Collectors, Collection efficiency, Testing of Solar collectors – IS code, Applications of solar energy. Solar Pond, Solar Energy storage and types. Photovoltaic and fuel cells.

Wind power: Power from wind, Site selection, Wind energy conversion systems and their classification, construction and working of typical wind mill, Design considerations for wind mills, present status.

Biomass power: Energy plantation, Combustion and fermentation, Anaerobic digester, Biomass gasification, Pyrolysis, various applications of Biomass energy, Bio-fuel – Relevance, types, and applications.

Hybrid Power Systems: Need for Hybrid systems, Range and type of hybrid systems, Case studies of Diesel-PV, Wind-PV, Micro-hydel-PV, Biomass-Diesel systems, hybrid electric vehicles, etc.

Unit 5	Analysis of Power Plants	(08 Hrs.)

Load Curves, Load duration curves, Performance and operational characteristics of power plants, Peak load, Intermediate load and Base load plants and their characteristics, Input output characteristics of power plants, Economic division of between Base load plant and peak load plants. Cost of energy generation, Tariff methods. Economics of load sharing, comparison of various power plants. Numericals based on the syllabus contents.		
Unit 6	**Energy Storage Technologies, Plant Safety and Maintenance**	**(08 Hrs.)**
Energy Storage Technologies: Pumped Hydroelectric Storage, Compressed Air Energy Storage, Battery Technologies - Traditional and Advanced, Flow Batteries, Flywheels, Superconducting Magnetic Energy Storage, Super-capacitors/Ultra-capacitors, Energy Storage Technology Comparisons, Functional Comparison, Cost Comparison. **Plant Safety and Maintenance:** Operation and Maintenance procedures of power plants, Operator training, Safety during selection of power plant equipment –safety in commissioning of thermal power plant equipments, hydrostatic and air leakage test, acid and alkali cleaning, safety in auxiliary plants. Cooling water system, Safety in maintenance of power plants.		

Reference Books

1. Modern Power Station Practice, Vol.6, Instrumentation, Controls and Testing, Pergamon Press, Oxford, 1971.
2. John V Grimaldi and Rollin H Simonds, Safety Management
3. M. M. El Wakil, Power Plant Technology –Mc Graw Hill. Int. Edition.
4. Domkundwar and Arora, Power Plant Engineering, Dhanpatrai and Sons.
5. Grainger John J, and Stevenson Jr. W.D. Power System Analysis, McGraw Hill 1994
6. L. K. Kirchmeyer, Economic Operation of Power Systems, John Wiley and Sons, 1993.
7. C. A. Gross, Power System Analysis, John Wiley and Sons, Inc.1986.
8. John Weisman & L.E. Eckart, Modern Power Engineering, Prentice Hall, 1985
9. A course on Power Plant Engineering Ramlingam SCITECH Publication
10. S. P. Sukhatme, Solar Energy, Tata McGraw Hill, 3rdEdition 1996.
11. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2011
12. P. K. Nag, Power plant Engineering, TMH, 3rd Edition 2002

Assignments-

1. Theory questions on different types of power plants.
2. Problems on performance of steam power plant based on Rankin cycle
3. Theory questions on components of steam power plant.
4. Theory questions on gas turbine, diesel and solar power systems.
5. Theory questions on wind, biomass and hybrid power systems.
6. Practical engineering problems based on analysis of power plants.
7. Questions based on various terms related to economics of power generation.

8. Questions based on energy storage technologies.
9. Case study on electricity terrify calculation both for industry as well as household purpose.
10. Questions based on plant safety and maintenance.

Term Work (Any EIGHT experiments from the list below)

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

Unit Tests-

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

9. INDUSTRIAL PRODUCT DESIGN

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical: 2 Hours / Week	Continuous Assessment: 40 Marks	PR: 01 Credit
	Term Work/ Oral: 50 Marks	**Total: 04 Credits**

Course Pre-requisites:

The Students should have knowledge of:

1.	Machine Drawing
2.	Machine Design
3.	CAD software *viz.* CATIA/ ProE/ SolidWorks/ UniGraphics

Course Objectives:

Students should be able to understand

1.	Various aspects of product design and development
2.	Concept generation and selection
3.	Aesthetic and Ergonomic considerations in product design

Course Outcomes:

Students should be able to

1.	Understand characteristics of successful product development.
2.	Understand different product design methods
3.	Estimate manufacturing cost, assembly and support costs.
4.	Understand the concept of prototyping
5.	Understand steps to establish the product specifications & concept generation,
6.	Understand ergonomic considerations in product design

Course Contents

UNIT - I	**Introduction to Product Design and Development**	**(06 Hrs.)**
	Market survey. Identify customer needs and product planning processes. Product architecture: Implication of architecture, establishing the architecture, related system level design issue. Overview of industrial design, Successful product, development of quality aspect of product design; Challenges of product development.	
UNIT - II	**Product Design Methods**	**(06 Hrs.)**
	Creative and rational, clarifying objectives - the objective tree method, establishing functions- the function analysis method, setting requirements–the performance specification method, determining characteristics–the QFD method, generating alternatives – morphological chart method, evaluating alternatives – the weighted objective method, improving details – the value engineering method and	

	design strategies.	
UNIT - III	**Product Specifications and Concept Generation**	**(06 Hrs.)**
	Product specification, steps to establish the target specifications, Concept generation, five step concept generation method, concept selection, concept screening, concept testing, product architecture	
UNIT - IV	**Industrial Design and Prototyping**	**(06 Hrs.)**
	Its need, impact and quality, industrial design process and its management, legal issues in product design, design resources, economics and management of product development projects. Prototyping: Basics and principles of prototyping, Rapid prototyping technologies, planning for prototypes.	
UNIT – V	**Ergonomics and Industrial Safety**	**(06 Hrs.)**
	Introduction-General approach to the man-machine relationship-workstation design working position and posture. An approach to industrial design - elements of design structure for industrial design in engineering applications in manufacturing systems. Environmental Application of ergonomics in industry for safety, health and environment control. Safety and ISO 14000 Systems.	
UNIT - VI	**Design for Manufacture**	**(06 Hrs.)**
	Estimating manufacturing cost, reducing component, assembly and support costs, design for assembly, design for disassembly, design for environment, design for graphics and packaging, effective prototyping-principle and planning. Product data management. Innovation and creativity in product design. Product costing, value engineering, aesthetic concepts.	
Assignments:		
1.	At least FIVE questions on market survey, concept generation and product architecture	
2.	At least FIVE questions on various product design methods	
3.	At least FIVE questions on various concepts related to design for manufacture	
4.	At least FIVE questions on industrial design and prototyping	
5.	At least FIVE questions on product specifications	
6.	At least FIVE questions on ergonomic considerations in product design	
7.	At least FIVE questions on safety considerations in product design	
8.	At least FIVE questions on concept generation	
Term Work: Use of different CAD software *viz.* CATIA/ ProE/ SolidWorks/ UniGraphics while doing following case studies:		

1.	A case study on market study to identify costumer needs
2.	A case study on use of morphological analysis
3.	A case study on Quality Function Development (QFD)
4.	A case study of one aesthetic considerations in product design
5.	Failure Modes and Effects Analysis (FMEA) in product design
6.	A case study on Design for Manufacturing
7.	A case study on Product Lifecycle Management (PLM)
8.	A case study of one ergonomic considerations in product design
9.	A case study of one industrial safety considerations in product design
Text Books/Reference Books:	
1.	Product Design and Development: Karl T. Ulrich, Steven G. Eppinger; Irwin McGraw Hill
2.	Product design and Manufacture: A.C. Chitale and R.C. Gupta; PHI Chitale & Gupta, "Product Development", Tata McGraw Hill
3.	New Product Development: Tim Jones, Butterworth, Heinemann, Oxford, 1997.
4.	Product Design for Manufacture and Assembly: Geoffrey Boothroyd, Peter Dewhurst and Winston Knight.
5.	Product Design : Otto and Wood; Pearson education.
6.	Industrial Design for Engineers: Mayall W.H, London, Hiffee books Ltd, 1988
7.	Introduction to ergonomics – R.C. Bridger, McGraw Hill Pub.
8.	Product Design – Kevin Otto, Kristin Wood Pierson Education

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

10. OPTIMUM DESIGN

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 04 Hrs. / Week	End Semester Examination: 60 Marks	TH: 04 Credits
Practical: -02 Hrs. / Week	Continuous Assessment: 40 Marks	PR: 01Credits
	Term Work/ Oral: 50 Marks	**Total: 05 Credits**

Course Pre-requisites:

The Students should have basic knowledge of

1.	Student should have knowledge of Fundamentals of Engineering Mechanics
2.	Student should have knowledge of Machine Design and Computer Aided Drafting
3.	Student should have knowledge of Machine Design –I & II
4	Student should have knowledge of Theory of Machine

Course Objectives:

	To develop competency for system visualization and design. To enable student to design pressure vessels and to use IS code. To enable student, select materials and to design internal engine components. To introduce student to optimum design and use optimization methods to design mechanical components. To enable student to design machine tool gearbox. Ability to apply the statistical considerations in design and analyze the defects and failure modes in components

Course Outcomes:

Students will be able to understand

1.	The student will understand the difference between component level design and system level design.
2.	Ability to design various mechanical systems like pressure vessels, machine tool gearboxes, etc.
3.	Ability to learn optimum design principles and apply it to mechanical components.

4.	Ability to handle system level projects from concept to product	
UNIT - I	**Design of Bevel Gear and Worm gears** Introduction, classification of bevel gears, terms used in bevel gears, formative or equivalent number of teeth for bevel gears, forces acting on a bevel gear, strength of bevel gears **worm and worm wheel:** Introduction, terms used in worm gearing, forces acting on worm gears, strength of worm gear teeth, wear tooth load for worm gear, efficiency of worm gearing, thermal rating of worm gearing	**(06 Hours)**
UNIT - II	**Design of Machine Tool Gearbox** Introduction to machine tool gear boxes, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, deviation diagram, difference between numbers of teeth of successive gears in a change gear box.	**(06 Hours)**
UNIT - III	**Statistical Considerations in Design**. Frequency Distribution-Histogram and frequency polygon, normal distribution-units of central tendency and dispersion – standard deviation- population combinations – design for natural tolerances – design for assembly- statistical analysis of tolerances, mechanical reliability and factor of safety.	**(06 Hours)**
UNIT - IV	**Pressure Vessels** Introduction, Classification of Pressure Vessels, Stresses in a Thin Cylindrical Shell due to an Internal Pressure, Circumferential or Hoop Stress, Longitudinal Stress, Thin Spherical Shells Subjected to an Internal, Thick Cylindrical Shell Subjected to an Internal Pressure, Compound Cylindrical Shells, Stresses in Compound Cylindrical Shells, Cylinder Heads and Cover Plates, Autofrettage.	
UNIT - V	**Optimum Design** Objectives of optimum design, adequate and optimum design, Johnson‘s Method of optimum design, primary design equations,	**(06 Hours)**

	subsidiary design equations and limit equations, optimum design with normal specifications of simple machine elements- tension bar, transmission shaft and helical spring, Pressure vessel. Introduction to redundant specifications (Theoretical treatment).	
UNIT - VI	**Product Design Processes and Design Economics** Technological innovation, product and process cycles, designing to codes and standards, design for manufacture and assembly, importance of economic decision making, value engineering, legal and ethical issues in design. Introduction to Design of Experiment. Mathematics of time value of money, cost comparison, depreciation, profitability of investments, benefit-cost analysis	**(06 Hours)**

Term Work/Practical's:

Assignments:

1. One design project

The design project shall consist of two imperial size sheets (Preferably drawn with 3D/2D CAD software)-one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances must be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted. Projects shall be in the form of design of mechanical systems including pressure vessel, multispeed gear box, etc.

2. Collect information about gear manufacturer along with catalog and identify designation, standards.

3. Write a brief note on Statistical Considerations in Design with reference to any case study.

4. Collect detailed information about pressure vessels types, uses, advantages, disadvantages with photos.

5. Discuss different modern software tools used for design optimization**.**

6. Write assignment on Digital Manufacturing.

Text Books /Reference Books:

1	Bhandari V.B.— Design of Machine Elements, Tata McGraw Hill Pub. Co. Ltd.
2	Juvinal R. C, Fundamentals of Machine Components Design, Wiley, India
3	Black P. H. and O. Eugene Adams, —Machine Design, McGraw Hill Book Co. Inc.

4	Johnson R. C., ―Mechanical Design Synthesis with Optimization Applications, Von Nostr and Reynold Pub
5	S. K. Basu and D. K. Pal,―Design of Machine Tools Oxford and IBH Pub Co.
6	Rudenko, Material Handling Equipment, M. I. R. publishers, Moscow
7	P. Kannaiah,‖Design of Transmission systems, SCIETCH Publications Pvt. Ltd
8	Pandy, N.C.and Shah, C. S.,―Elements of Machine Design―,Charotar Publishing House.
9	Singiresu S. Rao, Engineering Optimization: Theory and Practice, ,John Wiley & Sons.
10	M. V. Joshi, Process Equipment Design, Mc-Millan.
11	Design Data―,P.S.G.College of Technology, Coimbatore
12	I.S. 2825: Code for unfired pressure vessels

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective III: 11.1. INDUSTRIAL AUTOMATION AND ROBOTICS

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical: - Hours / Week	Continuous Assessment: 40 Marks	PR: -- Credits
	Term Work/ Oral: -- Marks	**Total: 03 Credits**

Course Pre-requisites:

The Students should have

1.	Knowledge of Mathematics & Theory of Machines
2.	Knowledge of Automatic Control Systems
3.	Knowledge of Sensors and Transducers

Course Objectives:

1.	To inculcate the basic concepts, parts of robots and types of robots
2.	To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming languages of robots
3.	To create manpower for working on robot

Course Outcomes:

After the successful completion of this course, the student will be able,

1.	To identify potential areas for automation and justify need for automation.
2.	To do line balancing of an automation system.
3.	To explain the basic principles of robotic technology, configurations, control and programming of robots.
4.	To select suitable sensor & design robotic gripper for different applications.
5.	To analyze robots through kinematic and dynamic study.
6.	To explain the basic principles of robot programming language and Identify typical robot applications.

Course Contents

UNIT I	**Introduction to Industrial Automation**	**(06 Hrs.)**

	Automation and Robotics, Historical Development, Basic concept of automation, Building Blocks of Automation Systems- Sensors, Analyzers, Actuators, Drives. Types of automation: fixed, flexible and programmable and their comparative study. Concept of Mechanization of Parts Handling.	
UNIT II	**High Volume Manufacturing System**	**(06 Hrs.)**
	Transfer Lines, Detroit type automation-Design and fabrication considerations. Analysis of automated flow lines- technology, analysis of transfer lines without storage, partial automation and automated flow lines with storage buffers, computer simulation of automated flow lines. Assembly system and line balancing- computerized line balancing methods.	
UNIT III	**Fundamentals of Robot Technology**	**(06 Hrs.)**
	Fundamentals of Robotics: Robot Definitions, Laws of Robotics, Basic Structure of Robots, links and Joints, types of Joints, types of links, types of end effectors, Wrist configuration: concept of: yaw, pitch and roll. Robot Anatomy, work volume, work envelope, robot manipulator. Specifications of robot: degrees of freedom (DOF), accuracy, repeatability, spatial resolution, compliance, loads carrying capacity, speed of response. **Classification of Robots**- 1) Co-ordinate system: Cartesian, cylindrical, spherical, SCARA, articulated 2) Control Method: Servo controlled and non-servo controlled, their comparative study 3) Form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study 4) Drive Technology: Hydraulic, Pneumatic, Electric (stepper motor, D.C. servo motor) in detail with selection criteria. Motion conversion: Rotary to rotary, rotary to linear and vice versa.	
UNIT IV	**Sensors and End-Effectors in Robotics**	**(06 Hrs.)**
	Sensors and Transducers in Robotics: Uses of Sensors in Robotics, type of sensors in robot systems, non-optical and optical position sensors, Touch Sensors-Tactile sensor, Pressure sensors, colour sensor, gas sensor and flexible force sensor, Torque sensors, Light sensors, Voice Communication.	

	End-Effectors in Robotics: Classification of End Effectors, Drive system for end effectors, Mechanical Grippers, Magnetic Grippers, Vacuum Grippers, adhesive Grippers, Hooks, Scoops, Tools as end effectors. Gripper force analysis and gripper design- Simple problems, Active and Passive Grippers.	
UNIT V	**Robot Kinematics and Dynamics**	**(06 Hrs.)**
	Introduction to manipulator kinematics, position representation, forward and reverse transformation of two degree of freedom robot arm, four degree of freedom manipulator in three dimensions. Robot Dynamics, D Alembert's Equations of Motion.	
UNIT VI	**Robot Programming Languages and Industrial Applications**	**(06 Hrs.)**
	Robot Programming Languages: Concept of on-line and off line programming, concept of teach pendant. Methods of robot programming- Lead through methods, Textual robot languages and their Features. **Applications of Robots**: Robot applications based on survilllance system, machining, material handling, house hold and service sector. Applications of Telechiric robots.	
Assignments:		
1.	At least five theory questions based on identifying the industrial applications of robotics & automation.	
2.	At least five theory questions on identifying the industrial applications of automation with building blocks.	
3.	At least five theory questions on identifying the fixed, flexible and programmable automation.	
4.	At least five theory questions on high volume manufacturing system.	
5.	At least five theory questions on study of line balancing of an automation system.	
6.	At least five PLC programs based on pick and place robot.	
7.	At least five theory questions based on fundamentals of robotics.	
8.	At least five theory questions based on selection of sensors.	
9.	At least five theory /numerical questions based on selection of end effectors of robot.	

10.	At least five theory /numerical questions based on robot kinematics and dynamics.
11.	At least five theory questions based on robot programming language and robot applications.
12.	At least five theory questions on identifying the industrial applications of robots.
Text Books/Reference Books:	
1.	"Industrial Robotics", Groover, Weiss, Nagel, McGraw Hill International
2.	Automation, Production Systems and Computer Integrated Manufacturing M.P.Groover, Pearson Education.5th edition, 2009
3.	Introduction to Robotics- John J. Craig, Addison Wesley Publishing, 3rd edition, 2010
4.	Robotics Technology and Flexible Automation, Second Edition, 2010 McGraw Hill Education (India) Private Limited
5.	P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995.
6.	Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010.
7.	A Robot Engineering Textbook "– Mohsen Shahinpoor – Harper & Row publishers, New York
8.	"Anatomy of Automation"- Amber G.H & P. S. Amber, Prentice Hall. Principles of CIM by Vajpayee, PHI.
9.	R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.
10.	Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India, New Delhi
11.	Arthur J. Critchlow, "Introduction to Robotics", Macmillan Publishers Limited, 1985
12.	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw Hill Book Company

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective III: 11.2 CRYOGENICS

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
Practical: - Hours / Week	Continuous Assessment: 40 Marks	Total: 03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:	
The Students should have	
1.	Knowledge of heat transfer.
2.	Knowledge of refrigeration and air conditioning.
Course Objectives:	
1.	To introduce Governing Equations of vicious fluid flows
2.	To introduce numerical modeling and its role in the field of fluid flow and heat transfer
3.	To enable the students to understand the various discretization methods
Course Outcomes:	
Students will be able to understand	
1.	Student should able to understand cryogenic systems
2.	Student should able to understand Behavior of materials at low temperature
3.	Student should able to understand Gas Liquification Systems
4.	Student should able to understand Gas Separation And Purification Systems
5.	Student should able to understand Measurement Systems For Low Temperatures , Fluid Storage And Transfer Systems
6.	Student should able to understand Application Of Cryogenic Systems

Course Contents

UNIT - I	**Introduction to Cryogenic and properties of materials**	**(06 Hrs.)**
	History and development it's importance, cryogenic temperature scale. Low temperature properties of materials, Mechanical properties Thermal properties, electric and magnetic properties, Properties of cryogenics& fluids.	
UNIT - II	**Gas Liquification Systems**	**(06 Hrs.)**
	Introduction- production of low temperature , Liquefaction systems for N2, Neon, Hydrogen, He etc.(Numerical Treatment)	
UNIT - III	**Cryocoolers**	**(06 Hrs.)**
	Regenerative systems – Overview of regenerative coolers, Introduction to Pulse Tube Coolers, Stirling Coolers, G-M Coolers, J-T Coolers, Cryocooler applications.	

UNIT - IV	**Gas Separation And Purification Systems**	**(06 Hrs.)**
	Thermodynamically ideal separation systems- properties of mixtures , principles of gas separation Rectification column- Linde single and double column system of air separation.	
UNIT - V	**Fluid Storage And Transfer Systems**	**(06 Hrs.)**
	Dewar vessel, insulation types and importance. Components of transfer system with importance. Importance of vacuum and it's measurement.	
UNIT - VI	**Application Of Cryogenic Systems**	**(06 Hrs.)**
	Applications in mechanical, electrical, food preservation, biological and medical, space technology etc.	

Assignments:	
Assignments will be based on above syllabus	
1.	History and development it's importance, cryogenic temperature scale.
2.	Low temperature properties of materials, Mechanical properties Thermal properties, electric and magnetic properties
3.	Introduction- production of low temperature , Liquefaction systems for N2
4.	Liquefaction systems for Neon, Hydrogen, He
5.	Regenerative systems – Overview of regenerative coolers, Introduction to Pulse Tube.
6.	Stirling Coolers, G-M Coolers, J-T Coolers, Cryocooler applications.
7.	Thermodynamically ideal separation systems- properties of mixtures , principles of gas separation Rectification column- Linde single
8.	Dewar vessel, insulation types and importance.
9.	Components of transfer system with importance. Importance of vacuum and it's measurement
10.	Applications in mechanical, electrical, food preservation, biological.
Text Books/Reference Books:	
1.	Cryogenics systems – Randall Barron – Mc Graw Hill Book Co
2.	Cryogenic Engineering – R. B. Scott – Van Nosfrand Co.
3.	Cryogenic Engineering –J. H. Bell – Prentice Hall
4.	Cryogenic Engineering – R. W. Vance – John Welley
5.	Cryocoolers - Walkers – Prentice Hill Publication

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective III: 11.3 PROJECT MANAGEMENT & ETHICS		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
	Continuous Assessment: 40 Marks	
	Term Work/ Oral: -- Marks	**Total: 03 Credits**

Course Pre-requisites:	
The Students should have	
1.	Basic knowledge of general management.
2.	Basic knowledge of statistics
3.	Basic knowledge of industrial management
Course Objectives:	
	The objective of the course is to create awareness of the concept of project management and its components to students
Course Outcomes:	
Students will be able to understand	
1.	Project management and its importance.
2.	Various techniques used to analyze a project.
3.	Methods for cost estimation of a project.
4.	Methods for planning and scheduling of a project.
5.	Methods for monitoring and control of projects.
6.	Project management and business ethics.

UNIT - I	**Introduction to Project Management**	**(06 Hours)**
	Project, Project Management, Management by projects, Project Management Associations, Benefits of Project Management, Project management Process, Role of Project Manager. Project Lifecycle	

UNIT - II	**Project Management Techniques and Risk Management**	**(06 Hours)**
	Feasibility Studies, Numerical Models (Payback Period, Return on Investment, Net Present Value, Internal rate of Return), Scoring Models, Break Even Analysis Project Risk Management: Introduction, Risk, Risk Management, Role of Risk Management in Overall Project Management, Steps in Risk Management, Risk Identification, Risk Analysis, Reducing Risks. Use of excel and MS project for feasibility studies and risk management.	
UNIT - III	**Project Cost Estimating**	**(06 Hours)**
	Estimating terminology, Project Costs, Estimating Methods (Jobbing, Factoring, Inflation, Economies of Sales, Unit Rates, Day Work), Analogous Estimating, Parametric Estimating, Bottom-Up Estimating, Three-Point Estimates, Monte Carlo Simulation, Project Budgeting, Resource Allocation, Cost Forecasts Use of excel and MS project for project cost estimating	
UNIT - IV	**Project Planning and Scheduling**	**(06 Hours)**
	Project Planning: Introduction, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS) Scheduling: Introduction, Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, Measures of variability, CPM Model, Network Cost System Use of MS project Project Planning and Scheduling	
UNIT - V	**Project Monitoring and Control**	**(06 Hours)**
	Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control Project Management Information System: Introduction, Project Management Information System (PMIS), Planning of PMIS, Design of PMIS Project Performance Measurement and Evaluation: Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement	

	and Evaluation, Controlling the Projects	
UNIT - VI	**Professional Responsibility (Ethics)**	**(06 Hours)**
	Ensuring Integrity and Professionalism, Project Management Knowledge Base, Enhancing Individual Competence, Balancing Stakeholder Interests, Interactions with Team Members and Stakeholders, Templates, Tools and Techniques	

Assignments:	
1.	At least five questions based on the introduction to project management
2.	Case study involving various aspects of project.
3.	Case study involving various techniques used for project selection.
4.	At least five Numericals on various techniques used for project selection.
5.	Case study of project cost estimation
6.	At least five Numericals on project cost estimation
7.	Case study of project scheduling
8.	At least five Numericals on project scheduling
9.	Case study based on project scheduling
10.	At least five questions based on project monitoring
11.	At least five questions based on ethics
12.	Industrial case study of project ethics

Text Books/Reference Books:

1	Project Management Institute; "A Guide to the Project Management Body of Knowledge (PMBOK Guide)"; 5th Revised edition (1 January 2013)
2	Harold Kerzner; "Project Management: A Systems Approach to Planning, Scheduling and Controlling Paperback"; Wiley; tenth edition (20 November 2012)
3	Erik Larson, Clifford Gray; "Project Management: The Managerial Process"; McGraw Hill Education; Sixth edition (1 July 2014)
4	Panneerselvam R; "Project Management"; Prentice Hall India Learning Private Limited; 1 Edition (2009)

5	Samuel J. Mantel, Jack R. Meredith; "Project Management: A Managerial Approach"; Wiley; Eighth edition (6 August 2012)
6	Gupta R; "Project Management"; Prentice Hall India Learning Private Limited; Second edition (2014)

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

Elective III: 11.4. TOTAL QUALITY MANAGEMENT

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 03 Hrs/Week	End Semester Examination: 60 Marks	TH: 03 Credits
	Continuous Assessment: 40 Marks	Total: 03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites:

The Students should have

1.	Basics of Quality Control
2.	Basics of Measurements and measuring Instruments
3.	Knowledge of Statistics.

Course Objectives:

To understand the Total Quality Management concept and principles and the various tools available to achieve Total Quality Management and to understand the statistical approach for quality control.

Course Outcomes:

1.	Implement the principles of total quality management.
2.	Apply six sigma concepts and increase the quality of product.
3.	Make use of TQM techniques
4.	They will be able to implement TQM Tools.
5.	Execute Quality standards in companies
6.	Make use of Advanced Techniques of Total Quality Management like Design of experiments, Failure mode effect analysis, Taguchi method Taguchi's quality engineering

UNIT-I: Quality & Total Quality Management **(06 Hrs)**

Quality, Definitions of Quality, New philosophy of quality, Product quality, & its prospects.

Overview of TQM : Concept & definition, Fundamentals, Principles of TQM, Elements of TQM,Approaches of TQM, Models of TQM, Zero defect concept, Benefits of TQM.

Customer satisfaction - Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement - Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits,

UNIT-II: Quality Assurance **(06 Hrs)**

Basic concepts, Quality assurance input – process – output. Significance of feedback for Quality assurance, Process capability analysis, Concept of Six Sigma.

Internal customer approach, Customer – Satisfaction, data collection & complaint, Redressal mechanism.

UNIT-III: TQM Tools **(06 Hrs)**

Continuous Process Improvement - Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership - Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures - Basic Concepts, Strategy, Performance Measure,Just – in- Time, Quality Function Deployment (QFD) - House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) - Concept, Improvement Needs, FMEA - Stages of FMEA., FMEA, TPM.	
UNIT-IV: TOYOTA Production System and Lean Manufacturing	**(06 Hrs)**
History of TPS. History, Scope, What is lean production? – Introduction, background, and lean thinking. Lean production preparation – System assessment, process and value-stream mapping – Sources of waste. Lean production processes, approaches and techniques. —Importance of focusing upon flow. Tools include: a. Workplace organization – 5S. b. Stability. c. Just-In-Time – One piece flow – Pull. d. Cellular systems. e. Quick change and set-up reduction methods. f. Total productive maintenance. g. Poka-Yoke – mistake proofing, quality improvement. h. Standards. i. Leveling. j. Visual management. Employee involvement – Teams – Training – Supporting and encouraging involvement – Involving people in the change process -- communication -- Importance of culture	
UNIT-V: Quality Systems	**(06 Hrs)**
Policy & objectives, Quality standards, Concept of quality system standards, Relevance & origin of ISO 9000–2000 standard & certification, Benefits. Elements of ISO 9001, 9002, 9003 series–Clauses, contents, interpretations & implementation. TS - 16949, QS-9000, ISO 14000, OHSAS	
UNIT-VI: Advanced Techniques of Total Quality Management	**(06 Hrs)**
Design of experiments, Failure mode effect analysis, Taguchi methodTaguchi's quality engineering –Loss function, orthogonal arrays, Signal to noise ratio, parameter design & tolerance design.Total Quality in service sector.S. S. Technique, Kanban (Little's Law for KANBAN system)	
Term work: Detail Study and Presentations on Above topics to be submitted.	
Assignments	
1. Assignment on TQM 2. Assignment on Six sigma concept. 3. Assignment on TQM principles. 4. Assignment on TQM tools. 5. Assignment on Quality Systems 6. Assignment on Advanced Techniques of Total Quality Management	

Text Books/ References

1. Sundar Raju, “Total Quality Management”, Tata McGraw Hills.
2. M. Zairi, “Total Quality Management for Engineers”, Aditya Books.
3. ISO 9000 Quality System”, Dalela& Saurabh, Standard Publishers.
4. R.C. Gupta, “Statistical Quality Control”.
5. Grant E. L. & R. Leavenworth, “Statistical Quality Control”, Tata McGraw Hills
6. TapanBagchi, “Taguchi Methods Management”, Pearson Education.
7. Feigenban, “Total Quality Control”, Tata McGraw Hills.
8. Total Quality Management Handbook, J. K. Hradeskym, Tata McGraw Hills.

Unit Test

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

Elective III: 11.5. FINITE ELEMENT ANALYSIS		
Teaching Scheme:	**Examination Scheme:**	**Credits Allotted:**
Theory: 03 Hours / Week	End Semester Examination: 60 Marks	TH: 03 Credits
	Continuous Assessment: 40 Marks	Total :03 Credits
	Term Work/ Oral: -- Marks	

Course Pre-requisites: Students should have knowledge of Engineering Mathematics-I, Strength of Machine Elements, Numerical Methods, Machine Design and Heat Transfer.

Course Objectives:

- To develop the finite element formulation for a model one-dimensional problem like axially loaded bar for the case of simplest approximation (i.e., linear approximation).
- Develop the Shape Functions for Various Elements.
- To discuss the possible refinements of the simplest approximation.
- To develop the frame work of a finite element code to solve the one-dimensional problem.
- To extend the finite element formulation to other one-dimensional problems like the beam problem.
- To develop the two-dimensional finite element formulation for a model 2-D problem like 2-D steady-state heat conduction problem.

Course Outcomes:

- Students will be able to understand Formulation of Finite Element Method.
- Students will able to solve 1 D Problems.
- Students will be able to solve 2 D Structural and Thermal Problems.
- Students will be able to analyze Mechanical Engineering real life problems.
- Students will be able to solve Mechanical Engineering Problems subjected to Heat Transfer.
- Students will be able to solve Mechanical Engineering Problems subjected to Mechanical Vibration.

UNIT – I (6 Hrs.)	**Introduction** Basic Steps in FEM Formulation, Error Analysis P & h formulation; Stress Equilibrium equation; Strain displacement equation; Stress-Strain equation; Introduction to Solvers; Variational Approach, Ritz Method. Derivation of Elemental Equations, Assembly, Imposition of Boundary Conditions, Solution of the Equations. Computer implementation: Pre-processor, Processor, Post-processor.
UNIT – II (6 Hrs.)	**One Dimensional Problem** 1 -D Elements, Relationship between Global and Natural coordinate system; Formulation of Element Stiffness Matrix and Load Vector by Potential Energy approach; Shape Functions using LAGRANGE Polyomials for Two noded Bar Element, Rectangular Element, hexahedron Brick Element; Convergence Criteria, Temperature effect.
UNIT – III (6 Hrs.)	**Two Dimensional Problem** Plain Stress , Plain Strain; Types of 2 D Element, Formulation of Element Stiffness matrix and Load Vector for Constant Strain Triangles, Formulation of Element Stiffness matrix and Load Vector for 2D Trusses; Introduction to Higher Order Elements.
UNIT – IV (6 Hrs.)	**Axisymmetric Formulation:** Stress calculation and Temperature effect on Flywheel using Galerkin Approach; Isoparametric Elements; Element Quality Criterion; Full and Reduced integration; Sub Modelling and Sub Structuring.
UNIT – V (6 Hrs.)	**1D Steady State Heat Transfer**: Governing Differential Equation; Steady State Heat transfer Formulation of 1 D Element for Conduction and Convection; Boundary Conditions and Solving for Temperature Distribution; 1D Heat Transfer Steps involved in Processing Steps.
UNIT – VI (6 Hrs.)	**Dynamic Analysis:** Lumped mass and Consistent Mass Matrices; Free Vibration Problems, Formulation of Eigen Value and Eigen Vector Problem by Power Method, Step wise solution of Problems on Vibration in Bar Element; FEM Formulation. Time-dependent Problems.
Term Work/Practicals:	
1. Structural Analysis of Corner Bracket, Truss Structure and Spring.	
2. Static and Dynamic Analysis of Cantilever Beam.	
3. Modal analysis of Simple Pendulum**.**	
4. Steady State Heat Transfer through a Plate with Hole.	
5. Analysis of Connecting Rod.	

6. Analysis of Composite Leaf Spring.	
7. Analysis of Piston.	
8. Analysis of Burnished Components.	
9. Analysis of Knuckle Joint.	
10. Analysis of Screw Jack.	
Assignments:	
1. Introduction to Finite Element method.	
2. Derivations and Numerical on Variational Approach and Ritz Method.	
3. Derivations and Numerical on Potential Energy Approach.	
4. Determination of Shape Functions for Various Elements.	
5. Derivations and Numerical on CST Elements.	
6. Derivations and Numerical on Trusses.	
7. Stress calculation and Temperature effect on Flywheel using Galerkin Approach.	
8. Isoparametric Elements: Full and Reduced integration methods Numerical.	
9. Derivation and Numerical on Steady State Heat transfer Formulation of 1 D Element for Conduction and Convection by Differential Equation.	
10. Analysis of any one Mechanical Component subjected to Heat transfer.	
11. Determination of Eigen value and Eigen vector for any Mechanical component.	
12. Analysis of Time Dependent problem.	
Text Books/Reference Books:	
1	S. S. Rao, The Finite Element Methods in Engineering, Pergomon Press Oxford, 2nd edition, 1989
2	Sagarlind L. J, Applied Finite Element Analysis, John Wiley, 1984
3	Chandrupatla & Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 1999
4	Reddy. J.N, An Introduction to Finite Element Methods, Tata McGraw Hill, 1997
5	Cook, Robert, Davis Etal, Concept & Applications of Finite Element Analysis, John Wiley & Sons, 1999

Syllabus for Unit Test:	
Unit Test -1	Unit I to III
Unit Test -2	Unit IV to VI

12. PROJECT STAGE -II

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 00 Hours / Week	End Semester Examination: -- Marks	TH: -- Credits
Practical: - 04 Hours / Week	Continuous Assessment: -- Marks	TW/OR: 08 Credits
	Term Work/ Oral: 200 Marks	**Total: 08 Credits**

Course Pre-requisites:

The Students should have

1	Knowledge of basic concepts in heat transfer.
2	Basic information of thermodynamics
3	Basic knowledge of fluid mechanics.
4	Knowledge of basic concepts in mechanical engineering
5	Basic knowledge of design

Course Objectives:

1.	To fabricate the designed equipments
2.	To conduct laboratory and field testing of the new equipment
3.	To analyze performance of the equipment with different performance parameters
4.	To make changes in design if necessary based on the performance analysis
5.	To prepare project report and deliver presentation
6.	To work sincerely as a member of team

Course Contents

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

In Semester II concentration will be on

1. Hard ware fabrication
2. Testing of equipment
3. Preparing a project report

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