Jabalpur Engineering College, Jabalpur

Semester VII Credit Based Grading System (CBGS) w.e.f. July 2018
Scheme of Examination
Bachelor of Engineering B.E. (Mechanical Engineering)
Subject Wise Distribution of Marks and Corresponding Credits
Scheme of Examination w.e.f. July 2018 Acadamic Session 2018-19

S.No.	Subject Code	Subject Name & Title	Maximum Marks Allotted					Total Marks	Hours/Week			Total Credits	Total Marks
			Theory			Practical			L	T	P		
			End. Sem.	Mid Sem. MST	Quiz, Assignment	End Sem.	Lab Work						
1	ME7001	Refrigeration & Air Conditioning	70	20	10	30	20	150	3	1	2	6	
2	ME7002	Vibration & Noise Control	70	20	10	30	20	150	3	1	2	6	
3	ME7003	OR & Supply Chain	70	20	10	30	20	150	3	1	2	6	
4	ME7004	Elective-III	70	20	10	-	-	100	3	1	-	4	
5	ME7005	Elective-IV	70	20	10	-	-	100	3	1	-	4	
6	ME7006	Project-I	-	-	-	60	40	100	-	-	4	4	
7	ME7007	Industrial Training (Two Weeks)	-	-	-	30	20	50	-	-	2	2	
		Total	**350**	**100**	**50**	**180**	**120**	**800**	**15**	**5**	**12**	**32**	**800**

MST: Minimum of two mid semester tests to be conducted. **L: Lecture** **T: Tutorial** **P: Practical**

Department Elective-III (Three Subjects)			Department Elective-IV (Three Subjects)	
S.No.	Subject Code	Subject Name	Subject Code	Subject Name
1	ME7004A	Industial Robotics	ME7005A	Renewable Energy
2	ME7004B	Computer Aided Engineering & FEM	ME7005B	Design of Heat Exchanger
3	ME7004C	Finite Element Analysis	ME7005C	Gas Dynamics & Jet Propulsion

Controller (Exam.)
Jabalpur Engineering College
Jabalpur - 482 011 (M.P.)

Registrar (Academic)
for Principal
Jabalpur Engineering College
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DEAN
Academic
JEC, Jabalpur (M.P.)

Principal
Jabalpur Engineering College
Jabalpur - 482 011 (M.P.)

Jabalpur Engineering College, Jabalpur (M.P)
PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 6	ME-7001	Refrigeration & Air Conditioning	L: 3, T: 1, P: 2

Course Objective

1. Learn the basic concepts and principles of refrigeration and air conditioning.
2. Learn the fundamental analysis methodology of refrigeration.
3. Learn the basic process and systems of air conditioning.
4. Will apply the course knowledge to do a design project of HVAC system.

Course Content

Unit-I Introduction: Principles and methods of refrigeration, freezing; mixture cooling by gas reversibleexpansion, throttling, evaporation, Joule Thomson effect and reverse Carnot cycle; unit of refrigeration, coefficient of performance, vortex tube & thermoelectric refrigeration, adiabatic demagnetization; air refrigeration cycles- Joule's cycle Boot-strap cycle, reduced ambient cycle and regenerative cooling cycles.

Unit-II Vapour compression system: Vapor compression cycle, p-h and t-s diagrams, deviations fromtheoretical cycle, sub-cooling and super heating, effects of condenser and evaporator pressure on cop; multi-pressure system: removal of flash gas, multiple expansion & compression with flash inter cooling; low temperature refrigeration: production of low temperatures, cascade system, dry ice, production of dry ice, air liquefaction system,.

Unit-III (a) **Vapour absorption system**: Theoretical and practical systems such as aqua-ammonia, Electrolux & other systems;
(b) **Steam jet refrigeration**: Principles and working, simple cycle of operation, description and working of simple system,
(c)**Refrigerants:** nomenclature & classification, desirable properties, common refrigeration, comparative study, leak detection methods, environment friendly refrigerants and refrigerant mixtures, brine and its properties

Unit-IV Psychometric: Calculation of psychrometric properties of air by table and charts;psychrometric processes: sensible heating and cooling, evaporative cooling, cooling and dehumidification, heating and humidification, mixing of air stream, sensible heat factor; principle of air conditioning, requirements of comfort air conditioning, ventilation standards, infiltrated air load, fresh air load human comfort, effective temperature & chart, heat production & regulation of human body,

Unit-V Air conditioning : Calculation of summer & winter air conditioning load, bypass factor ofcoil, calculation of supply air rate & its condition, room sensible heat factor, grand sensible heat factor, effective sensible heat factor, dehumidified air quantity. Problems on cooling load calculation. Air distribution and ventilation systems

Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

References:

1. Arora CP; Refrigeration and Air Conditioning; TMH
2. Sapali SN; Refrigeration and Air Conditioning; PHI
3. Ananthanarayan; Basic Refrigeration and Air conditioning; TMH
4. Manohar Prasad; Refrigeration and Air Conditioning; New Age Pub
5. Ameen; Refrigeration and Air Conditioning; PHI
6. Pita ; Air conditioning Principles and systems: an energy approach; PHI
7. Stoecker W.F, Jones J; Refrigeration and Air conditioning; McGH, Singapore
8. Jordan RC and Priester GB Refrigeration and Air Conditioning, PHI USA

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Course Outcomes:

At the completion of this course, students should be able to

CO1	Explain the principles and methods of refrigeration.
CO2	Evaluation of VCRS and Vapor absorption systems and applications.
CO3	Analyze psychrometric properties and processes.
CO4	Elaborate the heating and cooling load for a given AC system.

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2								
CO2	1	3	1	1								
CO3	1	2	2	2								
CO4	1	2	1	1								

List of Experiments:

1. General Study of vapor compression refrigeration system.
2. General Study of Ice Plant
3. General Study and working of cold storage
4. General Study Trane Air Condition (Package Type).
5. General Study of Electrolux Refrigeration
6. General Study One tone Thermax refrigeration unit.
7. General Study of Water cooler
8. General Study of Psychrometers (Absorption type)
9. General Study of Leak Detectors (Halide Torch).
10. General Study and working of Gas charging Rig.
11. General Study of window Air Conditioner.
12. General Study and working of Vapor compression Air conditioning Test rig.
13. Experimentation on Cold Storage of Calculate COP & Heat Loss.
14. Experimentation on Vapor compression Air Conditioning test rig.
15. Changing of Refrigerant by using Gas Charging Kit.

Evaluation:

Evaluation will be continuous and integral part of the class followed by the final practical examination as well as through external assessment

Course Outcomes: (Lab)

At the completion of this course, students should be able to

CO1	Evaluate the principles of ice plant and cold storage.
CO2	Analyse the Electrolux Refrigeration system and Psychrometric processes
CO3	Elaborate the working of Gas charging Rig.
CO4	Formulate the problem and solution of window AC.

Mapping of Course outcomes (COs) with Program Outcomes (POs):(Lab)

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2								
CO2	1	3	1	1								
CO3	1	2	2	2								
CO4	1	2	1	1								

Jabalpur Engineering College, Jabalpur (M.P)

PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 6 ME-7002 Vibration & Noise Control L: 3, T: 1, P: 2

Course Objective

1. Learn the basic concepts and principles of vibration in mechanical systems.
2. Learn the fundamental damped free and undamped free vibration.
3. Learn the basic principle of noise engineering.

Course Content

Unit I: Fundamental Aspects of Vibrations: Vibration, main causes, advantages and disadvantages; engineering applications of vibration and noise; vector method of representing harmonic motion; characteristics of vibration, harmonic analysis and beats phenomenon, work done by harmonic forces on harmonic motion; periodic, non-harmonic functions- Fourier series analysis; evaluation of coefficients of Fourier series; elements of vibratory system; lumped and distributed parameter systems. **Undamped Free Vibrations:** Derivation of differential equation of motion: the energy method, the method based on Newton's second law of motion, and Rayleigh's method. Solution of differential equation of motion: Natural frequency of vibration. Systems involving angular oscillations: the compound pendulum.

Unit II: Damped Free Vibrations: Viscous damping: coefficient of damping; damping ratio; under damped, over damped and critically damped systems; logarithmic decrement; frequency of damped free vibration; Coulomb or dry friction damping; frequency, decay rate and comparison of viscous and Coulomb damping; solid and structural damping; slip or interfacial damping.

Unit III: Harmonically excited Vibration: One degree of freedom- forced harmonic vibration; vector representation of forces; excitation due to rotating and reciprocating unbalance; vibration Isolation, force and motion transmissibility; absolute and relative motion of mass (Seismic Instruments).
Whirling Motion and Critical Speed: Whirling motion and Critical speed : Definitions and significance. Critical –speed of a vertical, light –flexible shaft with single rotor : with and without damping .Critical speed of a shaft carrying multiple discs (without damping), Secondary critical speed.

Unit IV: Systems With Two Degrees of Freedom : Un-damped free vibration of 2 d.o.f and Principal modes of vibration; torsion vibrations; Forced, Un-damped vibrations with harmonic excitation ; Coordinate coupling; Dynamic vibration absorber; torsion Vibration Absorber; Pendulum type of dynamic vibration.

Unit V: Noise Engineering – Subjective response of sound: Frequency and sound dependent human response; the decibel scale; relationship between, sound pressure level (SPL), sound power level and sound intensity scale; relationship between addition, subtraction and averaging, sound spectra and Octave band analysis; loudness; weighting networks; equivalent sound level, auditory effects of noise; hazardous noise, exposure due to machines and equipments; hearing conservation and damage risk criteria, daily noise doze.
Noise: Sources, Isolation and Control: Major sources of noise on road and in industries, noise due to construction equipments and domestic appliances, industrial noise control, strategies- noise control at source (with or without sound enclosures), noise control along the path (with or without partitions and acoustic barriers); noise control at the receiver, ear defenders, earplugs, semi-insert protectors.

Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

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References:

1- Ambekar A.G.,' Mechanical Vibrations and Noise Engineering; PHI
2- Meirovitch Leonard; Element of Vibration Analysis; TMH
3- Dukikipati RV Srinivas J Text book of Mechanical Vibrations; PHI
4- Kelly SG and kudari SK; Mechanical Vibrations; Schaum Series;TMH
5- Thomson , W.T., Theory of Vibration with Applications , C.B.S Pub & distributors .
6- Singiresu Rao, 'Mechanical Vibrations ' , Pearson Education .
7- G.K. Grover, ' Mechanical Vibration , Nem chand and Bross , Roorkee .

Course Outcomes:

At the completion of this course, students should be able to-

CO1	Analyze Undamped and Damped free vibration systems.
CO2	Evaluate the two Degrees of Freedom and
CO3	Explain whirling motion and critical speed in Harmonically excited Vibration.
CO4	Evaluate sound pressure level (SPL), sound power level and sound intensity

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1									
CO2	1	1	2									
CO3	1	1	2									
CO4	1	1	2									

List of experiments:

1. To find out effect of load on natural frequency of vibrations of a lever pin supported at one end carrying adjustable load on a vertical screwed bar and spring supported at some intermediate point (i) When the dead weight of rods is neglected and (ii) when their dead weight is taken into account .
2. To find out frequency of damped free vibration and rate of decay of vibration-amplitude in the system.
3. To find out natural frequency and damped free frequency of a torsion pendulum and , hence to find out coefficient of damping of the oil ;
4. To observe the phenomenon of 'whirl' in a horizontal light shaft and to determine the critical speed of the shaft.
5. To observe the mode shapes of a spring-connected, double pendulum and hence to demonstrate the phenomenon of beats.
6. To demonstrate the principle of tuned Undamped Dynamic Vibration Absorber and to determine the effect of mass-ratio (of main and auxiliary mass) on the spread of the resulting natural frequencies ;
7. To take measurements of sound Pressure Level (SPL) and to carry out octave band analysis of a machine using Noise Level Meter.

Evaluation:

Evaluation will be continuous and integral part of the class followed by the final practical examination as well as through external assessment

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Jabalpur Engineering College, Jabalpur (M.P)

PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 6	ME-7003	Operations Research & Supply Chain	L: 3, T: 1, P: 2

Course Objective:

The student will be made to learn.

1. To be familiar with all the OR Techniques and optimization methods.
2. To understand the role of logistics in the supply chain within a focal firm as well as between organisations linked within a given supply chain network. and ,
3. To be familiar with various inventory control techniques.
4. Students will get a clear idea of the decision making and meta-heuristic algorithm.

Course Content:

Unit 1 Linear system and distribution models: Mathematical formulation of linear systems by LP, Graphical solution of LP for two variables, Simplex method, special cases of LP- transportation and assignment models and their solution, Vogels Approximation Method (VAM) or penalty method, cell evaluation degeneracy, basics of SW Lindo, Tora, Excell.

Unit II Supply chain (SCM): Definition, importance, expenditure and opportunities in SCM; integration of inbound, outbound logistics and manufacturing to SCM, flow of material money and information, difficulties in SCM due to local v/s system wide (global) optimization and uncertainties in demand and transportation; Bull-whip effect; customer value; IT, info-sharing and strategic partnerships; plant and warehouse-network configuration; supply contracts and revenue sharing; outsourcing; transportation, cross docking and distribution, forecasting models in SCM; coordination and leadership issues; change of purchasing role and vendor rating, variability from multiple suppliers.

Unit III Inventory models: Necessity of inventory in process and safety stock, problem of excess inventory and cycle time, JIT/ Lean Mfg; basics of inventory models with deterministic demand, Classical EOQ Model, ABC, VED and other analysis based on shelf life, movement, size, MRP technique and calculations, lot sizing in MRP, linking MRP with JIT; evolution of MRP to ERP to SCM and e-business.

Unit IV (a) **Waiting Line Models:** Introduction, Input process, service mechanism, Queue discipline, single server (M/M/1), average length and average time calculations, optimum service rate; basic multiple server models (M/M/s)

(b) **Competitive strategy:** concept and terminology, assumptions, pure and mixed strategies, two-person zero sum games, saddle point, dominance, graphical, algebraic and LP methods for solving game theory problems.

Unit V: (a) **Network Analysis:** Project Planning, Scheduling and Controlling; Project management; Network Techniques and its role in project management, Network logics, Fulkerson's Law, Merits and Demerits of AON Diagrams; Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Determination of critical path, Float/Slack.

(b) **Meta-heuristics:** Definition of heuristic and meta-heuristic algorithms; introduction to Tabu search, Simulated Annealing and Genetic algorithms and solution of traveling salesman, non linear optimization problems.

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Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

References:

1. Hillier FS and Liberman GJ; Introduction to Operations Research concept and cases; TMH
2. Simchi-Levi, Keminsky; Designing and managing the supply chain; TMH.
3. Srinivasan G; Quantitative Models In Operations and SCM; PHI Learning
4. Mohanty RP and Deshmukh SG; Supply Chain Management; Wiley India
5. Taha H; Operations research; PHI
6. Sen RP; Operations Research-Algorithms and Applications; PHI Learning
7. Sharma JK; Operations Research; Macmillan
8. Ravindran , Philips and Solberg; Operations research; Wiley India
9. Vollman, Berry et al; Manufacturing planning and control for SCM; TMH.
10. Bowersox DJ, Closs DJ, Cooper MB; Supply Chain LogistiMgt; TMH
11. Burt DN, Dobler DW, StarlingSL; World Class SCM; TMH
12. Bronson R ;Theory and problems of OR; Schaum Series; TMH
13. George Hadley; Linear programming; Addison Wesley

Course Out Comes:

Upon successful completion of this course the student will be able to:

CO1	Formulate linear programming problems.
CO2	Elaborate optimum solution of transportation problems and forecasting in supply chain.
CO3	Determine average queue length and waiting time of queuing models.
CO4	Estimate optimum inventory and cost in inventory models.

Mapping of course outcomes (COs) with Program Outcomes (POs):

course outcome	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1								1
CO2	1		3									
CO3	1	1		1								1
CO4	2	1	1									

LIST OF EXPERIMENTS:

1. Use computer and software as Lindo, Tora, and Excell to solve problems contained in the syllabus.
2. Case studies on SCM.
3. Problems on ABC Analysis.
4. Problems on Economic order quantity.
5. Problems on Waiting Line Models.
6. Problems on Game Theory.

Jabalpur Engineering College, Jabalpur (M.P)

PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 4 Elective –III (A) ME-7004 Industrial Robotics L: 3, T: 1, P:0

Course Objective:

1. Introduction and need of industrial robots.
2. End Effectors and Drive systems industrial robots
3. Understanding the basic principle Sensors.
4. Understanding the basic principle robotics programming

Course Content:

Unit I Introduction: Need and importance, basic concepts, structure and classification of industrial robots, terminology of robot motion, motion characteristics, resolution, accuracy, repeatability, robot applications.

Unit II End Effectors and Drive systems: Drive systems for robots, salient features and comparison, different types of end effectors, design, applications.

Unit III Sensors: Sensor evaluation and selection Piezoelectric sensors linear position and displacement sensing, revolvers, encoders, velocity measurement, proximity, tactile, compliance and range sensing. Image Processing and object recognition.

Unit IV Robot Programming: Teaching of robots, manual, walk through, teach pendant, off line programming concepts and languages, applications.

Unit V Safety and Economy of Robots: Work cycle time analysis, economics and effectiveness of robots, safety systems and devices, concepts of testing methods and acceptance rule for industrial robot.

Evaluation:

Evaluation will be continuous an integral part of the class as well through external assessment.

References:

1. Nagrath IJ and Mittal RK; Robotics and Control; TMH
2. Groover M.P,Weiss M, Nagel, OdreyNG; Industrial Robotics-The Appl; TMH
3. Groover M.P; CAM and Automation; PHI Learning
4. Spong Mark and Vidyasagar; Robot Modelling and control; Wiley India
5. Yoshikava ; Foundations of Robotics- analysis and Control; PHI Learning;
6. Murphy ; Introduction to AI Robotics; PHI Learning
7. FU KS, Gonzalez RC, Lee CSG; Robotics Control, sensing; TMH
8. Shimon, K; Handbook of Industrial Robots; John Wiley & Sons,
9. Bhupendra Gupta, A text book of Industrial Robotics: Dhanpat Rai Publishing company, New Delhi.
10. Ghosal Ashitava; Robotics Fundamental concepts and analysis; Oxford
11. Saha S; Introduction to Robotics; TMH 11. Yu Kozyhev; Industrial Robots Handbook; MI

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Course Outcomes:

At the completion of this course, students should be able to-

CO1	Illustrate the concept of robot and its motion characteristics.
CO2	Identify different types of end effectors and drive systems required for specific applications
CO3	Explain the working of various types of sensors and their applications.
CO4	Develop programming principles and languages for a robot control system

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1								1
CO2	1	2	2	2								
CO3	1	2	2	2								
CO4	1	2	2	2								

Jabalpur Engineering College, Jabalpur (M.P)
PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 4 Elective–III (B) ME-7004 Computer Aided Engineering and FEM L: 3, T: 1, P:0

Course Objective:
To enable the students to utilize the knowledge of CAD and FEM to model the real life problems.

Course Content:

Unit-I Introduction : Structural analysis, objectives, static, Dynamic and kinematics analyses, Skeletaland continuum structures, Modeling of infinite d.o.f. system into finite d.o.f. system, Basic steps in finite element problem formulation, General applicability of the method.

Unit-II Element Types and Characteristics : Discretization of the domain, Basic element shapes,Aspect ratio, Shape functions, Generalized co-ordinates and nodal shape functions; ID bar and beam elements, 2D rectangular and triangular elements; axis-symmetric elements.

Unit-III Assembly of Elements and Matrices : Concept of element assembly, Global and localcoordinate
systems, Band width and its effects, Banded and skyline assembly, Boundary conditions, Solution of simultaneous equations, Gaussian elimination and Choleksy decomposition methods, Numerical integration, One and 2D applications.

Unit-IV Higher Order and iso-parametric Elements: One dimensional quadratic and cubic elements,Use of natural co-ordinate system, Area co-ordinate system continuity and convergence requirements, 2D rectangular and triangular requirement.

Unit-V (A) Static Analysis: Analysis of trusses and frames, Analysis of machine subassemblies, Usecommercial software packages, Advantages and limitations

(B) Dynamic Analysis: Hamilton's principle, Derivation of equilibrium, Consistent and lumped mass matrices, Derivation of mass matrices for ID elements, Determination of natural frequencies and mode shapes, Use of commercial software packages.

Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

References:

1. Gokhle Nitin; et al; Practical Finite Element Analysis; Finite to Infinite, 686 BudhwarPeth, Pune.
2. Logan DL ; A First Course in Finite element Method; Cegage
3. Krishnamoorthy; Finite Element Analysis, theory and programming; TMH
4. Buchanan; Finite Element Analysis; Schaum series; TMH
5. Seshu P; Textbook of Finite Element Analysis; PHI.
6. Chennakesava RA; Finite Element Methods-Basic Concepts and App; PHI Learning
7. Reddy JN; An introduction to finite element method; TMH
8. Desai Chandrakant S et al; Introduction to finite element Method; CBS Pub
9. Hutton D; Fundamentals of Finite Element Analysis; TMH
10. Zienkiewicz; The finite element Method; TMH
11. Martin and Grahm; Introduction to finite element Analysis (Theory and App.)
12. Rao, S.S., The Finite Element Method in Engineering; Peragamon Press, Oxford.
13. Robert DC., David DM et al, Concepts and Application of Finite Element Analysis; John Wiley.
14. Chandrupatla, T.R. an Belegundu, A.D., Introduction to Finite Elements in Engineering,PHI

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Course Outcomes:

At the completion of this course, students should be able to-

CO1	Illustrate degree of freedom of a system and basic principles of FEM analysis.
CO2	Demonstrate different types of elements & derive shape functions.
CO3	Develop element matrix and their assembly for a system.
CO4	Apply the FEM principles to truss & frames problem by using commercial software packages.

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1									
CO2	2	2		1	2							
CO3	2	1	2	1	1							
CO4	1	2	2	1	3							

Jabalpur Engineering College, Jabalpur (M.P)
Programme: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 4 Elective-III (C) ME7004 Finite Element Method L: 3, T: 1, P: 0

Course Objective:

1. Learn the basic concepts and principles of Structural analysis.
2. Learn the fundamental of discretization of the domain.
3. Learn the basic process assembly of elements and matrices.

Course Contents:

Unit-I: Introduction

Structural analysis, objectives, static, Dynamic and kinematics analyses, Skeletal and continuum structures, Modeling of infinite D.O.F. system into finite D.O.F. system, Basic steps in finite element problem formulation, General applicability of the method.

Unit-II Element Types and Characteristics

Discretization of the domain, Basic element shapes, Aspect ratio, Shape functions, generalized co-ordinates and nodal shape functions. 1D bar and beam elements, 2D rectangular and triangular elements, Axisymmetirc elements.

Unit-III Assembly of Elements and Matrices

Concept of element assembly, Global and local Co-ordinate systems, Band width and its effects, Banded and skyline assembly, Boundary conditions, Solution of simultaneous equations, Gaussian elimination and Choleksy decomposition methods, Numerical integration, 1D and 2D applications.

Unit-IV Higher Order and Iso-parametric Elements

One dimensional quadratic and cubic elements, Use of natural Co-ordinate system, Area Co-ordinate system continuity and convergence requirements, 2D rectangular and triangular requirement.

Unit-V Static & Dynamic Analysis

Analysis of trusses and frames, Analysis of machine subassemblies, Use commercial software packages, Advantages and limitations Hamilton's principle, Derivation of equilibrium, Consistent and lumped mass matrices, Derivation of mass matrices for ID elements, Determination of natural frequencies and mode shapes, Use of commercial software packages.

Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

References:

1. Rao, S.S., The Finite Element Method in Engineering, 2nd ed.., Peragamon Press,Oxford.
2. Robert, D. Cook. David, S. Malkins, and Michael E. Plesha, Concepts andApplication of Finite Element Analysis 3rd ed., John Wiley.
3. Chandrupatla, T.R. anBelegundu, A.D., Introduction to Finite Elements inEngineering, Prentice Hall of India Pvt. Ltd.
4. Zienkiewicz O C, The Finite Element Method, 3rd ed, Tata McGraw Hill.

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Course Outcomes:

At the completion of this course, students should be able to-

CO1	Make use of finite element method to solve simple problems from Structural & Dynamic domain.
CO2	Develop the concept of various elements and their characteristics.
CO3	Create element and global stiffness, displacement and force matrices for 1D and 2D FEA Problems.
CO5	Apply the finite element analysis using available commercial FEA tools.

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1								
CO2	3	3	1	2								
CO3	3	3	3	2								
CO5	3	3	3	3								

Jabalpur Engineering College, Jabalpur (M.P)
PROGRAMME: B.E. Mechanical Engineering (VII-Semester) CBGS

Credits: 4	Elective –IV (A)	ME-7005	Renewable Energy	L: 3, T: 1, P:0

Course Objective:

1. Understanding the solar radiation its measuring instrument. Solar thermal conversion techniques and Principle of photovoltaic conversion of solar energy.
2. Understanding theWind energy conversion principles, Power, torque and speed characteristics; power curve of wind turbine.
3. Understanding the Biomass conversion routes: biochemical, chemical and thermochemical Biochemical conversion of biomass to energy: anaerobic digestion, biogas production mechanism, technology, types of digesters, design of biogas plants,
4. Understanding the Principle of ocean thermal energy conversion system, ocean thermal power plants. Principles of ocean wave energy and Tidal energy conversion
5. Understanding the Origin of geothermal resources, Hydrogen Energyand Fuel Cells:

Course Content:

UNIT-I Solar Radiation: Extra-terrestrial and terrestrial, radiation measuring instrument, radiationmeasurement and predictions. **Solar thermal conversion**: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, solar cooling and refrigeration. **Solar photovoltaic**: Principle of photovoltaic conversion of solar energy; Technology for fabrication ofphotovoltaic devices; Applications of solar cells in PV generation systems; Organic PV cells.

UNIT-II Wind energy characteristics and measurement: Metrology of wind speed distribution, windspeed statistics, Weibull, Rayleigh and Normal distribution, Measurement of wind data, Energy estimation of wind regimes; **Wind Energy Conversion**: Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics; power curve of wind turbine, capacity factor, matching wind turbine with wind regimes; Application of wind energy.

UNIT-III Production of biomass, photosynthesis-C3 & C4 plants on biomass production; Biomassresources assessment; Co2 fixation potential of biomass; Classification of biomass; Physicochemical characteristics of biomass as fuel **Biomass conversion** routes: biochemical, chemical and thermochemical
Biochemical conversion of biomass to energy: anaerobic digestion, biogas production mechanism, technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas plant manure-utilization and manure values.
Biomass Gasification: Different types, power generation from gasification, cost benefit analysis of power generation by gasification.

UNIT-IV Hydropower Systems: Overview of micro, mini and small hydro system; hydrology;Elements of turbine; Assessment of hydro power; selection and design criteria of turbines; site selection and civil works; speed and voltage regulation; Investment issue load management and tariff collection; Distribution and marketing issues. **Ocean Energy:** Ocean energy resources, ocean energy routs; Principle of ocean thermal energy conversion system, ocean thermal power plants. Principles of ocean wave energy and Tidal energy conversion.

UNIT-V Geothermal energy: Origin of geothermal resources, type of geothermal energy deposits, siteselection geothermal power plants; **Hydrogen Energy**: Hydrogen as a source of energy, Hydrogenproduction and storage. **Fuel Cells**: Types of fuel cell, fuel cell system and sub-system, Principle of working, basic thermodynamics

21.7.18

Evaluation:
Evaluation will be continuous and integral part of the class as well as through external assessment.

References:

1. Kothari, Singal&Rajan; Renewable Energy Sources and Emerging Technologies, PHI Learn
2. Khan, B H, Non Conventional Energy, TMH.
3. Sukhatme and Nayak, Solar Energy, Principles of Thermal Collection and Storage, TMH.
4. Tiwari and Ghosal, Renewable Energy Resources: basic principle & application, NarosaPubl
5. Koteswara Rao, Energy Resources, Conventional & Non-Conventional, BSP Publication.
6. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, technologies and Application, PHI L
7. AbbasiTanseem and Abbasi SA; Renewable Energy Sources; PHI Learning
8. Ravindranath NH and Hall DO, Biomass, Energy and Environment, Oxford University Press.
9. Duffie and Beckman, Solar Engineering of Thermal Process, Wiley
10. Nikolai, Khartchenko; Green Power; Tech Book International
11. Tester, Sustainable Energy-Choosing Among Options, PHI Learning.
12. Godfrey Boyle, Renewable Energy: Power for a sustainable future, Oxford OUP.

Course Outcomes:
At the completion of this course, students should be able to

CO1	Classifysolar energy conversion systems and applications.
CO2	Selection and estimation of the Wind energy potential of site and turbines.
CO3	Explain assessment of hydro power and Tidal energy conversion.
CO4	Analyzegeothermal energy, Hydrogenproduction and storage and Fuel cell.

Mapping of Course outcomes (COs) with Program Outcomes (POs):

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1								
CO2	1	1	1									
CO3		1	1									
CO4	1	1										