VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

MECHANICAL ENGINEERING

BE/B.Tech. Scheme of Teaching and Examinations

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2018 – 19)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

VI SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME61	Finite Element Methods		3	2	--	03	40	60	100	4
2	PCC	18ME62	Design of Machine Elements II		3	2	--	03	40	60	100	4
3	PCC	18ME63	Heat Transfer		3	2	--	03	40	60	100	4
4	PEC	18ME64X	Professional Elective -1		3	--	--	03	40	60	100	3
5	OEC	18ME65X	Open Elective -A		3	--	--	03	40	60	100	3
6	PCC	18MEL66	Computer Aided Modelling and Analysis Lab		--	2	2	03	40	60	100	2
7	PCC	18MEL67	Heat Transfer Lab		--	2	2	03	40	60	100	2
8	MP	18MEMP68	Mini-project		--	--	2	03	40	60	100	2
9	Internship	--	Internship	To be carried out during the vacation/s of VI and VII semesters and /or VII and VIII semesters.								
				TOTAL	**15**	**10**	**06**	**24**	**320**	**480**	**800**	**24**

Note: PCC: Professional core, PEC: Professional Elective, OE: Open Elective, MP: Mini-project.

Professional Elective -1

Course code under 18XX64X	Course Title	Course code under 18XX64X	Course Title
18ME641	**Non-Traditional Machining**	18ME644	**Vibrations and Noise Engineering**
18ME642	**Refrigeration and Air conditioning**	18ME645	**Composite Materials Technology**
18ME643	**Theory of Elasticity**	18ME646	**Entrepreneurship Development**

Open Elective -A

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX65X).

Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Mini-project work:

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the Mini-project work, shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all the guides of the college.

The CIE marks awarded for the Mini-project, shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Mini-project:

(i) Single discipline: Contribution to the Mini-project and the performance of each group member shall be assessed individually in the semester end examination (SEE) conducted at the department.

(ii) Interdisciplinary: Contribution to the Mini-project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belongs to.

Internship: All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements.

Updated on 16.04.2020/28092020

B. E. MECHANICAL ENGINEERING **Choice Based Credit System (CBCS) and Outcome Based Education (OBE)** **SEMESTER - VI**			
FINITE ELEMENT METHODS			
Course Code	**18ME61**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To learn the basic principles of finite element analysis procedure
- To understand the design and heat transfer problems with application of FEM.
- Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Module-1

Introduction to Finite Element Method: General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method.

Boundary conditions: Homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, **Types of elements:** 1D, 2D and 3D, Node numbering, Location of nodes. **Strain-** displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, temperature effects.

Interpolation models: Simplex, complex and multiplex elements, linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

Module-2

Introduction to the stiffness (Displacement) method: Introduction, Derivation of stiffness matrix, Derivation of stiffness matrix for a spring element, Assembly the total stiffness matrix by superposition. One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 3 8), 2D iso-parametric element, Lagrange interpolation functions.

Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Force terms: Body force, traction force and point loads, Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of

Module-3

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

Module-4

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using vibration method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.

Module-5

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.

Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.

CO2: Develop element characteristic equation and generation of global equation.

CO3: Formulate and solve Axi-symmetric and heat transfer problems.

CO4: Apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi-symmetric and dynamic problems

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	A first course in the Finite Element Method	Logan, D. L	Cengage Learning	6th Edition 2016
2	Finite Element Method in Engineering	Rao, S. S	Pergaman Int. Library of Science	5th Edition 2010
3	Finite Elements in Engineering	Chandrupatla T. R	PHI	2nd Edition 2013
Reference Books				
1	Finite Element Method	J.N.Reddy	McGraw -Hill International Edition	
2	Finite Elements Procedures	Bathe K. J	PHI	
3	Concepts and Application of Finite Elements Analysis	Cook R. D., et al.	Wiley & Sons	4th Edition 2003

E- Learning

- VTU, E- learning

B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER - VI			
DESIGN OF MACHINE ELEMENTS II			
Course Code	**18ME62**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand various elements involved in a mechanical system.
- To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.
- To select transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
- To design a mechanical system integrating machine elements.
- To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.

Module-1

Springs: Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads.
Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs.
Introduction to torsion and Belleville springs.
Belts: Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition.
Selection of flat and V belts- length & cross section from manufacturers' catalogues. Construction and application of timing belts.
Wire ropes: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.

Module-2

Gear drives: Classification of gears, materials for gears, standard systems of gear tooth, lubrication of gears, and gear tooth failure modes.
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.
Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Module-3

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.
Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Module-4

Design of Clutches: Necessity of a clutch in an automobile, types of clutch, friction materials and its properties. Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.
Design of Brakes: Different types of brakes, Concept of self-energizing and self-locking of brakes. Practical examples, Design of band brakes, block brakes and internal expanding brakes.

Module-5

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design.

Antifriction bearings: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep grove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds;probability of survival.

Assignment:

Course work includes a **Design project**. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing mounting, C-clamp, screw jack, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Design project should be given due credit in internal assessment.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Apply design principles for the design of mechanical systems involving springs, belts, pulleys, and wire ropes.

CO2: Design different types of gears and simple gear boxes for relevant applications.

CO3: Understand the design principles of brakes and clutches.

CO4: Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue.

CO6: Apply engineering design tools to product design.

CO7: Become good design engineers through learning the art of working in a team.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Shigley's Mechanical Engineering Design	Richard G. Budynas,and J. Keith Nisbett	McGraw-Hill Education	10^{th} Edition, 2015
2	Fundamentals of Machine Component Design	Juvinall R.C, and Marshek K.M	John Wiley & Sons	Third Edition 2007 Wiley student edition
3	Design of Machine Elements	V. B. Bhandari	Tata Mcgraw Hill	4th Ed 2016.
4	Design of Machine Elements-II	Dr.M H Annaiah Dr. J Suresh Kumar Dr.C N Chandrappa	New Age International (P) Ltd.,	1s Ed., 2016
Reference Books				
1	Machine Design- an integrated approach	Robert L. Norton	Pearson Education	2^{nd} edition
2	Design and Machine Elements	Spotts M.F., ShoupT.E	Pearson Education	8^{th} edition, 2006

3	Machine design Hall, Holowenko, Laughlin (Schaum's Outline Series	adapted by S.K.Somani	Tata McGraw Hill Publishing Company Ltd	Special Indian Edition, 2008
4	Elements of Machine Design	H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil	IK International	First edition,2019
5	Design of Machine ElementsVolume II	T. Krishna Rao	IK international publishing house	2013
6	Hand book of Mechanical Design	G. M. Maithra and L.V.Prasad	Tata McGraw Hill	2nd edition,2004

Design Data Hand Books:

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.
[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.
[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010
[4] PSG Design Data Hand Book, PSG College of technology, Coimbatore.

B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER - VI			
HEAT TRANSFER			
Course Code	**18ME63**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module-1

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Types of boundary conditions. General three dimensional Heat Conduction Equation: Derivation of the equation in (i) Cartesian, coordinate only. Discussion of three dimensional Heat Conduction Equation in (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) without heat generation and (ii) constant thermal conductivity - in Cartesian system with various possible boundary conditions. Brief Introduction to variable thermal conductivity and heat generation [No numerical on variable thermal conductivity and heat generation] Thermal Resistances in Series and in Parallel. Critical Thickness of Insulation in cylinder and spheres Concept. Derivation

Module-2

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts.

Module-3

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction and one dimensional unsteady conduction, boundary conditions, solution methods.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's displacement law, Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange between parallel plates, concentric cylinders, and concentric spheres, Radiation Shield.

Module-4

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

Module-5

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts.

Introduction to boiling: pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Understand the modes of heat transfer and apply the basic laws to formulate engineering systems.

CO2: Understand and apply the basic laws of heat transfer to extended surface, composite material and unsteady state heat transfer problems.

CO3: Analyze heat conduction through numerical methods and apply the fundamental principle to solve radiation heat transfer problems.

CO4: Analyze heat transfer due to free and forced convective heat transfer.

CO5: Understand the design and performance analysis of heat exchangers and their practical applications, Condensation and Boiling phenomena.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principals of heat transfer	Frank Kreith, Raj M. Manglik, Mark S. Bohn	Cengage learning	Seventh Edition 2011.
2	Heat transfer, a practical approach	Yunus A. Cengel	Tata Mc Graw Hill	Fifth edition
Reference Books				
1	Heat and mass transfer	Kurt C, Rolle	Cengage learning	second edition
2	Heat Transfer A Basic Approach	M. NecatiOzisik	McGraw Hill, New York	2005
3	Fundamentals of Heat and Mass Transfer	Incropera, F. P. and De Witt, D. P	John Wiley and Sons, New York	5th Edition 2006
4	Heat Transfer	Holman, J. P.	Tata McGraw Hill, New York	9th Edition 2008

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B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

NON-TRADITIONAL MACHINING

Course Code	**18ME641**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn various concepts related to modern machining processes & their applications.
- To appreciate the differences between conventional and non-conventional machining processes.
- To acquire a functional understanding of non-traditional manufacturing equipment.
- To know about various process parameters and their influence on performance and their applications.
- To impart knowledge on various types of energy involved in non-traditional machining processes.

Module-1

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

Module-2

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

Module-3

ELECTROCHEMICAL MACHINING (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.

Module-4

ELECTRICAL DISCHARGE MACHINING (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

PLASMA ARC MACHINING (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

Module-5

LASER BEAM MACHINING (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

ELECTRON BEAM MACHINING (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Understand the compare traditional and non-traditional machining process and recognize the need for Non- traditional machining process.

CO2: Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.

CO3: Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.

CO4: Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.

CO5: Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Modern Machining Process	by P.C Pandey and H S Shah	McGraw Hill Education India Pvt. Ltd.	2000
2	Production technology	HMT	McGraw Hill Education India Pvt. Ltd	2001
Reference Books				
1	New Technology	Dr. Amitabha Bhattacharyya	The Institute of Engineers (India)	2000
2	Modern Machining process	Aditya		2002

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

REFRIGERATION AND AIR CONDITIONING

Course Code	**18ME642**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
- Understand the working principles and applications of different types of refrigeration systems.
- Study the working of air conditioning systems and their applications.
- Identify the performance parameters and their relations of an air conditioning system.

Module-1

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air.

Industrial Refrigeration-Chemical and process industries, Dairy plants , Petroleum refineries, Food processing and food chain, Miscellaneous

Module-2

Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.

Module-3

Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems,Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.Practical problems – crystallization and air leakage, Commercial systems

Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermoacoustic refrigeration systems

Module-4

Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures

Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Module-5

Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Transport air conditioning Systems:Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships

Course Outcomes: At the end of the course, the student will be able to:
CO1: Illustrate the principles, nomenclature and applications of refrigeration systems.
CO2: Explain vapour compression refrigeration system and identify methods for performance improvement
CO3: Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermoacoustic refrigeration systems.
CO4: Estimate the performance of air-conditioning systems using the principles of psychrometry.
CO5: Compute and Interpret cooling and heating loads in an air-conditioning system.
CO6: Identify suitable refrigerant for various refrigerating systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Refrigeration and Air-conditioning	Arora C.P	Tata Mc Graw –Hill, New Delhi	2nd Edition, 2001
2	Principles of Refrigeration	Roy J. Dossat	Wiley Limited	
3	Refrigeration and Air-conditioning	Stoecker W.F., and Jones J.W.,	Mc Graw - Hill, New Delhi	2nd edition, 1982.
Reference Books				
1	Heating, Ventilation and Air Conditioning	McQuistion	Wiley Students edition	5th edition2000.
2	Air conditioning	PITA	Pearson	4th edition 2005
3	Refrigeration and Air-Conditioning	S C Arora& S Domkundwar	Dhanpat Rai Publication	
4	Principles of Refrigeration	Dossat	Pearson	2006
5	Refrigeration and Air-Conditioning	Manohar prasad		
6	Handbook of Air Conditioning and Refrigeration	Shan K. Wang	McGraw-Hill Education	2/e,2001

Data Book:

1. Mathur M.L. & Mehta,Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers,2008

E- Learning

- http://nptel.ac.in/courses/112105128/#

E-Resources

- VTU, E- learning, MOOCS, Open courseware

B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER – VI Professional Elective- 1			
THEORY OF ELASTICITY			
Course Code	**18ME643**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide the student with the mathematical and physical principles of Theory of Elasticity.
- To provide the student with various solution strategies while applying them to practical cases.

Module-1

Analysis of Stress: Definition and notation of stress, Equations of equilibrium in differential form, Stress components on an arbitrary plane, Equality of cross shear, Stress invariants, Principal stresses, Octahedral stress, Planes of maximum shear, Stress transformation, Plane state of stress, Mohr's diagram for 3dimensional state of stress.

Module-2

Analysis of Strain: Displacement field, Strains in term of displacement field, Infinitesimal strain at a point, Engineering shear strains, Strain invariants, Principal strains, Octahedral strains, Plane state of strain, Compatibility equations, Strain transformation. Principle of super position, Saint Venant principle.

Module-3

Two-Dimensional classical elasticity: Cartesian co-ordinates, Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy's stress functions, investigation of Airy's stress function for simple beams. Bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of simply supported beam under UDL, stress concentration, stress distribution in an infinite plate with a circular hole subjected to uniaxial and biaxial loads.

General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures.

Module-4

Stress analysis in Axisymmetric body: Stresses in rotating discs of uniform thickness and cylinders. Numerical Problems.

Torsion: Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, Torsion of thin walled thin tubes, Torsion of thin walled multiple cell closed sections.

Module-5

Thermal stress: Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Understand the Basic field equations of linear elastic solids, force, stress, strain and equilibrium in solids.

CO2: Analyse the 2D structural elements, beams, cylinders.

CO3: Use analytical techniques to predict deformation, internal force and failure of simple solids and structural components.

CO4: Analyse the axisymmetric structural elements.

CO5: Analyse the structural members subjected to torsion

CO6: Determine the thermal stresses in plain stress and plane stain conditions.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Elasticity	S. P. Timoshenko and J. N Gordier	Mc-Graw Hill International	3rd edition, 2010
2	Advanced Mechanics of solids	L. S. Srinath	Tata Mc. Graw Hill	2009
Reference Books				
1	Theory of Elasticity	Sadhu Singh	Khanna Publications	2004
2	Applied Elasticity	T.G. Seetharamuand Govindaraju	Interline Publishing	2008.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

ADAVNCED VIBRATIONS

Course Code	**18ME644**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To enable the students to understand the theoretical principles of vibration and vibration analysis techniques for the practical solution of vibration problems.
- To enable the students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations
- To make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi-degree of freedom linear systems.
- Be able to write the differential equation of motion of vibratory systems.

Module-1

Forced vibrations (1DOF): Introduction, analysis of forced vibration with constant harmonic excitation, MF, rotating and reciprocating unbalances, excitation of support (Relative and absolute amplitudes), force and motion transmissibility, energy dissipated due to damping and numerical problems.

Systems with 2DOF: Principal modes of vibrations, normal mode and natural frequencies of systems (Damping is not included), simple spring-mass systems, masses on tightly stretched strings, double pendulum, tensional systems, combined rectilinear and angular systems, geared systems and numerical problems.

Module-2

Numerical methods for multi DOF systems: Maxwell's reciprocal theorem, influence coefficients, Rayleigh's method, Dunkerley's method, stodola method, orthogonality principle, method of matrix iteration and numerical.

Modal analysis and condition monitoring: signal analysis, dynamic testing of machines and structures,

Module-3

Vibration measuring instruments and whirling of shafts: seismic instruments, vibrometers, accelerometer, frequency measuring instruments and numerical. Whirling of shafts with and without damping.

Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers and Vibration dampers.

Module-4

Transient Vibration of single Degree-of freedom systems: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.

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 equipment; hearing conservation and damage risk criteria, daily noise doze.

Module-5

Noise: Sources, Isolation and control: Major sources of noise on road and in industries, noise due to construction equipment 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.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Characterize the single and multi-degrees of freedom systems subjected to free and forced vibrations with and without damping.

CO2: Apply the method of vibration measurements and its controlling.

CO3: Determine vibratory responses of SDOF and MDOF systems to harmonic, periodic and non-periodic excitation.

CO4: Analyze the mathematical model of a linear vibratory system to determine its response.

CO5: Obtain linear mathematical models of reallife engineering systems.

CO6: Apply the principles of vibration and noise reduction techniques to real life engineering problems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanical Vibrations	S. S. Rao	Pearson Education	
2	Fundamentals of Mechanical Vibration	S. Graham Kelly	McGraw-Hill	
3	Mechanical Vibrations	W.T. Thomson	Prentice Hill India	
4	Vibraitons and Acoustics – Measurements and signal	C Sujatha	Tata McGraw Hill	
Reference Books				
1	Mechanical Vibrations	G. K. Grover	Nem Chand and Bros.	
2	Theory of Vibration with Application	William T. Thomson, Marie Dillon Dahleh, Chandramouli	Pearson Education	5th edition
3	Mechanical Vibrations	V. P. Singh	Dhanpat Rai & Company	
4	Mechanical Vibrations and Noise engineering	Amberkar A.G.	PHI	

E- Learning

• VTU, E- learning

B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER – VI Professional Elective- 1			
COMPOSITE MATERIALS TECHNOLOGY			
Course Code	**18ME645**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To know the behaviour of constituents in the composite materials
- To Enlighten the students in different types of reinforcement
- To Enlighten the students in different types of matrices
- To develop the student's skills in understanding the different manufacturing methods available for composite material.
- To understand the various characterization techniques
- To illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

Module-1

Introduction to Composite Materials: Definition, classification & brief history of composite materials.
Constituent of composite materials: Reinforcements, Matrix, Coupling agents, coatings & fillers.
Reinforcements: Introduction, Glass Fibers, Boron Fibers, Carbon Fibers, Organic Fibers, Ceramic Fibers, Whiskers, Other Non-oxide Reinforcements, Comparison of Fibers
Matrix Materials: Polymers, Metals and Ceramic Matrix Materials.
Interfaces: Wettability, Crystallographic nature of interface, types of bonding at the interface and optimum interfacial bond strength.

Module-2

Polymer Matrix Composites (PMC): Processing of PMC's; Processing of Thermoset Matrix Composites, Thermoplastic Matrix Composites, Sheet Moulding Compound and carbon reinforced polymer composites. Interfaces in PMC's, Structure & Properties of PMC's, applications
Metal Matrix Composites: Types of metal matrix composites, Important Metallic Matrices, Processing, Interfaces in Metal Matrix Composites, Properties & Applications.

Module-3

Ceramic Matrix Composites (CMC): Processing of CMC's; Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis, Electrophoretic Deposition, Self-Propagating High Temperature Synthesis. Interfaces, properties and applications of CMC's.
Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon Composites, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites.
Multi-filamentary Superconducting Composites: The Problem of Flux Pinning, Types of Super Conductor, Processing & structure of Multi filamentary superconducting composites. Applications of multi-filamentary superconducting composites.

Module-4

Nonconventional Composites: Introduction, **Nanocomposites;** Polymer clay nanocomposites, self healing composites, self-reinforced composites. Biocomposites, **Laminates;** Ceramic Laminates, Hybrid Composites.
Performance/Characterization of Composites: Static Mechanical Properties; Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Interlaminar Shear Strength.
Fatigue Properties; Tension–Tension Fatigue, Flexural Fatigue. **Impact Properties;** Charpy, Izod, and Drop-Weight Impact Test.

Module-5

Micromechanics of Composites: Density, Mechanical Properties**;** Prediction of Elastic Constants, Micromechanical Approaches, Halpin-Tsai Equations, Transverse Stresses, Thermal properties. Numerical Problems.

Macromechanics of Composites: Introduction, Elastic constants of an isotropic material, elastic constants of a lamina, relationship between engineering constants and reduced stiffnesses and compliances.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Use different types of manufacturing processes in the preparation of composite materials

CO2: Analyze the problems on macro mechanical 88ehavior of composites

CO3: Analyze the problems on micromechanical 88ehavior of Composites

CO4: Determine stresses and strains relation in composites materials.

CO5: Understand and effective use of properties in design of composite structures

CO6: Perform literature search on a selected advanced material topic.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Composite Material Science and Engineering	Krishan K. Chawla	Springer	Third Edition First Indian Reprint 2015
2	Fibre-Reinforced Composites, Materials, Manufacturing, and Design	P.K. Mallick	CRC Press, Taylor & Francis Group	Third Edition
3	Mechanics of Composite Materials & Structures	MadhijitMukhopadhay	Universities Press	2004
Reference Books				
1	Mechanics of Composite materials	Autar K. Kaw	CRC Taylor & Francis	2nd Ed, 2005
2	Stress analysis of fiber Reinforced Composites Materials	Michael W, Hyer	Mc-Graw Hill International	2009
3	Mechanics of Composite Materials	.Robert M. Jones	Taylor & Francis	1999

E- Learning

- VTU, E- learning

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B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

NON CONVENTIONAL ENERGY SOURCES

Course Code	**18ME651**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To introduce the concepts of solar energy, its radiation, collection, storage and application.
- To introduce the concepts and applications of Wind energy, Biomass energy, Geothermal energy and Ocean energy as alternative energy sources.
- To explore society's present needs and future energy demands.
- To examine energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable energy sources such as solar, biomass (conversions), wind power, geothermal, etc.
- To get exposed to energy conservation methods.

Module-1

Introduction: Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative).

Solar Radiation: Extra-Terrestrial radiation, spectral distribution of extra terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data.

Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples.

Radiation Flux on a Tilted Surface: Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical examples.

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of

Module-3

Performance Analysis of Liquid Flat Plate Collectors: General description, collector geometry, selective surface (qualitative discussion) basic energy-balance equation, stagnation temperature, transmissivity of the cover system, transmissivity – absorptivity product, numerical examples. The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss coefficient, problems (all correlations to be provided). Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency (all expressions to be provided). Effect of various parameters on the collector performance; collector orientation, selective surface, fluid inlet temperature, number covers, dust.

Photovoltaic Conversion: Description, principle of working and characteristics, application.

Module-4

Wind Energy : Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.
Ocean Thermal Energy Conversion: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.

Module-5

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.
Energy from Bio Mass: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages.
Hydrogen Energy: Properties of Hydrogen with respected to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production bio-chemical production.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
CO2: Know the need of renewable energy resources, historical and latest developments.
CO3: Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation, drying, cooking etc.
CO4: Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.
CO5: Understand the concept of Biomass energy resources and their classification, types of biogas Plants-applications
CO6: Compare Solar, Wind and bio energy systems, their prospects, Advantages and limitations.
CO7: Acquire the knowledge of fuel cells, wave power, tidal power and geothermal principles and applications.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Non-Convention Energy Resources	B H Khan	McGraw Hill Education (India) Pvt. Ltd.	3rd Edition
2	Solar energy	Subhas P Sukhatme	Tata McGraw Hill	2nd Edition, 1996.
3	Non-Conventional Energy Sources	G.D Rai	Khanna Publishers	2003
Reference Books				
1	Renewable Energy Sources and Conversion Technology	N.K.Bansal, Manfred Kleeman&MechaelMeliss	Tata McGraw Hill.	2004
2	Renewable Energy Technologies	Ramesh R & Kumar K U	Narosa Publishing House New Delhi	
3	Conventional Energy Systems	K M, Non	Wheeler Publishing Co. Ltd., New Delhi	2003

4	Non-Conventional Energy	Ashok V Desai	Wiley Eastern Ltd, New Delhi	2003

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

WORLD CLASS MANUFACTURING

Course Code	**18ME652**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concept of world class manufacturing, dynamics of material flow, and Lean manufacturing.
- To familiarize the students with the concepts of Business excellence and competitiveness.
- To apprise the students with the need to meet the current and future business challenges.
- To prepare the students to understand the current global manufacturing scenario.

Module-1

Historical Perspective World class Excellent organizations – Models for manufacturing excellence: Schonberger, Halls, Gunn and Maskell models, Business Excellence.

Module-2

Benchmark, Bottlenecks and Best Practices, Concepts of benchmarking, Bottleneck and best practices, Best performers – Gaining competitive edge through world class manufacturing – Value added manufacturing – Value Stream mapping – Eliminating waste –Toyota Production System –Example.

Module-3

System and Tools for World Class Manufacturing. Improving Product & Process Design – Lean Production – SQC, FMS, Rapid Prototyping, Poka Yoke, 5-S,3 M, JIT, Product Mix , Optimizing , Procurement & stores practices , Total Productive maintenance, Visual Control.

Module-4

Human Resource Management in WCM: Adding value to the organization– Organizational learning – techniques of removing Root cause of problems–People as problem solvers–New organizational structures. Associates–Facilitators– Teamsmanship–Motivation and reward in the age of continuous improvement.

Module-5

Typical Characteristics of WCM Companies Performance indicators like POP, TOPP and AMBITE systems– what is world class Performance –Six Sigma philosophy.
Indian Scenario on world class manufacturing –Task Ahead. Green Manufacturing, Clean manufacturing, Agile manufacturing.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Understand recent trends in manufacturing.
CO2: Demonstrate the relevance and basics of World Class Manufacturing.
CO3: Understand customization of product for manufacturing.
CO4: Understand the implementation of new technologies.
CO5: Compare the existing industries with WCM industries.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	World Class Manufacturing-Strategic Perspective	Sahay B.S., Saxena KBC. and Ashish Kumar	Mac Milan Publications	New Delhi
2	Just In Time Manufacturing	Korgaonkar M.G	MacMilan Publications	
Reference Books				
1	Production and Operational Management	Adam and Ebert	Prentice Hall learning Pvt. Ltd.	5th Edition
2	The Toyota Way – 14 Management Principles	Jeffrey K.Liker	Mc-Graw Hill	2003
3	Operations Management for Competitive Advantage	Chase Richard B., Jacob Robert	McGraw Hill Publications	11th Edition 2005
4	Making Common Sense Common Practice	Moore Ron	Butterworth-Heinemann	2002
5	World Class Manufacturing- The Lesson of Simplicity	Schonberger R. J	Free Press	1986

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

SUPPLY CHAIN MANAGEMENT

Course Code	**18ME653**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
- To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
- To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.

Module-1

Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Supply chain strategy - Supply Chain Performance Measures.

Module-2

Strategic Sourcing Outsourcing – Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy - Supplier Selection and Contract Negotiation. Creating a world class supply base- Supplier Development - World Wide Sourcing.

Module-3

Warehouse Management Stores management-stores systems and procedures-incoming materials control-stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling-transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement.

Supply Chain Network Distribution Network Design – Role - Factors Influencing Options, Value Addition – Distribution Strategies - Models for Facility Location and Capacity allocation. Distribution Center Location Models.

Module-4

Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management. Pricing and Revenue Management.

Module-5

Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain restructuring, Supply Chain Mapping - Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E-Business in supply chain.

Course Outcomes: At the end of the course the student will be able to:

CO1: Understand the framework and scope of supply chain management.

CO2: Build and manage a competitive supply chain using strategies, models, techniques and information technology.

CO3: Plan the demand, inventory and supply and optimize supply chain network.

CO4: Understand the emerging trends and impact of IT on Supply chain.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Supply Chain Management– Text and Cases	Janat Shah	Pearson Education	2009
2	Supply Chain Management- Strategy Planning and Operation	Sunil Chopra and Peter Meindl	PHI Learning / Pearson Education	2007
Reference Books				
1	Business Logistics and Supply Chain Management	Ballou Ronald H	Pearson Education	5th Edition, 2007
2	Designing and Managing the Supply Chain: Concepts, Strategies, and Cases	David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi	Tata McGraw-Hill	2005
3	Supply Chain Management- Concept and Cases	Altekar Rahul V	PHI	2005
4	Modeling the Supply Chain	Shapiro Jeremy F	Thomson Learning	Second Reprint , 2002
5	Principles of Supply Chain Management- A Balanced Approach	Joel D. Wisner, G. Keong Leong, Keah-Choon Tan	South-Western, Cengage Learning	2008

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

ADVANCED MATERIALS TECHNOLOGY

Course Code	**18ME654**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To impart knowledge on material selection methods and basics of advanced engineering materials.
- To introduce the basics of smart materials, composite materials, ceramics and glasses and modern metallic materials and their applications in engineering.

Module-1

Classification and Selection of Materials: Classification of materials, properties required in Engineering materials, Selection of Materials; Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

Module-2

Composite Materials: Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.

Module-3

Ceramics and Glasses - Bio-ceramics: Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine.

Low & High Temperature Materials: Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.

Module-4

Modern Metallic Materials: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides.

Non-metallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers.

Module-5

Smart Materials: Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications.

Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Explain the concepts and principles of advanced materials and manufacturing processes.

CO2: Understand the applications of all kinds of Industrial materials.

CO3: Apply the material selection concepts to select a material for a given application.

CO4: Define Nanotechnology, Describe nano material characterization.

CO5: Understand the behaviour and applications of smart materials, ceramics, glasses and non-metallic materials.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Reference Books				
1	Engineering Material Technology	James A. Jacobs & Thomas F. Kilduff	Prentice Hall	
2	Materials Science and Engineering	WD. Callister Jr.	Wiley India Pvt. Ltd	2010
3	Engineering Design: A Materials and Processing Approach	G.E. Dieter	McGraw Hill	1991
4	Materials Selection in Mechanical Design	M.F. Ashby	Pergamon Press	1992
5	Introduction to Engineering Materials & Manufacturing Processes	NIIT	Prentice Hall of India	
6	Engineering Materials Properties and Selection	Kenneth G. Budinski	Prentice Hall of India	
7	Selection of Engineering Materials	Gladius Lewis	Prentice-Hall, New Jersey	

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B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER - VI			
COMPUTER AIDED MODELLING AND ANALYSIS LAB			
Course Code	**18MEL66**	CIE Marks	40
Teaching Hours /Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To acquire basic understanding of Modeling and Analysis software
- To understand the concepts of different kinds of loading on bars, trusses and beams, and analyze the results pertaining to various parameters like stresses and deformations.
- To lean to apply the basic principles to carry out dynamic analysis to know the natural frequencies of different kind of beams.

Sl. No.	Experiments
	PART A
1	**Study of a FEA package and modeling and stress analysis of:** a. Bars of constant cross section area, tapered cross section area and stepped bar b. Trusses – (**Minimum 2 exercises of different types)** c. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc. **(Minimum 6 exercises)** d. Stress analysis of a rectangular plate with a circular hole.
	PART B
2	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions **(Minimum 4 exercises of different types)**
3	Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition b) Response of beam with fixed – fixed end conditions subjected to forcing function c) Response of Bar subjected to forcing functions
	PART C(only for demo)
4	a. Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver. b. Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis. c. Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Use the modern tools to formulate the problem, create geometry, descritize, apply boundary conditions to
solve problems of bars, truss, beams, and plate to find stresses with different-loading conditions.

CO2: Demonstrate the ability to obtain deflection of beams subjected to point, uniformly distributed and varying loads and use the available results to draw shear force and bending moment diagrams.

CO3: Analyze and solve 1D and 2D heat transfer conduction and convection problems with different boundary conditions.

CO4: Carry out dynamic analysis and finding natural frequencies of beams, plates, and bars for various boundary conditions and also carry out dynamic analysis with forcing functions.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

One Question from Part A - 40 Marks

One Question from Part B - 40 Marks

Viva-Voce - 20 Marks

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B. E. MECHANICAL ENGINEERING Choice Based Credit System (CBCS) and Outcome Based Education (OBE) SEMESTER - VI			
HEAT TRANSFER LAB			
Course Code	**18MEL67**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum.
- Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

Sl. No.	Experiments
	PART A
1	Determination of Thermal Conductivity of a Metal Rod.
2	Determination of Overall Heat Transfer Coefficient of a Composite wall.
3	Determination of Effectiveness on a Metallic fin.
4	Determination of Heat Transfer Coefficient in free Convection
5	Determination of Heat Transfer Coefficient in a Forced Convention
6	Determination of Emissivity of a Surface.
	PART B
7	Determination of Stefan Boltzmann Constant.
8	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
9	Experiments on Boiling of Liquid and Condensation of Vapour.
10	Performance Test on a Vapour Compression Refrigeration.
11	Performance Test on a Vapour Compression Air – Conditioner.
12	Experiment on Transient Conduction Heat Transfer.
	PART C (OPTIONAL)
13	Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).
14	Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package).

Course Outcomes: At the end of the course, the student will be able to:

CO1: Determine the thermal conductivity of a metal rod and overall heat transfer coefficient of composite slabs.

CO2: Determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values.

CO3: Evaluate temperature distribution characteristics of steady and transient heat conduction through solid cylinder experimentally.

CO4: Determine surface emissivity of a test plate and Stefan Boltzmann constant

CO5: Estimate performance of a refrigerator and effectiveness of a fin and Double pipe heat exchanger

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made

Scheme of Examination:

One Question from Part A - 40 Marks

One Question from Part B - 40 Marks

Viva-Voce - 20 Marks