Department of Mechanical Engineering
National Institute of Technology Raipur
(Institute of National Importance)
G. E. Road, Raipur-492010 (CG)

B. Tech. in Mechanical Engineering
V Semester CBCS Scheme

Sl. No	Course Title	Course Code	Course Name	Type	L	T	P	TA		MSE		ESE		Total Marks	Credits
								Max	Min	Max	Min	Max	Min		
1.	Program Elective-I	ME105201ME	Dynamics and Vibration	T	3	0	0	20	0	30	0	50	0	100	3
2.	Program Elective-I	ME105202ME	Industrial Engineering & Management												
3.	Program Elective-I	ME105203ME	Introduction to Aerospace Engineering												
4.	Program Elective-II	ME105211ME	Design and Optimization of Energy systems	T	3	0	0	20	0	30	0	50	0	100	3
5.	Program Elective-II	ME105212ME	Measurement and Control												
6.	Open Elective-I	ME105301ME	Computational Fluid Dynamics	T	3	0	0	20	0	30	0	50	0	100	3
7.	Open Elective-I	ME105302ME	Composite Materials and Mechanics												
8.	Open Elective-I	ME105303ME	Finite Element Method												
9.	Program Core	ME105101ME	Heat and Mass Transfer	T	3	1	0	20	0	30	0	50	0	100	4
10.	Program Core	ME105102ME	Refrigeration and Air Conditioning	T	3	1	0	20	0	30	0	50	0	100	4
11.	Program Core	ME105103ME	Machine Design - 1	T	3	1	0	20	0	30	0	50	0	100	4
12.	Laboratory	ME105401ME	Mechanical Lab - 5	P	0	0	2	40	0	20	0	40	0	100	1
13.	Laboratory	ME105402ME	Mechanical Lab - 6	P	0	0	2	40	0	20	0	40	0	100	1
14.	Internship	ME105701ME	Summer Internship 1	P	0	0	0	50	0	0	0	50	0	100	1
Total					18	3	4							900	24

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Dynamics and Vibration**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105201ME**
6.	Status (Core/Elective)	**Program Elective-I**
7.	Pre-requisites (course no./title)	Physics, Engineering Mechanics and Kinematics of Machines
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Apply the concepts of Newtonian and Lagrangian Mechanics in deriving the Equation of Motion of a Discrete System. 2. Model an Equivalent Single Degree of Freedom (**SDOF**) System and Analyze the characteristics. 3. Understand the concept of Eigen values and Eigen vectors in the context of Multi-Degree of Freedom (**MDOF**) system and predict the motion characteristics of the same. 4. Get a preliminary understanding of the Dynamics of Rotors and the Vibration responses of continuous systems.	
10.	**Course Syllabus** **UNIT I - Review of Dynamics** Review of Newtonian Mechanics, Dynamics of Rigid Bodies. Degrees of Freedom and Generalized Coordinates, Coordinate Systems (Cartesian, Polar, Cylindrical and Spherical coordinate Systems), Velocity and Acceleration in different coordinate systems, Velocity and Acceleration in different frames of references. Constraints and Types of Constraints. **Introduction to Analytical Dynamics**: Lagrangian and Hamiltonian Dynamics, Conservative Force Fields Euler- Lagrange Equation of Motion, Deriving the Equation of Motion of the given system, Variational Approach, Extended Hamilton's Dynamics, Introduction to Rayleigh Dissipation Function. Coordinate Coupling. **UNIT II – Single Degree of Freedom (SDOF) System** Response of first order and second order systems, Free vibration of **SDOF** Spring mass system, Introduction to Harmonic oscillator, Solution to the **SDOF** Spring Mass system, Introduction to Damping, types of damping (Viscous, Coulomb and Quadratic Damping models), Response of **SDOF** Spring Mass and Damper System, Nature of Damped System (underdamping, Critical damping and Over damping). Solution to the Equation of motion of **SDOF** spring mass and damper system.	

	Forced response of **SDOF** spring mass system, Response of system to periodic forcing, impulse forcing and step forcing. Forced response of **SDOF** spring mass and damper system, Response to rotating Imbalance problem, base excitation, and shock. Single cylinder engine vibration analysis. **UNIT III – Multi-degree of Freedom (MDOF) System** Concept of Eigen Values and Eigen vectors, Eigen Frequencies, modelling a **CO_2** molecule for Stretch as **MDOF** system, Principle of Orthogonality of Eigen values, Coordinate coupling, Solution to Equation of motion of **MDOF** Spring Mass Damper System. Response of two degree of freedom system under harmonic excitation, Modal Analysis. **Vibration Absorber:** Concept of Undamped Vibration Absorber, Tuned Mass Damper, Dynamic Vibration absorber, modelling a **MDOF** system consisting of Rotor imbalance, Forced Response of **MDOF** System **UNIT IV – Dynamics of Rotors and Vibration of Continuous Systems** **Dynamics of Rotors:** Whirling Speed, Critical Speed, Vibration response of Eccentrically mounted Rotors, Response of Rotors modelled as Vibrating System. **Vibration of Continuous systems:** Introduction to continuous systems, Axial Vibration of Bars and Bending Vibration of Beams and Bars, Orthogonality of Natural Modes, Expansion Theorem, Rayleigh ritz method, Rayleigh's Quotient, Introduction to vibration of plates and Shells.
11.	**Text Books-** 1. **Engineering Dynamics**, J H Ginsberg, Cambridge University Press. 2. **Elements of Vibration Analysis**, Leonard Meirovitch, Tata McGraw Hill.
12.	**Reference Books-** 1. **Advanced Dynamics**, J H Ginsberg, Cambridge University Press. 2. **Mechanical Vibration**, S. S. Rao, Addison Wesley Publishes 2nd Edition. 3. **Vibration and Waves in Continuous Mechanical Systems**, Peter Hagedorn and Anirvan DasGupta, Wiley Publishers.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Introduction to Aerospace Engineering**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105203ME**
6.	Status (Core/Elective)	**Program Elective-I**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Demonstrate knowledge on evolution of plates, functioning of different components, role of regulatory and authorities and safety aspects of flight. 2. Gain knowledge on aerodynamic behaviour of rigid curved surfaces and their significance in controlling flight 3. Exercise good command on structured anatomy and strength aspects of different components of aircraft. 4. Identify different types of engines that suit the needs of different aerospace vehicles 5. Exhibit the science of flying an aerospace vehicle and controlling of crucial subsystems that make a full-fledged flight.	
10.	**Course Syllabus** **UNIT I – Introduction** Introduction Evolution of planes, pre-Wright brother era to present plane, progress in structure airplane design and applications, classification of aircrafts and space vehicles, functions of major components of an airplane, conventional control and power controls, role of DGCA in air safety and regulatory authority, accident investigation, human factors in flight safety, Introduction to FAA. **UNIT II** Basic Aerodynamics Aerospace atmosphere, types, characteristics, pressure, temperature and density variations, lapse rate, aerofoil nomenclature, forces acting on aerofoil, characteristics of aerofoils. Flight Control Surfaces: Aircraft principle axes, main control surfaces- ailerons, elevators, rudders, spoilers and flaps, use of flaps during take-off, landing and maneuvering. **UNIT III** Structures Structural arrangement of monocoque and semi-monocoque structures,	

	geodesic construction. Structural layout of wing, fuselage and tail plane, types of wings, monoplanes, biplanes, triplanes and multiplanes, wing geometry - different types and purpose. **UNIT IV** Propulsion Piston engines and gas turbine engines, various means of thrust production, comparative merits. Ramjet, pulse jet and scramjet. Rockets - principle of operation, types and applications. Helicopters: Rotorcraft, types of rotorcraft, autogyro, gyrodyne. Helicopters, main rotor system, fully articulated, semi rigid and rigid rotor system, transmission system.
11.	**Text Books-** 1. **Introduction to Flight,** J. D. Anderson, 6/e, McGraw Hill,2010. 2. **Fundamentals of Flight,** R. S. Shevell, 2/e, Pearson, 2004.
12.	**Reference Books-** 1. **Flight Without Formulae,** A.C. Kermode, 5/e, Pearson, 1989. 2. **Helicopter Engineering,** L. Gupta, Himalayan Books, 1996. 3. **Interactive Aerospace Engineering and Design,** D. Newman, McGraw Hill, 2002. 4. **Aircraft Flight,** R. H. Barnard and D. R. Philpot, 3/e, Pearson, 2004.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Industrial Engineering & Management**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105202ME**
6.	Status (Core/Elective)	**Program Elective-I**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** The course is intended to provide the concepts, knowledge, objectives, functions, contributions and place of industrial engineering and management to the students, so that students will be able to 1. Provide strategic decisions regarding location, site selection, plant layout and line balancing for the industries. 2. Understand the concept of work study, method study, work measurement and able to provide the solution in this regard for the industries. 3. Recognize the need and furnish the solutions of maintenance, replacement policies and inventory planning issues for the business organization. 4. Identify, formulate, and solve the managerial problems of the design, planning, control, and improvement of both manufacturing and service operations.	
10.	**Course Syllabus** **UNIT I - Introduction** Definition of Industrial engineering, History & development, Objective of Industrial Engineering, Function of Industrial engineer, Definition of Management, System approach to Management, Social responsibility, ethics and management, Functions of Management, Nature and purpose of organizing, Formal and informal organization, Types of organizational structure and their selection. **UNIT II –Location, Layout, Line balancing & Work Measurement** Facility Location and Layout: Need for a suitable location, Factors affecting location, Quantitative method for evaluation of plant location, Objectives & Principles of plant layout, Types of layout and their suitability, Line balancing concepts, Line balancing techniques, Work Study, Method Study & Work Measurement: Productivity, Definitions, Recording techniques, Flow Process Charts, man-machine chart, Motion economy principles, Micro motion study – Therbligs, Work measurement techniques, Rating, Allowances, Normal and standard time determination, Work sampling. **UNIT III –Maintenance Management and Inventory Planning & Control** System Objectives and need for maintenance, Types of maintenance, Breakdown,	

	Predictive and Preventive Maintenance, Condition based maintenance system, reliability, Work study for Maintenance, Total Productive Maintenance (TPM), Equipment replacement policy: Overhaul and Replacement, Reasons for replacement, Deterioration, Obsolescence, Depreciation, Methods for depreciation calculation, Inventory Control: Scope, purchasing and storing, economic lot size, ABC analysis. **UNIT IV – Production Planning & Control** Functions, Sequencing, forecasting, routing, Product selection & Process selection, Production Control: Gantt chart, work order, CPM and PERT techniques. Inspection and Quality control: Types of inspections, statistical quality control; Control charts for variables and attributes: X bar, R, p and c charts; Sampling, concepts and scope of TQM and QFD
11.	**Text Books-** 1. **Essential of Management**- H. Koonz and H. Weihrich, McGraw-Hill. 2. **Modern Production / Operations Management**- Buffa, E.S., and Sarin, R.K., John Wiley & Sons. 3. **Industrial Engineering and Production Management**- Martand Telsang, S Chand & Company. 4. **Industrial Engineering Handbook**- Maynard, H.B., McGraw-Hill.
12.	**Reference Books-** 1. **Industrial Engineering & Management–A new perspective**, Philip E Hicks, McGraw-Hill. 2. **Comprehensive Industrial Engineering**- N. J. Manek, Laxmi Publications. 3. **Industrial Engineering and Management Systems –** S. Dalela, Mansoor Ali, Standard Pub.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Design and Optimization of Energy systems**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105211ME**
6.	Status (Core/Elective)	**Program Elective-II**
7.	Pre-requisites (course no./title)	Thermodynamics, Fluid Mechanics, Numerical Techniques
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Understand the procedure of Designing the Energy System 2. Estimate the design cost of the propose system 3. Model and simulate the Thermal System 4. Apply different optimization Techniques for suggesting the suitable Energy Systems.	
10.	**Course Syllabus** **UNIT I – Introduction** Introduction to design and specifically system design, Morphology of design with a flow chart, very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique., Concept of workable design, practical example on workable system and optimal design. **UNIT II – System Simulation** Classification, Newton Raphson method-one unknown, Newton Raphson method, Gauss Seidel method, Data Analysis, Rudiments of finite difference method for partial differential equations with an example. **UNIT III - Single Variable Optimization** Introduction, Formulation of optimization problems, Calculus techniques- Search Methods - Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, Fibonacci search and Golden section search method. **UNIT IV - Multi Variable Optimization** Evolutionary Optimization Method, Cauchy's steepest descent method. Lagrangian multiplier method for constrained/unconstrained optimization, Linear programming-two variable problem-graphical solution, Modern optimization techniques	

11.	**Text Books-** 1. **Essentials of Thermal System Design and Optimization,** C. Balaji, Ane Books. New Delhi in India and CRC Press in the rest of the world.
12.	**Reference Books-** 1. **Design and optimization of thermal systems,** Y.Jaluria, Mc Graw Hill, 1998. 2. **Elements of thermal fluid system design,** L.C.Burmeister, Prentice Hall, 1998. 3. **Design of thermal systems**, W.F.Stoecker, Mc Graw Hill, 1989. 4. **Introduction to optimum design,** J.S.Arora, Mc Graw Hill, 1989. 5. **Optimization for engineering design - algorithms and examples,** K. Deb, Prentice Hall, 1995.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Measurement and Control**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105212ME**
6.	Status (Core/Elective)	**Program Elective-II**
7.	Pre-requisites (course no./title)	Basic Electrical and Mechanical Engineering, Engineering Mechanics, Engineering Drawing
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. To understand the characteristics, functioning and calibrations of various measuring instruments. 2. To understand the use of instruments for measuring displacement, velocity, pressure, and temperature. 3. To understand the working of strain gauges and their use for measuring force and torque. 4. To understand the use of instruments for measuring flow rate, noise, and vibrations. 5. To understand the data acquisition system for enhancing the productivity 6. To understand the surface characteristics and their measurement using mechanical and optical instruments.	
10.	**Course Syllabus** **Unit-I** **Generalized Measurement System:** Definition, application of measurement instrumentation, functional elements of a generalized measuring system, measuring standards, types of measurement, types of input to measuring instruments and instrument system, classification of measuring instruments, merits and demerits of mechanical measuring systems, Errors: Introduction to error, types of error, Sources of error, Sensor and Transducers- Types of sensor and Transducers and their characteristics. **Static and Dynamic characteristics of Instruments** Introduction, Static characteristics: accuracy, error and correction, calibrations, precision, resolution, static sensitivity, linearity, hysteresis, dead zone, backlash, and drift, Selection of measuring instruments, Mechanical and Electrical loading. Transient and steady state analysis of Zero, first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp, and parabolic inputs.	

	Unit-II **Displacement Measurement**: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer **Strain Measurement**: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge-based load cells and torque sensors **Measurement of Angular Velocity:** Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods. **Acceleration Measurement**: Theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers. **Measurement of flow**: Obstruction meters, Variable head meters, Hot wire and magnetic meters, Ultrasonic flow meters. Vibration and noise measurement: Seismic instruments, Vibration pickups and decibel meters. **Unit-III** **Metrology:** Linear and angular measurement devices and systems limit gauges, Gauge blocks. Measurement of geometric forms like straightness, Flatness, Roundness and Circularity, principles and application of optical projectors, Microscope, Autocollimators etc. Principle and use of interferometers, Comparators, Measurement of screw threads and gears, Surface texture measurement. **Data acquisition system:** Introduction to data acquisition systems, Single and multichannel systems, Microprocessors and PC based data acquisition systems. Input – output devices signal transmission and Processing, Devices, and systems. **Unit-IV** **Control:** Introduction to control systems, Classification of control system. Open loop and closed loop systems. Mathematical modeling of control systems, concept of transfer function, Block diagram algebra. **Stability analysis**: Introduction to concepts of stability, The Routh criteria for stability, Experimental determination of frequency response, Stability analysis using Root locus, Bode plot and Nyquist Plots, State space modeling, Process control systems, ON-OFF control. P-I-D Control.
11.	**Text Books-** 1. **Measurement Systems, Application and Design** – E.O. Doebelin - McGraw Hill 2. **Mechanical Measurements and Control** – D.S. Kumar – S.K. Kataria & Sons 3. **Mechanical Measurements** – G. Beckwith &Thomas G. – Pearson Education 4. **Experimental Methods for Engineers** - J. P. Holman. - McGraw Hills Int. Edition 5. **Instrumentation & Mechanical Measurements** - A.K. Thayal.
12.	**Reference Books-** 1. **Engineering Metrology** – K.J. Hume - MacDonald and Company 2. **Engineering Metrology** – I.C. Gupta - Dhanpat Rai & Sons 3. **Mechanical & Industrial Measurements** – R.K. Jain – Khanna Publishers 4. **Mechanical Engineering Measurements** - A. K. Sawhney – Dhanpat Rai& Sons, New Delhi.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Computational Fluid Dynamics**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105301ME**
6.	Status (Core/Elective)	**Open Elective-I**
7.	Pre-requisites (course no./title)	Basic course in Fluid Mechanics
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Equip the students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems. 2. Define and setup flow problem properly within CFD context. 3. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution. 4. Use CFD software to model relevant engineering flow problems, analyze the CFD results. Compare with available data and discuss the findings.	
10.	**Course Syllabus** **UNIT I - MATHEMATICAL MODELLING OF FLUID FLOW** Conservation laws & governing equations for fluid flow: Continuity equation, Momentum equation etc. and their derivations, General form of conservation equations, Boundary conditions, Classification of equations, Mathematical modeling practices of basic fluid flow problems and its solution, Methods of flow visualization. **UNIT II - METHODS OF DISCRETIZATION** Introduction to Computational methods, Components and properties of computational methods, Various methods of discretization; Illustration of Finite volume method (FVM) for generalized form of conservation equations, Solution of steady & unsteady diffusion equations, Solution of convection-diffusion equation with illustration of various differencing schemes. **UNIT III - SOLUTION OF LAMINAR FLOW PROBLEMS** Basic equations for Laminar flow cases, Calculation of flow field variables, Difficulties involved in solution of momentum equations, Staggard grid, Navier-Stokes solvers, SIMPLE algorithm & its variants, Solution of simple viscous laminar flow problems as Couette flow, Poiseuille flow, boundary layer flows, etc., Implementation of various boundary conditions, Numerical techniques for solution of algebraic equations.	

	UNIT IV - (A) INTRODUCTORY SOLUTION OF TURBULENT FLOW PROBLEMS Important features of turbulent flow, Reynolds average Navier-stoke (RANS) equation, Necessity of turbulence modeling, Different types of turbulence model, Illustrative example and practice. **(B) ERRORS AND POST-PROCESSING OF CFD** Error estimation in computational method, Mesh independent study, validation of CFD results, Post processing of results, Reporting and Documentation of CFD results, Graphic techniques used in CFD, Guidelines for CFD practices, Benchmark problems.
11.	**Text Books-** 1. **An Introduction to Computational Fluid Dynamics: The finite volume Method,** Versteeg, H.K., and Malalasekera, W. 2. **Computational fluid dynamics – The basics with applications,** Anderson, J.D. 3. **Computational Methods for Fluid dynamics,** Ferziger and Peric.
12.	**Reference Books-** 1. **Numerical heat transfer and fluid flow**, Patankar, S. V., Hemisphere Publishing Corporation, 2004. 2. **Turbulent flows,** Pope S. B., Cambridge university press. 3. **Computer simulation of flow and heat transfer,** Ghoshdastidar, P. S., Tata McGraw Hill Publishing Company Ltd., 1998.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Composite Materials and Mechanics**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105302ME**
6.	Status (Core/Elective)	**Open Elective-I**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Discuss the benefits and disadvantages of using composites in aerospace and other applications 2. To identify the properties of different materials (fibres, resins, cores) used in composites, select the most appropriate manufacturing process for fabricating composite components 3. To predict the elastic properties of both long and short fibre composites based on the constituent properties. 4. Calculate the elastic and strength properties of unidirectional laminates using micromechanics theory 5. To apply failure criteria and critically evaluate the results of the failure strength of a laminated composite plate. 6. Get knowledge on issues in fracture of composites and environmental degradation of composites	
10.	**Course Syllabus** **UNIT I** Basic concepts and characteristics, Geometric and Physical definitions, natural and man-made composites, applications, types and classification of composites. Reinforcements, Particulate composites, Polymer composites, Thermoplastics, Metal matrix and ceramic composites. **UNIT II** Characterization of composite properties. Manufacturing methods. Micromechanics, Unidirectional composites, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. **UNIT III** Coordinate transformation, Hooke's law for two dimensional unidirectional lamina, Transformation of stress and strain, Numerical examples of stress strain transformation,	

	Graphic interpretation of stress-strain relations. Elastic behaviour of unidirectional composites, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations. **UNIT IV** Failure mechanics. Application of composite materials in different areas of engineering with case studies.
11.	**Text Books-** 1. **Mechanics of Composite Materials,** R. M. Jones, McGraw Hill. 2. **Mechanics of Composite Materials,** Autar K. Kaw, CRC
12.	**Reference Books-** 1. **Advanced Mechanics of Composite Materials,** Vasiliev and Morozov, Elsevier.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Finite Element Method**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME105303ME**
6.	Status (Core/Elective)	**Open Elective-I**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Introduction and Objective:** Finite Element Method (FEM) is widely used in industry for analyzing and modelling structures and continua, whose physical behaviour is described by ordinary and partial differential equations. The subject is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of FEM for obtaining an approximate solution of ordinary and partial differential equations. Fundamentals of the Finite Element Method covering Methods of Weighted Residuals, Weak formulation, Elements and their shape functions and application of these in problems from all domains of Computational Mechanics will be covered. Being offered as an open elective, the course will cover applications from Mechanical, Civil, Chemical and Bio-Mechanical engineering domains. The learning process will be enhanced by completing assignments using software and libraries such as OCTAVE/MATLAB, FREEFEM++, FENICS, AGROS2D, ELMER MP, CALCULIX and ANSYS. **Course Outcomes:** This course will develop the technical competence capability and at the conclusion of this course, students should be able to demonstrate: 1. Knowledge of the concepts, mathematical formulation and numerical implementation of FEM. 2. Knowledge of the FEM as applied to solid mechanics, fluid mechanics and heat transfer problems. 3. The ability to invoke appropriate assumptions, select proper elements and develop and validate a Finite Element model using a range of techniques. 4. Application of complex problem-solving using Software/libraries. Be able to communicate effectively in reporting (both textually and graphically) the method used, the implementation and the numerical results obtained.	
10.	**Course Syllabus** **UNIT I – A. Introduction and Approximations** Introduction to Finite Element Method, Discretization, Methods of weighted residual,	

	Strong and weak forms for 1D and 2D problems. **B. Elements and their shape functions** Global, local and natural coordinates, shape functions and their properties, Lagrange interpolation-, one-, two- and three-dimensional elements, Serendipity elements, h-p elements, isoparametric elements. **UNIT II - Direct Formulation** Principle of Minimum Potential Energy, Direct approach, element and assembly stiffness, treatment of boundary conditions, bar, truss, beam and frame elements, Gauss-Legendre's quadrature. **UNIT III - Energy Principle based formulation** Constitutive and compatibility relations, Finite element formulation for plane stress, plane strain and axisymmetric problem. Work equivalence, structural formulation using CST and isoparametric elements. **UNIT IV - Scalar field problem and Dynamics** One- and two-dimensional formulation of Scalar field problems, Application to in-viscid and viscid flows, heat transfer, analogous problems of torsion. Hamilton's Principle, Lagrange's equation, lumped and consistent mass matrices.
11.	**Text Books-** 1. **Text Book of Finite Element Analysis,** P. Seshu, PHI Learning Pvt. Ltd., 2003.
12.	**Reference Books-** 1. **Concepts and Analysis of Finite Element Applications,** R. D. Cook, D. S. Malkus, M. E. Plesha and R. J. Witt, John Wiley & Sons, 1981. 2. **An introduction to the Finite Element Method,** J.N. Reddy, McGraw- Hill, 2006. 3. **A First Course in the Finite Element Method,** Daryl L. Logan, Cengage Learning, 2011. 4. **Finite Element Analysis: Theory and Application with ANSYS,** Saeed Moaveni, Pearson Education.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Heat and Mass Transfer**
3.	L-T-P Structure	**3+1+0**
4.	Credits / # of period	4
5.	Course Number (Code)	**ME105101ME**
6.	Status (Core/Elective)	**Program Core**
7.	Pre-requisites (course no./title)	Thermodynamics, Fluid Mechanics
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of the course, the students will be able to: 1. Distinguish different modes of heat transfer and solve steady-state conduction problems. 2. Analyze finned surfaces and (assess how effectively and efficiently fins enhance heat transfer) solve transient heat conduction problems. 3. Apply convective heat transfer correlations (Forced and Natural convection) for external and internal flows. 4. Perform energy analysis on heat exchangers and obtain LMTD and effectiveness relations. AIso, calculate mass-diffusion through-plane layer under steady-state conditions. 5. Identify two-phase heat transfer and obtain relations for radiative heat transfer between surfaces.	
10.	**Course Syllabus** **UNIT I – Conduction** **Introduction:** Various modes of heat transfer, Fourier's, Newton's and Stefan Boltzmann's Law, Combined modes of heat transfer, Thermal transfer, Thermal diffusivity, Overall heat transfer coefficient. Conduction: The thermal conductivity of solids, liquids and gases, Factors influencing conductivity measurement. The general differential equation of conduction, one dimensional steady-state conduction, Linear heat flow through a plane and composite wall, cylinder and sphere, Critical thickness of insulation, Effect of variable thermal conductivity. Conduction with heat generation in slab and cylinders, Spheres. **UNIT II – Fins and Transient conduction** **Fins:** Conduction convection system, Extended surfaces rectangular, triangular, circumferential and pin fins, General conduction analysis, Fins of uniform and non-uniform cross-sectional area. Heat dissipated by a fin. Effectiveness and efficiency of fins, approximate solution. Design of fins for maximum heat transfer, Solution for different boundary conditions, Use of fin analysis for measuring temperature error of	

	Thermometer. **Transient/Unsteady State Heat Conduction:** System with negligible internal resistance Lumped capacity method and its Validity. Unsteady state conduction through finite and semi-infinite slab without surface resistance, convection boundary conditions. Solution through Heisler's chart. **UNIT III - Convection** **Forced Convection:** Physical Mechanism of Forced Convection, Dimensional analysis for forced convection, velocity and Thermal Boundary layer, Flow over plates, Flow across cylinders and spheres, Flow in tubes, Reynold's analogy. **Natural Convection:** Physical Mechanism of Natural Convection, Dimensional analysis of natural convection; Empirical relationship for natural convection. Natural convection over Surfaces (vertical and horizontal plates, vertical and horizontal cylinders, spheres) **Two Phase Heat Transfer:** Boiling heat transfer, Pool boiling, Boiling regimes and boiling curve, Next transfer correlations in pool boiling, Condensation heat transfer, Film condensation, Derivation for the average heat transfer coefficient 'h' for the case of laminar film condensation over vertical plate, Heat transfer correlation for inclined plates, Vertical tubes, Horizontal bank tubes. **UNIT IV - Heat Exchangers, Thermal Radiation and Mass transfer** **Heat Exchangers:** Different types of heat exchangers; Determination of heat exchanger performance, Heat exchanger transfer units, Analysis restricted to parallel and counter flow |heat exchanger (LMTD and NTU method). **Thermal Radiation:** Introduction, absorption and reflection of radiant energy, Emission, Radiosity and irradiation, Black and non-black bodies, Kirchhoff's law, Intensity of radiation, Radiation exchange between black surface, Geometric Configuration factor. Grey body relation exchange between surface of unit configuration factors, Electrical analogy to thermal radiation simple problems. Errors in temperature measurement due to radiation. **Introduction to Mass Transfer:** Mass and mole concentrations, Molecular diffusion, Eddy diffusion, Molecular diffusion from an evaporating fluid surface, Introduction to mass transfer in laminar and turbulent convection Combined heat and mass transfer, the wet and dry bulb thermometer.
11.	**Text Books-** 1. Fundamental of Engineering Heat & Mass Transfer R. C. Sachdeva- New Age Publishers. 2. Heat Transfer - J.P. Holman - Tata McGraw Hill. 3. Heat transfer- C P Arora, Tata McGraw Hill. 4. Heat Transfer - R.K. Rajput.
12.	**Reference Books-** 1. Fundamental of Heat & Mass Transfer - Incropera and De Witt. 2. Heat Transfer- A Practical Approach - Yunus A. Cengel - McGraw Hill. 3. Heat Transfer a Basic Approach - M. Necati Ozisik.

Department of Mechanical Engineering

National Institute of Technology Raipur

(Institute of National Importance)

G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Refrigeration and Air Conditioning**
3.	L-T-P Structure	**3+1+0**
4.	Credits / # of period	4
5.	Course Number (Code)	**ME105102ME**
6.	Status (Core/Elective)	**Program Core**
7.	Pre-requisites (course no./title)	Thermodynamics, Fluid Mechanics, Heat and Mass Transfer
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. To make students capable to analyze Vapour Compression Refrigeration System and its performance, its evolution, its modification and learn to evaluate effects of various parameters affecting the system. 2. To learn how to recommend multi-stage compression and multi Evaporator systems with different arrangement of expansion devices and inter cooling arrangements including cascading systems. 3. To learn analyzing Gas cycle refrigeration, its evolution and understand different types and their comparison with its application in Aircraft Refrigeration with suitability. 4. To learn designing of suitable indoor conditions for thermal comfort of human beings for any outdoor conditions with the understanding of psychrometry and various psychrometric processes. **Course Outcomes (CO):** At the end of the course, the students will be able to: 1. Analyze Vapour Compression Refrigeration System and its performance, its evolution, modifications and evaluate effect of various parameters affecting the system. 2. Recommend Multi-stage compression and Multi Evaporator systems with different arrangement of expansion devices and inter cooling arrangement including cascade systems. 3. Analyze Gas Cycle Refrigeration its evolution and different types and their comparison with Application in Aircraft Refrigeration. 4. Design suitable indoor conditions for thermal comfort of human beings for any outdoor conditions with the understanding of psychrometry and various psychometric processes.	
10.	**Course Syllabus** **UNIT I** Refrigeration and second law of thermodynamics, Reversed Carnot Cycle and It's practical limitations, Standard Vapor compression Refrigeration System and its performance analysis. Effect of evaporator and condensing temperatures. Modifications,	

	its effects, Liquid-to-Suction heat exchanger, Effect of Superheat and criteria for optimum superheat, Actual vapour compression refrigeration systems, Limitations of single stage. **UNIT II** **Multi-stage systems:** Concept of flash gas removal using flash tank, inter cooling with flash gas removal and inter cooling, use of flash tank for flash gas removal only, limitations of multi-stage systems. **Multi-Evaporator systems:** Applications, Comparison, advantages, Systems using single compressor and a pressure reducing valve with: Individual expansion valves & multiple expansion values, Systems with multi compression, inter cooling and flash gas removal, with individual compressors and multiple expansion valves, Cascade systems. **UNIT III** **Gas Cycle Refrigeration:** Limitation of Carnot and reversed Carnot Cycle, Modified Cycle, Reversed Bell- Coleman, Actual Bel-Coleman Cycle, Application of Aircraft Refrigeration, Different methods: Simple, Evaporative, boot strap, boot strap with evaporative, Reduced ambient, Regenerative and comparison of different air-cooling system in Aircraft. **UNIT IV** **Psychrometry, estimating properties of moist air:** psychrometry chart, Straight-line law, adiabatic saturation and thermodynamic wet bulb temperature, psychrometer and the precautions, psychrometric processes and their representation, various psychrometric processes, equations for heat and mass transfer rates, Concept of SHF, By-pass factor and ADP, Air washer and its use. **Inside and Outside Design Condition:** Fixing suitable indoor and outdoor design conditions, Psychometric calculations, Simple summer air conditioning system with 100% re-circulated air, various summer air conditioning systems with ventilation and with zero and non-zero by-pass factor, with re-heat for high latent cooling load applications, Selection guidelines for supply air conditions.
11.	**Text Books-** 1. Refrigeration And Air Conditioning by C.P. Arora, Tata McGraw-Hill. 2. Refrigeration And Air Conditioning by R.K. Rajput, Kaston Publication. 3. Refrigeration And Air Conditioning by Arora & Domkundwar, Dhanpat raj Sons.
12.	**Reference Books-** 1. Basic Refrigeration and Air Conditioning, Ananthanarayan, Tata McGraw-Hill. 2. Refrigeration And Air Conditioning by Stooker W.F. 3. Refrigeration And Air Conditioning by Ahmadaul Ameen, PHI publication. 4. Handbook of Air Conditioning and Refrigeration by Shan K. Wang, Tata McGraw-Hill.

Department of Mechanical Engineering

National Institute of Technology Raipur

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Machine Design -I**
3.	L-T-P Structure	**3+1+0**
4.	Credits / # of period	4
5.	Course Number (Code)	**ME105103ME**
6.	Status (Core/Elective)	**Program Core**
7.	Pre-requisites (course no./title)	Engineering Mechanics, Engineering Graphics, Mechanics of Solid, Material Science,Kinematics of Machine
8.	Frequency of offer	Once per Academic Year
9.	**(A) Course Objectives:** The course is intended to teach students, design of basic mechanical elements based on available theories of failure. The focus is on blending fundamental concept development with practical implementation. This will enable the students to familiarize with the basis of decisions taken for use of mechanical components. **(B) Course Outcome:** At the end of this course, the students are expected to be able to 1. Apply the various stress based theories to design machine components. 2. Design basic machine elements like keys, joints, couplings, transmission shaft and mechanical springs. 3. Design various types of threaded joints and power screws. 4. Design permanent joints riveted and welded.	
10.	**Course Syllabus** **UNIT I - Design Considerations** Mechanical engineering design, dimensions and tolerances, Selection of Materials, Stress and strength, Factor of Safety, Theories of failure for ductile and brittle materials. Design for variable and repealed loading, Stress concentration factor in tension, bending and torsion, Fatigue stress concentration factor, Notch sensitivity, Endurance limit and fatigue strength, Endurance diagrams, Introduction to fracture mechanics. **UNIT II - Design of Keys, Joints, Couplings, Shafts and Springs** **Keys, Joints and Couplings:** Design of keys, Cotter joints and Knuckle joint, Design of muff, flange and flexible couplings. **Shaft:** Design of transmission shaft, Design against static load, Design for strength, Rigidity and stiffness, Design of shafts under continuous loading or Fatigue **Mechanical Springs:** Design of helical coil springs of circular section for tension, compression and torsion, Design of helical coil springs under fatigue loading, Design of	

	Leaf springs, Design of Disk springs. **UNIT III - Design of Screws, Fasteners and Non-permanent Joints** **Threaded fasteners:** Geometry of thread forms, Terminology of screw threads and thread standards, Specifications of steel bolts, Initial tension, Relation between bolt tension and torque, Design of statically loaded tension joints, Design of bolted joints due to eccentric loading. **Power Screws:** Power screws, Force analysis for square and trapezoidal threads, Collar friction, Stresses in screw, Coefficient of friction, Efficiency of thread, Design of power Screw. **UNIT IV - Design of Permanent Joints Riveted and Welded Joints** **Riveted Joints:** Failure of rivets and riveted joint, Strength of rivet joint, Efficiency of riveted joint, Design of riveted joint, Eccentrically loaded riveted joint. **Welded joint:** Stresses in butt and fillet welds, Strength of welded joints, Location and dimension of weld design, Eccentrically loaded joint, Welded joint subjected to bending moment, Design procedure, Fillet welds under varying loads, Stress relieving techniques.
11.	**Text Books-** 1. Shigley's Mechanical Engineering Machine Design by R.G. Budynas & J.K. Nisbett McGraw Hill Education. 2. Design of Machine Elements by V.B. Bhandari - TMH Publications. 3. Design Data Book - Data Book of Engineers by PSG College of Coimbatore.
12.	**Reference Books-** 1. Machine Design by P.C.Sharma and D.K. Agrawal - Kataria & Sons Publications. 2. Principles of Mechanical Design by R. Phelan - McGraw Hill Pub. 3. Machine Design - An Integrated Approach by Robert L.Norton Addison Wesley Longman. 4. Machine Design by M. F. Spott – PHI. 5. Machine Design, Theory & Practice - J. Michels Walter, E. Wilson Charles MacMilan Publishers. 6. Machine Design Data Book by V B Bhandari - McGraw Hill Education