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

B. Tech. in Mechanical Engineering
VII 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 Core	ME107101ME	Production Management	T	3	1	0	20	0	30	0	50	0	100	4
2.	Program Elective-IV	As per given in list		T	3	0	0	20	0	30	0	50	0	100	3
3.	Program Elective-V	As per given in list		T	3	0	0	20	0	30	0	50	0	100	3
4.	Open Elective-III	As per given in list		T	3	0	0	20	0	30	0	50	0	100	3
5.	Laboratory	ME107401ME	Mechanical Lab – 9	P	0	0	2	40	0	20	0	40	0	100	1
6.	Internship	ME107701ME	Summer Internship II	P	0	0	4	50	0	0	0	50	0	100	2
7.	Laboratory	ME107801ME	Project Work	P	0	0	8	40	0	20	0	40	0	100	4
Total					12	1	14							700	20

The List of Program Elective-IV

SN	Course Code	Subject Name
1.	ME107202ME	Solar Energy Utilization
2.	ME107203ME	Computational Fluid Dynamics
3.	ME107204ME	Finite Element Method

The List of Program Elective-V

SN	Course Code	Subject Name
1.	ME107211ME	Energy Conversion System
2.	ME107212ME	Power Plant Engineering
3.	ME107213ME	Tribology

The List of Open Elective-III

SN	Course Code	Subject Name
1.	ME107301ME	Air Pollution Control
2.	ME107302ME	Integrated Product Development
3.	ME107303ME	Optimization Techniques
4.	ME107304ME	Industry 5.0 for Engineers

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Production Management**
3.	L-T-P Structure	**3+1+0**
4.	Credits / # of period	4
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Core**
7.	Pre-requisites (course no./title)	Mathematics
8.	Frequency of offer	Once in a Year
9.	**Course Objectives:** 1. Understand the basic concept of production management, cost analysis and forecasting techniques to identify the various demand patterns. 2. Understand the Inventory control and learn the various inventory control techniques to solve the real-life problems. 3. Understand the production planning and control objectives, functions, steps and leans the various sequencing and scheduling techniques. 4. Understand the line balancing and supply chain management concept to solve the real-life industrial problems. **Course Outcomes (CO):** The students will be able to: 1. Apply the appropriate forecasting model based on different demand pattern. 2. Determine the level of inventory and apply the appropriate model and technique to solve the industrial problems. 3. Apply the various concepts of production management (production planning and control, line balancing, MRP, SCM) to solve the industrial problems.	
10.	**Course Syllabus** **UNIT - I:** **Introduction:** Introduction, Objectives, Scope of Production management, Production Systems, Types of Production Systems (Job, Batch, Mass and Continues Production System, Flexible production System, Lean Production System, Push and Pull Production Control System), Product Life Cycle. **Cost Analysis:** Element of Costs, Break even Analysis, Incremental Costs, Make or Buy Decisions **Demand Forecasting:** Purpose, Types of Forecasting, Qualitative Method of Forecasting – opinion Survey Method, Market Trials, Delphi Method etc., **Quantitative Models:** a). Level/Constraint Model, Weightage Method, Moving Average Method, Exponential Method etc. b). Trend Model – Least Square Method, Holts Model.	

	c). seasonal Model, Basic Model, Winter Model. **UNIT - II:** **Inventory Control:** Objectives, Scope and Classification, Inventory Control techniques, Economic Order Quantity, Wilson Harrise Model, Inventory Model for Back Order, Discount Model, All Quantity Discount Model and Marginally, Quantity Discount Model, Inventory Model for Multiple items, Production and Consumption Model with and without Backordering, Safety Stock, General Idea regarding Inventory Control under Risk and Uncertainty. **Material Requirement Planning:** Dependent Demand, Material Requirement Planning, Structure of MRP System, MRP Calculations, Planning Issues, Incrimination Issues, MRP-I vs. MRP-II. **UNIT - III:** **Production Planning and Control (PPC):** Introduction, Objectives and Functions of PPC, Steps in PPC, Routing, Master Production Schedule, Sequencing for Single Machine, Flow Shop Scheduling, Job Shop Scheduling, Johnson Algorithm, Modified Johnson Algorithm, Branch and Bound Method, Palmer Heuristic, Campball Dudek Smith (CDS) Algorithm, Shifting Bottleneck Heuristic, Gantt Chart, Dispatching, Expediting. **UNIT - IV:** **Line Balancing:** Introduction, Objectives, Line Efficiency, Smoothness Index, Shortest Processing Time Algorithm. **Supply Chain Management:** Introduction, Definitions, Objectives and Major Drivers of Supply Chain, Supply Chain Strategies, Supply Chain Integration Concept.
11.	**Text Books-** 1. Chase, R. B., Jacobs F. R. and Aquilano N. J., "Operations Management for Competitive Advantages", 11th Edition, Tata McGraw Hill Book Company, New Delhi, 2010. 2. Hopp W. J. and Spearman M. L., "Factory Physics: Foundations of Manufacturing Management", McGraw Hill International Edition, 3rd Edition, 2008. 3. Chary S. N., "Production and operations Management", McGraw Hill International Edition.
12.	**Reference Books-** 1. Richard B., Chase, Ravi Shankar, and F. Robert Jacobs, "Operations & Supply Chain Management (14th edition)", McGraw Hill Publishing Company Ltd, New Delhi. 2. David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi and Ravi Shankar, "Designing and managing the Supply Chain: Concepts, Strategies and Case Studies (Third Edition)", McGraw Hill Publishing Company Ltd, New Delhi.

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Solar Energy Utilization**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107202ME**
6.	Status (Core/Elective)	**Program Elective-IV**
7.	Pre-requisites (course no./title)	Thermodynamics, Heat and Mass Transfer
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. To teach the students about how to estimate the amount of solar radiation received by any surface, at any place, on any date over the globe. 2. To teach the students about how to estimate, evaluate and analyse the amount of distillation of potable water by various techniques based on solar energy. 3. To make students to learn the evaluating and analysing the use of various solar thermal applications that includes air heater, solar chimney, solar dryer for energy conservation as a benefit to the society and to mankind. 4. To make students capable to estimate the economic feasibility of any proposed solar thermal application in the light of payback period and life cycle etc. **Course Outcomes (CO):** At the end of the course, the student will be able to 1. Estimate the amount of solar radiation received by any surface, at any place, on any date over the globe. 2. Estimate, Evaluate and analyse the amount of distillation of potable water by various techniques based on solar energy. 3. Evaluate and analyse the use of various solar thermal applications that includes air heater, solar chimney, solar dryer for energy conservation as a benefit to the society and to mankind. 4. Estimate the economic feasibility of any proposed solar thermal application in the light of payback period and life cycle etc.	
10.	**Course Syllabus** **UNIT I** **Calculation of solar radiation received:** The sun, Solar Radiation: Terrestrial, Extraterrestrial, Sun Earth angles, Availability of solar radiation on inclined surface, on horizontal surface, Solar Time, Sun rising, and sun set time, day length, sunshine hours, Estimation of beam and diffused components of hourly, daily, monthly average, radiation on any surface on any day and at any place. **UNIT II** **Solar distillation:** Introduction, working principle, thermal efficiency, instantaneous	

	efficiency, overall thermal efficiency, heat transfer, external heat transfer, top loss coefficient, bottom and side loss coefficient, internal heat transfer, radiative loss coefficient, convective loss coefficient, evaporative loss coefficient, determination of distillate output, passive solar stills, effect of various parameters, other designs, modified internal heat transfer. **UNIT III** **Solar thermal devices**, Description and classifications, conventional heaters, double exposure heaters, air heater with flow above and both side of the absorber, two pass solar air heater, heater with finned absorber, vee-corrugated absorber, reverse absorber heater, with porous absorber, testing of solar air collector, parametric studies, applications of air heater, comparison of performance of liquid and air collector. Other Solar Thermal Devices: solar cooker, solar driers, solar chimney etc. **UNIT IV** **Economic analysis of solar equipment:** Introduction, cost analysis, Cash flow diagrams, cost comparison with equal and unequal duration, Payback time with and without interest, benefit cost analysis, Effect of depreciation, cost comparison after taxes.
11.	**Text Books-** 1. **Solar Energy Fundamentals, Design Modelling and Applications** By G.N.Tiwari, Narosa publication 2. **Solar distillation practice for water desalination systems**: By G.N.Tiwari and A.K.Tiwari, Anamaya Publishers. 3. **Solar Energy Principles of thermal collection and** storage By S P Sukhatme and J K Nayak
12.	**Reference Books-** 1. **Advance solar distillation systems** By G N Tiwari and Lovedeep Sahota 2. **Solar Engineering of Thermal Processes** by Duffie and Beckman

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Semester- VII

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)	**ME107203ME**
6.	Status (Core/Elective)	**Program Elective-IV**
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- VII

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)	**ME107204ME**
6.	Status (Core/Elective)	**Program Elective-IV**
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-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Energy Conversion System**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107211ME**
6.	Status (Core/Elective)	**Program Elective-V**
7.	Pre-requisites (course no./title)	Physics, MOS-1, Basic Mechanical Engineering
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. To understand the principle of steam generation theory and steam generators. 2. To understand the different components of steam power plants. 3. To estimate the performance of boilers, draft, and condensers. 4. To understand the working principle of aircraft engines and rockets. 5. To understand various types of non-conventional energy resources. **Course Outcomes (CO):** At the end of this course, the students will be able to 1. Explain the functioning of different types of high-pressure boilers. 2. Apply thermodynamics principle in closed and open system. 3. Differentiate various forms of non- conventional energy sources. 4. Apply the principle of momentum and thrust equation for jet propulsion systems.	
10.	**Course Syllabus** **UNIT I - Boilers** Classification of boilers, Boiler mountings & accessories, Draught & its classification, Chimney height & diameter calculation, Efficiency of a chimney, Draught losses. High pressure boilers - La-Mont, Benson, Velox and Super critical boiler, Fluidized bed boiler. **UNIT II - Steam Condensers** Function, Types of condensers, Efficiency and measurement. Analysis of condenser operation, Source of air leakage, Effect of air leakage, Air extraction, Thermodynamic analysis. **UNIT III - Direct Energy Conversions** Tidal energy conversion, OTEC, MHD power system, Geothermal energy, Conversion technique, Thermo-electric effects, Thermo-electric & thermionic converters. **UNIT IV - Jet Propulsion**	

	Aircraft Propulsion: Types of jet engines, Principle and operation, Thermodynamics of turbo jet, Efficiency and performance, Turbo prop, Ram jet, Pulse jet, Comparison of various propulsive devices **Rocket Propulsion:** Types of rocket engines**,** Basic theory, Physics equations, Classifications, Liquid propellant rockets and its advantage, Efficiency and performance, Rocket projection and escape velocity.
11.	**Text Books-** 1. **Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion** - S.M. Yahya - New Age International Publishers. 2. **Thermal Engineering -** Mahesh M. Rathore- McGraw Hill Education. 3. **Thermodynamics & Heat Engines** - R. Yadav - CPH. 4. **Non Conventional Energy Resources**- B. H. Khan- McGraw Hill Education
12.	**Reference Books-** 1. **Fundamental of Compressible Fluid Dynamics** - P. Balachandran - PHI. 2. **Gas Turbine Theory & Jet Propulsion** - J.K. Jain - Khanna Publishers. 3. **High Pressure Boilers**- Frederick M. Steingress, Harold J. Frost, Daryl R. Walker- American Technical Publishers. 4. **Thermal Engineering (engineering Thermodynamics & Energy Conversion Techniques)**- P. L. Ballaney- Khanna Publishers.

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Power Plant Engineering**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107212ME**
6.	Status (Core/Elective)	**Program Elective-V**
7.	Pre-requisites (course no./title)	Strength of Materials, Fluid Mechanics, Machine Design, Engineering Mechanics, Material science and engineering mathematics
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. To know the basics of various powerplants like steam, hydroelectric, nuclear and diesel power plant. 2. To understand and solve problems related to power developed. 3. To understand power plant economics. **Course Outcomes (CO):** At the end of this course, the students will be able to 1. The steam power plant. 2. The Hydroelectric power plant. 3. The Nuclear power plant. 4. The Diesel power plant 5. Variable load problems and power station economics.	
10.	**Course Syllabus** **UNIT I** General Sources of power, Central Power Stations, Elements of electric power systems primary and secondary distribution substations (in brief). **Steam Power Plant:** Elements of modern steams power stations, brief layout and arrangement of elements and complements, Foundation. Heat Balance in steam cycles, Fuels and fuel handling System and Ash handling System, Air pre-heater, Feed water pre-heaters, Steam re-heaters, Deaerators, Feed water treatment, Pumping and regulation water walls, Modern developments in steam boilers, Important instrumentation and piping of gas and water loop. Factors to be controlled from maximum efficiency and variable output. **UNIT II** **Hydro Electric power station** -Potential power with reference to rainfall and catchments **a**rea, Water storage, Equipment used in hydro-electric power stations, Characteristics of hydraulic turbines, Comparison of the factors governing the cost of hydro steam and diesel power stations.	

	Diesel power station -Application of Diesel in power field, Suitability of dieselengines for bulk power, Layout of Diesel Power Plant, Advantages and limitations of diesel, Power stations, Performance Characteristics. **UNIT III** **Nuclear Power Station -** Evolution of nuclear energy from atoms by fission and fusion, Chain reactions, Fission materials, Type of reactors, gas cooled, Boiling water liquid,Metal cooled and fast reactor, Arrangements of various elements in a nuclear power station, Steam cycles and boilers coolant heat exchangers, Reactor control, Reactor shielding and safety methods. **UNIT IV** **Variable load problems:** Idealized and realized load curves, Effect of variable load on plant design and operation variable load operation. **Power station Economics:** Source of income, Cost of plant and production, Elements of cost, depreciation and replacement theory of rates.
11.	**Text Books-** 1. **Power Plant Engineering**, 2nd Edn. - P.K. Nag - Tata McGraw-Hill Pub. Com., New Delhi. 2. **Fundamental of Power Plant Engineering** -R. Yadav-Central Publishing House Allahabad,2011 3. **Plant Engineering** - G. R. Nagpal - Khanna Publishers.
12.	**Reference Books-** 1. **Power Plant Engineering** - F. T. Morse Affiliated East - West Press Pvt. Ltd., New Delhi. 2. **Power Plant Technology** - M. M. E1 - Wakil - McGraw Hill, International Edition 1984.

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Tribology**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107213ME**
6.	Status (Core/Elective)	**Program Elective-V**
7.	Pre-requisites (course no./title)	Strength of Materials, Fluid Mechanics, Machine Design, Engineering Mechanics, Material science and engineering mathematics
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** The main objective of the course is to explain the importance of Tribology in the context of industrial applications. Also, other objectives of this course are listed below: 1. The basic objective of the course is to deal fundamentals of friction, wear and lubrication. 2. The course is useful in understanding the nature of surfaces of engineering materials. 3. The course is useful in understanding the various lubricants and tribological applications (Bearings, Gears, etc.) **Course Outcomes (CO):** The students will be able to 1. Explain the role of friction in tribological applications. Also, discuss different wear mechanism and their remedies. 2. Distinguish between different types of lubricants and their selection in different engineering applications. Summarize the importance of surface finish and condition monitoring. 3. Design different bearings (hydrodynamics, anti-friction, etc) 4. Discuss tribological aspects of gear applications. 5. Explain the Green and Nano Tribology	
10.	**Course Syllabus** **UNIT I** Tribology Introduction, Historical background, Practical Importance and subsequent use in the field. **Friction:** Origin, Friction Theories, measurement methods, friction of metals and non metals.	

	Wear: Classification and Mechanisms of Wear, Delamination theory, Testing methods, approach to wear reduction **UNIT II** **Lubricants:** Types and specific field of applications. Requisite properties of lubricants. Viscosity, its measurement, effect of temperature and pressure on viscosity, standard grades of lubricants, selection of lubricants. Lubrication Types, Basic equation of lubrication. **Surface Roughness:** Standardization, measurement with contacting and non-contacting instruments, Statistical analysis of surface, characteristics of the surface. **Condition Monitoring:** Condition monitoring & monitoring techniques for tribological systems, Lubricant monitoring, Temperature monitoring, Corrosion monitoring, Surface roughness monitoring. **UNIT III** Behaviour of Tribological components, Bearings, Classification, selection, effect of frictional torque, factors affecting performance, failure modes, bearing lubrication. **Hydrodynamic Bearings:** Mechanism of pressure development, classification, Idealized Journal Bearing, oil film thickness, pressure distribution, load carrying capacity. **Elasto-hydrodynamic Lubrication:** Theoretical considerations, line and point contacts, film thickness equations, different regimes in EHL contact. **UNIT IV** **Antifriction Bearings:** Ball and roller bearings, geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. **Gears:** friction & stresses, wear, lubrication & failure. Failure Case Studies. **Green Tribology:** Basics and Applications **Nano Tribology:** Basics and Applications Case Studies in different areas of Engineering.
11.	**Text Books-** 1. **Engineering Tribology**- Prasanta Sahoo - Prentice Hall of India Pvt. Ltd., New Delhi, 2005. 2. **Fundamentals of Tribology -** S.K. Basu, S.N. Sengupta, B.B. Ahuja - PHI Learning Pvt. Ltd., 2010. 3. **Tribology in Industries** - S.K. Shrivastava - S. Chand & Company Ltd., New Delhi, 2001
12.	**Reference Books-** 1. **Engineering Tribology** - G.W. Stachowiak, A.W. Batchelor - Elsevier India Pvt. Ltd., New Delhi. 2. **Introduction to Tribology of Bearings** - B.C. Majumdar - S. Chand & Company Ltd., New Delhi. 3. **Rolling Bearing Analysis** - T.A. Harris - John Wiley & Sons, Inc., New York

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Air Pollution Control**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107301ME**
6.	Status (Core/Elective)	**Open Elective-III**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. Understand sources of air pollution and its effect, relationship between pollutant concentrations, legislation and regulation. 2. Understand emission from I.C. engines, major industries and control measures. 3. Understand meteorological aspects of air pollutant dispersion. 4. Understand air pollution sampling, measurement, pollution control method and control equipment. **Course Outcomes (CO):** At the end of the course, the student will be able to 1. Identify sources of air pollution and its effect, relationship between pollutant concentrations, legislation & regulation. 2. Explain about emission from IC engine &major industries along with control measures. 3. Discuss meteorological aspects of air pollutant dispersion 4. Discuss air pollution sampling& measurements, pollution control method and control Equipment.	
10.	**Course Syllabus** **UNIT I** **Air Pollution: Introduction** Air Pollution, sources & classification of air pollutants, aerosols, Primary & secondary air pollutants, Photochemical Air pollution, Effect of air pollution on human health, vegetation and materials, Pollutant concentration, types, relationship between different concentration Air pollution indices, determination of index, Air pollution legislation & regulations (1981 & 1986). **UNIT II** **Air pollution: Transportation & Major Industries** Air pollution due to automobiles, types of emission from IC Engines, Effect of various operating variables on exhaust emission, control of emissions from IC Engines. Air pollution from major industries: Fe & Steel Industry, Thermal Power Plants Cement	

	Industries. Smoke, measurement of smoke and its control. **UNIT III** **Meteorological Aspects of Air pollutant Dispersion** Temperature Lapse rates & stability, wind velocity and turbulence, Plume Behaviour, Dispersion of air pollutants, the Gaussian Plume Model. **Air Pollution Sampling & Measurement** Types of pollutant sampling techniques and measurement, Ambient Air Sampling, collection of gaseous air pollutants and particulate pollutants, stack sampling techniques, analysis of air pollutants. **UNIT IV** **Air Pollution control methods & Equipment** Air pollution source correction methods: Process changes, equipment modification/ machinery replacement etc. Gases/ Odour control: Combustion, Absorption, Adsorption. Control equipment's: Objectives and choice of control equipment, Settling chamber, Inertial separators, Cyclones, filters, Electrostatic Precipitator, Scrubbers.
11.	**Text Books-** 1. **Air Pollution-** M.N. Rao, H.V.N. Rao, Tata McGraw Hill Company. 2. **Environmental Pollution Control Engineering** - C.S. Rao, New Age International Limited Publishers.
12.	**Reference Books-** 1. **Air Pollution control Theory**- Martin Crawford, Tata McGraw Hill Company.

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Integrated Product Development**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107302ME**
6.	Status (Core/Elective)	**Open Elective-III**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives:** 1. gain the knowledge of the product development process, on various product development methodologies, product management problems regarding the product development in the industries. 2. understand the integration of customer requirements in product design concept generation, selection and testing for development of product. 3. Understand the concept of industrial product design process, testing methods and report documentation for development of product. 4. Understand and analyze on different service industries and their product development process including intellectual property rights and confidentiality, security and configuration management concept with case studies. 5. launch own ideas and the ideas of others, which enables you to manage your own company as well as to work with innovation and development in large companies. **Course Outcomes (CO):** 1. Analyse various global trends, product development process and product development methodologies to decide on the scope of the new product in the market & industries. 2. Summarize the types of product requirements, product development methodologies and management. 3. Analyse the different product design concept, and selection of developed product through real life case studies. 4. Conceptualize the product of integrating hardware, software, controls, electronics and mechanical system and detailed product design and testing. 5. Develop product test specifications standards, validate the product and confirm its performance as per design specifications. 6. Enumerate the end product development process of trade off, IPR, security and configuration management.	
10.	**Course Syllabus** **UNIT I - Fundamentals of Product Development** **Global Trends Analysis and Product decision:** Types of various trends affecting product decision - Social Trends, Technical Trends, Economic Trends, Environmental	

	Trends, political/Policy Trends; PESTLE Analysis. **Introduction to Product Development Methodologies and Management:** Overview of Products and Services; Types of Product Development (NPD/ Re-Engineering; Overview of Product Development methodologies; Product Life Cycle; Product Development Planning and Management. **UNIT II - Requirements and System Design** **Requirement Engineering:** Types of Requirements (Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific); Requirement Engineering (Gathering (VOC), Analysis (QFD), Design Specification); Traceability Matrix and Analysis; Requirement Management. **UNIT III - Design and Testing** **Conceptualization:** Industrial Design and User Interface Design; Introduction to Concept generation Techniques; Concept Screening & Evaluation. **Detailed Design:** Component Design and Verification; High Level Design/Low Level Design of S/W Programs, S/W Testing; Hardware Schematic, Component design, Layout and Hardware Testing. **Testing, Certification and Documentation:** Introduction to Product verification processes and stages (DFMEA, FEA, CFD); Introduction to Product validation processes and stages - Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing); Product Testing standards and Certification - Industry specific; Product Documentation (Compliance Documentation, Catalogue, Brochures, user manual, maintenance Manual, Spares Parts List, Warranty, Disposal Guide, IETMS, Web Tools). **UNIT IV - Business Dynamics - Engineering Services Industry** **The industry:** Engineering Services Industry - overview; Product development in Industry versus Academia. **The IPD Essentials:** Introduction to vertical specific product development processes; Product development Trade-offs; Intellectual Property Rights and Confidentiality; Security and configuration management.
11.	**Text Books-** 1. **Student handbook,** by NASSCOM and NIT Silchar
12.	**Reference Books-** 1. **Product Design and Development,** 4th edition, Karl T. Ulrich and Steven D. Eppinger, Irwin McGraw-Hill, 2008. 2. **Quality Function Deployment, Productivity Press**, Akao, Y., ed. (1990), Cambridge MA. Becker Associates Inc. 3. **The Mechanical Design Process,** Ullman, David G. Mc Graw-Hill, 4th edt., 2009 4. **Product design techniques in reverse engineering and new product development,** Kevin Otto, Kristin Wood, Pearson, India, 2001 5. **Designing engineering systems for sustainability,** Sandborn P, Myers J., In: Misra KB, editor. **Handbook of performability engineering**, Springer; 2008.

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Optimization Techniques**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107303ME**
6.	Status (Core/Elective)	**Open Elective-III**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of the course, the student will be able to 1. Acquire knowledge and develop basic understanding of the concepts of optimization and mathematical modelling. 2. Acquire knowledge for basic modelling techniques to formulate the real-life practical problems into a mathematical model. 3. Use different direct and gradient based optimization method to solve single and multivariable un-constrained or constrained nonlinear function for minimization or maximization. 4. Use non-traditional optimization methods such as Genetic Algorithms, Simulated Annealing, Global Optimization 5. Application of software for optimization and develop the computer programs for different optimization algorithms 6. Get aware to Goal Programming, Advanced Optimization Techniques and Dynamic Programming	
10.	**Course Syllabus** **UNIT I** Introduction, Single Variable Optimization, Bracketing Methods (Exhaustive Search Method, Bounding Phase Method), Region Elimination Methods (Interval halving Method, Fibonacci Search Method, Golden Section Method), Point Estimation Methods, Gradient Based Methods (Newton-Raphson Method, Bisection Method, Secant Method, Cubic Search Method) **UNIT II** Multivariable Optimization Techniques, Unidirectional Search Methods, Direct Search Methods (Evolutionary Optimization Method, Simplex Search Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method), Gradient Based Methods (Cauchy's Steepest Descent Method, Newton's Method, Marquardt's Method	

	UNIT III Constrained Optimization Algorithms, Transformation Methods (Penalty Function Method, Method of Multipliers), Direct Search (Variable Elimination Method, Random Search Method). **UNIT IV** Introduction to Non-Traditional optimization techniques (Genetic Algorithms, Simulated Annealing), Software related to Optimization, Introduction to Goal Programming, Introduction to Advanced Optimization Techniques.
11.	**Text Books-** 1. **Optimization: Theory and Applications**, S. S. Rao.
12.	**Reference Books-** 1. **Optimization for Engineering Design**, Kalyanmoy Deb, Mohan C Joshi & K. M. Moudgalya

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Semester-VII

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Industry 5.0 for Engineers**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	**ME107304ME**
6.	Status (Core/Elective)	**Open Elective-III**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year

9.

COURSE OBJECTIVE (CO):

The aim of Industry 5.0 is to improve the previous industrial revolution by developing technologies in a human-centric way that empowers the workers more instead of replacing them with machines. The objective of the present course is to introduce the concepts of Industry 5.0 a need of the students across all Engineering disciplines which will be beneficial in mitigating the challenges in the current industrial sectors. Subject also emphasize on the latest technologies like sustainable manufacturing, circular economy, and resilient business models.

COURSE OUTCOMES:

The under students will be able to:

1. Understand Industry 5.0 and its applications.
2. Gain knowledge about the rate of modern technology creation in demand to different industrial sectors.
3. Integrate IOTs with machine tool operations in the manufacturing units.
4. Impact of enabling technologies on existing systems.
5. Design personalized products based upon costumer needs.

10. **Course Syllabus**

UNIT I: Introduction to Industry 5.0

Introduction of Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 5.0, Comparison of Industry 5.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Automation and Transformation Processes.

UNIT II: Importance of Internet of Things (IOTs)

Introduction to Internet of Things (IoT), Industrial Internet of Things (IIoT), Internet of Services,

Fundamental of Predictive Analytics, Smart Logistics, Smart Devices and Products.

UNIT III: Technology Evolution

Basics of cyber Physical Systems, Process Automations and Collaborative robots, Fundamental to artificial Intelligence, Mobile Computing, Cyber Security, Ethical technology, Responsive and distributed supply chain system, Human-centric and Value-oriented approaches.

UNIT IV: Technology Implementation and Case Studies

3D printing, Solar energy sector, Healthcare sector, Maintain records related to education, finance, clean bioenergy generation and Intelligent NextG Wireless Networks. Case studies on CNC/NC automation, In-house, Healthcare services.

Text Books-

1. *Uthayan Elangovan*, Industry 5.0, "The Future of the Industrial Economy", First Edition, Taylor & Francis, ISBN: 978-1-032-04127-8, 2022.
2. *Alessandro Massaro*, "Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances", Wiley-IEEE Press, 2021, ISBN: 2021028944.

Reference Books-

1. *Alasdair Gilchrist*, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
2. *Lan Gibson, David W. Rosen and Brent Stucker,* "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. *Hans Bernhard Kief, Helmut Roschiwal, Karsten Schwarz*, "The CNC Handbook: Digital Manufacturing and Automation from CNC to Industry 4.0", Industrial Press Inc., U.S. ISBN 0831136367, Nov 2021.
4. *Andreas Gebhardt*, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
5. *Janya Chanchaichujit, Albert Tan, Fanwen Meng, Sarayoot Eaimkhong*, "Healthcare 4.0 Next Generation Processes with the Latest Technologies", Palgrave Pivot, 2019, ISBN978-981-13-8113-3.
6. *Charles J. Brooks, Philip A. Craig Jr.,* "Practical Industrial Cybersecurity", John Wiley & Sons, Inc., Hoboken, New Jersey, 2022, ISBN: 978-1-119-88302-9.
7. *Jean-Paul Bourrières*, Cybersecurity of Industrial Systems, ISTE Ltd and John Wiley & Sons, Inc., 2019, ISBN 978-1-78630-421-6.
8. *Le, Chung Van; Le, Dac-Nhuong; Nguyen, Nhu Gia; Tromp, Jolanda G,* "Emerging Technologies for Health and Medicine", John Wiley & Sons; Salem, 2018, ISBN: 978-1-119-50981-3,1119509815.