

**Syllabus for the courses offered by  
Department of Mechanical Engineering  
(for B.Tech. in Mechanical Engineering with  
specialization in Design and manufacturing)**

Course Title	Course Code	Structure (I-P-C)		
Engineering Mechanics	ME101	3	0	3

**Pre-requisite:** Nil

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

CO1	Draw free body diagrams and understand equilibrium analysis techniques.
CO2	Apply static equilibrium equations to various mechanical systems.
CO3	Understand particle kinematics and kinetics.
CO4	Understand rigid body kinematics and kinetics.
CO5	Apply the concepts of angular momentum and torque for rigid body dynamics.

### Syllabus:

**Forces and Particle Equilibrium:** definition of a force, representation of a force as a vector in two (2D) and three (3D) dimensions, particle equilibrium; equilibrium of systems of particles. Moments: definition of a moment, moment of a force about a point, line or axis, and moment due to a couple. Equilibrium and Equivalence of Force Systems: equilibrium equations in two (2D) and three (3D) dimensions. Free Body Diagrams and Equilibrium Analysis Techniques. Application of Static Equilibrium Equations.

**Applications of the Equations of Static Equilibrium to Interacting Bodies or Parts of a Structure;** Systems Containing Multi-Force Members; Frames and Machines. Plane Trusses. Space Trusses. Shear Force and Bending Moment Diagrams. Cable Support Systems. Coulomb Friction and Belt Friction.

**Particle Kinematics;** Particle Kinetics – Newton’s Laws and Euler’s Laws; Motion of Particles and Mass Centers of Bodies. Work-Energy Principle for Particles/Systems of Particles. Planar (2D) Rigid Body **Kinematics:** planar (2D) rigid body kinematics, relative velocity equation, rotation about a fixed axis, instantaneous center of zero velocity, and relative acceleration equations. Planar (2D) Rigid Body Kinetics: planar (2D) rigid body kinetics, translation, moment of momentum - angular momentum, and equations of motion; Work-Energy Method; Impulse-Momentum Method and Conservation of Momentum.

**Angular Velocity; Angular Acceleration.** Velocities in Moving Reference Frames; Accelerations in Moving Reference Frames; The Earth as a Moving Frame. Eulerian Angles; Eulerian Angles Rotation Matrices; Angular Momentum in 3D; Inertial Properties of 3D Bodies. Translational and Rotational Transformations of Inertial Properties; Principal Axes and Principal Moments of Inertia.

### Textbook(s) and Reference(s):

1. Andy Ruina and Rudra Pratap, Introduction to Mechanics for Engineers. Springer, 2019.
2. F. Beer. R. Johnston, Vector mechanics for engineers: statics and dynamics. Tata McGraw-Hill, 2010.
3. Meriam. J. L and Kraige. L. G, Engineering Mechanics, Vol. I – Statics, Vol 2: Dynamics, 2007.
4. Daniel Kleppner and Rober Kolenkow, An Introduction to Mechanics, McGraw Hill Education, 2017.

Course Title	Course Code	Structure (I-P-C)		
Engineering Skills Practice	ME102	0	3	2

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the basic manufacturing processes.
<b>CO2</b>	Apply knowledge for various joining processes.
<b>CO3</b>	Apply knowledge for assembling of simple circuits.
<b>CO4</b>	Design and fabrication of domestic wiring.
<b>CO5</b>	Disassemble and assemble a PC to working condition
<b>CO6</b>	Perform the installation of various PC system software and required device drivers

### Syllabus:

Experiments will be framed to train the students in following common engineering practices:

**Basic manufacturing processes:** Fitting, Drilling & Tapping, Material joining processes

Familiarization on conventional lathe operation

Familiarization on CNC programming and CNC machine operation

Familiarization of electronic components by Nomenclature, meters, power supplies, function generators and Oscilloscope

**Bread board assembling of simple circuits:** IR transmitter and receiver – LED emergency lamp – Communication study: amplitude modulation and demodulation

**PCB:** designing and making of simple circuits – Soldering and testing of electronic components and circuits

**Various types of Domestic wiring practice:** Fluorescent lamp connection, Staircase wiring

Estimation and costing of domestic and industrial wiring – power consumption by Incandescent, CFL and LED lamps

Identify the peripherals of a computer and prepare for assembly and disassembling to working condition.

Installation of operating system and applications.

Working with word processing tools.

Working with spread sheet tools.

Working with Presentation

### References:

1. Uppal S. L., "Electrical Wiring & Estimating", 5Edn, Khanna Publishers, 2003.
2. Chapman. W. A. J., Workshop Technology, Part 1 & 2, Taylor & Francis.
3. Clyde F. Coombs, "Printed circuits hand book", 6Edn, McGraw Hill, 2007.
4. John H. Watt, Terrell Croft, "American Electricians' Handbook: A Reference Book for the Practical Electrical Man", Tata McGraw Hill, 2002.
5. The Complete Computer upgrade and repair book, 3rd edition Cheryl A Schmidt, WILEY Dreamtech
6. Introduction to Information Technology, IITL Education Solutions limited, Pearson Education.
7. PC Hardware - A Handbook – Kate J. Chase PHI (Microsoft)
8. LaTeX Companion – Leslie Lamport, PHI/Pearson.
9. IT Essentials PC Hardware and Software Companion Guide Third Edition by David Anfinson and Ken Quamme. – CISCO Press, Pearson Education.
10. IT Essentials PC Hardware and Software Labs and Study Guide Third Edition by Patrick Regan – CISCO Press, Pearson Education.

Course Title	Course Code	Structure (I-P- C)		
Concepts in Engineering Design	ME151	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Identify different types of engineering design.
<b>CO2</b>	Describe the life cycle of a product.
<b>CO3</b>	Apply conceptualization techniques in the engineering design process.
<b>CO4</b>	Apply and validate different screening and testing methods.
<b>CO5</b>	Analyze the design and development of a product.

**Syllabus:**

Design Conceptualization and Philosophy, Original, Adaptive, Variant and Re-Design, Evolution of Concept, Need for Systematic design Past methods of and design.

Product life cycle, Innovation, Types of innovation

Needs and opportunities, Vision and Mission of a concept, Type of needs, Technology S - curve, Need analysis, market analysis and competitive analysis, Kano Diagrams, SWOT analysis

Conceptualization techniques – Idea generation – ideation, brainstorming, Trigger session Brainwriting, Mind maps, SCAMPER, TRIZ, Biomimicry, Shape mimicry, Familiarity Matrix

Concepts screening, Concept testing - exploratory tests, Assessment tests, Validation tests Comparison tests – Case studies

Organization of design concept and design methods, Engineering Design - Descriptive and prescriptive model, Design decisions and development of design

Group work and case studies

**Text Book(s) and References:**

1. Otto. K and Wood, K, Product Design, Pearson Education, 2001.
2. Pahl. G and Beitz. G, Engineering Design, Springer, 1996.
3. Ullman. D. G, The Mechanical Design Process, McGraw- Hill, 1997.

Course Title	Course Code	Structure (I-P-C)		
Design Realization Practice	ME152	0	3	2

**Pre-requisite, if any:** Nil

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

CO1	Develop an understanding of the design process and principles of design thinking.
CO2	Develop proficiency in prototyping, model-making, and fabrication techniques.
CO3	Evaluate the properties and characteristics of different materials for specific applications.
CO4	Demonstrate an ability to test and evaluate designs based on performance and user feedback.
CO5	Develop skills in design optimization and refinement techniques.
CO6	Develop proficiency in project management, teamwork, and presentation skills.

**Syllabus:**

**Introduction to Design Realization:** Introduction to design thinking and the design process; Design brief development; Conceptualization and ideation; Sketching and visualization techniques

**Experiments:**

1. Brainstorming and ideation exercises to develop creative solutions to design problems.
2. Sketching and visualization exercises to explore different design options.
3. Model-making exercises to bring designs to life in three dimensions.
4. Design brief development exercises to define project goals and objectives.
5. User research exercises to understand user needs and preferences.

**Design Implementation and Prototyping:** Introduction to prototyping and model-making techniques; Materials selection and sourcing; Basic machining and fabrication techniques; Introduction to Computer-Aided Design (CAD) and 3D printing

**Experiments:**

1. Basic prototyping exercises using a range of materials and fabrication techniques.
2. Rapid prototyping exercises using CAD and 3D printing.
3. Material selection exercises to evaluate the properties and characteristics of different materials for specific applications.
4. Fabrication exercises to develop skills in basic machining, forming, and joining techniques.
5. Design for manufacturing exercises to optimize designs for efficient production.

**Testing and Evaluation:** Introduction to testing and evaluation methods; Performance testing of designs; User testing and feedback; Data analysis and interpretation

**Experiments:**

1. Performance testing exercises to evaluate the functional capabilities of designs.
2. User testing exercises to assess usability and user experience.
3. Materials testing exercises to evaluate the properties and characteristics of materials under different conditions.
4. Data analysis and interpretation exercises to draw conclusions from test results and user feedback.

5. Prototype iteration exercises to refine designs based on testing and evaluation.

**Design Optimization and Refinement:** Introduction to design optimization and refinement techniques; Reducing design complexity and cost; Enhancing design functionality and performance; Design iteration and improvement

**Experiments:**

1. Design optimization exercises to reduce complexity and cost while maintaining functionality and performance.
2. Design refinement exercises to enhance functionality and performance while maintaining simplicity and affordability.
3. Design iteration exercises to refine designs based on feedback and testing results.
4. Material substitution exercises to identify suitable alternatives for materials that are difficult to source or too expensive.
5. Value engineering exercises to optimize designs for cost, reliability, and performance.

**Project Management and Presentation:** Introduction to project management principles; Project scheduling and budgeting; Project team management and collaboration; Presentation skills and techniques

**Experiments:**

1. Project management exercises to develop skills in project scheduling, budgeting, and team management.
2. Collaboration exercises to develop teamwork and communication skills.
3. Presentation skills exercises to improve communication skills and build confidence in presenting design concepts and ideas.
4. Design documentation exercises to develop skills in technical writing and project reporting.
5. Final project presentation and exhibition to showcase design projects and receive feedback from peers and industry professionals.

**Text Book(s) and References:**

1. Shamieh, C. (2015). Electronics for dummies. John Wiley & Sons.
2. Abbey, J. E. (2015). Mechanics of materials lab manual. Jones & Bartlett Learning.
3. Alciatore, D. G., & Histand, M. B. (2018). Introduction to mechatronics and measurement systems. McGraw-Hill Education.
4. Leake, J. (2017). Engineering Design Graphics: Sketching, Modeling, and Visualization (2nd ed.). Wiley.
5. Craig, J. J. (2019). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.
6. Monk, S. (2016). Programming Arduino: Getting Started with Sketches (2nd ed.). McGraw-Hill Education.
7. Severance, C. (2016). Python for Everybody: Exploring Data in Python 3. CreateSpace Independent Publishing Platform.

Course Title	Course Code	Structure (I-P-C)		
Engineering Graphics	ME153	1	3	3

**Pre-requisite:** Nil

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

CO1	Learn the basic concepts involved in technical drawing skills.
CO2	Develop basic visualization competency.
CO3	Understand engineering drawings used in 3D objects.
CO4	Represent ideas on both paper and computer.
CO5	Develop the necessary artistic skills required for the engineer to make communication with the industrial designers.

**Syllabus:**

- Importance of engineering drawing; Engineering drawing instruments and uses, B.I.S and I.S.O. conventions for drawings; Construction of basic shapes; Use of plane scales and representative fraction.
- Introduction to principal planes, Notation system, Projection of line parallel/perpendicular to principal plane, Concept of true length of line.
- Concept of different planes, Projections of planes with its inclination to one principal plane and with two principal planes; Concept of auxiliary plane method for projections of the plane.
- Classifications of solids, Projections of solids with their axis parallel to two and perpendicular to one of the principal planes, axis parallel to one and inclined to two principal planes, axis inclined to all the three principal planes.
- Section of solids.
- Principle of projection, Principal planes of projection, Projections from the pictorial view of the object on the principal planes using first angle projection method and third angle projection method.
- Isometric projection.
- Intersection of solids and development of surfaces.
- Principles of perspective drawing, perspective drawing of planar and curved shapes.
- Introduction to CAD.
- Part modelling and assembly.

**Textbook(s) and Reference(s):**

1. Bhatt. N.D., Engineering Drawing, New Age International, 2007.
2. Jolhe D.A., Engineering Drawing with an Introduction to AutoCAD, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Venugopal K., Engineering Drawing and Graphics, New Age International.
4. Gill P.S., A text book of Engineering Drawing, S.K. Kataria & Sons, Delhi.
5. Jeyapooan T., Engineering Drawing & Graphics using Auto CAD, Vikas Publishing House Pvt. Ltd., New Delhi.

Course Title	Course Code	Structure (I-P-C)		
Material Science and Metallurgy	ME154	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the basic concept of material science and metallurgy.
<b>CO2</b>	Analyze the crystal structures, crystal defects, deformation, and strengthening mechanisms.
<b>CO3</b>	Classify steels, cast irons, and their alloys based on their constitutions and applications.
<b>CO4</b>	Interpret the phase diagrams and apply the heat treatment process for various materials.
<b>CO5</b>	Describe different mechanical properties of engineering materials
<b>CO6</b>	Understand the basic concepts of powder metallurgy and its applications.

### Syllabus:

**Introduction to Material Science and Metallurgy:** Classification of Engineering Materials, Engineering Requirements of Materials, Properties of Engineering Materials, Criteria for Selection of Materials for Engineering Applications, Environmental Degradation of Engineering Materials.

**Introduction to Crystal Structure:** Coordination Number, Atomic Packing Factor, Simple Cubic, BCC, FCC, and HCP Structures, Crystal Directions and Planes, Miller Indices, Polymorphism or Allotropy, Mechanism of Crystallization - Nucleation and Growth, Factors affecting Nucleation and Growth. Crystal Imperfections– Point, Line, Surface, and Volume Imperfections, Geometry and Properties of Dislocation, Deformation of Single Crystal by Slip and Twinning, Mechanisms of Strengthening in Metals, Atomic Diffusion, and Factors affecting Diffusion.

**Constitution of Alloys:** Types of Alloys, Types of Solid Solution, Substitutional and Hume Rothery's Rules for Solid Solution, Construction and Interpretation of Binary Equilibrium Diagram - Isomorphous, Eutectoid, Eutectic and Peritectic diagrams, Lever Rule, Intermediate Phases and Gibb's Phase Rule.

**Iron Carbon System:** Allotropy of Iron, Iron-Carbon Diagram - Phases Present and their Properties, Different Reactions of the Iron-Carbon System, Constituents, Microstructures and Properties of Plain Carbon Steels. Alloy groups (Wrought Irons, Steels, and Cast Irons) of Iron-Carbon System and their Characteristics, Equilibrium Cooling of Eutectoid, Hypoeutectoid, and Hypereutectoid Steels – Microstructures, Correlated Properties, and Applications. IS and ISO Codification, Different Specifications, and Designations of Steels.

**Heat Treatments of Steels:** Classification of Steels with Applications, Effect of Common Alloying Elements on Steels, Theory of Heat Treatment, Time-Temperature Transformation (TTT) Curves, Continuous Cooling Transformation (CCT) Curves, Study of Heat Treatment Processes – Annealing, Normalizing, Hardening, Tempering, Austempering & Martempering, Surface Hardening – Carburizing, Nitriding, Cyaniding, Induction Hardening, Flame Hardening and Age Hardening of Aluminum-Copper Alloys and PH steels, Types of Cast Irons – White, Grey, Malleable, and Nodular, etc., Properties and Application of Cast Irons.

**Mechanical Properties:** Stress-Strain Diagrams showing Ductile and Brittle Behavior of Materials, Engineering Stress and True Strains, Mechanical Properties– Stiffness, Yield strength, Ductility, Ultimate Tensile strength, Toughness, Hardness and Hardness measurement, Elasticity, Tensile property, Impact



property and Ductile to Brittle Transition Temperature (DBTT), Fatigue, Creep, etc.

**Powder Metallurgy:** Basic Concepts, Applications, and Advantages of Powder Metallurgy, Manufacturing Processes, Production of Powder, Compacting, Sintering, Products of Powder Metallurgy.

**Text Book(s) and References:**

1. Callister's Materials Science and Engineering, 2<sup>nd</sup> ED, adapted by R Balasubramaniam, 2010, ISBN-13: 978-8126521432, Wiley India Ltd.
2. V. Raghavan, Materials Science and Engineering, 4<sup>th</sup> Ed, Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.
3. D. R. Asklund & P. P. Phule, The Science and Engineering of Materials, 4<sup>th</sup> Ed. Cengage Learning, 2003.
4. Principles of Physical Metallurgy by Prof. R. N. Ghosh, NPTEL (<https://nptel.ac.in/courses/113105023>)

Course Title	Course Code	Structure (I-P-C)		
Thermodynamics	ME155	3	0	3

**Pre-requisite, if any: Nil**

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

<b>CO1</b>	Identify different forms of energy.
<b>CO2</b>	Describe the laws of thermodynamic principles related to various thermal systems.
<b>CO3</b>	Apply the laws of thermodynamics to estimate the performance parameters of thermal systems.
<b>CO4</b>	Estimate the properties of ideal gases and pure substances.
<b>CO5</b>	Analyze the thermodynamic cycles of various thermal systems.

### Syllabus:

**Fundamentals:** System, Control volume, Property, State, Process, Cycle, Equilibrium, Zeroth law, Principles of Thermometry, Energy-Forms of Energy, Heat, Work, Different forms of work.

**First law:** First law Analysis of Closed System for Cyclic & non-cyclic process, Internal energy, Enthalpy, Free expansion process, Application of First law to flow processes, SFEE, Examples of steady flow devices: Nozzle, Diffuser, Turbine, Compressor, Throttling Valve and Heat Exchangers, PMM-I, Limitations of first law.

**Second law:** Qualitative difference between the heat and work, Heat Engines, Refrigerators, Heat Pumps, Kelvin-Planck & Clausius Statements, PMM-II, Carnot Cycle, Reversible & Irreversible cycles. Entropy: Clausius inequality, Definition of Entropy, Demonstration that entropy is a property, T-s diagram, Isentropic efficiency, Available and unavailable energy, Concept of irreversibility and lost work, T-ds equations.

**Pure Substances:** Properties of pure substances, Water and steam - Constant temperature and constant pressure heating, Use of steam tables: Saturation tables, Superheated tables, Mollier chart.

**Thermodynamic relations:** Maxwell relations - TdS Equations - heat capacities relations - Energy equation, Joule- Thomson experiment - Clausius-Clapeyron equation

**Properties of gases and Mixtures:** Properties of Ideal gas, real gas - Equations of state for ideal and real gases. Vander Waal's relation - Reduced properties - Principle of Corresponding states - Generalized Compressibility Chart.

### Text Book(s) and References:

1. P. K. Nag, "Engineering Thermodynamics," McGraw-Hill, 6th Edition, 2013.
2. Y. A. Cengel, and M. A. Boles, "Thermodynamics: An Engineering Approach", McGraw-Hill, 8th Edition, 2011.
3. C. Borgnakke and R. E. Sonntag, "Fundamentals of Thermodynamics," 7th Edition, Wiley, 2009.
4. Moran, Shapiro, Boettner and Bailey, "Principles of Engineering Thermodynamics", 8th Edition, Wiley, 2015.

Course Title	Course Code	Structure (I-P-C)		
Mechanics of Materials	ME201	3	0	3

**Pre-requisite, if any: Engineering Mechanics**

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

<b>CO1</b>	Describe the material behavior under different kind of static loading conditions
<b>CO2</b>	Analyze the problems related to deformation of elastic bodies
<b>CO3</b>	Design simple structures under static loadings, i.e. beams, shafts, columns,etc.
<b>CO4</b>	Design the structures under combined loads
<b>CO5</b>	Apply the different failure theories based on the application

**Syllabus:**

Review of equilibrium, compatibility, stress and strain at a point and Mohr's circle.

Pure bending of beams – shear force and bending moment diagrams; beams with composite cross- sections; Deflection of beams

Torsion of circular cross sections – application and transmission of torque; Combined loads – application to pressure vessels and springs.

Theory of failures for ductile and brittle materials.

Buckling of columns – eccentric loading; various end constraints.

**Text Book(s) and References & Web Resources:**

1. W. Nashand, N. Malik, "Strength of Materials", McGraw Hill Education Pvt. Ltd, 4th Edition, 2010.
2. F. P. Beer, E. R. Johnston, J. T. Dewolf, and D. Mazurek, "Mechanics of Materials," McGraw Hill, 7th Edition, 2014.
3. R. C. Hibbeler, "Mechanics of Materials," Prentice Hall, 8th Edition, 2010.
4. A. C. Ugural, "Mechanics of Materials," Wiely, 1st Edition,2007.
5. J. M. Gere and S. Timoshenko, "Mechanics of Materials", PWS Publishing Company, 4th Edition,1997.

Course Title	Course Code	Structure (I-P-C)		
Kinematics of Machines	ME202	3	0	3

**Pre-requisite: Engineering Mechanics**

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

CO1	Demonstrate a good understanding of the principles of rigid body motion.
CO2	Predict the degrees of freedom, velocity and acceleration of different mechanisms using graphical or analytical methods.
CO3	Synthesize the four bar and slider crank mechanism using path synthesis, function generation and point synthesis.
CO4	Analyze the problems related to cam and follower motions.
CO5	Illustrate different types of gears, gear trains and analyze the speed of gear train.

**Syllabus:**

**Introduction to mechanisms**-rigid body motion- joints, pairs and couplings; Constraints, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion.

**Mobility and degree of freedom**, Kutzbach and Grubler criterion, Number Synthesis, Grashof's law.

**Kinematics (Displacement, Velocity and Acceleration analysis) of rigid bodies** – analytical and graphical methods. Instantaneous Centre (IC) of Velocity, Velocity analysis using IC.

**Dimensional synthesis of mechanism**; motion, path and function generation. Three position synthesis, graphical approach for four link mechanisms. Advanced synthesis solutions, branch and order defects.

**Cams** – classification of cams and followers, nomenclature, description and analysis of follower motion. Determination of basic dimensions and synthesis of cam profiles.

**Gears** – terminology, fundamental law of gearing, interference and undercutting, minimum number of teeth, contact ratio.

**Gear Trains** – simple, compound and epicyclic gear trains.

**Textbook(s) and Reference(s):**

1. A. Ghosh and A. K. Mallik, "Theory of Mechanism and Machines," Affiliated East –West Press Private Ltd., 2009.
2. Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agrawal, "Kinematics, Dynamics, and Design of Machinery," Wiley, 3rd edition, 2016.
3. J. S. Rao, and R. V. Dukkupati, "Mechanism and Machine Theory," New Age International, 2006.
4. S. S. Rattan, "Theory of Machines," Tata McGraw-Hill, 2005.
5. T. Bevan, "Theory of Machines," Pearson Education, 3rd Edition, 2009.

Course Title	Course Code	Structure (I-P-C)		
Fluid Mechanics and Hydraulic Machinery	ME203	3	0	3

**Pre-requisite, if any: Engineering Mechanics**

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

<b>CO1</b>	Understand the concepts of fluid statics and dynamics.
<b>CO2</b>	Apply the concepts of fluid statics and dynamics to various engineering applications and flow-measuring devices.
<b>CO3</b>	Understand the concepts of laminar & turbulent flows and boundary layer formation.
<b>CO4</b>	Understand the working principles of hydraulic devices such as Turbines and Pumps.
<b>CO5</b>	Analyze the performance parameters of hydraulic devices.

### Syllabus:

**Fluid Statics:** Physical properties of fluids - Specific Gravity, Viscosity, Surface Tension, Vapour Pressure and their influence on fluid motion, Basic equations of hydrostatics – pressure measurement, Analysis of submerged surfaces – Buoyancy and stability

**Fluid Kinematics and Dynamics:** Classification of Flows, Stream function, Velocity potential, Conservation of mass, momentum and energy, Application of Bernoulli's Equation and Momentum equations, Measurement of flow: Venturi-meter, Orifice Meter and Pitot Tube

**Flow through Pipes and the Concept of Boundary layer:** Reynolds Experiment, Losses in pipes, Pipe connections, Total Energy Line, Hydraulic Gradient Line, Water hammer, Laminar & Turbulent Boundary Layer, Boundary Layer Thickness, Boundary layer separation.

**Hydraulic Turbines:** Impact of jets, Classification of Turbines, Pelton Wheel, Francis Turbine, Kaplan Turbine, Velocity diagrams, Governing of Turbines, Unit and Specific Quantities, Geometric Similarity, Cavitation, Performance characteristic curves.

**Hydraulic Pumps:** Classification of reciprocating and centrifugal pumps, working principles, Velocity triangles, Losses and Efficiencies, Specific Speed, Pumps in Series, Parallel, Performance characteristic curves, NPSH, Cavitation.

### Text Book(s) and References & Web Resources:

1. S K Som, Gautam Biswas and S Chakraborty, "Introduction to Fluid Mechanics & Fluid Machines", McGraw Hill, 3rd edition, 2011.
2. Robert W. Fox, Philip Journal Pritchard and Alan T. McDonald, "Introduction to Fluid Mechanics", 8th Edition, Wiley India Pvt. Ltd., 2013.
3. Merle C Potter, David C Wiggert and Bassem H Ramadan, "Mechanics of Fluids", Cengage Learning India; 4th edition, 2012.
4. Streeter V.L., Benjamin Wylie, Bedford K.W., "Fluid Mechanics", McGraw Hill, 9th Edition, 2017.
5. P. N. Modi and S. M. Seth, "Hydraulics & Fluid Mechanics Including Hydraulics Machines", 22nd Edition, Standard Book House, 2017.

Course Title	Course Code	Structure (I-P-C)		
Electrical Drives, Sensor and Microprocessor	ME204	3	0	3

**Pre-requisite, if any: Nil**

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

CO1	Understand the working principles of power electronic rectifiers, converters and inverters operate.
CO2	Understand the control mechanism of electrical drives.
CO3	Select a suitable sensor for a particular instrumentation task
CO4	Design signal conditioning circuit and calibrate the sensor
CO5	Program the microprocessors/microcontrollers for solving practical problems
CO6	Interface peripherals with microprocessors/microcontrollers and run the devices like stepper motor etc.

**Syllabus:**

**Power Electronics:** Semiconductor Power Devices-DC converter, DC-DC Converter, DC-AC Converter, AC-AC Converter

**Electrical Machines:** DC Motor, AC Motor, BLDC, PMDC, Servomotor, Stepper motor – Construction, Working Principles, Starting and Control Mechanism

**Sensor:** Introduction: Description of measuring devices and dynamic characteristics, active and passive sensors and transducers, classifications, Basics of Signal Conditioning for sensor

**Sensors and Transducers:** Flow, temperature, force, pressure and torque sensors; Current, torque and speed measurements using digital measurement techniques.

**Microprocessor:** Architecture and Programming of 8085 Microprocessor. Interfacing of 8085 with memory and input /output ports, hex keyboards etc., Architecture and Programming of 8085 Microprocessor. Interfacing of 8085 with memory and input /output ports, hex keyboards etc.,

Introduction to the ARM microcontrollers programming and interfacing with A/D, D/A converters, Sensor interfacing and signals conditioning.

**Text Book(s) and References:**

1. M. Rashid, "Power Electronics: Circuits, Devices & Applications", 3rd Edition, Prentice Hall, 2003.
2. Doebelin, "Measurement systems: Applications and Design", 5th Edition, McGraw Hill, 2004.
3. Ian R. Sinclair, "Sensors and Transducers", Elsevier, 2001, ISBN: 978-0-7506-4932-2.
4. R. Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", 6th Edition, Penram, 2013.
5. R. Krishnan, "Electric Motor Drives: Modelling, Analysis, and Control," Prentice Hall, 2001.
6. N. Mohan, "Electric Drives: An Integrative Approach", MNPERE, 2001
7. Jon S. Wilson, "Sensor Technology Handbook", Newnes, 2004, ISBN: 0750677295.
8. M. MorrisMano, "DigitalLogicandComputerDesign", 1st Edition, Pearson, 2013.

Course Title	Course Code	Structure (I-P-C)		
Materials and Mechanics Practice	ME205	0	3	2

**Pre-requisite(s): Nil.**

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

CO1	Understand the stress-strain curve of materials under tension and compression.
CO2	Understand torsional stresses for large plastic strains.
CO3	Measure hardness of different materials.
CO4	Understand the S-N curve and effect of stress concentration on fatigue.
CO5	Understand and design different mechanisms and their applications, and perform the displacement analysis
CO6	Design cam profiles based on follower displacements.

**Syllabus:**

Experiments on

- The tension test.
- The torsion test.
- The hardness test.
- Fatigue of metals.
- Brittle failure and impact testing.
- Residual stresses.
- Study of applications of kinematic linkages and mechanisms.
- Freudenstein's method: an analytical solution for 4-bar synthesis 3-pt function generation.
- Study of quick return mechanism.
- Graphical Synthesis – Path Generation Mechanism using Kinematic Inversion.
- Cam design.

**Textbook(s) and Reference(s):**

1. George E. Dieter, "Mechanical Metallurgy," McGraw Hill Education, 3<sup>rd</sup> edition, 2017.
2. A. Ghosh and A. K. Mallik, "Theory of Mechanism and Machines," Affiliated East –West Press Private Ltd., 2009.
3. Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agrawal, "Kinematics, Dynamics, and Design of Machinery," Wiley, 3<sup>rd</sup> edition, 2016.

Course Title	Course Code	Structure (I-P-C)		
Electrical Drives, Sensor, and Microprocessor Practice	ME206	0	3	2

**Pre-requisite, if any: Nil**

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

CO1	Choose the right sensing system for various applications.
CO2	Design signal conditioning circuit and calibrate the sensor
CO3	Choose the right Electrical drive system for various applications.
CO4	Select a suitable sensor for a particular instrumentation task
CO5	Design signal conditioning circuit and calibrate the sensor
CO6	Program the microprocessors/microcontrollers for solving practical problems
CO7	Interface peripherals with microprocessors/microcontrollers and run the devices like stepper motor etc.

**Syllabus:**

**Experiments on:**

**Electrical Drives Experiments:** Converters, Inverters, DC Motor, Induction Motor, BLDC motor, Stepper Motor, PMDC motor

**Sensor:** Signal Conditioning Circuits, Temperature sensor, Strain Gauge, Magnetic Sensor

**Microprocessor:** Interfacing of 8085 with memory and input /output ports, hex keyboards etc., ARM microcontrollers programming and interfacing with A/D, D/A converters, Sensor interfacing and signals conditioning.

**Textbook(s) and References:**

1. M. Rashid, "Power Electronics: Circuits, Devices & Applications", 3rd Edition, Prentice Hall, 2003.
2. Doebelin, "Measurement systems: Applications and Design", 5th Edition, McGraw Hill, 2004.
3. Ian R. Sinclair, "Sensors and Transducers", Elsevier, 2001, ISBN: 978-0-7506- 4932-2.
4. R. Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", 6th Edition, Penram,2013.
5. R. Krishnan, "Electric Motor Drives: Modelling, Analysis, and Control," Prentice Hall, 2001.
6. N. Mohan, "Electric Drives: An Integrative Approach", MNPERE, 2001
7. Jon S. Wilson, "Sensor Technology Handbook", Newness, 2004, ISBN: 0750677295.
8. M. Morris Mano, "Digital Logicand ComputerDesign", 1st Edition, Pearson,2013



Course Title	Course Code	Structure (I-P-C)		
Machine Drawing and Manufacturability Analysis Practice	ME207	0	3	2

**Pre-requisite, if any: Engineering Graphics**

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

<b>CO1</b>	1. Develop 3D models of machine components and generate 2D drawing from 3D models
<b>CO2</b>	2. Digitize existing products using reverse engineering
<b>CO3</b>	3. Create assembled and exploded views of machine components
<b>CO4</b>	4. Analyze the machine component design for its manufacturability, environmental impact and eas of assembly using 3D models

**Syllabus:**

**Machine drawing:**

1. Introduction to Machine drawing and Conventional representation of different materials and threaded joints
2. Orthographic projections of different part drawings.
3. Generating 2D drawings from 3D models and create production drawings using standard notations.
4. Assembly drawing of simple machine components like cotter and sleeve joint.
5. Assembly drawing of knuckle joint.

**Modelling using CATIA:**

1. Drafting: Development of part drawings for various components in the form of orthographic and isometric.
2. Modeling machine components in 3D modeling software using feature-based design concepts.
3. Modeling machine components in 3D modeling CATIA software using Boolean based design concepts.
4. Assembly Modelling of cotter and sleeve joint in 3D modeling software using feature-based design concepts.
5. Assembly Modelling of knuckle joint in 3D modeling software
6. Term project on assembly modeling of different components like screw jack, plumber block, footstep bearing, connecting rod, clutch, Oldham coupling, etc.

**Text Book(s) and References:**

1. N.D Bhatt, "Engineering Drawing", Charotar Publishing house, 2017.
2. K.L. Narayana, P. Kannaiah, K.Venkata Reddy, "Machine Drawing", New age company, 2015.
3. S. Bogolyubov. A. Voinov., "Engineering Drawing", Van Nostrand Reinhold Company, 2001.
4. D. E. Hewitt., "Engineering Drawing and Design for Mechanical Technicians", Macmillan Press Ltd,2006.
5. Boothroyd G., Dewhurst P., and Knight W. A., "Product Design for Manufacture and Assembly", 3rd Edition, CRC Press,2010.

Course Title	Course Code	Structure (I-P-C)		
Basic Concepts in Manufacturing Processes	ME251	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the basic concept of manufacturing processes.
<b>CO2</b>	Determine the appropriate manufacturing process(es) for the product to be made.
<b>CO3</b>	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.
<b>CO4</b>	Perform cost analysis for various manufacturing processes to minimize the cost of processing the material.
<b>CO5</b>	Understand the basics of material joining processes

### Syllabus:

**Introduction:** Introduction of manufacturing processes, manufacturing process categories and classification

**Casting:** Types of casting processes and applications; Sand casting: patterns – types, materials and allowances; molds and cores–materials, making, and testing; design of gating system and riser; casting techniques of cast iron, steels, and non-ferrous metals and alloys; analysis of solidification and microstructure development; Other casting techniques: Pressure die casting, Centrifugal casting, Investment casting, Shell mold casting; Casting defects, inspection and testing.

**Metal Forming:** Stress-strain relations in elastic and plastic deformation; von Mises and Tresca yield criteria, Concept of flow stress; Hot, warm, and cold working.

**Bulk forming processes** – forging, rolling, extrusion and wire drawing.

**Sheet metal working processes** – blanking, punching, bending, stretch forming, spinning and deep drawing; Ideal work and slab analysis; Defects in metal working and their causes.

**Materials Removal Processes:** Introduction and classification of material removal processes.

**Conventional Machining:** Orthogonal and oblique machining, Single point cutting tool and tool signature, Chip formation, cutting forces, Merchant’s analysis, Specific cutting energy and power; Machining parameters and material removal rate; tool materials, Tool wear and tool life; Thermal aspects of machining, cutting fluids, machinability; Economics of machining; Machining processes – turning, taper turning, thread cutting, drilling, boring, milling, gear cutting, thread production; Finishing processes – grinding, honing, lapping and super-finishing.

**Non-Conventional Machining:** Introduction, Classification, Principles and applications of USM, AJM, WJM, AWJM, EDM and Wire EDM, LBM, EBM, PAM, CHM, ECM; Effect of process parameters on material removal rate, surface roughness and power consumption.

**Material Joining Processes:** Introduction and classification of material joining processes; Principles of fusion welding processes using different heat sources (flame, arc, resistance, laser, electron beam), Heat transfer and associated losses; Arc welding processes – SMAW, GMAW, GTAW, plasma arc, submerged arc welding processes; Principles of solid state welding processes – friction welding, friction stir welding, ultrasonic welding; Welding defects – causes and inspection; Principles of adhesive joining, brazing and soldering processes.

**Textbook(s) and References:**

1. S. Kalpakjian, and S.R. Schmidt, "Manufacturing Engineering and Technology," 7th Edition, Pearson India, 2009.
2. M. P. Groover, "Principles of Modern Manufacturing," 5th Edition, Wiley, India, 2014.
3. A. Ghosh and A. K. Mallik, Manufacturing Science, Wiley Eastern, 2010
4. P. N. Rao, Manufacturing Technology: Foundry, Forming And Welding, Tata McGraw Hill, 2017.
5. M. P. Groover, Introduction to Manufacturing Processes, Wiley, 2011
6. E. P. DeGarmo, J. T. Black, and R. A. Kohser, "DeGarmo's materials and processes in manufacturing," John Wiley & Sons,2011.
7. Gibson, D. W. Rosen, and B. Stucker, "Additive manufacturing technologies," Springer, 2010.
8. Stephenson, David A., and John S. Agapiou, "Metal cutting theory and practice," Vol. 68, CRC press,2005.
9. S. Kalpakjain, and S. R. Schmid, "Manufacturing processes for engineering materials," 5th Edition, Pearson Education, India,2010.

Course Title	Course Code	Structure (I-P-C)		
Dynamics of Machines	ME252	3	0	3

**Pre-requisite(s): Kinematics of Machines and Engineering Mechanics.**

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

CO1	Analyse the forces in different mechanisms.
CO2	Apply the analytical and graphical methods for balancing of rotating and reciprocating engines.
CO3	Understand and design different machinery such as gyroscopes, clutches, brakes, governors and flywheels.
CO4	Understand the concepts of vibration.
CO5	Use the knowledge in any possible domains of applications such as mechanical engineering, civil engineering, aerospace engineering, and many others.

**Syllabus:**

Dynamics of rigid body in plane and planar mechanisms – static and dynamic force analysis of slider crank mechanism.

Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships.

Balancing of rotating and reciprocating masses and engine balancing.

Turning moment diagram and flywheel analysis.

Clutches: single plate, multi-plate and centrifugal clutch.

Brakes: Simple block brakes, Band brake, internal expanding brake, braking of vehicle. Dynamometers – absorption and transmission types.

Governors-spring loaded and gravity-controlled governors.

Review of vibrations; free vibrations and harmonically excited vibration of single degree of freedom system; Vibration isolation.

**Textbook(s) and Reference(s):**

1. A. Ghosh and A. K. Mallik, “Theory of Mechanism and Machines,” Affiliated East –West Press Private Ltd., 2009.
2. Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agrawal, “Kinematics, Dynamics, and Design of Machinery,” Wiley, 3rd edition, 2016.
3. J. S. Rao, and R. V. Duddipati, “Mechanism and Machine Theory,” New Age International, 2006.
4. S. S. Rattan, “Theory of Machines,” Tata McGraw-Hill, 2005.
5. T. Bevan, “Theory of Machines,” Pearson Education, 3rd Edition, 2009.

Course Title	Course Code	Structure (I-P-C)		
Design of Machine Elements	ME253	3	0	3

**Pre-requisite: Engineering Mechanics, Mechanics of Materials**

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

CO1	Outline the knowledge of design process and design standards, theories of failures, analyses the stresses and strains for various machine elements.
CO2	Understand the Design procedure of riveted joints and welded joints for engineering, apply application like boilers, pressure vessels, ships and trusses.
CO3	Inculcate an ability to design belt drives and selection of belt, rope and chain drives.
CO4	Apply the design and development procedure for different types of springs by using Design Data Handbook.
CO5	Determine the fatigue life of shafts, gears and bearings under varying loads.

**Syllabus:**

Design philosophy, revision of failure theories, limits, fits and design under static load.

Design for variable loading - fatigue strength and design of shafts.

Design of riveted, bolted, welded joints and power screws.

Design of springs: basic spring nomenclature, spring stiffness, various spring type and configurations, materials for spring.

Design and selection of belt drives.

Design of gears: spur and worm gears, contact fatigue strength, gear accuracy.

Design of brakes and clutches.

Tribology: lubricant theories, design of Journal bearings; selection of ball and roller bearings.

**Textbook(s) and Reference book(s):**

1. V Bhandari, 'Design of Machine Elements', McGraw-Hill Education, 3rd Edition, 2010.
2. R G Budynas, K J Nisbett, 'Mechanical Engineering Design', McGraw Hill, 10th Edition, 2014.
3. R L Norton, 'Machine Design', Prentice Hall, 5th Edition, 2013.
4. C S Sharma and K Purohit, 'Design of Machine Elements', Prentice Hall, 2008 P C Gope, 'Machine Design: Fundamentals and Applications', Prentice Hall India, 201.
5. Hall A. S., Holowenko A. R. and Laughlin H. G., "Theory and Problems of Machine Design", Schaum's outline series, Tata McGraw Hill Publication. Co. Ltd, New Delhi

Course Title	Course Code	Structure (I-P-C)		
Heat Transfer	ME254	3	0	3

**Pre-requisite, if any: Thermal Engineering – Concepts & Applications, Fluid Mechanics and Hydraulic Machinery**

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

CO1	Understand the basics of heat transfer and its practical relevance in various simple geometries.
CO2	Interpret the steady and unsteady state heat transfer scenarios.
CO3	Apply the relevant expressions to solve free and forced convection problems.
CO4	Apply the concepts of heat transfer in boiling, condensation, and radiation thermal systems.
CO5	Design the Fins and heat exchangers for engineering applications

**Syllabus:**

**Basics:** Basic modes and Applications of heat transfer.

**Conduction:** General heat conduction equation, Initial and boundary conditions, One-dimensional steady-state conduction in the plane and composite systems, Electrical analogy, Systems with variable thermal conductivity, heat generation, Critical radius of insulation, Analysis of Extended surfaces, One-dimensional transient conduction, lumped system analysis.

**Convection:** Dimensional analysis, the concept of the boundary layer, Forced convection in external and internal flows, natural convection in external flows, heat transfer phenomena in boiling and condensation.

**Thermal Radiation:** Nature of radiation, Concept of Black and Non-black bodies, Laws of Black Body Radiation, Radiation heat exchange between surfaces, Radiation shields.

**Heat exchangers:** Classification, flow arrangement, Overall heat transfer coefficient, fouling, compactness, LMTD &  $\epsilon$ -NTU methods of Heat Exchanger analysis

**Text Book(s) and References:**

1. J. P. Holman and Souvik Bhattacharyya, "Heat Transfer", McGraw Hill, 10th edition, 2017.
2. Incropera, Dewitt, Bergmann, Lavine, "Incropera's Principles of Heat and Mass Transfer, Wiley India Edition", Wiley, 2018.
3. Frank Kreith, Mark S. Bohn, Raj Manglik, "Principles of Heat Transfer", Cengage Learning Custom Publishing; 7th International student edition, 2010.
4. M. Necati Ozisik, "Heat Transfer- A basic Approach", 4th Edition, McGraw, 1985.
5. C. P. Kothandaraman and Subramanian, "Heat and Mass Transfer Data Book", New Age International Publications, 9th Edition, 2018.

Course Title	Course Code	Structure (I-P-C)		
Basic Manufacturing Processes Practice	ME255	0	3	2

**Pre-requisite, if any: Design Realization**

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

<b>CO1</b>	Understand the basic manufacturing processes.
<b>CO2</b>	Accustomed to the handling of Machine tools.
<b>CO3</b>	Realize the products using primary manufacturing processes
<b>CO4</b>	Understand the 3D printer basics.

### **Syllabus:**

The following experiments will be conducted:

1. Realization of Cylindrical Parts using Traditional Lathe (Turning operation)
2. Realization of Cylindrical Parts using Traditional Lathe (Step Turning operation)
3. Realization of Cylindrical Parts using Traditional Lathe (Threading operation)
4. Realization of Cylindrical Parts using Traditional Lathe (Taper Turning operation)
5. Making of Square box with GI sheet by using Sheet Metal Bending Practice
6. Making of Rectangular box with required dimensions of GI sheet by using Sheet Metal Bending Practice
7. Practice on Universal Milling Machine (Facing operation)
8. Gear Cutting by using indexing on Universal Milling Machine
9. Machining on CNC Router cum Milling machine
10. Developing a physical model by using Fusion Deposition Modelling (3D Printer)

### **Text Book(s) and References**

1. E. P. DeGarmo, J. T. Black, and R. A. Kohser, "DeGarmo's materials and processes in manufacturing", John Wiley & Sons, 2011.
2. M. P. Groover, "Principles of Modern Manufacturing", 5th Edition, Wiley, 2014
3. S. Kalpakjain, and S. R. Schmid, "Manufacturing processes for engineering materials", 5th Edition, Pearson Education, 2010.

Course Title	Course Code	Structure (I-P-C)		
Dynamics of Machines Practice	ME256	0	3	2

**Pre-requisite(s): Nil.**

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

CO1	Apply the principles of balancing of masses to various links, mechanisms and engines.
CO2	Analyze the principles of cam & follower motion.
CO3	Understand and design different machinery such as gyroscopes, governors and flywheels.
CO4	Understand the concepts of free vibration, forced vibration, viscous damping and coulomb damping
CO5	Gain hands on experience on sensor data acquisition, signal processing and data analysis.
CO6	Learn traditional control using P, PI, PID and speed and position control under variable loads.

### Syllabus

Experiments on:

1. Estimate the applied torque of given motorized gyroscope.
2. Study the balancing of rotating masses under static condition and dynamic condition.
3. Study the pressure distribution in the journal bearing.
4. Estimate the critical speed of the shaft with different end conditions.
5. Analyse the follower displacement versus cam rotation angle for different types of cams.
6. Predict the radius of gyration of rod by using bi-filler and tri-filler suspension.
7. Estimate the natural frequency of underdamped free vibrations of spring-mass system.
8. Analyse the forced vibration of spring mass system.
9. Analyse the natural frequency of torsional vibration of single rotor system using universal vibration test setup.
10. Acquire the MEMS accelerometer data with the help of data acquisition system and estimate the coefficient of viscous damping.
11. Study the effect of coulomb friction.
12. Tradition control experiments using P, PI, and PID on a DC motor control kit.

### Textbook(s) and Reference(s):

1. A. Ghosh and A. K. Mallik, "Theory of Mechanism and Machines," Affiliated East –West Press Private Ltd., 2009.
2. Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agrawal, "Kinematics, Dynamics, and Design of Machinery," Wiley, 3rd edition, 2016.
3. S. S. Rattan, "Theory of Machines," Tata McGraw-Hill, 2005.
4. L. Meirovitch, "Fundamentals of Vibrations," McGraw-Hill Education, 2000.



Course Title	Course Code	Structure (I-P-C)		
Fluid Mechanics and Heat Transfer Practice	ME257	0	3	2

**Pre-requisite, if any:** Fluid Mechanics and Hydraulic Machinery

**Course Objective:** The objective of this course is to familiarize the students with fluid mechanics and heat transfer equipment.

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

CO1	Compute the different losses in pipe flows.
CO2	Estimate the thermal conductivity of different materials
CO3	Estimate the Fin performance parameters.
CO4	Evaluate the free and forced convection heat transfer coefficients.
CO5	Determine the overall heat transfer coefficient of the Drop and Film wise condensation.

**Syllabus:**

The following Experiments are designed to:

- Estimate the major and minor losses in a flow through pipe.
- Study of linear and radial heat transfer conduction using Fourier's Law.
- Measurement of thermal conductivity of non-metallic material under steady state experiments.
- Estimate the Effectiveness and efficiency of the pin fin apparatus under forced condition.
- Determine the overall heat transfer coefficient of both the Drop and Film wise condensation.
- Estimate the Heat Transfer coefficient of both Natural and forced convective system.

**Text Book(s) and References:**

1. J. P. Holman and Souvik Bhattacharyya, "Heat Transfer", McGraw Hill, 10th edition, 2011.
2. Incropera, Dewitt, Bergmann, Lavine, "Fundamentals of Heat and Mass Transfer", Wiley, 6th edition, 2010.
3. Robert W. Fox, Philip Journal Pritchard and Alan T. McDonald, "Introduction to Fluid Mechanics", 8th Edition, Wiley India Pvt. Ltd., 2013.

Course Title	Course Code	Structure (I-P-C)		
Quality Inspection and Product Validation	ME301	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Understand various metrology principles and techniques
CO2	Acquire the knowledge to select suitable techniques and equipment to inspect and to ensure product quality
CO3	Acquaintance with various quality control methodologies, standards, and certifications
CO4	Understand the basics concepts of surface metrology
CO5	Analyze the suitability of statistical quality control tools in a real time manufacturing system

**Syllabus:**

**Engineering Metrology:** Basic principles of engineering metrology – Metrology, need for inspection, accuracy and precision, objectives of metrology and measurements, role of metrology in quality assurance, errors in measurement, Standards of measurement: standards and their roles, line and end standards, transfer from line standard to end standard. Limits, Fits and Tolerance, Linear Measurement, Angular Measurement, Gauges and Comparators.

**Measurement Practices:** Optical metrology and laser interferometers, measurement of flatness, straightness and form errors, Metrology of surface finish: concepts, terminology, analysis of surface traces, method of measuring surface finish, coordinate measuring machine (CMM), vision application in metrology, Mechanical measurements: concepts, basic definitions, transducers, measurement of temperature, pressure, and force.

**Statistical Methodologies:** Graphical methods, Statistical control charts, Regression analysis, Analysis of variance, Sampling and acceptance.

**Standards and Certifications:** BIS, ISO, SAE, ASME, ASTM, IEEE

**Case studies:** Inspection and Validation practices adopted in various industries.

**Textbook(s) and References:**

1. T. G. Beckwith, R. D. Marangoni, and J. H. Lienhard, “Mechanical Measurements”, 6th Edition, Pearson Higher Education, 2007.
2. R. K. Jain, “Engineering Metrology”, Khanna Publishers, 20th Edition, 2014.
3. D. J. Whitehouse, “Hand book of surface and nanometrology”, 2nd Edition, CRC Press, 2010.
4. G. T. Smith, “Industrial Metrology”, Springer, 2002.
5. R. C. Gupta, “Statistical Quality Control”, Khanna Publishers, 8th Edition, 2008.
6. Doebelin E O, Measurement Systems, Application and Design, 4th Edition, McGraw Hill Higher Education (1989).
7. Hume K J, Engineering Metrology, 3rd Edition, TBS The Book Service Ltd (1970).

Course Title	Course Code	Structure (I-P-C)		
Automation in Manufacturing	ME302	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Understand the concept of Product Life Cycle and Importance of Automation in Manufacturing.
CO2	Analyze and design the mechatronics-based system in the manufacturing environment.
CO3	Develop a manufacturing system with various sensors, actuators and controllers.
CO4	Apply the learnings of PLC and microprocessors in manufacturing automation.
CO5	Develop pneumatic and hydraulic circuits for manufacturing applications.
CO6	Understand the concepts of Robotics in Automation.

**Introduction:** Introduction to Automation in Manufacturing; Types of Automation; Automation in Production System; The Product Life Cycle: Importance of Automation in the Manufacturing Industry

**Introduction to Mechatronics:** Overview and Disciplines of Mechatronics, Mechatronics for Replacement of Mechanics; Mechatronics based Systems; Design of an Automated System: Building Blocks of Mechatronics based Automated System, Development of an equivalent mechatronics-based system: working principle and example; Elements of an Automated System and their selection; Flexible Manufacturing System; Elements of FMS; CNC Machine Tools: Tool magazines, Automatic Palletizing System, Adaptive Control in CNC Operation: Tool Wear Monitoring System, Automated Storage & Retrieval System (AS/RS); Industrial Conveyors.

**Measurement System & its elements in Manufacturing:** Terms related to sensors and actuators; Sensor and Transducer: Examples and the Concept of Smart Sensor; Construction and principle of operation of sensors required in a typical automated system for manufacturing.

**PLCs and Microprocessors:** Basic Structure-Input/Output Processing-Programming-Mnemonics Timers, Internal relays and counters-Data Handling-Analog input/output- Selection of PLC, Programming and interfacing of microprocessors in manufacturing applications.

**Hydraulic Systems:** Flow, pressure and direction control valves, actuators, supporting and control elements, pumps, servo valves and actuators, electro hydraulic servo-valves, proportional valves and their applications, design of hydraulic circuits for manufacturing applications and performance analysis.

**Pneumatic Systems:** Production, distribution and conditioning of compressed air, System components and graphic representations, Design of circuits-switching circuits and sequential circuits, Cascade methods, Step counter method, compound circuit design.

**Robotics in Automation:** Robot classification and anatomy, forward and inverse kinematics, DH matrix transformation, Jacobian and differential motion, Trajectory planning, Static and dynamic analysis, applications in manufacturing.

**Text Book(s), References & Web Resources:**

1. Morris A. Cohen and Uday M. Apte, "Manufacturing Automation", McGraw Hill, 1997.
2. HMT Ltd. Mechatronics, Tata McGraw-Hill, New Delhi, 1988.
3. Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001.
4. Parr, A. A., Hydraulics and pneumatics, Elsevier, 1999.
5. M P. Groover, "Industrial Robotics: Technology, Programming and Applications", McGraw- Hill, 2<sup>nd</sup> Edition, 2012.
6. Bolton, W., "Mechatronics: electronic control systems in mechanical and electrical engineering", McGraw Hill, 2009.
7. Deb S. R., "Robotics technology and flexible automation", 2<sup>nd</sup> Edition, Mc Graw Hill, 2009.
8. Boucher, T. O., "Computer automation in manufacturing - an Introduction", Chapman and Hall, 1996.
9. Automation in Manufacturing by Prof. Shrikrishna N. Joshi, IIT Guwahati, NPTEL ([https://onlinecourses.nptel.ac.in/noc21\\_me120/preview](https://onlinecourses.nptel.ac.in/noc21_me120/preview))

Course Title	Course Code	Structure (I-P-C)		
Thermal Engineering	ME303	3	0	3

**Pre-requisite, if any: Thermodynamics**

**Course Objective:** The objective this course is to provide an insight of fundamentals and salient features of major energy conversion systems using the concepts of Thermal Engineering.

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

CO1	Understand the concepts of a Steam power plant.
CO2	Comprehend the concepts of a Gas turbine plant.
CO3	Acquire the knowledge of the Internal Combustion engine components.
CO4	Appreciate the concepts of Refrigeration and their applications.
CO5	Analyze the psychrometric properties and processes used in Air Conditioning systems.

**Syllabus:**

**Steam power cycles:** Steam Power plant and its components, site selection, Carnot Vapour Power Cycle, Rankine cycle, Rankine Cycle with Reheat, Superheat, and Regeneration, Plant efficiency, Cogeneration.

**Gas Turbines:** Gas turbine plant and its components, Brayton cycle, Classification, Analysis of Closed and Open cycle Gas Turbine plants, Methods of improving performance, Intercooler, Regeneration and Reheating, Applications.

**Internal Combustion Engines:** Basic components and nomenclature, Classification, working principles of 2-stroke & 4-stroke SI and CI, Engines, Air-standard and Real cycles, Fuels, Stoichiometric Air-Fuel ratio, Combustion: Detonation and Knocking, Carburetion, Injection, Ignition and cooling systems, Parameters of performance, Exhaust emissions.

**Refrigeration:** Gas Refrigeration system, Vapour compression cycle, Effect of sub-cooling and superheating, Multistage systems, Cascade systems, Vapour Absorption cycle, Refrigerants

**Air-conditioning:** Psychrometric properties, Psychrometric chart, Psychrometric processes, Components of Air conditioning system, Classification of Air conditioning systems

**Text Book(s) and References:**

1. T. D. Eastop, A. McConkey, "Applied Thermodynamics for Engineering Technologists", 5th Edition, Pearson India, 2002.
2. P. K. Nag, "Power Plant Engineering", 4th Edition, McGraw Hill, 2014.
3. Wilbert F. Stoecker and J.W. Jones, "Refrigeration and Air Conditioning", 2<sup>nd</sup> Edition, McGrawHill, 2002.
4. John B. Heywood, "Internal Combustion Engine Fundamentals, McGraw Hill, 2011.
5. V. Ganesan, "Internal Combustion Engines", 4th edition, McGraw Hill, 2012.
6. V. Ganesan, "Gas Turbines" – McGraw Hill, 3<sup>rd</sup> Edition, 2010.
7. H. I. H. Saravanamuthoo, H. Cohen, G. F. C. Rogers, "Gas Turbine Theory", 5<sup>th</sup> Edition, Pearson, 2001.

Course Title	Course Code	Structure (I-P-C)		
Operations Research	ME304	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Understand the concepts of operations research modeling approaches.
CO2	Formulate and solve linear programming problems in engineering and management
CO3	Formulate and solve transportation, assignment, and sequencing-related problems
CO4	Understand and solve CPM/PERT and network model problems
CO5	Solve queueing, forecasting, and inventory-related problems
CO6	Understand and analyze managerial problems in industry for effective utilization of resources (Men Machines, Materials, Methods, Money).

**Syllabus:**

**Introduction:** Historical Overview of Operations Research (OR) – Origin and Development, General Methodology and Basic OR Models, Applications of OR to Industrial Problems.

**Introduction to Linear Programming:** Formulation of Linear Programming Problems (LPPs), Product mix Problems, Deterministic Models, Graphical Solutions, Simplex Method, Artificial Variable Technique, Degeneracy in LPPs, Duality and Sensitivity Concept, Dual Linear Programming, Application of Elementary Sensitivity Analysis.

**Transportation Model:** Formulation, Finding an Initial Feasible Solution – North West Corner Method, Least Cost Method, Vogel’s Approximation Method, Finding an Optimal Solution using MODI method, Special cases in Transportation problems – Unbalanced Transportation Problem, Degeneracy, and the Transportation Problem, Testing the Solution for Optimality, Prohibited Routes; Maximization and the Transportation Techniques.

**Assignment Model:** Assignment Table, Special Features of Assignment Problems, Methods for Solving Assignment Problems – Hungarian Method, Sequencing Models – Processing ‘n’ Jobs through Two Machines and Three Machines, Processing Two Job Through ‘n’ Machines.

**Network Optimization:** The Terminology of Networks, Network Optimization Models – Examples, The Shortest-Path Problem, The Minimum Spanning Tree Problem, The Maximum Flow Problem.

**CPM/PERT:** Origin, History, and Applications, Using a Network to Visually Display a Project, Scheduling a Project with CPM/PERT, Dealing with Uncertain Activity Durations, An Evaluation of PERT/CPM.

**Queuing Theory:** Queuing Systems and Concepts, Classification of Queuing Situations; Kendall’s Notation, Solution of Queuing Problems, Single Channel, Single Stage, Finite and Infinite Queues with Poisson Arrival and Exponential Service Time, Applications to Industrial Problems.

**Forecasting:** Judgmental Forecasting, Time Series, Forecasting Errors

**Inventory Model:** Components, Deterministic, Continuous-Review, Models, Deterministic, Periodic-Review Model

**Text Book(s), References & Web Resources:**

1. F. S Hillier and G. J Liberman, Introduction to Operations Research, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2006.
2. H. A Taha, Operations Research: An Introduction, Prentice Hall of India, 2002.
3. S D Sharma, Operations Research, Kedarnath, Ramnath & Co., Meerut, 2010.
4. P K Gupta and D S Hira, Operations Research, S Chand & Co., New Delhi, 2008
5. R L Rardin, Optimization in Operations Research, Pearson Education, Prentice Hall, 1997.
6. <https://www.edx.org/course/operations-research-an-active-approach>

Course Title	Course Code	Structure (I-P-C)		
Quality Inspection and Product Validation Practice	ME305	0	3	2

**Pre-requisite, if any:** Nil

**Course Objective:** Students will learn to Calibrate and understand the sources of various measurement errors and familiarize with the use of metrological equipment.

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

CO1	Identify the suitable metrology instruments, gauges, and tools
CO2	Calibrate and understand the sources of various measurement errors
CO3	Apply various statistical control charts in process control.

**Syllabus:**

The following experiments will be performed in this Practice session:

1. Error mapping of measuring Instruments and measurement of Linear dimensions of aluminum rod using Vernier height gauge and Dial Vernier
2. Calibration of Inside micrometer and Digital micrometer by measuring Internal dimensions of Specimen (Washer)
3. Measuring and Comparing the Depth & Thickness of Gear tooth with Theoretical Values
4. Measuring and comparing the internal dimensions of specimens (Gear block, Pipe) by Telescopic gauge
5. Comparing Flatness measurement using Spirit level and Sine bar finding angles of the Specimen
6. Temperature Measurement during the machining operation using Infrared gun
7. Measuring the Angles of the specimen by using Bevel Protractor
8. Calibration of dial gauge & bore gauge and measurement of internal dimensions and bores.
9. Measurement of roundness and cylindricity of the specimen.

**Text Book(s) and References:**

1. T. G. Beckwith, R. D. Marangoni, and J. H. Lienhard, "Mechanical Measurements", 6thEdition, Pearson Higher Education.
2. R. K. Jain, "Engineering Metrology", Khanna Publishers, 20thReprint,2014.
3. R. C. Gupta, "Statistical Quality Control", Khanna Publishers, 8<sup>th</sup>Edition,2008.



Course Title	Course Code	Structure (I-P-C)		
Automation in Manufacturing Practice	ME306	0	3	2

**Pre-requisite, if any:** Nil

**Course Objective:** To acquire hands-on experience in integrating various mechatronic and automation devices such as hydraulic, pneumatic, robotic systems, PLCs and computers in manufacturing systems.

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

<b>CO1</b>	Integrate various electro-mechanical devices in manufacturing.
<b>CO2</b>	Develop pneumatic and hydraulic circuits for manufacturing applications.
<b>CO3</b>	Automate a manufacturing system with various sensors, actuators, robot mechanisms, PLCs and other controllers

**Syllabus:**

The following experiments are conducted:

1. Integration of various sensors, actuators and other mechatronic devices in manufacturing applications.
2. Identification of faulty components, orientation errors, assembly errors etc.
3. Computer based design and simulation of automated manufacturing systems.
4. Design, development and implementation of pneumatic and hydraulic circuits for the given manufacturing problem.
5. Programming and integration of robot mechanisms in manufacturing automation.
6. Programming and integration of PLCs and control of equipment in manufacturing.
7. Design and development of microprocessor and computer-based control schemes in manufacturing automation

**Text Book(s) and References:**

1. Anthony Esposito, "Fluid power with applications", 7<sup>th</sup> Edition, PrenticeHall, 2008.
2. M P. Groover, "Industrial Robotics: Technology, Programming and Applications", McGraw- Hill, 2<sup>nd</sup> Edition, 2012.
3. K. S. Fu, "Robotics: control, sensing, vision and intelligence", McGraw-Hill, 1987.
4. Bolton, W., "Mechatronics: electronic control systems in mechanical and electrical engineering", McGraw Hill, 2009.

Course Title	Course Code	Structure (I-P-C)		
Thermal Engineering Practice	ME307	0	3	2

**Pre-requisite, if any: Heat Transfer**

**Course Objective:** The objective of this course is to imbibe practical knowledge of various modern thermal systems

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

<b>CO1</b>	Estimate the heat transfer coefficients of various heat exchangers.
<b>CO2</b>	Estimate LMTD and effectiveness for parallel and counter flow heat exchanger
<b>CO3</b>	Study the performances of Solar PV Trainer kit and Wind energy trainer kit.
<b>CO4</b>	Familiarize the students with Refrigeration and Air-Conditioner test rigs.
<b>CO5</b>	Familiarize the students with IC engines.

**Syllabus:**

The following experiments are conducted to:

1. Find out the COP of a Refrigeration Test rig at various loading conditions.
2. Estimate the COP of Air Conditioner Test rig at various loading conditions.
3. Determine the overall heat transfer coefficient and dirt coefficient of the given shell and tube heat exchanger.
4. Determine the overall heat transfer coefficient and film coefficient for jacketed vessel with coil heat exchanger.
5. Determine LMTD, effectiveness and overall heat transfer coefficient for parallel and counter flow heat exchanger for concentric tube flow.
6. Understand relationship of heat transfer and flow regime in a plate heat exchanger geometry.
7. Study the performance of Petrol Engine
8. Study the performance of Solar PV Trainer kit.
9. Study the performance of Wind energy trainer kit.

**Text Book(s) and References:**

1. J. P. Holman and Souvik Bhattacharyya, "Heat Transfer", 10th edition, McGraw Hill, 2011.
2. V. Ganesan, "Internal Combustion Engines", 4th edition, McGraw Hill, 2012.
3. Wilbert F. Stoecker and J.W. Jones, "Refrigeration and Air Conditioning", 2nd Edition, McGraw Hill, 2002.
4. P. K. Nag, "Power Plant Engineering", 4th Edition, McGraw Hill, 2014.

Course Title	Course Code	Structure (I-P-C)		
Computational Methods in Engineering	ME351	3	0	3

**Pre-requisite, if any: Engineering Mechanics, Fluid Mechanics, Heat Transfer, Mechanics of Materials**

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

CO1	Understand the importance of obtaining approximate solutions to various practical problems
CO2	Model machine elements and structures, and analyze the stresses and strains
CO3	Analyze the heat transfer problems

**Syllabus:**

**Fluid flow & Heat Transfer:** Difference representation of PDEs including errors, consistency and stability.

**Application of Numerical Methods:** To Heat equation, Laplace's equation and Burgers' equation. Application of Finite Volume Formulation to One-dimensional Steady diffusion.

**Boundary value problems - Classical solution methods:** Weighted residual techniques and Rayleigh-Ritz method.

**Finite Element Method:** Discretization, shape functions, boundary conditions, element stiffness matrix, assembly technique for global matrices - Numerical integration - Application to trusses, beams and heat transfer problems. Tutorials.

**Text Book(s) and References:**

1. Richard H. Pletcher, John C. Tannehill, Dale Anderson, "Computational Fluid Mechanics and Heat Transfer", Third Edition (Series in Computational and Physical Processes in Mechanics and Thermal Sciences), CRC Press, 2012.
2. T R Chandrupatla and A D Belegundu, 'Introduction to Finite Elements in Engineering', 3rd Edition, PHI Learning, 2009
3. J N Reddy, 'An Introduction to the Finite Element Method', McGraw-Hill Education, 3<sup>rd</sup> Edition, 2005
4. Patankar, S.V., Numerical Heat Transfer and Fluid Flow, McGraw-Hill, 1980.
5. Muralidhar, K., Sundarajan T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
6. Versteeg Henk Kaarle, Malalasekera Weeratunge, "An introduction to computational fluid dynamics: The finite volume method", Pearson Education, 2007.
7. Seshu P., "Finite Element Analysis", Prentice Hall India, 2003.
8. Jacob Fish and Ted Belytschko, "A first Course in Finite Elements", John Wiley & Sons, 2007

Course Title	Course Code	Structure (I-P-C)		
Machine Tool Technology	ME352	3	0	3

**Pre-requisite, if any: Basic Concepts in Manufacturing Process**

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

CO1	Tabulate different types tool-based machine tools used in manufacturing industry
CO2	Identify different parts of the machine tools
CO3	Explain various machine tool mechanisms
CO4	Propose an ideal machining process for fabricating a product for specific application with due consideration for the process capabilities and product quality requirements.
CO5	Recommend appropriate finishing process to achieve final product requirement
CO6	Design Jigs and Fixtures for work and tool holding in machining a given product.

**Syllabus:**

**Engine Lathe:** Principle of working and specification of lathe–Types of lathes–Work holders and tool holders–Lathe accessories–Operations on Lathe–Taper turning–Thread turning and lathe attachments.

**Turret and Capstan Lathes:** Principle of working–Collet chucks–Other work and tool holding devices–Box and tool layout.

**Shaping, Slotting and Planing Machines:** Principles of working–Principal parts–Specification, classification, operations performed, machining time calculations.

**Drilling and Boring Machines:** Principles of working, specifications, types, operations performed–tool holding devices–twist drill–Boring machines–Fine boring machines–Jig Boring machine. Deep hole drilling machine.

**Milling Machines:** Principle of working–Specifications–Classifications of milling machines–Principal features of horizontal, vertical and universal milling machines–Machining Operations–Types–Geometry of milling cutters–Milling cutters–Methods of indexing–Accessories to milling machines.

**Grinding Machines**–Fundamentals–Theory of grinding–Classification of grinding machine–Cylindrical and surface grinding machine–Tool and cutter grinding machine–special types of grinding machines.

**Lapping, Honing and Broaching Machines:** Comparison to grinding–lapping and honing. Constructional features of speed and feed units, machining time calculations.

**Jigs and Fixtures:** Principles of design of Jigs and fixtures and uses. Classification of Jigs & Fixtures–Principles of location and clamping–Types of clamping & work holding devices. Typical examples of jigs and fixtures.

**Textbooks and References:**

1. G. C. Sen and A. Bhattacharya, “Principles of Machine Tools,” New Central Book Agency.
2. G. Boothroyd, and W. A. Knight, “Fundamentals of machining and machine tools,” 3<sup>rd</sup> Edition, Taylor & Francis.

3. D. K. Pal and S. K. Basu, "Design of Machine Tool," 4<sup>th</sup> Edition, Oxford & IBH Publishing Pvt. Ltd.
4. G. E. Dieter, "Engineering Design: A Materials and processing approach," McGraw Hill, 1991.

Course Title	Course Code	Structure (I-P-C)		
Computational Methods in Engineering Practice	ME353	0	3	2

**Pre-requisite, if any:** Heat Transfer, Mechanics of Materials

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

<b>CO1</b>	Draw 1D, 2D and 3D Finite Element Models of mechanical systems.
<b>CO2</b>	Understand the solution techniques available in computer-aided engineering tools.
<b>CO3</b>	Evaluate the design of mechanical systems by conducting stress analysis, thermal analysis or fluid flow analysis.

**Syllabus:**

Creation of Finite Element Models and Evaluation of Displacements, Stresses and Reaction Forces of axially and transversely loaded members, thin plates or discs, long pipes or dams, and brackets using Static Structural Analysis.

Evaluation of natural frequencies and mode shapes of axially and transversely loaded members using Dynamic Structural Analysis.

Construction of Finite Element Models and study of temperature distribution in fins or composite plane walls and chimneys or other plane sections using Thermal Analysis.

Building of Finite Element Models and study of velocity distribution of fluid in channels or pipes over bluff bodies using steady state fluid flow analysis.

**Text Book(s) and References:**

1. Saeed Moaveni, "Finite Element Analysis: Theory and Application with ANSYS", Pearson, 2011.
2. Tirupathi R. Chandrupatla and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 2001.
3. Erdogan Madenci and Ibrahim Guven, "The Finite Element Method and Applications in Engineering Using ANSYS", Springer, 2015.

Course Title	Course Code	Structure (I-P-C)		
Machine Tool Technology Practice	ME354	0	3	2

**Pre-requisite, if any: Machine Tool Technology**

**Course Objective:** The objective of this course is to develop competency in understanding machine tools and their working principles.

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

CO1	Select suitable machining operations for manufacturing a given component by applying knowledge of machine tools.
CO2	Make use of measuring devices like vernier, micrometer, surface roughness tester, CMM, etc.
CO3	Plan sequence of various operations so as to complete the task with minimum time
CO4	Create simple components using Lathe, CNC Lathe, Milling machine, Shaper, Grinding machine.

**Syllabus:**

**List of suggested experiments:**

1. Machining operations on conventional lathe like (a) straight turning, (b) taper turning (c) thread cutting (d) Knurling, (e) boring, etc.
2. Machining operation on CNC lathe like (a) straight turning, (b) taper turning (c) step turning
3. Machining operation on shaping machine (a) flat surface (b) inclined surface (c) slots, etc.
4. Machining operation on milling machine (a) flat surface (b) slot, (c) gear cutting
5. Grinding operation using surface grinding

**References:**

1. HMT, Production Technology. Tata McGraw Hill, 2004
2. ASTME, Tool Engineer's Handbook
3. E. P. DeGarmo, J. T. Black, and R. A. Kohser, "DeGarmo's materials and processes in manufacturing", John Wiley & Sons, 2011.
4. M. P. Groover, "Principles of Modern Manufacturing", 5th Edition, Wiley, 2014
5. S. Kalpakjain, and S. R. Schmid, "Manufacturing processes for engineering materials", 5th Edition, Pearson Education, 2010.
6. W. A. J. Chapman, Workshop Technology, Vol. 2 & 3. CBS Publishers & Distributors, 1980
7. N. K. Mehta, Machine Tool Design and Numerical Control, 2<sup>nd</sup> ed. Tata McGraw Hill, 1996

Course Title	Course Code	Structure (I-P-C)		
Product Design Practice	ID351	0	3	2

**Pre-requisite, if any:** Design Realization Practice, Product Realization Practice

**Course Objective:** Students will develop cross-discipline products and prototype them using product realization tools in a multi-disciplinary team setting.

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

CO1	Develop a cross-disciplinary idea
CO2	Conceive, design and prototype an innovative idea
CO3	Work in cross-functional groups and to apply the concepts learnt in theory to a practical problem
CO4	Manage group projects, maintain timeliness and follow a method-oriented approach to problem solving

- This course is an interdisciplinary team-based product design and prototyping course.
- The concept of the course is to provide hands-on learning experience in interdisciplinary fields of engineering and exposure to the context of a “real” product design problems. In this course, students will design a product by following the systematic product design process.
- A team consist of students from different discipline will choose their own innovative product and while designing, students will consider many issues like market opportunities, formal requirements and constraints, the environment in which the product will be used, product look and feel; technical legitimacy, and manufacturing considerations for the products.
- During the course, students will learn and put in to practice team working, project management and product realization practices commonly found in product developers in industry. Throughout the semester, the student teams have several opportunities to present their progress to their fellow students and faculty.

**Text Book(s) and References:**

1. Carl Liu, "Innovative Product Design Practice", Kindle Edition, ASIN: B00B29V9RQ
2. Bjarki Hallgrimsson, "Prototyping and Model making for Product Design", Laurance King Publishing Limited, 2012.



# Electives

Course Title	Course Code	Structure (I-P-C)		
Computer-Aided Design & Manufacturing (CAD/CAM)	ME401	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Understand the need and applications of computers in design and manufacturing.
CO2	Design engineering components using geometric modelling techniques.
CO3	Apply geometric transformation techniques for better design understanding.
CO4	Understand the concept of group technology and flexible manufacturing system
CO5	Develop CNC programs to manufacture industrial components.
CO6	Understand the computer-aided process planning and computer-integrated manufacturing

### Syllabus:

**Introduction to Computer-Aided Design:** The Design Process, Product Life Cycle, Application of CAD, Hardware Requirements of CAD – Principles of Interactive Computer Graphics; Overview of Hardware Available for use in CAD.

**Product Data Exchange:** Graphics Standards – GKS, Bitmaps, Open GL, Data Standards – IGES, STEP, CALS, DXF, STL, Communication Standards – LAN, WAN.

**Geometric Modeling – Curves:** Types of Mathematical Representation of Curves, Analytical Curves – Lines, Circle, Ellipse, Parabola, Hyperbola; Synthetic Curves – Hermite Cubic Splines, Bezier Curves, B-splines, NURBS

**Geometric Modeling – Surfaces:** Analytical Surfaces, Surfaces of Revolution, Mathematical Representation of Surfaces, Surface Model, Surface Entities, Surface Representation; Parametric Representation of Surfaces, Plane Surface, Rule Surface; Surface of Revolution, Tabulated Cylinder.

**Geometric Modeling – Solid:** Solid Representation, Boundary Representation (B-rep), Constructive Solid Geometry (CSG), and Sweep Representation.

**2-D and 3-D Geometric Transformations:** Translation, Rotation, Scaling, Mirror Concatenation, and Coordinate Transformations.

**Computer Numerical Control (CNC):** Introduction to Computer Numerical Control (CNC) – Origin, History, and Applications, CNC Programming: Part Programming Fundamentals, Manual Part Programming, APT Programming, Geometric & Motion commands, Post Processor Commands.

**Group Technology:** Introduction to Group Technology, Part Classification & Coding Systems: OPITZ, MICLASS.

**Flexible Manufacturing System (FMS):** Components of FMS, FMS Equipment & Control, FMS Case Studies.

**Computer Aided Process Planning (CAPP):** Introduction to CAPP, Variant & Generative Methods of CAPP, Hybrid CAPP, Advantages of CAPP.

**Computer Integrated Manufacturing:** Elements of CIM, Computer Integrated Production Planning Systems, CIM Case Studies.

**Text Book(s) and References:**

1. M. P. Groover & E. W. Zimmers, CAD-CAM – Prentice Hall, ISBN: 978-81-758-465, 2008
2. P. N. Rao, CAD/CAM Principles & Applications, McGraw Hill, New Delhi, 2010.
3. S D Sharma, Operations Research, Kedarnath, Ramnath & Co., Meerut, 2010.
4. I. Zeid & R Sivasubramanian, CAD/CAM Theory and Practice, TMH, New Delhi, 2009.
5. I. Zeid, Mastering CAD/CAM, Special Indian Edition 2007, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Course Title	Course Code	Structure (I-P-C)		
Refrigeration and Air Conditioning	ME402	3	0	3

**Pre-requisite, if any: Thermodynamics**

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

<b>CO1</b>	Understand the basic concepts of refrigeration and their applications.
<b>CO2</b>	Evaluate the performance parameters of different types of refrigeration systems.
<b>CO3</b>	Identify the desirable refrigerant and its use in various refrigeration systems.
<b>CO4</b>	Analyze the psychrometric properties and processes used in Air Conditioning systems.
<b>CO5</b>	Design of Air Conditioning systems for human comfort conditions.

**Syllabus:**

### **INTRODUCTION**

**FUNDAMENTALS OF REFRIGERATION:** Introduction- Necessity and applications, unit of refrigeration and C.O.P-Heat Engine, Refrigerator and Heat pump-Types of Refrigeration systems, and its Applications. **REFRIGERANTS:** Classification of refrigerants- Desirable properties-Nomenclature-Commonly used refrigerants- Alternate refrigerants –Green house effect, global warming. **AIR REFRIGERATION SYSTEM:** Introduction-Air refrigeration system working on Reversed Carnot cycle – Air refrigeration system working on Bell Coleman cycle- COP- Open and Dense air systems, Applications.

### **VAPOUR COMPRESSION REFRIGERATION SYSTEM**

Working principle-Simple vapour compression refrigeration cycle – COP- Representation of cycle on T-s and P-h charts- Effect of Sub cooling and Superheating --Actual Vapour compression cycle and its applications.

**VCR SYSTEM COMPONENTS:** Compressors- Classification -Working -Condensers– Classification - Working-Evaporators –Classification-Working, Expansion devices –Types-Working.

### **OTHER REFRIGERATION SYSTEMS**

**VAPOUR ABSORPTION REFRIGERATION SYSTEM:** Description and working of Aqua- Ammonia system- Calculation of maximum COP- Lithium Bromide- Water system-Principle of operation of three fluid absorption system, Applications.

**STEAM JET REFRIGERATION SYSTEM:** Principle of working –Analysis- Applications. **NON-CONVENTIONAL REFRIGERATION SYSTEMS-** Thermo electric Refrigeration, Vortex tube refrigeration, Adiabatic demagnetization Refrigeration.

### **PSYCHROMETRIC PROPERTIES AND PROCESSES**

Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air-conditioning processes, mixing of air streams.

## **AIR CONDITIONING SYSTEMS**

Introduction-Components of Air conditioning system- Classification of Air conditioning systems-Central and Unitary systems- Summer, Winter and Year round systems- Cooling load estimation. DESIGN OF AIR CONDITION SYSTEMS: Summer air conditioning –ADP-System with Ventilated and re-circulated air with and without bypass factor- RSHF, GSHF and ESHF.

### **Text Book(s) and References:**

1. R. Dossat, Principles of Refrigeration - - Pearson 4<sup>th</sup> Edition 2001
2. Wilbert F.Stoecker, Jerold W. J.Jones, MGH, 1986.
3. ASHRAE Hand book, Fundamentals, 2010
4. JonesW.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2007
5. C. P. Arora. , Refrigeration and air conditioning - TMH, 2<sup>nd</sup> Edition, 2000.
6. S. C. Arora, Domkundwar, A course in refrigeration and air conditioning-Dhanapat Rai& sons 5<sup>th</sup> Edition, 1997

Course Title	Course Code	Structure (I-P-C)		
Automobile Engineering Systems	ME403	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Acquire the basic knowledge of the anatomy of an Automobile and its components.
<b>CO2</b>	Understand the working principles of suspension, transmission, control systems of an automobile.
<b>CO3</b>	Realize the functions of various electrical and electronic systems used in automobiles.
<b>CO4</b>	Understand the role of alternative fuels and pollution free vehicles.

**Syllabus:**

**Introduction:** Principles of Engine operation, engine parts, cooling systems, lubrication systems, fuel systems, Emission standard and Testing.

**Structures:** Construction, function, loading, principles of suspension systems and mechanics.

**Transmission systems:** Clutch, Fly-wheel, Gear boxes-types and construction.

**Vehicle controls:** Steering geometry and types, Brakes- types and construction.

**Auto electrical and electronics:** Battery generator, starting motor, lighting and ignition, Electronic Fuel injection.

**Alternative concepts:** Alternative fuels, basics of electric and hybrid vehicles, fuel cells.

**Text Book(s) and References:**

1. J. Heitner, "Automotive Mechanics", 2nd Edition, CBS Publisher, 2006.
2. H. Heisler, "Advanced Vehicle Technology", 2nd Edition, Butterworth-Heinemann Series, 2002.
3. Kirpal Singh, "Automobile Engineering - Vol I & II", 13<sup>th</sup> Edition, Standard Publishers Distributors, 2014.
4. David A Crolla, "Automotive Engineering", 1st edition, Butterworth-Heinemann series, 2009.
5. "Automotive handbook", 3rd Edition, Robert Bosch GmbH, S.A.E., 1993.

Course Title	Course Code	Structure (I-P-C)		
Designing Intelligent Systems	ME404	3	0	3

**Pre-requisite, if any: Systems Thinking for Design**

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

<b>CO1</b>	Principles of Complex and living systems
<b>CO2</b>	Concepts such as Information intensity & Knowledge
<b>CO3</b>	Introduction to emerging digital technologies
<b>CO4</b>	Apply these ideas in design

**Syllabus:**

Design Metaphors & Patterns (incl biomimetic), Metaphors such as living systems, complex networks, viable systems

Key principles governing living / complex systems (Self-organization, self- production, recursion, fractal)

Increasing information-intensity in products

Concept of information intensity vs material/energy intensity

Self-learning, usage patterns, early warning systems

Using data, voice, collaborative technologies (semantic, big data, speech, Remote-help, Indic computing), Internet-of-things

Synthesizing the above ideas for creative design

Course Title	Course Code	Structure (I-P-C)		
Design for Quality and Reliability	ME405	3	0	3

**Pre-requisite, if any: Nil**

**Course Objective:** The objectives of the course are to help engineering students understand the concepts of quality & reliability and also evaluate the overall reliability of a system from component reliability.

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

<b>CO1</b>	Conclude whether a process is in statistically control state
<b>CO2</b>	Assess the capability of process to meet the design requirement
<b>CO3</b>	Use various probability density distributions significant to reliability calculations
<b>CO4</b>	Calculate the individual component and system reliability
<b>CO5</b>	Assess the ways in which a product/process can fail through conducting FMEA

**Syllabus:**

Concepts of Product Quality, Quality Function Deployment / House of Quality, Six Sigma.

Concepts of Reliability, Basic concepts of repairable and non-repairable systems, Reliability, Availability and Maintainability.

Failure data analysis, Fitting discrete and continuous distributions to failure data sets, Weibull analysis, estimation of important reliability parameters.

Calculation of System Reliability from Component reliabilities, Reliability Logic Diagrams, Fault-tree analysis.

Preventive and Predictive maintenance, Failure Modes and Effects Analysis.

**References:**

1. Louis Cohen, Joseph P. Ficalora, "Quality Function Deployment and Six Sigma: A QFD Handbook", Second Edition, Prentice Hall, 2009.
2. V. N. A.Naik, "Reliability Engineering and Life Testing", PHI Learning, 2010.
3. Singiresu S. Rao, "Reliability Engineering", Pearson Education, 2014.
4. Patrick O Connor, "Practical Reliability Engineering", John Wiley, 2009.
5. B.L. Hansen and P.M. Ghare, "Quality Control and Applications", Prentice Hall, 1997.



Course Title	Course Code	Structure (I-P-C)		
Information Systems in Manufacturing	ME521	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Apply computer models of common engineering information types
<b>CO2</b>	Find importance and be able to critically discuss the role of management information systems
<b>CO3</b>	Extend the information systems roles to design, engineering, and manufacturing problems
<b>CO4</b>	Find engineering data management issues across the extended enterprise.
<b>CO5</b>	Evaluate and determine data management models for all global and local enterprises
<b>CO6</b>	Demonstrate an appreciation of the complex relationship between information systems and organization.

### Syllabus:

**Manufacturing organizations and management:** Networked enterprises, Globalization challenges and opportunities, Dimensions of Information systems

**Approaches to study information system:** Technical and Behavioural approach. Organizations, management, and the networked enterprise: Information systems in global business today, Global e-business: Use of information systems in manufacturing functions, information system, organizations, and strategy, ethical and social issue in information systems.

**Information Technology Infrastructure:** IT Infrastructure and Emerging Technologies, Foundations of Business Intelligence: Databases and Information Management, Telecommunications, the Internet, and Wireless Technology, Securing Information Systems, shop floor communications.

**Key System Applications:** Achieving Operational Excellence and Customer Intimacy: Enterprise Applications, E-Commerce: Digital Markets, Digital Goods, Managing Knowledge and Collaboration, Enhancing Decision Making.

**Smart manufacturing and connected enterprise:** ISA 95, Functional and physical sub-divisions, Global connected supply chain, mass customization, customer co-creation. Case studies of information systems for key manufacturing functions: Life cycle, supply chain, enterprise, quality, maintenance, materials, energy and sustainability information systems.

### Text Book(s) and References:

1. K. Laudon and J. Laudon, Management Information Systems, 14th edition, Pearson Higher Education, 2016, ISBN: 9780136093688.
2. F. Cecelja, Manufacturing Information and Data Systems, 1st edition, Butterworth Heinemann, 2002, ISBN: 9781857180312.
3. T. O. Boucher and A. Yalçın, Design of Industrial Information Systems, 1st edition, Elsevier, 2006, ISBN: 9780123704924.
4. K. E. Kurbel, Enterprise Resource Planning and Supply Chain Management: Functions, Business Processes and Software for Manufacturing Companies, 1st edition, Springer, 2013, ISBN: 9783662509869.
5. R. Zurawski, Integration Technologies for Industrial Automated Systems, 1st edition, CRC Press, 2006, ISBN: 9780849392627.

Course Title	Course Code	Structure (I-P-C)		
Inspection and Testing in Manufacturing	ME522	3	0	3

**Pre-requisite, if any: Engineering Metrology**

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

CO1	Understand each of the testing and inspection methods
CO2	Find the importance and able to critically discuss the need for material testing
CO3	Extend the inspection and testing systems / methods to real time design, engineering, and manufacturing problems
CO4	Find engineering solutions across the extended manufactured component.
CO5	Evaluate and determine suitability and purpose of different testing methods
CO6	Demonstrate a novel method to understand the relationship between design and manufactured component availing NDT techniques.

### Syllabus:

**Types and purposes of testing of manufactured components:** Precautions in inspections, Accuracy of measurement and important terms; Destructive Physical Analysis (DPA): Suitability and purpose;

**Review of Mechanical testing methods:** Tensile Testing (TT); Compression test, Charpy Impact test, Hardness Testing (HT) - Micro and Nano-hardness test, Stress Rupture Testing (SRT); Toughness, Fatigue and Fracture toughness test, Bend test, Creep test, Chemical tests, Macrographs study; ASTM standard test methods: Tensile test, Charpy Impact test, Micro-hardness evaluation, Fracture toughness test, Crack growth rate study, Flexural strength of beam;

**Introduction to NDT:** Visual Optical methods, Dye penetrant testing, Methods of application, Developer; Magnetic particle testing, Magnetization methods, Field indicators, Particle application, Inspection; Eddy current testing, Faraday's law, Inductance, Lenz's law, Self and Mutual Inductance, Impedance plane, Inspection system;

**Acoustics and wave induced material testing:** Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers, Distance and Area calibration, Weld inspection by UT; Acoustic emission testing: Sources of acoustic emission, Source parameters, Kaiser-Felicity theory, Equipment and Data analysis;

**Radiography methods:** X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering; Image formation, Image quality, Digital Radiography, Image interpretation, Radiation Shielding; ASTM standard test method for NTD tests, like Radiographic, Ultrasonic, Electromagnetic (eddycurrent), X-ray, Acoustic and Tomographic techniques; and Comparison and selection of NDT methods.

### Text Book(s) and References:

1. Nondestructive Testing, Louis Cartz, ASM International
2. Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17.
3. Non-Destructive Test and Evaluation of Materials By J Prasad, McGraw Hill, 2017
4. Welding Inspection, American Welding Society, 3rd Ed., 2000
5. The Mechanical Testing of Metals and Alloys By foster, P. Field, Cousens Press, 2007
6. Metals Handbook: Mechanical testing, American Society for Metals, 1978
7. ASTM standards for mechanical test, such as: ASTM E8/E8M (Tension test for metals)
8. ASTM D6110-10 (Charpy impact test), ASTM E9-09 (Compression test), ASTM E139-11 (Creep test)
9. ASTM standards for various non-destructive tests

Course Title	Course Code	Structure (I-P-C)		
Lasers in Manufacturing	ME523	3	0	3

**Pre-requisite, if any:** Basic concepts of manufacturing processes

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

CO1	Understand essential characteristics of lasing materials and principles of lasers.
CO2	Find the importance and able to critically discuss the properties of lasers
CO3	Extend and identify their suitability for various applications.
CO4	Determine the requirement of laser components in different configurations.
CO5	Evaluate and differentiate the lasers required for various material processes and manufacturing
CO6	Demonstrate a laser method with theoretical modeling of the laser material processing extended to the design, manufacturability and economics of a component.

### Syllabus:

**Introduction to Lasers:** Basic principle of laser generation, Stimulated Emission; Properties of laser beam, Industrial, medical and scientific applications of Laser.

**Basic concept of the Laser System:** Gain Medium, Optical Resonator, Pump Source, Laser beam delivery systems; Introduction and basic fundamentals and characteristics of different industrial lasers: He-Ne, CO<sub>2</sub>, Nd:YAG, Excimer, Fiber, Diode and Ultra-short pulse lasers.

**Laser processing fundamentals:** Laser beam interaction with metal, semiconductor and insulator; Ultra-short laser pulse interaction; heat flow theory.

**Laser Material Processing Applications:** process characteristics, mode of material removal: Laser Cutting and Drilling; Laser Welding; Laser Surface Modifications; Laser Additive Manufacturing; Laser Metal Forming; Laser shock peening; Laser Etching and Paint Striping; LCVD and LPVD; Laser hybrid machining; Liquid assisted laser machining: applications and advantages;

**Overview of Industrial & Scientific Applications of laser:** Metrological applications, Holography (Non-destructive Testing), Laser Isotope Separation, Laser fusion ; Theoretical modeling of laser material processing; and Economics of Laser Applications in Manufacturing, Laser safety standards and safety procedures.

### Text Book(s) and References:

1. Laser Fundamentals By William T. Silfvast, Cambridge University Press, New Delhi, 2nd South Asian Edition, 2004.
2. Principles of Lasers By SveltoOrazio, Springer, 5th Ed. 2010
3. Laser Material Processing By W. M. Steen and J. Mazumder, Springer, 4th Ed. 2010.
4. Laser Materials Processing By Elijah Kannatey-Asibu, Jr, Wiley, 2009
5. Laser Fabrication and Machining of Materials By Narendra B. Dahotre&Sandip P. Harimkar, Springer, 2007.

Course Title	Course Code	Structure (I-P-C)		
Digital Manufacturing	ME524	3	0	3

**Pre-requisite, if any:** Basic concepts of manufacturing processes

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

CO1	Understand essential concepts of digital design
CO2	Find the importance and able to critically discuss additive and subtractive digital manufacturing
CO3	Extend and identify their suitability for various shape digitization and manufacturing
CO4	Determine the comprehensive understanding of the digital manufacturing technology
CO5	Evaluate the application and potential in modern manufacturing practices.
CO6	Demonstrate a digital description that is required for direct fabrication of products from raw materials

**Syllabus:**

**Digital design:** Geometrical design of curves, Surfaces and solids, Introduction to computer aided engineering analysis and optimum design. Consideration of manufacturing and assembly aspects in design.

**Shape digitization:** 3D object scanning, Solid reconstruction from point cloud and tessellated data, Downstream applications;

**Digital manufacturing:** Subtractive manufacturing: Basic architecture, Control hardware and software details, Tooling, Sculptured surface machining.

**Additive Manufacturing:** Basics, Hardware details and capabilities of commercial systems, Planning of material addition, Rapid tooling solutions;

**Computer Aided Process Planning:** CAPP and route sheet development, CAPP system, Computer aided plant layout, Computer Aided Production Planning and Control, Algorithms for CAPP.

**Product Database Management Systems:** Types, Management Information System, Manufacturing data preparation, Shop-floor control, automatic identification systems (sensors, trackers), Product life cycle management; and Introduction of Industry 4.0.

**Text Book(s) and References:**

1. Fundamentals of Digital Manufacturing Science, by Z. Zhou, S. Xie, D. Chen, Springer, 2012.
2. Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010.
3. Mastering CAD CAM By Ibrahim Zeid, McGraw Hill, 2005.
4. Automation, production systems, and computer-aided manufacturing By M P Groover, Pearson, 2016.

Course Title	Course Code	Structure (I-P-C)		
Smart Materials and Structures	ME525	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Analyze the behaviour and properties of various smart materials and structures and assess their suitability for different applications.
<b>CO2</b>	Design and develop smart sensors and actuators using appropriate principles of operation and integration techniques with smart materials and structures.
<b>CO3</b>	Apply modeling and simulation techniques to analyze and optimize the performance of smart materials and structures in complex and dynamic environments.
<b>CO4</b>	Develop control strategies for smart materials and structures, including feedback and feedforward control, and optimize their performance using advanced techniques.
<b>CO5</b>	Evaluate emerging trends and developments in smart materials and structures and assess their impact on engineering and other fields.
<b>CO6</b>	Critically evaluate the ethical and societal implications of smart materials and structures and propose solutions to address potential risks and challenges associated with their development and use.

**Syllabus:**

**Fundamentals of Smart Materials and Structures:** Introduction to smart materials and structures; Materials and structures exhibiting smart behavior; Characterization techniques for smart materials and structures; Properties and performance of smart materials and structures; Applications of smart materials and structures in engineering and other fields

**Smart Sensors and Actuators:** Introduction to sensors and actuators; Types of sensors and actuators; Principles of operation and design of sensors and actuators; Applications of smart sensors and actuators; Integration of sensors and actuators with smart materials and structures

**Modeling and Simulation of Smart Materials and Structures:** Introduction to modeling and simulation; Constitutive models for smart materials and structures; Finite element analysis of smart materials and structures; Multiphysics modeling of smart materials and structures; Validation and verification of modeling and simulation results

**Control and Optimization of Smart Materials and Structures:** Introduction to control and optimization; Control strategies for smart materials and structures; Optimization techniques for smart materials and structures; Feedback and feedforward control of smart materials and structures; Applications of control and optimization in smart materials and structures

**Advanced Topics in Smart Materials and Structures:** Emerging trends and developments in smart materials and structures; Bio-inspired and bio-integrated smart materials and structures; Soft robotics and wearable technologies; Advanced fabrication and manufacturing techniques for smart materials and structures; Ethics and societal implications of smart materials and structures

**Text Book(s) and References:**

1. Frecker, M., Inman, D., & Kota, S. (2007). *Smart materials and structures*. Cambridge University Press.
2. Cheng, F. Y. (2005). *Smart structures: Analysis and design*. Cambridge University Press.
3. Fagan, M. J. (2008). *Introduction to smart materials*. CRC Press.
4. Ramaswamy, S., & Raghavan, S. (2017). *Multiphysics modeling: Numerical methods and engineering applications*. John Wiley & Sons.
5. Chattopadhyay, A., & Ganguli, R. (2011). *Control of smart structures: An introduction*. John Wiley & Sons.
6. Laschi, C., & Mazzolai, B. (Eds.). (2016). *Soft robotics: From theory to applications*. Academic Press.

Course Title	Course Code	Structure (I-P-C)		
Design for Manufacturing and Assembly	ME526	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	In-depth understanding on the concepts of Design for Manufacturing
CO2	Find the importance of appropriate design for economical production and selection of the materials
CO3	Extend and emphasise on assemblies using powered and non – powered machine shop equipment in conjunction with mechanical documentation.
CO4	Determine the need/problem identification, competitive benchmarking, and aspects of human factors in DFMA
CO5	Evaluate the application and potential of design in modern manufacturing practices.
CO6	Demonstrate and integrate the knowledge of compliance analysis and interference analysis for assembly and also availing visco-elastic and creep in plastics

**Syllabus:**

**Design methodology and philosophy:** Types of designs, design models, concurrent engineering, and product life cycle.

**Design Teams – Organizations & product Planning:** Need Analysis & Scope- mission statement, customer study, Kano diagram-Establishing Product Function- functional decomposition, FAST and SOP, function structure.

**Product Teardown- reverse engineering:** Product Specifications- product design tools, QFD, Computer Aided Design, Robust design, DFX, DFM, DFA, DFMA, DFSS.

**Design guidelines:** For metallic and non-metallic products to be manufactured by various processes.

**Generation and evaluation of concepts:** TRIZ, Decision matrix etc.

**Industrial Design:** Aesthetics and ergonomic aspects of product design. Value Engineering. Failure mode and effects analysis.

**Text Book(s) and References:**

1. Ashby M.F., Materials Selection in Mechanical Design, Butterworth-Heinemann, (2016).
2. Swift K.G., Booker J.D., Process Selection: From Design to Manufacture, Butterworth-Heinemann , (2003)
3. Dieter G.E., Schmidt L.C., Engineering Design, McGraw-Hill higher education, (1991).
4. Bralla J.G., Handbook for Product Design for Manufacture: A practical guide to low cost production, McGraw-Hill, (1986).
5. Ashby M.F., Johnson K., Materials and Design – the art and science of materials selection in product design, Butterworth-Heinemann, (2014).
6. Courtney T.H., Mechanical Behaviour of Materials, McGraw Hill, (2000).

Course Title	Course Code	Structure (I-P-C)		
Additive Manufacturing	ME527	3	0	3

**Pre-requisite, if any:** Basic concepts of manufacturing processes

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

CO1	In-depth understanding on the concepts of AM, various AM technologies
CO2	Find the importance of appropriate selection of materials for AM, modeling of AM processes
CO3	Extend and emphasise on applications of AM in disparate fields of modern manufactured components.
CO4	Determine the need/problem identification, competitive aspects for which conventional subtractive manufacturing can be replaced with AM techniques.
CO5	Evaluate the application and potential of AM in ability to manufacture 3D objects availing hybrid methods
CO6	Demonstrate and integrate the knowledge of compliance of AM involving planned strategies for post processing methods

### Syllabus:

**Introduction to Additive Manufacturing (AM):** General overview, Introduction to reverse engineering Traditional manufacturing vis AM, Computer aided design (CAD) and manufacturing (CAM) and AM, Different AM processes and relevant process physics, AM process chain Application level: Direct processes–Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing.

**Materials science for AM:** Discussion on different materials used, Use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, Structure property relationship, Grain structure and microstructure.

**AM technologies:** Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, and electron beam melting. involvement), Printing processes (droplet based 3DSolid-based AM processes - extrusion based fused deposition modeling object Stereo lithography Micro- and Nano-additive

**Process selection, planning, control for AM:** Selection of AM technologies using decision methods, Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects.

### Text Book(s) and References:

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
3. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
4. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.



Course Title	Course Code	Structure (I-P-C)		
Materials Fabrication and Characterization	ME528	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand basic principles of the synthesis techniques and fabrication techniques
<b>CO2</b>	Find the importance of appropriate physical, morphological and chemical properties of materials
<b>CO3</b>	Extend and interpret various materials characterization techniques.
<b>CO4</b>	Determine the principle and operation of characterization equipment's and the adjustment of operation variables to obtain good images / results
<b>CO5</b>	Evaluate and compare principle; operation of different characterization tools such as optical microscope, scanning electron microscopes and transmission electron microscope
<b>CO6</b>	Demonstrate and integrate the knowledge of materials by comprehend analysis availing characterization techniques

**Syllabus:**

**Nanopowder synthesis:** Synthesis of nanomaterials: Gold, Silver, different types of Nano oxides, TiO<sub>2</sub>, ZnO by using sol-gel method, Co-precipitation, Hydrothermal, Microwave, Solvothermal and bio synthesis methods, Nanotubes and Nanowires, Carbon nanotubes, Graphene preparation, powder syntheses, crystal growth techniques, zone refining, properties and applications.

**Alloying methods:** Top down and bottom up synthesis- mechanical alloying, Mechanical ball-milling, Ion implantation, Inert gas condensation, Arc discharge, RF-plasma arc technique, Laser ablation, Template assisted synthesis, Clusters, Colloids, Zeolites, Porous silicon.

**Deposition Techniques:** Chemical vapour deposition (CVD), Metal Organic chemical vapour deposition (MOCVD), Epitaxial growth techniques: Molecular beam epitaxy, Atomic layer deposition, Pulsed laser deposition, Pulsed electrochemical deposition, Magnetron sputtering, Spin coating, Introduction to Lithography techniques.

**Material characterization:** Principle, Theory, Working and Application; X-Ray Diffraction, Field Emission Scanning Electron Microscopy, High Resolution-Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Microscopy.

**Advanced characterization:** Photoluminescence Spectroscopy, Raman Spectroscopy, X-Ray Photoelectron Spectroscopy (XPS), Thermal analysis – Differential Scanning Calorimetry (DSC) – Thermogravimetric Analysis (TGA) – Differential Thermal Analysis (DTA) – Dynamic Mechanical Analysis (DMA), Mechanical Testing- Nano Indentation -Vibrating Sample Magnetometer, Zeta Potential and Particle size measurement.

**Text Book(s) and References:**

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.
5. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York.2005.
6. B. D. Cullity, "Elements of X-ray Diffraction", 4th Edition, Addison Wiley,1978.
7. M. H. Loretto, "Electron Beam Analysis of Materials", Chapman and Hall,1984
8. ASM Handbook: Materials Characterization, ASM International, 2008.
9. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2008.
10. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.
11. V. T. Cherapin and A. K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.

Course Title	Course Code	Structure (I-P-C)		
Introduction to Smart Manufacturing	ME529	3	0	3

**Pre-requisite, if any: Basics of computer and manufacturing operations**

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

<b>CO1</b>	Develop a comprehensive understanding of the fundamental principles of smart manufacturing, including cyber-physical systems, data analytics, machine learning, artificial intelligence, and the Internet of Things.
<b>CO2</b>	Gain hands-on experience with programming languages and tools commonly used in smart manufacturing, including Python, R, and MATLAB.
<b>CO3</b>	Develop the ability to apply data mining and machine learning techniques to analyze large-scale data sets in order to improve manufacturing processes.
<b>CO4</b>	Understand the importance of integrating data analytics and machine learning techniques with traditional engineering principles in order to design and optimize manufacturing processes.
<b>CO5</b>	Develop the ability to use simulation and modeling tools to design and test manufacturing processes, and to analyze the impact of different variables on process performance.
<b>CO6</b>	Gain a deeper understanding of the ethical and societal implications of smart manufacturing, including issues related to privacy, security, and automation.

#### **Syllabus:**

**Introduction to Smart Manufacturing:** Overview of smart manufacturing and its benefits; Cyber-physical systems and their role in smart manufacturing; Applications of smart manufacturing in different industries

**Industrial IoT and Smart Sensors:** Introduction to the Internet of Things (IoT) and its role in smart manufacturing; Smart sensors and their importance in collecting data for smart manufacturing; Case studies of IoT and smart sensors in manufacturing.

**Big Data Analytics and Machine Learning:** Introduction to big data analytics and its role in smart manufacturing; Machine learning algorithms and their applications in smart manufacturing; Case studies of big data analytics and machine learning in manufacturing

**Artificial Intelligence and Smart Manufacturing:** Introduction to artificial intelligence and its role in smart manufacturing; AI techniques and their applications in smart manufacturing; Case studies of artificial intelligence in manufacturing

**Digital Twin and Virtual Commissioning:** Introduction to digital twin technology and its role in smart manufacturing; Virtual commissioning and its importance in reducing manufacturing costs and time-to-market; Case studies of digital twin and virtual commissioning in manufacturing.

**Smart Factory and Industry 4.0:** Introduction to Industry 4.0 and its role in smart manufacturing; Smart factory concepts and their applications in Industry 4.0; Case studies of smart factories and Industry 4.0 in different industries

**Cybersecurity and Smart Manufacturing:** Introduction to cybersecurity risks in smart manufacturing; Best practices for securing smart manufacturing systems and data; Case studies of cybersecurity incidents in smart manufacturing.

**Future of Smart Manufacturing:** Emerging trends and technologies in smart manufacturing; Implications of

smart manufacturing for the workforce and society; Opportunities and challenges for companies adopting smart manufacturing

**Text Book(s) and References:**

1. Smart Manufacturing: Concepts and Methods by J. Paulo Davim
2. Cyber-Physical Systems: Integrated Computing and Engineering Design by Fei Hu
3. Modern Manufacturing Engineering: by J. Paulo Davim
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurélien Géron
5. Python for Data Analysis by Wes McKinney
6. Applied Artificial Intelligence: A Handbook For Business Leaders by Mariya Yao, Adelyn Zhou, Marlene Jia
7. Kumar, K., Zindani, D., & Davim, J. P. (2019). Industry 4.0: Developments towards the fourth industrial revolution. Cham, Switzerland: Springer.
8. Cioffi, R., Travaglioni, M., Piscitelli, G., Petrillo, A., & Parmentola, A. (2020). Smart manufacturing systems and applied industrial technologies for a sustainable industry: A systematic literature review. *Applied Sciences*, 10(8), 2897.
9. Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2019). Smart manufacturing: Characteristics, technologies and enabling factors. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 233(5), 1342-1361.

Course Title	Course Code	Structure (I-P-C)		
Processing of Alloys and Composites	ME530	3	0	3

**Pre-requisite, if any: Material science and metallurgy**

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

<b>CO1</b>	Identify and classify different types of composites and soft materials, including their structures and properties.
<b>CO2</b>	Analyze and explain the mechanisms behind different types of phase transformations and their impact on material properties.
<b>CO3</b>	Evaluate and apply various surface engineering techniques to improve the properties and durability of different types of materials.
<b>CO4</b>	Assess and compare the design, structure, and properties of conventional and high entropy materials, including single and multiphase HEAs.
<b>CO5</b>	Analyze and predict the mechanical behavior of materials under different conditions, including stress-strain relationships, fracture, fatigue, and wear.
<b>CO6</b>	Demonstrate proficiency in using different tools and techniques in failure analysis, such as metallographic techniques, fractography, and non-destructive testing.

#### **Syllabus:**

**Composites:** Introduction, classification of composites, strengthening mechanism in composite, types of reinforcements, production methods for reinforcements, metal matrix composites, carbon-carbon composites, ceramic matrix composites, polymer matrix composites, interfaces and interphases, properties.

**Soft Materials:** Introduction to ‘soft’ materials in terms of structure, property- Colloids, foams, gels, liquid crystals, soft biological materials such as DNA, and polymers (synthetic and natural) Structure (states and configuration) of polymers, synthesis, effect of temperature (glass transition and melting), branching, cross-linking on properties, crystallization in polymers (types and mechanism), mechanical behaviour – viscoelasticity -spring dash pod models – relaxation behaviour (time and temperature effect) Self-assembly and Supramolecular organization with reference to cellulose, silk, collagen and biological macromolecules

**Phase Transformations:** Phase stability and free energy of mixing; free energy-composition diagrams and phase diagrams; defects and diffusion; nucleation and growth; liquid-solid, precipitation, disorder-order, spinodal and martensitic phase transformations

**Surface Engineering:** Surface dependent engineering properties, common surface-initiated engineering failures, mechanism of surface degradation, classification and scope of surface engineering in metals, ceramics, polymers and composites, Surface protection and surface modification techniques.

**High Entropy Material:** Conventional vs high entropy alloy (HEA) design, thermodynamic aspects, structure and properties of single and multiphase HEAs, special subclasses of HEAs, high entropy related materials including oxides, carbides, nitrides and borides and their properties.

**Functional and Structural polymers:** Structural polymers, crystallisation in polymers (types and mechanism), mechanical behaviour - viscoelasticity -spring dash pod models - relaxation behaviour (time and temperature effect), functional polymers (conducting polymers, liquid crystalline polymers, polymeric

photonic crystals), characterization- scattering by polymers, flow in polymers- rheology, polymer blends and composites, blending (solubility and compatibility)

**Mechanical Behaviour and Testing:** Mechanical behaviour of composites, stress-strain relations, elastic properties, thermal stresses, strength, fracture, toughness, fatigue, creep and wear

Tools and techniques in failure analysis: General Practices, Photography, X-rays techniques, Mechanical property evaluations, Metallographic techniques, Fractography, Non-destructive testing technique

**Text Book(s) and References:**

1. Young, R.J., and Peter A. Lovell, Introduction to Polymers, 3rd revised edition, CRC Press, 2011.
2. Rudin, A., The Elements of Polymer Science and Engineering, 3rd edition, Academic Press, 2012.
3. Barbero, E.J., Introduction to Composite Materials Design, Second Edition, CRC Press, 2011.
4. Kar, K. K., Composite Materials: Processing, Applications, Characterizations, Springer, 2017.
5. Practical engineering failure analysis, H.M. Tawancy, A. Ul-Hamid and N.M. Abbas, Marcel Dekker, New York, 2004.
6. Introduction to Dislocations, D. Hull and D.J. Bacon, Pergamon Press, Oxford, 1984.
7. Introduction to Microfabrication by Sami Fransilla (Wiley)
8. Koo, J.H., Polymer Nanocomposites: Processing, Characterization, and Applications, McGraw-Hill, 2010.
9. A.J. McEvily, Metal Failures: Mechanisms, Analysis, Prevention, John Wiley and Sons, 2002.
10. Failure analysis and prevention, Volume 11, ASM Handbook, The Materials Information Society, 2002.
11. Failure analysis of engineering structures: Methodology and case histories, V. Ramachandran, A.C. Raghuram, R.V. Krishnan and S.K. Bhaumik, ASM International, 2005.
12. Failure analysis of Engineering Materials, Charles R. Brooks and Ashok Choudhury

Course Title	Course Code	Structure (I-P-C)		
Computer Integrated Manufacturing Systems	ME531	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Analyze and evaluate the key components and architecture of CIM systems, including the role of computers and communication protocols in system integration.
<b>CO2</b>	Design and integrate CIM systems using database and software engineering principles, with a focus on achieving optimal communication and interoperability between different manufacturing systems.
<b>CO3</b>	Demonstrate proficiency in using CIM technologies such as CAD, CAM, FMS, AMHS, robotics, and automated assembly systems to design and implement automated manufacturing processes.
<b>CO4</b>	Apply manufacturing planning and control (MPC) systems to manage and optimize CIM processes, including quality control and inspection techniques.
<b>CO5</b>	Evaluate and assess the impact of human factors on CIM systems, and identify strategies for managing the human-machine interface in automated manufacturing environments.
<b>CO6</b>	Analyze and critique advanced topics in CIM, such as real-time control and monitoring, simulation and optimization, and concurrent engineering, and apply these concepts to design and optimize CIM systems.

**Syllabus:**

**Introduction to CIM Systems:** Definition and evolution of CIM; Advantages of CIM systems; CIM system components and architecture; Role of computers in CIM

**CIM System Design and Integration:** Designing and integrating CIM systems; Role of databases and software engineering in CIM; Communication protocols and standards for CIM integration; Integration of different manufacturing systems

**CIM Technologies:** Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM); Flexible Manufacturing Systems (FMS); Automated Material Handling Systems (AMHS); Robotics and automated assembly systems

**CIM System Management:** Manufacturing Planning and Control (MPC) systems; Quality Control and Inspection in CIM; Maintenance of CIM systems; Human factors in CIM

**Advanced Topics in CIM:** Real-time control and monitoring in CIM; Simulation and optimization of CIM systems; Concurrent engineering and product design in CIM; Integration of CIM with other enterprise systems (ERP, CRM, etc.)

**Text Book(s) and References:**

1. Rehg, J. A., & Kraebber, H. W. (2005). Computer integrated manufacturing. Pearson Education.
2. Groover, M. P. (2014). Automation, production systems, and computer-integrated manufacturing. Pearson Education.
3. Jacobs, F. R., & Berry, W. L. (2011). Manufacturing planning and control for supply chain management. McGraw-Hill.

4. Chang, T. C., & Wysk, R. A. (2017). *Computer-Aided Manufacturing*. CRC Press.
5. Gilchrist, A. (2016). *Industry 4.0: The Industrial Internet of Things*. Wiley.
6. Brown, S. G. B., & Staveland, P. (2019). *Manufacturing Systems Engineering*. CRC Press.



Course Title	Course Code	Structure (I-P-C)		
Industrial Instrumentation & Metrology	ME532	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Demonstrate an understanding of the fundamental principles of instrumentation and metrology, including measurement uncertainty, accuracy, precision, and repeatability.
<b>CO2</b>	Analyze and select appropriate measurement tools and techniques for a given application, taking into account factors such as sensor resolution, sensitivity, and noise.
<b>CO3</b>	Design and implement measurement systems, including data acquisition and signal processing components, that meet specific performance criteria and requirements.
<b>CO4</b>	Evaluate the performance of measurement systems through statistical analysis of data, identification and control of error sources, and estimation of uncertainty.
<b>CO5</b>	Apply knowledge of instrumentation and metrology to solve real-world problems in a range of industrial settings, such as manufacturing, process control, and quality assurance.
<b>CO6</b>	Communicate technical information effectively through written and oral presentations, including formal technical reports and presentations to non-technical audiences.

#### **Syllabus:**

**Introduction to Industrial Instrumentation:** Definition and scope of industrial instrumentation; Types of instruments and their classification; Elements of measuring systems: sensor, transducer, signal conditioning, data acquisition; Performance criteria and accuracy of measuring instruments; Calibration techniques and standards; Trends and recent developments in industrial instrumentation

**Sensors and Transducers:** Introduction to sensors and transducers; Mechanical sensors: force, torque, pressure, and displacement sensors; Optical sensors: fiber optic sensors, photodiodes, and phototransistors; Thermal sensors: thermocouples, RTDs, and thermistors; Chemical sensors: pH sensors, gas sensors, and biosensors; Signal conditioning and amplification of sensor signals

**Signal Processing and Data Acquisition:** Introduction to signal processing and data acquisition  
Analog signal processing techniques: filtering, amplification, and modulation; Digital signal processing techniques: sampling, quantization, and coding; Data acquisition systems: sensors, signal conditioning, and signal digitization; Real-time systems and control applications; Trends and recent developments in signal processing and data acquisition

**Metrology and Quality Control:** Introduction to metrology and quality control; Measurement standards and traceability; Measurement uncertainty and error analysis; Statistical process control and quality assurance; Calibration systems and procedures; Trends and recent developments in metrology and quality control

**Advanced Topics in Industrial Instrumentation:** Introduction to advanced topics in industrial instrumentation; Smart sensors and wireless sensor networks; Industrial automation and control systems; Robotics and mechatronics; Machine vision and image processing; Trends and recent developments in advanced topics in industrial instrumentation

**Text Book(s) and References:**

1. Beckwith, T. G., Marangoni, R. D., & Lienhard V, J. H. (2013). Mechanical measurements. Pearson Education.
2. Doebelin, E. O., & Manik, D. N. (2014). Measurement systems: Application and design. McGraw-Hill Education.
3. Helfrick, A. D., & Cooper, W. D. (2016). Modern electronic instrumentation and measurement techniques. Pearson Education.
4. Jones, D. A., & Hawkins, G. A. (2014). Engineering metrology. John Wiley & Sons.
5. Bar-Cohen, Y. (Ed.). (2018). Measurement, instrumentation, and sensors handbook: Electromagnetic, optical, radiation, chemical, and biomedical measurement. CRC Press.
6. Jayaraman, K., & Brown, R. G. (Eds.). (2015). Handbook of dimensional measurement. John Wiley & Sons.

Course Title	Course Code	Structure (I-P-C)		
MEMS/NEMS and Sensors	ME533	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the fundamental principles and technologies of MEMS/NEMS and sensors, including their design, fabrication, and characterization.
<b>CO2</b>	Analyze the various types of MEMS/NEMS and sensors, including their advantages, limitations, and applications.
<b>CO3</b>	Design and optimize MEMS/NEMS and sensors for specific applications, using analytical and simulation tools.
<b>CO4</b>	Evaluate the performance of MEMS/NEMS and sensors through experimental testing and measurement techniques and interpret the results.
<b>CO5</b>	Apply knowledge of MEMS/NEMS and sensors to real-world problems and propose innovative solutions.
<b>CO6</b>	Communicate effectively, both orally and in writing, about MEMS/NEMS and sensors concepts, designs, and results, to both technical and non-technical audiences.

#### **Syllabus:**

**Introduction to MEMS/NEMS and Sensors;** Fundamentals of MEMS/NEMS and sensors; History and evolution of MEMS/NEMS and sensors; Applications of MEMS/NEMS and sensors; Market trends and future directions

**Fabrication and Packaging Techniques:** Silicon-based fabrication techniques; Non-silicon based fabrication techniques; Thin film deposition techniques; Surface and bulk micromachining; Packaging techniques for MEMS/NEMS and sensors

**MEMS/NEMS and Sensor Design:** Design considerations for MEMS/NEMS and sensors; Mechanical design of MEMS/NEMS devices; Electrical design of MEMS/NEMS and sensors; Sensing mechanisms and transduction principles; Design of microfluidic systems for sensors

**Characterization and Testing of MEMS/NEMS and Sensors:** Static and dynamic characterization of MEMS/NEMS devices; Electrical testing and calibration of sensors; Optical and thermal characterization techniques; Reliability testing and failure analysis of MEMS/NEMS and sensors

**Emerging Trends in MEMS/NEMS and Sensors:** MEMS/NEMS for biomedical applications; MEMS/NEMS for energy harvesting and storage; MEMS/NEMS for environmental monitoring; NEMS and beyond: Carbon nanotubes and graphene-based devices; Sensor fusion and integrated systems for IoT and smart applications.

#### **Text Book(s) and References:**

1. Madou, M. J. (2011). Fundamentals of microfabrication and nanotechnology (3rd ed.). CRC Press.
2. Maluf, N. I., Williams, K. R., & Muller, R. S. (2004). An introduction to microelectromechanical systems engineering (2nd ed.). Artech House.

3. Sze, S. M., & Lee, M. (2017). *Nanoelectronics and nanosystems: From transistors to molecular and quantum devices*. Wiley.
4. Hsu, W. H., & Tai, Y. C. (2011). *MEMS and microsystems: Design, manufacture, and nanoscale engineering*. Wiley.
5. Gardner, J. W., & Varadan, V. K. (Eds.). (2001). *Microsensors, MEMS, and smart devices*. Wiley.
6. Bhushan, B. (Ed.). (2018). *Handbook of nanomaterials properties*. Springer.

Course Title	Course Code	Structure (I-P-C)		
Metal Forming	ME534	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the fundamental principles of metal forming, including deformation mechanisms, flow stress, and material behavior.
<b>CO2</b>	Analyze and design various metal forming processes, such as rolling, forging, extrusion, and sheet metal forming, based on material properties and process parameters.
<b>CO3</b>	Apply numerical modeling techniques, such as finite element analysis, to predict and optimize the behavior of metal forming processes.
<b>CO4</b>	Develop expertise in the use of metal forming equipment and tools, including presses, dies, and tooling.
<b>CO5</b>	Understand the principles of process monitoring and control in metal forming, including sensors, actuators, and feedback systems.
<b>CO6</b>	Apply the principles of metal forming to specific applications, such as the automotive industry, aerospace, and medical devices, and evaluate the advantages and limitations of different metal forming techniques for these applications.

**Syllabus:**

**Fundamentals of Metal Forming:** Introduction to metal forming processes; Classification of metal forming processes; Characteristics of metals and alloys for forming; Deformation mechanisms in metal forming; Friction and lubrication in metal forming

**Bulk Forming Processes:** Rolling processes and applications; Forging processes and applications; Extrusion processes and applications; Drawing processes and applications; Stretch forming processes and applications

**Sheet Metal Forming Processes:** Introduction to sheet metal forming; Bending and forming of sheet metal; Deep drawing of sheet metal; Hydroforming of sheet metal; Superplastic forming of sheet metal

**Special Metal Forming Processes:** Introduction to special metal forming processes; Explosive forming; Electromagnetic forming; Incremental forming; Powder metallurgy processes; Joining processes in metal forming

**Modeling, Simulation, and Optimization of Metal Forming Processes:** Introduction to modeling, simulation, and optimization; Finite element analysis of metal forming processes; Process modeling and design optimization; Process monitoring and control; Emerging trends and developments in metal forming

**Text Book(s) and References:**

- Hosford, W. F., & Caddell, R. M. (2011). Metal forming: Mechanics and metallurgy. Cambridge University Press.
- Sahai, Y. (2016). Fundamentals of metal forming technology. CRC Press.
- Boljanovic, V., & Singh, J. (2010). Sheet metal forming processes and die design. Industrial Press Inc.
- Altan, T., & Tekkaya, A. E. (2012). Metal forming analysis. Butterworth-Heinemann.
- Trent, E. M. (2010). Precision metal forming. CRC Press.
- Müller, U., & Schubert, A. (2015). Joining processes in the automotive industry: Development, modeling, and optimization. Springer.

Course Title	Course Code	Structure (I-P-C)		
Total Quality Management	ME535	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the principles and practices of Total Quality Management, including the historical development of TQM and its impact on organizations.
<b>CO2</b>	Develop skills in statistical process control and quality measurement techniques, including the use of tools such as Pareto charts, histograms, and control charts.
<b>CO3</b>	Analyze the impact of quality management on organizational performance, including the relationship between TQM and customer satisfaction, employee engagement, and financial outcomes.
<b>CO4</b>	Identify strategies for implementing TQM in a variety of organizational settings, including manufacturing, service, and healthcare industries.
<b>CO5</b>	Evaluate the role of leadership and organizational culture in successful TQM implementation, including the importance of effective communication, training, and continuous improvement.
<b>CO6</b>	Apply TQM principles and practices in a real-world setting through case studies, simulations, and/or research projects, demonstrating the ability to identify problems, analyze data, and develop and implement solutions to improve organizational performance.

**Syllabus:**

**Introduction to TQM:** Historical perspective of TQM; Definition and principles of TQM; Quality gurus and their contributions; Importance of TQM in today's business environment

**Mathematical details:** Statistical quality control techniques such as control charts, process capability indices, and acceptance sampling plans will be covered. Students will learn to use statistical software packages for analyzing quality data.

**TQM Tools and Techniques:** Process mapping and analysis; Statistical process control; Failure mode and effects analysis; Quality function deployment; Root cause analysis

**Mathematical details:** Students will learn to apply statistical process control techniques such as control charts, process capability indices, and statistical hypothesis testing to monitor and improve processes. They will also learn to use quality function deployment tools to identify customer requirements and translate them into design specifications.

**TQM Implementation:** Creating a quality culture; Employee involvement and empowerment; Leadership and management commitment; Continuous improvement and problem-solving; Benchmarking and best practices

**Mathematical details:** Students will learn to use statistical techniques to identify and prioritize quality improvement opportunities. They will also learn to use process improvement tools such as process flow charts, cause-and-effect diagrams, and Pareto charts.

**TQM and Business Strategy:** Strategic planning and deployment; Customer focus and satisfaction; Supplier management and partnerships; Performance measurement and metrics; Alignment with organizational goals

and objectives

**Mathematical details:** Students will learn to use statistical methods to analyze customer satisfaction data and to develop performance metrics that align with organizational goals and objectives.

**TQM and Organizational Change:** Change management principles and practices; Resistance to change and how to overcome it; Developing a change management plan; Communication strategies for change; Sustaining TQM initiatives over time

**Mathematical details:** Students will learn to use statistical process control techniques to monitor the effectiveness of change management initiatives and to identify opportunities for improvement.

**Text Book(s) and References:**

1. Goetsch, D. L., & Davis, S. B. (2021). Quality management for organizational excellence: Introduction to total quality (9th ed.). Pearson.
2. Liker, J. K. (2004). The Toyota way: 14 management principles from the world's greatest manufacturer. McGraw-Hill.
3. Juran, J. M., & De Feo, J. A. (2010). Juran's quality handbook: The complete guide to performance excellence (6th ed.). McGraw-Hill.
4. Dale, B. (2015). Total quality management. John Wiley & Sons, Ltd.
5. Oakland G. F. Total Quality Management, Oxford, 2003.
6. S. S. Singh, Total quality control essentials by McGraw Hill Inc.93 Singapore.

Course Title	Course Code	Structure (I-P-C)		
Nano Finishing Science and Technology	ME536	3	0	3

**Pre-requisite, if any: Material science and metallurgy**

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

<b>CO1</b>	Understand the principles and concepts of nano finishing, including surface metrology, tribology, and surface integrity at nanoscale.
<b>CO2</b>	Demonstrate knowledge of advanced finishing processes, such as abrasive flow machining, electrochemical polishing, magnetic abrasive finishing, and superfinishing.
<b>CO3</b>	Develop an understanding of nanomaterials and their applications in nano finishing, including surface modification and nanoparticle-assisted finishing.
<b>CO4</b>	Apply surface characterization techniques, such as atomic force microscopy and X-ray photoelectron spectroscopy, to measure surface roughness, energy, and adhesion at nanoscale.
<b>CO5</b>	Analyze the economic and environmental aspects of nano finishing, and evaluate its industrial applications in sectors such as aerospace, automotive, biomedical, and electronics.
<b>CO6</b>	Demonstrate proficiency in writing technical reports, presenting research findings, and working collaboratively in a team environment.

#### **Syllabus:**

**Fundamentals of Nano Finishing:** Introduction to nano finishing science and technology; Principles of surface metrology and characterization; Surface roughness and its measurement at nanoscale; Fundamentals of surface integrity and tribology; Overview of conventional and non-conventional finishing processes

**Advanced Finishing Processes:** Principles and applications of advanced finishing processes, such as abrasive flow machining, electrochemical polishing, and magnetic abrasive finishing; Surface nanocrystallization and its applications; Chemical mechanical polishing and planarization; Magnetorheological finishing and polishing; Superfinishing and ultraprecision machining

**Nanomaterials and Nanofinishing:** Introduction to nanomaterials and their properties; Role of nanomaterials in nano finishing; Surface modification of nanomaterials; Nanoparticle assisted finishing; Surface functionalization using nanomaterials

**Surface Metrology and Characterization Techniques:** Advanced surface metrology techniques, such as atomic force microscopy, scanning electron microscopy, and X-ray photoelectron spectroscopy; Surface energy and wettability measurements; Contact mechanics and surface adhesion; In situ characterization techniques for nano finishing; Surface texture analysis and machine vision

**Applications of Nano Finishing:** Industrial applications of nano finishing in sectors such as aerospace, automotive, biomedical, and electronics; Advancements in nano finishing for additive manufacturing; Nano finishing for micro/nano-electromechanical systems; Nano finishing for surface patterning and functionalization; Economic and environmental aspects of nano finishing

#### **Text Book(s) and References:**

1. Bhushan, B. (Ed.). (2008). Springer Handbook of Nanotechnology (3rd ed.). Springer.
2. Luo, X., & Liang, Y. (Eds.). (2018). Nanofinishing Science and Technology: Basic and Advanced Finishing and Polishing Processes. CRC Press.



3. Pettersson, M., & Zhou, J. (Eds.). (2018). Handbook of Surface Metrology. Springer.
4. Zhang, X., & Wang, J. (Eds.). (2016). Nanomaterials in Advanced Manufacturing and Engineering Applications. Springer.
5. Jain, V. K. (2013). Advanced Machining Processes. Allied Publishers Pvt. Ltd.
- Hu, Z. (2014). Micro and Nano Fabrication Technology. McGraw Hill Education.

Course Title	Course Code	Structure (I-P-C)		
Processing of Composites	ME537	3	0	3

**Pre-requisite, if any: Material science and metallurgy**

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

<b>CO1</b>	Understand the principles and concepts of composite materials, including their types, constituents, properties, and applications.
<b>CO2</b>	Demonstrate knowledge of processing techniques for polymer, metal, and ceramic matrix composites, and design considerations for each.
<b>CO3</b>	Analyze the properties and performance of composites and evaluate their suitability for different applications.
<b>CO4</b>	Develop expertise in advanced manufacturing techniques for composites, including additive manufacturing, automation, and process optimization.
<b>CO5</b>	Apply computational tools and simulation techniques to model and analyze the manufacturing process and properties of composites.
<b>CO6</b>	Evaluate the environmental impact of composites manufacturing and identify opportunities to improve sustainability.

#### **Syllabus:**

**Introduction to Composites:** Overview of composites and their types; Constituents of composites; Manufacturing processes for composites; Properties and applications of composites

**Polymer Matrix Composites:** Types of polymer matrix composites; Processing techniques for polymer matrix composites; Properties and performance of polymer matrix composites; Design considerations for polymer matrix composites

**Metal Matrix Composites:** Types of metal matrix composites; Processing techniques for metal matrix composites; Properties and performance of metal matrix composites; Design considerations for metal matrix composites

**Ceramic Matrix Composites:** Types of ceramic matrix composites; Processing techniques for ceramic matrix composites; Properties and performance of ceramic matrix composites; Design considerations for ceramic matrix composites

**Advanced Manufacturing Techniques for Composites:** Additive manufacturing for composites; Automation and robotics for composites manufacturing; Process optimization and control for composites; Sustainability and environmental impacts of composites manufacturing

#### **Text Book(s) and References:**

1. Agarwal, B. D., & Broutman, L. J. (2018). Composite Materials: Science and Engineering (3rd ed.). Springer.
2. Kuo, W. S., & Chern, T. L. (2019). Processing of Polymer Matrix Composites (2nd ed.). Woodhead Publishing.
3. Srivatsan, T. S., & Kumar, R. (2015). Metal Matrix Composites (2nd ed.). CRC Press.
4. Bansal, N. P. (2018). Ceramic Matrix Composites: Materials, Modeling and Technology. John Wiley &

Sons.

5. Gibson, R. F. (2012). *Principles of Composite Material Mechanics* (4th ed.). CRC Press.
6. Kim, N. J. (Ed.). (2019). *Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewellery*. Springer.

Course Title	Course Code	Structure (I-P-C)		
Surface Engineering	ME538	3	0	3

**Pre-requisite, if any: Material science and metallurgy**

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

<b>CO1</b>	Understand the principles and concepts of surface engineering, including surface characterization and modification techniques.
<b>CO2</b>	Demonstrate knowledge of various surface analysis techniques and their applications in characterizing surfaces.
<b>CO3</b>	Analyze the properties and performance of surfaces, and evaluate their impact on material behavior and application.
<b>CO4</b>	Develop expertise in surface modification techniques, and design surfaces with specific properties and functionalities.
<b>CO5</b>	Apply computational tools and simulation techniques to model and analyze the behavior of engineered surfaces.
<b>CO6</b>	Evaluate the performance of surface-engineered materials for various applications and assess their potential for real-world applications.

#### **Syllabus:**

**Introduction to Surface Engineering:** Surface engineering concepts and applications; Types of surfaces and their characteristics; Surface properties and measurement techniques; Surface modification techniques and their applications

**Surface Characterization Techniques:** Surface analysis techniques (e.g., XPS, AFM, SEM, TEM); Microstructural characterization of surfaces; Surface texture measurement and analysis; Surface energy and wettability analysis

**Surface Modification Techniques:** Coating and thin film deposition techniques; Surface treatment techniques (e.g., plasma, laser, ion implantation); Surface functionalization techniques (e.g., grafting, self-assembled monolayers); Surface patterning and microfabrication techniques

**Surface Properties and Performance:** Surface properties and their impact on material performance; Surface degradation and failure mechanisms; Surface engineering for improved tribological performance; Surface engineering for enhanced corrosion resistance

**Applications of Surface Engineering:** Surface engineering for biomedical applications; Surface engineering for energy conversion and storage; Surface engineering for electronics and optoelectronics; Surface engineering for environmental protection

#### **Text Book(s) and References:**

1. Rickerby, D. G. (2018). Surface Engineering (2nd ed.). Woodhead Publishing.
2. Roy, D. (Ed.). (2018). Handbook of Surface Engineering and Nanotechnology (3rd ed.). CRC Press.
3. Wang, Q., & Liang, Y. (2019). Surface Modification Technologies XXVIII: Proceedings of the 28th International Conference on Surface Modification Technologies. ASM International.
4. Dowling, D. P. (2018). Surface Science: An Introduction (2nd ed.). John Wiley & Sons.

5. Li, X. (2019). *Advances in Surface Engineering*. Springer.
6. Khang, G., Lee, H., & Kim, B. S. (Eds.). (2017). *Surface Modification Technologies XV: Proceedings of the 15th International Conference on Surface Modification Technologies*. ASM International.

Course Title	Course Code	Structure (I-P-C)		
Modern Manufacturing Technologies	ME539	3	0	3

**Pre-requisite, if any: Basic concepts of Manufacturing**

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

<b>CO1</b>	Understand the fundamental principles of modern manufacturing technologies, including their advantages and limitations, and how to select the appropriate process for a given application.
<b>CO2</b>	Develop expertise in advanced machining processes, additive manufacturing, smart manufacturing, and materials processing and forming, including the ability to design, analyze, and optimize manufacturing processes and systems.
<b>CO3</b>	Gain practical experience in using modern manufacturing tools and techniques, such as computer-aided design (CAD), computer-aided manufacturing (CAM), and numerical simulation software.
<b>CO4</b>	Analyze and evaluate the impact of modern manufacturing technologies on society, including their economic, environmental, and ethical implications.
<b>CO5</b>	Communicate effectively about modern manufacturing technologies, including the ability to write technical reports and give oral presentations.
<b>CO6</b>	Develop the skills needed to continue learning about modern manufacturing technologies and keep up with advancements in the field throughout their careers.

**Syllabus:**

**Fundamentals of Metal Forming:** Introduction to metal forming processes; Classification of metal forming processes; Characteristics of metals and alloys for forming; Deformation mechanisms in metal forming; Friction and lubrication in metal forming

**Introduction to Modern Manufacturing Technologies:** Overview of modern manufacturing technologies and their applications; Trends and challenges in modern manufacturing; Classification and selection of modern manufacturing processes; Process planning and control in modern manufacturing; Safety and environmental considerations in modern manufacturing

**Advanced Machining Processes:** Principles and applications of advanced machining processes, such as ultrasonic machining, electrical discharge machining, and laser machining; Non-traditional machining processes and their advantages and limitations; Micro/nano-scale machining techniques and their applications; Advanced tool materials and coatings for machining; Machining of difficult-to-machine materials and complex shapes

**Additive Manufacturing and 3D Printing:** Principles and applications of additive manufacturing and 3D printing; Types of additive manufacturing technologies and their advantages and limitations; Materials and processes for additive manufacturing; Design for additive manufacturing and topology optimization; Post-processing and finishing of additively manufactured parts

**Smart Manufacturing and Industry 4.0:** Principles and applications of smart manufacturing and Industry 4.0; Cyber-physical systems and the Internet of Things in manufacturing; Advanced sensors and data analytics in manufacturing; Digital twins and virtual manufacturing; Applications of smart manufacturing and Industry 4.0 in various industries

**Materials Processing and Forming:** Principles and applications of materials processing and forming  
Advanced metal forming processes and techniques, such as high-speed forming and hydroforming  
Polymer processing techniques, such as injection molding and extrusion; Composite materials processing and manufacturing; Process monitoring and control in materials processing and forming

**Text Book(s) and References:**

1. Kalpakjian, S., & Schmid, S. R. (2014). *Manufacturing Engineering and Technology* (7th ed.). Prentice Hall.
2. El-Wardany, T. I. (2018). *Modern Manufacturing Processes* (1st ed.). CRC Press.
3. Gibson, I., Rosen, D. W., & Stucker, B. (2015). *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing* (2nd ed.). Springer.
4. Lienig, J., & Tolksdorf, R. (2017). *Smart Production: Wertschöpfung durch Geschäftsmodelle* (1st ed.). Springer.
5. Dieter, G. E., & Schmidt, L. C. (2017). *Engineering Design* (5th ed.). McGraw-Hill.
6. Ashby, M. F., Shercliff, H., & Cebon, D. (2019). *Materials: Engineering, Science, Processing and Design* (3rd ed.). Butterworth-Heinemann.

Course Title	Course Code	Structure (I-P-C)		
Mechanical Vibrations and Condition Monitoring	ME541	3	0	3

**Pre-requisite(s): Dynamics of Machines.**

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

CO1	Understand and apply the maintenance scheme to various industry problems.
CO2	Perform fault analysis, machine condition monitoring and faults diagnostics.
CO3	Use modern testing equipment to identify the faults in machines.
CO4	Understand application of vibration analysis to the condition monitoring of machines.
CO5	Learn techniques in the field of signal processing, thermography, ultrasonics apart from the traditional noise- and vibration-based monitoring.

### Syllabus:

Types of maintenance, preventive and corrective maintenance, preventive maintenance – time based & condition-based condition monitoring, cost effectiveness & performance monitoring, different condition monitoring techniques - on-line and off-line techniques.

Various techniques for fault detection, visual inspection, crack detection techniques: magnetic crack detection and radiography, oil analysis, wear particle analysis, ferrography, ultrasonic crack detection, thermography. Non-destructive techniques – important features, types of defects detected by NDT – visual, dye penetration, acoustic emission and its applications, X-ray, radiographic, magnetic flux test etc, application of NDT techniques.

Vibration data collection, techniques, instruments, vibration analysis of rotating machines and mechanical systems, faults diagnosed by vibration analysis, noise monitoring, temperature monitoring, pressure monitoring.

Signal analysis and computer aided data acquisition, time domain signal analysis, frequency domain signal analysis, spectrum analysis, fault detection transducers and instrumentation.

Applications of condition monitoring in mechanical systems, cutting tools and machine tools condition monitoring, IC engine condition monitoring, power plant condition monitoring, 3D printing condition monitoring, rotating machines condition monitoring.

### Textbook(s) and Reference(s):

1. R. Collacott, "Mechanical Fault Diagnosis and Condition Monitoring," Springer.
2. R. Barron, "Engineering Condition Monitoring Practice, Methods and Applications," Addison, Wesley Longman.
3. P. Girdhar, "Machinery vibration analysis and predictive maintenance," Elsevier.
4. R. Isermann, "Fault-Diagnosis Applications," Springer.
5. A. Ghosh and A. K. Mallik, "Theory of Mechanism and Machines," Affiliated East –West Press Private Ltd., 2009.



Course Title	Course Code	Structure (I-P-C)		
Mechanical Vibrations	ME542	3	0	3

**Pre-requisite(s): Dynamics of Machines.**

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

<b>CO1</b>	Understand the free and forced vibration of single and multi-degree-of-freedom systems.
<b>CO2</b>	Understand the working principle of vibration measuring instruments.
<b>CO3</b>	Mathematically model vibration problems and to mitigate vibration effects.
<b>CO4</b>	Design and develop vibration absorbers, dampers and vibration isolators.
<b>CO5</b>	Analyze the vibration of continuous systems such as shaft, rod and beams.

**Syllabus:**

**Single degree-of-freedom systems:** formulation, energy method, Newton-Euler method, free vibration, undamped and damped free vibration, forced vibration, harmonic excitation, solution of differential equation of motion, vector approach, complex frequency response, magnification factor, resonance, force transmissibility, displacement transmissibility, vehicular suspension, vibration measuring instruments.

**Multi degree-of-freedom systems:** the eigenvalue problem and its solution, natural frequencies and mode shapes, orthogonality, generalized coordinates, response to initial conditions and typical excitation forms, proportional and modal damping.

**Continuous systems:** MDOF systems as a limiting case of continuous systems, lumped parameter analysis and discretization, mass and stiffness operators for continuous systems as analogues to matrices for MDOF systems.

**Classic examples of one-dimensional continuous systems:** strings, rods, beams, derivation and solution of equations of motion, response to typical boundary conditions and excitation forms.

Two-dimensional continuous systems such as plates and membranes.

**Textbook(s) and Reference(s):**

1. L. Meirovitch, "Fundamentals of Vibrations," McGraw-Hill, 2002.
2. J.P. Den Hartog, "Mechanical Vibrations," Dover, 1985.
3. S.S. Rao, "Mechanical Vibrations," Pearson, 2003.
4. A. Leissa, "Vibrations of Continuous Systems," McGraw-Hill, 2011.
5. W.T. Thomson, "Theory of Vibration with Applications," Pearson, 2008.

Course Title	Course Code	Structure (I-P-C)		
Advanced Solid Mechanics	ME543	3	0	3

**Pre-requisite, if any: Mechanics of Materials**

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

<b>CO1</b>	Apply the stress-strain relations for linearly elastic members using normal stress, shear stress and distortion energy theories.
<b>CO2</b>	Analyse the mechanical structures using energy methods.
<b>CO3</b>	Design straight beams, curved and asymmetrical bending of beams
<b>CO4</b>	Analyse the beams under unsymmetrical loading.
<b>CO5</b>	Apply shear centre of thin wall beams, torsion & axisymmetric problems

**Syllabus:**

**Analysis of Stress** – Traction vector, stress tensor, Principle stresses, Hydrostatic and deviatoric stresses

**Analysis of Strain** – displacement field, deformation tensor, strain tensor, principle strain

Stress-Strain Relations for Linearly Elastic Solids-Anisotropic, isotropic behaviour

**Theories of Failure:** Significance of the theories of failure, Factor of safety in design.

**Energy Methods:** Hooke's law and the principle of superposition, Work done by forces and elastic strain energy stored, Reciprocal theorem, First theorem of Castigliano, Theorem of virtual work.

**Bending of Beams:** Straight beams and asymmetrical bending, Bending of curved beams.

**Torsion & Axisymmetric Problems:** Torsional of general prismatic bars-solid sections, Stresses in composite tubes, Thermal Stresses.

**Text Book(s) and References:**

1. Irving H. Shames, "Mechanics of Deformable Solids", Krieger Pub Co, 2008.
2. L.S. Srinath, "Advanced Mechanics of Solids", 3rd Edition, TMH, 2009.

Course Title	Course Code	Structure (I-P-C)		
IC Engines and Gas Turbines	ME545	3	0	3

**Pre-requisite, if any: Thermodynamics**

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

<b>CO1</b>	Solve problems on engine performance parameters.
<b>CO2</b>	Identify different types of dynamometers.
<b>CO3</b>	Understand the combustion process, carburetion of engines.
<b>CO4</b>	Understand the working of gas turbines and its performance.
<b>CO5</b>	Understand the working of jet propulsion and its parameters.

**Syllabus:**

**I.C. Engines :** Energy conversion, basic engine components, Working principle of engines - two stroke and four stroke engines, SI and CI engines, Classification of I.C. Engines, Valve and port timing diagrams, comparison of two stroke and four stroke engines, comparison of SI and CI engines, application of I.C engines. Engine Performance Parameters: The First law analysis of engine cycle, Brake power, indicated power, friction power, mean effective pressure, engine efficiencies, performance calculations, Heat balance.

**Measurements and Testing:** Measurement of Brake power – Rope brake, hydraulic, Eddy current and swinging field DC dynamometers; Friction power – Willian’s line method, Morse test, motoring test and retardation test.

**Combustion in S.I Engines:** Homogeneous and heterogeneous mixtures, principle of carburetion, stages of combustion in S.I Engines, knocking. Combustion in C.I Engines: Disintegration of fuel jet, stages of combustion, knocking. Super Charging: types of superchargers, advantages and limitations of super charging.

**Reciprocating air Compressors:** Introduction and classification of compressors, mechanical details and working principle of a single stage reciprocating compressor, equation for work, effect of clearance volume, isothermal, adiabatic, and volumetric efficiencies, two-stage compression, Condition for minimum work. Centrifugal & Axial flow Compressors: introduction, essential parts of a centrifugal compressor, principle of operation. – Introduction to axial flow compressor, geometry and working principle.

**Gas Turbines:** Simple Gas Turbine, ideal cycle, essential components, open and closed cycle arrangements, requirements of working medium, applications of Gas Turbines, comparison of Gas Turbines with reciprocating engines, work output and efficiency of a simple Gas Turbine cycle, optimum pressure ratio for maximum specific output, Gas Turbines with regeneration, reheating and intercooling.

**Jet Propulsion:** Introduction to Propeller engines and Gas Turbine engines, working principle of Ramjet engine, Pulse jet engine, Turboprop engine and Turbojet engine, Thrust and thrust equation, specific thrust, parameters affecting flight performance, introduction to Rocket propulsion, classification of Rockets and principle of Rocket propulsion.

**Text Book(s) and References**

1. V.Ganeshan, Internal Combustion Engines, TMH Publishers, 4<sup>th</sup> Edition, 2017.
2. V.Ganeshan, Gas Turbines, TMH Publishers, 3<sup>rd</sup> Edition, 2017.
3. Heywood John, , IC Engines Fundamentals, TMH Publishers, 2<sup>nd</sup> Edition, 2018.
4. Ferguson, Internal Combustion Engines, John Wiley Publisher, 2<sup>nd</sup> Edition, 2009.
5. Herb Saravana muttoo, Gas Turbine Theory, Prentice Hall Publisher, 6<sup>th</sup> Edition, 2008.

Course Title	Course Code	Structure (I-P-C)		
Computational Fluid Dynamics	ME546	3	0	3

**Pre-requisite, if any: Fluid Mechanics, Heat Transfer**

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

<b>CO1</b>	Formulate the basic fluid dynamics problem mathematically
<b>CO2</b>	Analyze the mathematical behavior of partial differential equations
<b>CO3</b>	Understand various solution methodologies.
<b>CO4</b>	Apply the FDM and FVM techniques to solve heat transfer problems.
<b>CO5</b>	Solve the elementary incompressible fluid problems using the CFD techniques

**Syllabus:**

Basics of Computational fluid dynamics, Governing equations of fluid mechanics and heat transfer, Physical boundary conditions - elliptic, parabolic, and hyperbolic equations, Finite different formulation, stability analysis.

Finite difference and finite volume formulation of steady/transient one-dimensional conduction equation, grid generation.

Finite volume formulation of steady one-dimensional convection and diffusion problems, central, upwind, hybrid and power-law schemes; Discretization equations for two-dimensional convection and diffusion.

Solution methodologies: Direct and iterative methods, Thomas algorithm, relaxation method, alternating direction implicit method.

Numerical methods for Navier-Stokes equation - Turbulence models: mixing length model, Two equation (k-epsilon) model.

**Text Book(s) and References:**

1. Patankar. S. V, "Numerical Heat Transfer and Fluid Flow", CRC Press, 1980.
2. H. Versteeg, W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2nd Edition, PHI, 2007
3. J. D. Anderson, "Computational Fluid Dynamics - Basics with Applications", Mc Graw Hill, 1995.
4. K. Muralidhar, T. Sundararajan, "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, 1995.
5. T. K. Sengupta, "Fundamentals of Computational Fluid Dynamics", University Press, 2004.

Course Title	Course Code	Structure (I-P-C)		
Optimization techniques for Mechanical Engineers	ME547	3	0	3

**Pre-requisite, if any: Calculus, Differential Equations**

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

<b>CO1</b>	Familiarize with the curve fitting techniques.
<b>CO2</b>	Understand the concepts and need for optimisation.
<b>CO3</b>	Familiarize with the various calculus and search techniques of optimisation problems.
<b>CO4</b>	Familiarize with the Non-traditional optimisation techniques.

**Syllabus:**

**Introduction:** Introduction to system design, Morphology of design with a flow chart, Concept of workable design, practical example on workable system and optimal design.

**System Simulation:** Successive substitution method, Newton Raphson method: One and Multiple unknowns, Gauss Siedel method, Rudiments of finite difference method for partial differential equations, with examples.

**Regression and Curve Fitting:** Need for regression in simulation and optimization; Concept of best fit and exact fit; Concept of least square regression fit; Gauss Newton method for nonlinear least squares regression

**Optimization:** Basic ideas, Need for optimisation, formulation, graphical method, linear programming problems, simplex method, Types of optimisation problems: Calculus methods; Lagrange multipliers, search techniques, local and global optimum.

**Non-traditional optimization techniques:** Genetic Algorithms, Simulated Annealing, Particle swarm optimisation algorithm, Artificial Neural networks.

**Text Book(s) and References:**

1. C. Balaji, "Essentials of Thermal System Design and Optimization", 2nd Edition, Ane Books, 2019.
2. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", 2nd edition, Prentice Hall India, 2012.
3. S. S. Rao, " Engineering Optimization: Theory and Practice", 4th edition, John Wiley & Sons, 2009
4. Yogesh Jaluria, "Design and Optimization of Thermal Systems", McGraw Hill, 1998.

Course Title	Course Code	Structure (I-P-C)		
Product Design and Development	ME548	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand overall awareness of the product design process
<b>CO2</b>	Find the importance of tools and principles applied in industries for the design and development of the product.
<b>CO3</b>	Extend and emphasise on methodologies for various steps of product design such as user study
<b>CO4</b>	Determine the need/problem identification, competitive benchmarking, and aspects of human factors in product design
<b>CO5</b>	Evaluate the application and potential of design in modern manufacturing practices.
<b>CO6</b>	Demonstrate a creative concept, generation of suitable design and prototyping/modelling for modern manufacturing practices

**Syllabus:**

**Design methodology and philosophy:** Types of designs, design models, concurrent engineering, and product life cycle.

**Design Teams – Organizations & product Planning:** Need Analysis & Scope- mission statement, customer study, Kano diagram-Establishing Product Function- functional decomposition, FAST and SOP, function structure.

**Product Tear down- reverse engineering:** Product Specifications- product design tools, QFD, Computer Aided Design, Robust design, DFX, DFM, DFA, DFMA, DFSS.

**Design guidelines:** For metallic and non-metallic products to be manufactured by various processes.  
**Generation and evaluation of concepts:** TRIZ, Decision matrix etc.

**Industrial Design:** Aesthetics and ergonomic aspects of product design. Value Engineering. Failure mode and effects analysis.

**Text Book(s) and References:**

1. Eppinger, S, Ulrich, K, Product design and development, McGraw-Hill, (2000).
2. Kevin Otto, Kristin Wood, Product design, Pearson, (2004).
3. George E. Dieter, Engineering Design, McGraw Hill, (2000).
4. David G Ullman, The Mechanical Design Process, McGraw Hill, (2003).

Course Title	Course Code	Structure (I-P-C)		
Computational Tools for Engineers	ME549	3	0	3

**Pre-requisite, if any: Basic concepts of computers**

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

<b>CO1</b>	Determine numerical methods used in linear algebra for optimizing manufacturing processes.
<b>CO2</b>	Analyze behavior of manufacturing processes under different conditions using numerical methods for solving nonlinear algebraic equations.
<b>CO3</b>	Effectively develop accurate models of manufacturing processes using interpolation methods.
<b>CO4</b>	Evaluate manufacturing process performance using numerical differentiation and integration methods.
<b>CO5</b>	Demonstrate the use of numerical methods for solving ordinary differential equations in optimizing manufacturing processes.
<b>CO6</b>	Develop numerical methods for solving partial differential equations to optimize manufacturing processes in complex systems.

**Syllabus:**

**Linear Algebraic Equations:** Direct and iterative solution techniques for simultaneous linear algebraic equations; Gauss elimination, Gauss-Jordon, LU Decomposition, QR Method; Eigenvalues and Eigenvectors; Power and inverse power method, householder transformation; Physical interpretation of eigenvalues and eigenvectors

**Nonlinear Algebraic Equations:** Bisection method, fixed-point iteration method; Newton-Raphson, Secant method; Solution of system of nonlinear algebraic equations

**Interpolation and Numerical Differentiation/Integration:** Polynomial interpolation, Lagrange interpolating polynomial, Hermite interpolation; Interpolation in 2 and 3 dimensions; Finite difference formula using Taylor series; Differentiation of Lagrange polynomials; Simpson's rule, Gauss-quadrature rule, Romberg method; Multiple integrals

**Ordinary Differential Equations:** Euler, Heun's method, and stability criterion; Second order and fourth order Runge-Kutta methods; Adams-Bashforth-Moulton method; System of ODEs and nonlinear ODEs

**Partial Differential Equations:** Classification of PDEs; Elliptic equations; Parabolic equations (Transient diffusion equation); Hyperbolic equations (Wave equation)

**Text Book(s) and References:**

1. S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books
2. Steven C. Chapra, Numerical Methods for Engineering, Mc-Graw Hill Education
3. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001)
4. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press

Course Title	Course Code	Structure (I-P-C)		
Soft Computing Techniques	ME550	3	0	3

**Pre-requisite, if any: MATLAB**

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

<b>CO1</b>	Determine numerical methods used in linear algebra for optimizing manufacturing processes.
<b>CO2</b>	Analyze behavior of manufacturing processes under different conditions using numerical methods for solving nonlinear algebraic equations.
<b>CO3</b>	Effectively develop accurate models of manufacturing processes using interpolation methods.
<b>CO4</b>	Evaluate manufacturing process performance using numerical differentiation and integration methods.
<b>CO5</b>	Demonstrate the use of numerical methods for solving ordinary differential equations in optimizing manufacturing processes.
<b>CO6</b>	Develop numerical methods for solving partial differential equations to optimize manufacturing processes in complex systems.

**Syllabus:**

**Problem Solving Methods and Tools:** Problem Space, Problem solving, State space, Algorithm's performance and complexity, Search Algorithms, Depth first search method, Breadth first search methods their comparison, A\*, AO\*, Branch and Bound search techniques, p type, Np complete and Np Hard problems.

**Evolutionary Computing Methods:** Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Genetic algorithms, Evolutionary strategy, Evolutionary programming, Genetic programming.

**Genetic Algorithm and Genetic Programming:** Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications.

**Swarm Optimization:** Introduction to Swarm intelligence, Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms.

**Advances in Soft Computing Tools:** Fuzzy Logic, Theory and applications, Fuzzy Neural networks, Pattern Recognition, Differential Evolution, Data Mining Concepts, Applications of above algorithms in manufacturing engineering problems.

**Artificial Neural Networks:** Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Back propagation algorithm, factors affecting back propagation training, applications.

**Text Book(s) and References:**

1. Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Springer, 2001.
2. Elaine Rich, Artificial Intelligence, McGraw Hill, 2/e, 1990.
3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, John Wiley and Sons, 2001.



Course Title	Course Code	Structure (I-P-C)		
Big Data Analytics	ME551	3	0	3

**Pre-requisite, if any: Basic Statistics**

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

<b>CO1</b>	Understand the principles of Big Data Analytics and its applications in Smart Manufacturing.
<b>CO2</b>	Acquire skills to collect, store, process, and analyze large volumes of data generated in the manufacturing process using various tools and technologies.
<b>CO3</b>	Learn how to extract insights from Big Data to optimize production processes, increase efficiency, and reduce costs in Smart Manufacturing.
<b>CO4</b>	Gain knowledge of the best practices in data management, data quality, and data governance in the context of Smart Manufacturing.
<b>CO5</b>	Explore the role of Artificial Intelligence, Machine Learning, and Deep Learning in Big Data Analytics for Smart Manufacturing.
<b>CO6</b>	Develop the ability to communicate the results of Big Data Analytics to non-technical stakeholders and make data-driven decisions in Smart Manufacturing.

#### **Syllabus:**

**Introduction to Big Data Analytics:** Introduction to Industry 4.0 and the role of Big Data Analytics; Overview of Big Data Analytics and its challenges and opportunities; Big Data Processing and Architecture for large-scale data analysis

**Data Acquisition and Pre-processing:** Data acquisition and integration from multiple sources; Data pre-processing techniques for large-scale data; Data transformation and cleaning for data quality

**Big Data Analytics Techniques:** Data mining concepts and techniques for pattern discovery; Association rule mining, classification, and clustering for data analysis; Anomaly detection and outlier analysis for quality control; Time series analysis for forecasting

**Big Data Analytics Tools and Technologies:** Apache Hadoop and Spark for distributed processing; NoSQL databases for scalable data storage; Cloud computing platforms for flexible and cost-effective infrastructure; Stream processing frameworks for real-time data analysis; Visualization tools for data presentation

**Applications of Big Data Analytics:** Predictive maintenance for equipment performance and reliability; Quality control and yield optimization for production efficiency; Production planning and scheduling for resource allocation; Supply chain management for logistics and inventory control; Customer relationship management for customer satisfaction and loyalty; Product design and innovation for market insights and trend analysis

#### **Practice:**

Initial few exercises using R on association rule mining, classification, clustering wherein various existing algorithms are tested over benchmark datasets – This shall expose students to the basics of AI perspective over databases. Mapreduce abstraction using the IDE framework, Hadoop, Architecture, Data deduplication storage systems, Venti and DDFS, Shingles and minhashing, locality sensitive hashing, Latent Semantic Indexing, case study for dimensionality reduction, Support for distributed / parallel computing in R, case studies of Clustering in high dimensional space, Web link analysis, Pagerank algorithm, survey / simulation.

**Text Book(s) and References:**

1. A. Rajaraman, J. Leskovec, J. Ullmann, Mining of Massive Data sets, Cambridge University Press, 2011, ISBN: 1107015359.
2. Maheshwari, A. (2018). Data analytics made accessible. Apress.
3. Ammari, H. M. (2016). Big data analytics for sensor-network collected intelligence. CRC Press.
4. Hahn, G. J., & Meeker, W. Q. (2017). Statistical process control and quality improvement. John Wiley & Sons.

Course Title	Course Code	Structure (I-P-C)		
Applied Operations Research	ME552	3	0	3

**Pre-requisite, if any: Linear Algebra**

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

<b>CO1</b>	In-depth understanding on the concepts of AM, various AM technologies
<b>CO2</b>	Find the importance of appropriate selection of materials for AM, modeling of AM processes
<b>CO3</b>	Extend and emphasise on applications of AM in disparate fields of modern manufactured components.
<b>CO4</b>	Determine the need/problem identification, competitive aspects for which conventional subtractive manufacturing can be replaced with AM techniques.
<b>CO5</b>	Evaluate the application and potential of AM in ability to manufacture 3D objects availing hybrid methods
<b>CO6</b>	Demonstrate and integrate the knowledge of compliance of AM involving planned strategies for post processing methods

**Syllabus:**

**Introduction to Operations Research:** Overview of Operations Research and its applications; Modeling and problem formulation; Linear Programming: formulation and graphical solution

**Linear Programming and Optimization:** Linear Programming: Simplex method; Linear Programming: Duality and Sensitivity Analysis; Network Models: Shortest path, minimum spanning tree, maximal flow; Integer Programming: Formulation and solution methods

**Nonlinear Optimization:** Unconstrained optimization: Gradient and Newton's methods; Constrained optimization: Kuhn-Tucker conditions; Nonlinear Programming: Formulation and solution methods; Convex optimization

**Stochastic Processes:** Probability theory and stochastic processes; Markov Chains: Definition and properties; Markov Chains: Stationary distribution and limiting probabilities; Queuing theory: Birth-death process, M/M/1, M/M/S, M/G/1 queues

**Simulation and Decision Analysis:** Monte Carlo Simulation: Sampling techniques, variance reduction, and applications; Decision Analysis: Decision Trees, Payoff Tables, and Expected Value of Perfect Information; Game Theory: Strategic games and Nash Equilibrium; Multi-criteria decision-making methods: Analytical Hierarchy Process (AHP), TOPSIS, GREY, MOORA, ELECTRE,...

**Text Book(s) and References:**

1. Anderson, Sweeny, and Williams, An Introduction to Management Science: Quantitative Approaches to Decision Making, 11th Edition.
  2. Ackoff, R.L. and Sasini, M. W., Fundamentals of Operations Research, Wiley & Sons, New York.
  3. Wagner, H.M., Principle of Operations Research, Prentice Hall, New Jersey.
  4. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill.
- Churchman, C.W.: Introduction to Operations Research John Wiley & Sons New York.

Course Title	Course Code	Structure (I-P-C)		
Digital Control for Automation	ME553	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Students will understand principles of digital control such as Z-transform, sampling, quantization, and linear difference equations and how to apply them to systems.
<b>CO2</b>	Students will be able to analyze the performance and stability of digital control systems.
<b>CO3</b>	Students will be able to design digital control systems to meet desired specifications and demonstrate their implementation with appropriate hardware or software as per the project requirement.
<b>CO4</b>	Students will be able to understand the steps involved in the design of Digital Control for industrial automation.

**Syllabus:**

**Module 1:**

- Introduction to Digital Control for Automation, need for discrete-time control, comparison between Analog and Digital Control, sampling, quantization, data reconstruction and filtering of sampled signals, Review of Z-transforms, z-transform and its properties.

**Module 2:**

- Controllability, observability, control law design, decoupling by state variable feedback, effect of sampling period. Estimator/ Observer Design: full order observers, reduced order observers, regulator design.
- Mathematical modelling of sampling process. Simulation examples- effect of sampling rate. Analysis of filters in discrete domain.

**Module 3:**

- Z-transform analysis of closed loop and open loop systems, multirate Z-transform. Nyquist stability criterion; Stability analysis of closed loop systems in the z-plane: root loci, frequency domain analysis, Stability tests. Discrete equivalents.
- Discrete time Fourier Transform, the relationship between the Fourier Transform and the z-transform.

**Module 4:**

- Digital controller design for SISO systems: design based on root locus method in the z-plane, design based on frequency response method, design of lag compensator, lead compensator, lag lead compensator, design of PID Controller based on frequency response method, direct design, method of Ragazzini.
- 2DOF discrete PID controller- software approach. State space representation in discrete system.

**Module 5:**

- Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations.
- Functional block diagram of computer control systems, alarms, interrupts. Characteristics of digital data, controller software, linearization. Digital controller modes: Error, proportional, derivative and composite controller modes. PLC: Evolution, Components, advantages over relay logic, Architecture, Programming devices, Discrete and Analog I/O modules.

**Module 6:**

Discrete LQR design. Introduction to event triggered systems: examples using state flow technique. Real-Time Applications of Computer Aided Design.

Course Title	Course Code	Structure (I-P-C)		
Non-linear Dynamics	ME554	3	0	3

**Pre-requisite, if any: Linear Algebra**

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

<b>CO1</b>	Interpret the nonlinear dynamical equation geometrically
<b>CO2</b>	Understand the system qualitatively without solving the nonlinear system.
<b>CO3</b>	Understand the deep simplicity in the chaotic system.

**Syllabus:**

Introduction to nonlinear dynamics; Flows on the line – geometrical way of thinking, Linear stability analysis, existence and uniqueness.

Bifurcations – saddle node, trans-critical, pitch fork; Flow on the curve – uniform and non-uniform oscillator

Linear two-dimensional systems – classification; Phase plane – phase portrait, fixed points and linearization, conservative systems.

Limit cycles – Ruling out closed orbits, Poincare – Bendixson theorem, Lienard systems, Relaxation Oscillators, Weakly nonlinear oscillators; Hopf bifurcation, Global bifurcation of cycles, Poincare map

Lorenz equation, chaos on a strange attractor, Lorenz map; 1D maps – Fixed points and cobwebs, Logistic maps, periodic window; Fractals, strange attractors.

**Text Book(s) and References:**

1. Steven H Strogatz, "Nonlinear Dynamics and Chaos", Perseus books, 1994.
2. J D Murray, "Mathematical Biology – an introduction", Springer.

Course Title	Course Code	Structure (I-P-C)		
Operations and Supply Chain Management	ME555	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Understand the importance of Operations and Supply Chain Management.
CO2	Apply forecasting techniques in estimating the number of products.
CO3	Use inventory management techniques to determine the optimum quantity of material.
CO4	Design the factory and plant layout using qualitative and quantitative models.
CO5	Decide the dispatch procedure required for production processes and other activities.
CO6	Understand the applications of information technology in the supply chain.

**Syllabus:**

**Introduction:** Introduction to Operations Management – Challenges, Methodologies

**Forecasting:** Need for forecasting, Qualitative and Quantitative Methods, Time series models – Simple Exponential smoothing, Linear Models, Regression, Holt’s, seasonality, Winter’s model, causal models, Goodness of the forecast.

**Facility layout and location:** Qualitative aspects, Quantitative models for layout decisions, Product, process, position, group layout, Location decisions-quantitative models. Capacity and aggregate planning, Capacity measurement, Long-term and short-term strategies, Aggregate planning.

**Inventory management:** Various costs in inventory management and need, Deterministic models and discounts, Probabilistic inventory management.

**Scheduling models and applications:** Scheduling in MRP system, Sequencing rules and applications, Batch production sequencing and scheduling.

**Introduction to the supply chain:** Definition, complexity, key issues, Centralized vs. decentralized systems.

**Value of information and supply chain integration:** Bullwhip effect, Push-based, pull-based systems. Outsourcing: Make or buy decisions. Transportation decision: Drivers of the decision, Network design decisions, Cross-docking, trans-shipment.

**Distribution and logistics in supply chains:** Direct shipment/intermediate storage policies, Vehicle routing models, Third-party logistics.

**Information technology in the supply chain:** Enabling the supply chain through IT, ERP vendor platforms, Service-oriented architecture (SOA), RFID

**Text Book(s), References and Web Resources:**

1. R. Panneerselvam, Production/Operations Management, Prentice Hall of India Pvt Ltd, 2007.
1. S. N. Chary, Production and Operations Management, TMH, 4th Edition 2010
2. Joseph.G.Monks, Operations Management, McGraw-Hill Inc., 3<sup>rd</sup> Revised edition
3. P.Rama Murthy, Production and Operations Management, New Age International, 2<sup>nd</sup> Edition, 2005.
4. Operations and Supply Chain Management by Prof. G. Srinivasan, IIT Madras  
(<https://nptel.ac.in/courses/110106045>).
5. Operations Management by Prof. Inderdeep Singh, IIT Roorkee  
([https://onlinecourses.nptel.ac.in/noc20\\_me30/preview](https://onlinecourses.nptel.ac.in/noc20_me30/preview)).

Course Title	Course Code	Structure (I-P-C)		
Industry 4.0	ME556	3	0	3

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand what is Industry 4.0 and distinguish various components in Industry 4.0 Environment
<b>CO2</b>	Identify the Challenges of Industry 4.0
<b>CO3</b>	Analyze the Importance and role of Big Data and Analytics
<b>CO4</b>	Importance of Connected Systems and Sensors
<b>CO5</b>	Understand necessary details of IoT, IIoT, 'Cyber Physical Systems (CPS)', Advanced Robotics, Image Processing Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL).

**Syllabus:**

Introduction to Industry Revolutions, Details of Industry 4.0

Sensors, Machine Vision and Connected Systems Analyzing Data and Modeling to Make Sense of Data

Data Analysis, the role of Big Data and Analytics, Control of Manufacturing Systems and Processes

Digital Twin, its importance in Industry 4.0

Impact of Industry 4.0 on various industries

Applications of Collaborative Robots, Image Processing Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL), Augmented Reality and Virtual Reality, in Manufacturing Environment  
Towards Manufacturing as an Autonomous System

**Text Book(s) and References:**

1. Luo, ZongWei, Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence, IGI Global, 2014.
2. Fei Tao, Meng Zhang, A.Y.C. Nee, Digital Twin Driven Smart Manufacturing, Academic Press, 2019.
3. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing the Digital Transformation".
4. Bartodziej, Christoph Jan, "The Concept Industry 4.0".
5. Klaus Schwab, "The Fourth Industrial Revolution".
6. Christian Schröder , "The Challenges of Industry 4.0 for Small and Medium-sized Enterprises"

Course Title	Course Code	Structure (I-P-C)		
Design and Analysis of Experiments	ME557	3	0	3

**Pre-requisite, if any:** Nil

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

CO1	Students will be able to understand the importance of testing and inspections.
CO2	Students will be able to draw the suitability and purpose of different testing methods.

**Syllabus:**

**Introduction to Designed Experiments:** Strategy of experimentation, Typical applications, Basic principles and guidelines for designing experiments.

**Basic statistical concepts:** Descriptive Statistics, Sampling and Sampling Distributions, Tests of Hypotheses.

**Single factor experiments with Fixed Effects:** ANOVA, Model Adequacy Tests, and Orthogonal Contrasts.

**Experiments with Blocking Factors:** Randomised Complete and Incomplete Block Designs, Latin Squares Design.

**Factorial Experiments:**  $2^2$ ,  $3^2$ , and  $2^k$  Designs, Blocking and Confounding, and Fractional Factorial Designs.

**Linear Regression Models:** Estimation of Parameters, Tests of Hypothesis, Regression Model Diagnostics.

**Response Surface Design:** Method of Steepest Ascent, Second-Order Response Surface, Experimental Designs, Computer Models, Mixture Experiments, Evolutionary Operations

**Advanced Design of Experiments:** Random Effects Models, Analysis of Covariance, Non-Normal Response, and Taguchi Methods.

**Text Book(s):**

1. Design and Analysis of Experiments, D. C. Montgomery, John Wiley & Sons, Wiley Student Edition, International Student Version, 7th Edition, 2009.
2. Design of Experiments: An Introduction Based on Linear Models, M. Morris, Chapman & Hall/CRC Texts in Statistical Science, First Edition, 2010.
3. Practical Guide to Designed Experiments: A Unified Approach, P. D. Funkenbusch, CRC Press, 2004.
4. The Theory of the Design of Experiments, D. R. Cox and N. Reid, Chapman and Hall/CRC, 200.
5. Design and Analysis of Experiments A. M. Dean and D. Voss, Springer Texts in Statistics, Second Edition, 2001.