Third Semester					
Theory					
Sl. No.	**Category**	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	**BSC**	**19CM3BS01T**	**Math-III (Probability, Statistics & Numerical Methods)**	**3-0-0**	**3**
2	**HSMC**	**19CM3HS01T/ 19CM3HS02T**	**Engineering Economics/Organizational Behavior**	**3-0-0**	**3**
3	**ESC**	**19CM3ES01T**	**Data Structure using C**	**3-0-0**	**3**
3	**ESC**	**19ME3ES02T**	**Engineering Mechanics**	**3-0-0**	**3**
4	**PCC**	**19ME3PC01T**	**PCC-1: Engineering Thermodynamics**	**3-0-0**	**3**
5	**PCC**	**19ME3PC02T**	**PCC-2: Introduction to Physical Metallurgy & Engineering Materials**	**3-0-0**	**3**
6	**MC**	**19CM3MC01T**	**Environmental Science**		**0**
Total Credit (Theory)					**18**
Practical					
1	**PCC**	**19ME3PC01L**	**Engineering Thermodynamics Lab**	**0-0-2**	**1**
2	**PCC**	**19ME3PC02L**	**Introduction to Physical Metallurgy & Engineering Materials lab**	**0-0-2**	**1**
3	**ESC**	**19CM3ES01L**	**Data Structure using C Lab**	**0-0-2**	**1**
4	**ESC**	**19ME3ES02L**	**Engineering Mechanics Lab**	**0-0-2**	**1**
4	**PSI**	**19ME3PS01L**	**Summer Internship**	**0-0-2**	**1**
Total Credit (Practical)					**5**
Total Semester Credit					**23**

Course Code:19FY3BS01T	Course Name: Mathematics-III	L-T-P 3- 0- 0	Credit 3

Course Objectives:

The course should enable the students to:

1. Enrich the knowledge of probability on single random variables and probability distributions.
2. Apply the concept of correlation and regression to find covariance. Analyse the given data for appropriate test of hypothesis Understand the foundations for classical inference involving confidence intervals and hypothesis testing. Knowledge of Numerical method for solving mathematical problems.

Syllabus:

Module-1 **(8 Hours)**

Random variables: discrete and continuous random variables, probability distribution of a random variable. Some characteristic of probability distribution. Probability mass function and probability density functions; Mathematical expectation: Mean, Variance and standard deviation of a probability distribution.

Module-2 **(8 Hours)**

Binomial distribution; Mean and variances of Binomial distribution, Recurrence formula for the Binomial distribution; Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, mean and variance of Poisson distribution, Recurrence formula for the Poisson distribution; Normal distribution; Mean, Variance, Characteristics of normal distribution.

Module-3 **(10 Hours)**

Methods of Sampling. Estimation, point and interval estimation, Basic data analysis, setting of hypothesis, null hypothesis and alternate hypothesis, testing of hypothesis, type I and type II

errors, critical region, confidence interval, level of significance. One sided test, two sided test. Chi-square test: Goodness of fit and test of association. Correlation: Coefficient of correlation, Computation of correlation coefficient, Regression: Lines of regression and their properties.

Module-4 **(8 Hours)**

Root Finding: Introduction, Numerical solution by Bisection Method, Newton Raphson method, Secant method, Fixed point method. Interpolation: Lagrange, Newton forward, Backward, Divided Difference Method.

Module-5 **(10 Hours)**

Numerical Integration; Trapezoidal Method, Simpson's 1/3 rule, Gauss-quadrature 2 & 3 points method, Solution of First Order Differential equation by Euler's method, Modified Euler's method, Runge-Kutta 4th order and Predicator & Corrector methods(Adams-Bash forth Method).

Course Outcomes:

On completion of this course, students are able to:

1. Use the basic probability rules, discrete and continuous probability distributions, including requirements of mean and variance and making decisions.
2. Identify the characteristics of different discrete and continuous distributions. Identify the type of statistical situation to which different distributions can be applied.
3. Use of continuous distribution various hypothesis of testing, Employee the principles of linear regression and correlation and significance of the correlation coefficient.
4. Use of the Numerical method for finding roots, fitting the data into a polynomial equation, integrating any integration and solve any first order ode with initial condition.

Text Books:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Tenth Edition, Willey.
2. Richards A Johnson, Irvin Miller and Johnson E Freund,*Probability and Statistics for Engineering*, 9th Edition, PHI.
3. M. K. Jain, S.R.K. Iyenger and R.K. Jain, *Numerical Methods for Scientific and engineering Computations*, New age International Publication (P) Ltd.

Reference Books:

1. Fundamentals Of Mathematical Statistics is written by SC Gupta and VK Kapoor and published by SULTAN CHAND & SONS, Delhi.
2. Rohit Khurana, Kanti B. Datta, Engineering Mathematics, Cengage Publications.
3. Jay l. Devore, Probability and Statistics for Engineering and the Sciences. 8th Edition, Cengage.
4. S Arora, Sumeet Arora, P N Arora. Comprehensive Statistical Methods, Schaum Series, S. Chand Publication.
5. B.V. Raman, Higher Engineering Mathematics, Mc-Graw Hills Education.
6. B. S. Grewal, Higher Engineering Mathematics, Khanna Publisher

Digital Learning Resources:

Course Name	Mathematics-III
Course Link	http://www.nptelvideos.in/2012/11/mathematics-iii.html
Course Instructor	Prof.P.N.Agarwal, Department of Mathematics, IIT Roorkee.

Course Code: 19CM3HS01T	Course Name: Engineering Economics	L-T-P 3- 0- 0	Credit 3

Module-I: **(8 Hours)**

Introduction to Economics: Definition, scope and nature of economics, consumption laws, demand & supply analysis, elasticity of demand& supply, indifference curve analysis.

Module-II: **(10 Hours)**

Production: factors of production, production function, law of variable proportion, laws of return to scale, elasticity of factor-substitution, optimal combination of factor-inputs, production efficiency, economies of scales, Cost of Production: types of costs, economic costs: fixed cost and variable costs, short-run and long-run cost functions.

Module-III: **(10 Hours)**

Market Structure: pure competition, perfect competition, imperfect market, monopoly and oligopoly. Indian Banking System, Functions and Roles of Commercial Banks and Reserve Bank of India.

Module-IV: **(12 Hours)**

Time value of money and interest formulae, Nominal and effective rate of interest, Present, Annual and Future worth analysis, Rate of Return Analysis, Cost-Benefit analysis in Public sector projects.

Module- V: (as per choice of faculty) **(8 Hours)**

Portion covered can be tested through Internal evaluation only not to be included in University examination.

Reference Books:

1. Koutsoyiannis, A., ‘Modern Microeconomics’, English Language Book Society, Macmillan.

2. Pindyck, R S, Rubinfeld, D L &Mehta , 'Microeconomics', 6 th Edition, Pearson Education India.
3. Varian, H R, 'Intermediate Microeconomics', 7th Edition, East West Press India.
4. Samuelson, Paul A, 'Economics', 5th Edition, McGraw Hill New York.
5. Basics of Engineering Economy; Leland Blank and Anthony Tarquin, TMH
6. Contemporary Engineering Economics, Chan. S Park, Pearson
7. Engineering Economics, Paneerselvam, PHI
8. Engineering Economics; Sasmita Mishra.

Digital Learning Resources:

Course Name	Engineering Economics
Course Link	https://www.classcentral.com/course/swayam-engineering-economic-analysis-9919
Course Instructor	Pradeep K. Jha ,IIT Roorkee.

Course Code:	Course Name:	L-T-P 3- 0- 0	Credit: 3
19CM3HS02T	Organizational Behavior		

Course Objectives:

Developing an understanding of the behavior of individuals and groups inside organizations by enhancing the skills in appreciating individuals, interpersonal, and group process for increased effectiveness both within and outside of organizations is the goal of any organization. Through this course students will develop theoretical and practical insights and problem-solving capabilities for effectively managing the organizational processes.

Syllabus:

Module-I: Fundamentals of OB: (6 Hours)

Definition, scope and importance of OB, Relationship between OB and the individual, Evolution of OB, Models of OB. Learning; Theories and their applications

Module II: Foundations of Individual Behavior: (12 Hours)

Personality and values: Definition and importance of Personality for performance, The Myers-Briggs Type Indicator and The Big Five personality model, Significant personality traits suitable to the workplace (personality and job – fit theory), Personality Tests and their practical applications. Attitude; ABC Model. Perception: Meaning and concept of perception, Factors influencing perception, Selective perception, Perceptual errors.

Motivation: Definition & Concept of Motive & Motivation, The Content Theories of Motivation (Maslow's Need Hierarchy & Herzberg's Two Factor model Theory), The Process Theories (Vroom's expectancy Theory & Porter Lawler model), Contemporary Theories – Equity Theory of Work Motivation.

Module- III: Foundations of Group Behavior: (8 Hours)

Group Dynamics, Types of Groups, The Five – Stage Model of Group Development.

Developing Work Teams, Team Effectiveness & Team Building.

Leadership: Concept, Types & Styles of Leadership, Traditional & Contemporary theories of leadership Success stories of today's Global and Indian leaders.

Module- IV: Foundations of Organizational Behavior: (10 Hours)

Organizational Culture; creating and maintenance. Organizational Change; concept and technique and theories of change. Organizational Development; concept and methods of doing development.

Text Books:

Organizational Behavior, Robbins, Judge, Sanghi, Pearson.

Reference Books:

1. Organizational Behaviour, K. Awathappa, HPH.
2. Organizational Behaviour, VSP Rao, Excel
3. Introduction to Organizational Behaviour, Moorhead, Griffin, Cengage.
4. Organizational Behaviour,Hitt, Miller, Colella, Wiley
5. Organizational Behaviour, Suba Rao,Mishra, Himalaya
6. Organizational Behaviour – Uma Sekharan
7. Understanding Organizational Behaviour, Parek, Oxford

Digital Learning Resources:

Course Name	Organizational Behavior
Course Link	https://onlinecourses.nptel.ac.in/noc20_mg51/preview
Course Instructor	By Prof. M. P. Ganesh ,IIT Hyderabad

Course Code: 19CM3ES01T	Course Name: Data Structure using C	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1. To introduce the concepts of ADT, Time and Space complexity and asymptotic performance of algorithms and apply the important algorithmic design paradigms and methods of analysis.
2. Analyse and Design of the Algorithms and how the different data structures (Linear and non-linear) are used for efficient accessing of the data and Manipulation of the data.
3. Implementation of the linear and non-linear data structures, searching and sorting techniques and analyzing their time complexities.

Syllabus:

MODULE - I **(14hours)**

Abstract data types –adt's, stack, queue, sparse matrices Review on structures, array of structures, pointer to structures, passing structure to a function, dynamic memory allocation, Function pointer, pointer to pointer, menu driven programs

Abstract data types – definition and representation, adt of rational number, adt of stack, data structure and adt. stack and its usages: reversing string, matching parentheses, in fix to postfix, decimal to binary number. queue: linear & circular queue, deque & applications. matrix – sparse and dense. representation of sparse matrix, transpose & addition of sparse matrices.

Module -II **(8 hours)**

Linked list and its representation: using array, using self-referential structure. Singly, circular and double linked lists. operations on linked list – insertion, deletion, traversals. usages of linked list, insertion sort, addition/multiplication of polynomials. addition/multiplication of large numbers.

Module -III **(12 hours)**

Tree: definition and terminologies, child and parent nodes, sub tree, root, leaf node, internal node, height of a tree, binary, ternary, quad tree. binary tree traversals. reconstruction of binary tree from traversals. binary search tree – inserting a new key, deleting a key, searching a key. avl tree – inserting a new key into an avl tree using rotations. b- tree : insertion and deletion using node splitting and merging.

Module -IV **(6 hours)**

Sorting and searching: bubble sort, selection sort quick sort and merge sort. Linear and binary search, Fibonacci search.

Module -V **(6 hours)**

Basic graph algorithm: graph representation – adjacency matrix and list – pros and cons. Graph, traversals – depth first search and breadth first search.

Course Outcomes:

On Completion of this Course, the students should be able to:

1. To understand the concept of ADT, Time and Space complexity, asymptotic performance of algorithms and understand how different data structures are used for data storage and retrieval.
2. Implement the linear data structures and non-linear data structures ,various searching and sorting techniques, BST, AVL trees and graph traversal algorithms

3. Analyzing the time complexities of algorithms used in learning the subject. Analyze the situation in hand and the type of data structure to be used and implement using a programming language.

Text Books:

1. Data Structures: A Pseudocode Approach with C – Gilberg & Forouzan, 2nd Edition, Cengage, Indian Reprint 2016
2. Data Structures and Program Design in C – Kruse, Leung, 2nd Edition, Pearson,2008
3. Data Structures Using C - Yedidyah Langsam & Moshe J. Augenstein Aaron M. Tanenbaum, 3rd Edition, Pearson, 2009
4. Algorithms and Data Structures: The basic toolbox, Kurt Mehlhorn and Peter Sanders, Springer, 2010
5. Programming and Data Structures (NPTEL) – (Video lectures by Dr. Naveen Garg, IIT Delhi, new course available from July 2019)

Reference books:

1. Schaums Outlines Data Structures with C by Seymour Lipschutz" , Publisher: Mcgraw Hill, 2011. (SIE)
2. Data Structures Using C, Oxford University Press, 2014.
3. Data Structures, Algorithms, and Applications in C++ , McGraw-Hill international Editions: Computer science series.

Digital Learning Resources:

Course Name	Data Structure using C
Course Link	https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs25/

Course Instructor	By Prof. Sudarshan Iyengar IIT Ropar

Course Code: 19ME3ES02T	Course Name: Engineering Mechanics	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1. The overall objective of this course is to learn how to draw the free body diagram and analyze the system of forces of structure. This includes the understanding of concurrent forces on plane.
2. The objective of this topic is to learn how to draw the free body diagram and analyze the Parallel forces, center of gravity forces, moment of inertia, and plane trusses.
3. The objective of this topic is to analyze the rectilinear motion of particle with the aid of D'Alembert's principle.
4. The objective of this topic is to analyze dynamics of particle with the help of momentum and impulse, work and energy and impact.
5. The objective of this topic is to analyze the curvilinear motion of particle with the aid of D'Alembert's principle.

Syllabus:

MODULE – I **(8 Hours)**

Concurrent forces on a plane – Composition and resolution of forces and equilibrium of concurrent coplanar forces, Method of projections, Methods of moment, Friction, Parallel forces in a plane- Two parallel forces, General case of parallel forces.

MODULE – II **(12 Hours)**

Center of parallel forces in a plane and center of gravity- centroids of composite plane figure and curves, Distributed parallel forces in a plane. General case of forces in a plane- composition of forces in a plane and equilibrium of forces in a plane. Moments of Inertia- Plane figure with respect to an axis in its plane and perpendicular to the plane- parallel axis theorem, Moment of Inertia of material bodies.

MODULE – III **(6 Hours)**

Plane trusses- method of joints and method of sections, Principle of virtual work –equilibrium of ideal systems.

MODULE – IV **(4 Hours)**

Rectilinear Translation- Kinematics- Principles of Dynamics- Concept of Inertial and Non-inertial frame of reference, D'Alembert's Principles.

MODULE – V **(6 Hours)**

Momentum and impulse, Work and Energy- impact; Curvilinear translation- Kinematics- equation of motion- projectile- D'Alembert's Principle in curvilinear motion, Moment of momentum, Work- Energy in curvilinear motion.; Introduction to kinetics of rotation of rigid body.

Course Outcomes:

On successful completion of these modules the student will be able to:

1. Apply the basic knowledge of mathematics, physics, and engineering mechanics to solve the engineering problems.
2. Identify the forces, draw the free body diagrams and determine the resultant forces and moments.

3. Determine the center of gravity for distributed forces and moments of inertia for plane and mass bodies.
4. Analyze the statistical determinate structure problems.
5. Formulate and determine the rectilinear motion of a rigid body by using the kinematics principle.
6. Application of Newton's law and D'Alembert's Principle for solving problems.
7. Apply fundamental concepts of kinematics and kinetics of particles and rigid bodies to the analysis of simple, practical problems.
8. Apply Conservation Laws to different type of collision and motion of rigid bodies.

Text Books:

1. S Timoshenko, D.H Young and J.V.Rao ,Engineering Mechanics, Fifth Edition, McGraw Hill Publishing Company,2017,New Delhi .
2. K.L. Kumar ,Engineering Mechanics , Fourth Edition, Tata McGraw Hill Publishing Company, 2010,New Delhi.

Reference books:

1. A. K. Tayal ,Engineering Mechanics Statics and Dynamics, , Fourteenth Edition, Umesh Publications, 2008, New Delhi.
2. S. Rajasekhara & G. Sankaran Subramaniam ,Fundamental of Engineering Mechanics, Vikash Publishing House Pvt. Ltd.

Digital Learning Resources:

Course Name	Engineering Mechanics
Course Link	https://nptel.ac.in/courses/112/106/112106286/
Course Instructor	PROF. K. RAMESH Department of Applied Mechanics, IIT Madras

Course Code: 19ME3PC01T	**Course Name: Engineering Thermodynamics**	**L-T-P 3- 0-0**	**Credit 3**

Course Objectives:

1. This course is designed to introduce a basic application of thermodynamic laws and application of thermodynamics concept to various practical engineering problems.
2. Evaluate availability and energy for a system with concept of entropy
3. States of pure substance and performance parameters for vapor power cycles based on the Rankine and Brayton cycle with superheat, reheat, and regeneration.
4. Demonstrate the ability to analyze the performance of refrigeration cycles.
5. Thermodynamics relation between the various thermodynamic property can be describe and evaluate.
6. Evaluate the performance of reciprocating air compressor in ideal and actual case

Syllabus:

Module-1: **(8 Hours)**

Introduction, ideal gas, work , heat transfer, first law of thermodynamics for closed and open system (steady flow), second law of thermodynamics, PMM1, PMM2, reversible and irreversible processes, heat engine, reverse heat engine, Carnot cycle,

Properties of pure substances, Steam formation, Types of Steam, Enthalpy, Specific volume, Internal energy and dryness fraction of steam, use of Steam tables. Related numerical.

Module-II **(8 Hours)** Basic Concept of Entropy, Clausius theorem, Clausius inequality, Principle of increase of entropy, Entropy change of pure substances, isentropic processes, property diagrams involving entropy, entropy change of liquids and solids, the entropy change of ideal gases, Third law of thermodynamics, Absolute entropy. Entropy generation ,Entropy balance for closed systems and steady flow systems, Available energy, Quality of energy, Availability for non-flow and flow process, Irreversibility, Energy balance, Second law efficiency.

Module-III **(8 Hours)**

Vapour Power Cycles: The Carnot vapor cycle and its limitations, The Rankine cycle, Means of increasing the Rankine cycle efficiency, The reheat cycle, The regenerative feed heating cycle, Cogeneration, Combined cycle power generation systems, Binary vapour cycles.

Module-IV **(8 Hours)**

Gas Power Cycles: Air standard cycles- Otto, Diesel, Dual Combustion and Brayton cycles, The Brayton cycle with non-isentropic flow in compressors and turbines, The Brayton cycle with regeneration, reheating and intercooling, Ideal jet propulsion.

Module-V **(8 Hours)**

Refrigeration cycles: Reversed Carnot cycle, Reversed Brayton cycle (Gas refrigeration system), The vapor compression cycle, The vapor absorption cycle.

Course Outcomes:

1. Understand the basics concepts, work and heat and first law of thermodynamics
2. Apply the 2nd law of thermodynamics to analyze boilers, heat pumps, refrigerators, heat engines, compressors and nozzles.
3. Evaluate the pure substances and performance of steam power cycles

4. Apply the knowledge of gas power cycle in analysis of engines
5. To analyse the refrigeration cycle to have better energy saving features

Text Books:

1. P. K. Nag, Engineering Thermodynamics, Sixth Edition, Tata McGraw Hill Publishing Company, 2017, New Delhi

Reference books:

1. P. Chattopadhyay, Engineering Thermodynamics, Second Edition, OXFORD University Press, 2011, New Delhi.
2. Sonntag, Borgnakke, Van Wylen, Fundamentals of Thermodynamics, Sixth Edition, John Wiley & Sons, New Delhi.
3. E. Radhakrishnan, Fundamentals of Engineering Thermodynamics, Second Edition, PHI Publication, 2005, New Delhi.

Digital Learning Resources:

Course Name	Engineering Thermodynamics
Course Link	https://nptel.ac.in/courses/101/104/101104063/
Course Instructor	Prof. D.P.Mishra Department Of Aerospace Engineering IIT Kanpur

Course Code: 19ME3PC02T	Course Name: Introduction to Physical Metallurgy & Engineering Materials	L-T-P: 3- 0- 0	Credit: 3

Course Objectives:

1. Give basic knowledge of science behind materials & physical metallurgy.
2. Introduce the concept of mechanical behavior of materials, phase & phase diagram, heat treatment, failure of materials, applications of advanced materials.
3. Develop intuitive understanding of the subject to present a wealth of real world engineering examples to give students a feel of how material science is useful in engineering practices.

Syllabus:

Module-I **(8 Hours)**

Classification of Engineering Materials, Engineering properties of materials. Characteristic property of metals, bonding in solids, primary bonds like ionic, covalent and metallic bond, crystal systems, common crystal structure of metals, representations of planes and directions in crystals, atomic packing in crystals, calculation of packing density, voids in common crystal structures and imperfections crystals.

Module-II **(8 Hours)**

Concept of plastic deformation of metals, critical resolve shear stress, dislocation theory, deformation by slip and twin, plastic deformation in polycrystalline metals, yield point phenomenon and related effects, concept of cold working preferred orientation. Annealing; recovery; recrystallization and grain growth;

Hot working. Concept of alloy formation, types of alloys, solid solutions, factors governing solids solubility viz. size factor, valency factor, crystal structure factor and chemical affinity factor; order-disorder transformation.

Module-III **(10 Hours)**

Binary phase diagrams (a) Isomorphism system, (b) Eutectic system, (c) Peritectic system, (d) Eutectoid system and (e) Peritectoid system. Allotropic transformation. Lever rule and its application, Interpretation of solidification behaviors and microstructure of different alloys belonging to those systems, Effect of non-equilibrium cooling, coring and homogenization.

Iron-cementite and iron-graphite phase diagrams, microstructure and properties of different alloys (alloy steels; stainless steel, tool steel, HSS, high strength low alloy steel) types of cast iron, their microstructures and typical uses. Specification of steel.

T.T.T. diagram: concept of heat treatment of steels i.e. annealing, normalizing, hardening and tempering; microstructural effects brought about by these processes and their influences on mechanical properties; factor affecting hardenability.

Module-IV **(5 Hours)**

Optical properties of Materials: Scattering, Refraction, Theory of Refraction and absorption, Atomic Theory of optical properties. Lasers, Optical fibres- Principle, structure, application of optical fibres; Plastic-: Thermosetting and thermoplastics; Ceramics: Types, structure, Mechanical properties, application.

Module-V **(5 Hours)**

Composite Materials: Agglomerated Materials: Cermet's.

Reinforced Materials: Reinforced Concrete. Fibre reinforced plastics, Properties of composites, Metal matrix composites, manufacturing procedure for fiber reinforced composite.

Course Outcomes:

1. Analyze & Distinguish between SC, BCC, FCC & HCP structures & to understand the types of crystal structures and relate it to the final properties
2. Understand the different types of crystal imperfections i.e. point defects, line defects, surface defects
3. Explain the phase rule, term involved in it and its application & the different types of binary phase diagrams, and their construction. Apply the principles of Tie-line rule and Lever rule to find the composition of the phases present and their weight percentages
4. Understand & suggest the purpose & objectives of Heat Treatment i.e. annealing,
5. tempering, normalizing ,etc and the concept of hardenability test (Jominy test).
6. To acquire knowledge about composite, plastics, ceramics materials, types, manufacturing methods & its applications & suggest suitable materials for the required application.

Text Books:

1. W.D.Callister ,Materials Science and Engineering, Eighth Edition, Wiley and Sons Inc, 2017, New Delhi.

Reference Books:

1. Avner, Introduction to Physical Metallurgy, Second Edition, Tata McGraw Hill Publishing Company, 2017, New Delhi.
2. Raghavan ,Physical Metallurgy: Principles and Practice, Third Edition, PHI Publication, 2015, New Delhi.

Digital Learning Resources:

Course Name	Introduction to Physical Metallurgy &Engineering Materials
Course Link	https://nptel.ac.in/courses/113/102/113102080/

Course Instructor	Prof. Rajesh Prasad Department of Mechanical Engineering, IIT Delhi

Course Code:	Course Name:	L-T-P 0- 0- 2	Credit
19CM3ES01L	Data Structure using C Lab		1

Course Objectives:

1. To choose the appropriate data structure and algorithm design method for a specified application and finding the performance of the programs.
2. To understanding about writing algorithms and step by step approach in solving problems with the help of fundamental data structures.
3. To solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, binary search trees, and graphs and writing programs for these solutions.
4. Students should acquire skills in using generic principles for data representation & manipulation with a view for efficiency, maintainability, and code-reuse.

Syllabus

1. Revisiting structure, union, dynamic memory allocation and pointers, pointers to structures and function pointers, menu driven programs.
2. Infix to postfix conversion and evaluation of postfix expressions using STACK.
3. Insert and delete operations on a Linear Queue.
4. Sparse matrix representation and addition of two sparse matrices.
5. Implementing a singly linked list – operations include insert (beg, mid, end), delete (beg, mid, end), traverse (fwd, backward), Reversing it, count nodes.
6. Polynomial representation and addition of 2 polynomials using linked list.

7. Performing various operations on a Binary Search tree – Create, traverse, find min, find max, mirror, delete, count internal and external nodes Related programs using BST.
8. Implementing various searching and sorting algorithms

Course Outcomes:

On Completion of this Course, the students should be able to:

1. Able to identify the appropriate data structure for given problem.
2. Determine and analyze the time and space complexity of given Linear and Non-Linear data structures Algorithms.
3. Implement operations like searching, insertion, and deletion, traversing mechanism etc. on various data structures (linear and non-linear) and analyzing the complexity of each operation.
4. Have practical knowledge on the applications of data structures.

Suggested Books:

1. Data Structures: A Pseudocode Approach with C – Gilberg & Forouzan, 2nd Edition, Cengage, Indian Reprint, 2016
2. Data Structures and Program Design in C – Kruse, Leung, 2nd Edition, Pearson,2008
3. Data Structures Using C - Yedidyah Langsam & Moshe J. Augenstein Aaron M. Tanenbaum, 3rd Edition, Pearson, 2009
4. Algorithms and Data Structures: The basic toolbox, Kurt Mehlhorn and Peter Sanders, Springer, 2010
5. Programming and Data Structures (NPTEL) – (Vodeo lectures by Dr. Naveen Garg, IIT Delhi, new course available from July 2019)

Reference books:

1. Schaums Outlines Data Structures with C by Seymour Lipschutz" , Publisher: Mcgraw Hill, 2011. (SIE)
2. Data Structures Using C, Oxford University Press, 2014.

Course Code:	Course Name: Engg. Mechanics Lab	L-T-P: 0- 0- 2	Credit :1

Course Objectives:

1. To supplement the theoretical knowledge gained in Engineering Mechanics with practical testing for determining resultant of forces. This would enable the student to have a clear understanding the concept of equilibrium and its application to solve different type of real life problems.
2. To understand the concept of friction and its application.
3. To develop knowledge in dynamics of particle.

Syllabus

List of Experiments:

(At least 10 out of 13 experiments should be done)

1. To verify the law of Force Polygon (or Parallelogram Law of Vector Addition)
2. To verify the law of Moments using Parallel Force apparatus.
3. To determine the co-efficient of friction between wood and various surface (like Leather, Wood, Aluminum) on an inclined plane.
4. Determination of Belt friction using belt friction apparatus.
5. Experiment on trusses to calculate the force in the member of simple trusses.
6. To find CG of an irregular body using Computation method.

7. Moment of Inertia of Flywheel.
8. Newton's Second Law of Motion
9. Ballistic Pendulum
10. Elastic and Inelastic Collision.
11. Projectile Motion
12. Simple & compound gear-train experiment.

Course Outcomes:

After completion of the course, the student will be able to

1. Verify the Parallelogram law of vector addition and law of Moments using Parallel Force apparatus (Different type of support).
2. Evaluate co-efficient of friction between the different surfaces in contact.
3. Analyze planar systems to determine the forces in members of trusses.
4. Determine the centroid and moment of inertia of plane lamina.
5. Demonstrate the types of collision/impact and determine corresponding coefficient of restitution.
6. Differentiate the kinematics and kinetics of a particle.

Course Code: 19ME3PC01L	Course Name: Engineering Thermodynamics Lab	L-T-P: 0- 0- 2	Credit: 1

Course Objectives:

1. Apply the laws of thermodynamics to the working of I.C engines like petrol and diesel engine.
2. To understand the working principle of 2-stroke,4-stroke I.C. engine
3. Design and working of thermal power plant
4. Analyze performance of reciprocating and centrifugal compressors.
5. Analyze various refrigeration systems with its components.
6. To determine the efficiency of gear pump.

Syllabus

List pf Experiments:

Select any 10 experiments from the list of 11 experiments

1. Model study of Fire Tube Boilers and Water Tube Boilers.
2. Model study of Two stroke I.C. Engine.
3. Model study of Four stroke I.C. Engine.
4. Model study of Refrigerator
5. Model study of Water Turbines.
6. Model study of Water pumps.
7. Study of Gears and Gear trains.
8. Verification of Bernoulli’s Theorem and its application to Venturi meter.

9. Calibration of Bourdon Tube Pressure gauge and measurement of pressure using manometers.
10. Model study of Automobile Parts.
11. Determination of velocity ratio of belt drive.

Course Outcomes:

On Completion of this Course, the students should be able to:

1. Classify the IC engines along with the working principle and combustion process.
2. Explain the working of air compressor (reciprocating and centrifugal) along with factors influencing its performance
3. Compute the cooling load for COP of refrigeration systems.
4. Students can describe about working principle of steam power plant.
5. Students can able to explain performance of gear pump.

Course Code: 19ME3PC02L	Course Name: Introduction to Physical Metallurgy & Engg Materials Laboratory	L-T-P: 0- 0- 2	Credit: 1

Course Objectives:

1. To introduce the physical origin of and demonstrate the correlation between crystal structure and properties of materials.
2. Learning the metallurgical sample preparation techniques: cutting, mounting, grinding and polishing & characterization of microstructure using optical microscope.
3. To understand how the mechanical behavior may be affected by using various heat treatment processes.
4. To measure and compare the hardness & impact toughness of several different materials.

Syllabus:

List of Experiments:

Select any 8 experiments from the list of 9 experiments

1. Study of Crystal Structures through Ball Models
2. Metallurgical Microscope: Principles and Operations
3. Specimen Preparation techniques for Metallographic Analysis
4. Microstructural Analysis of Carbon Steels & Cast Iron
5. Microstructural Analysis of Non-Ferrous Metals: Brass & Copper
6. Heat treatment of Steels
7. Jominy end quench test.
8. Hardness testing of ferrous material

9. Impact testing (Charpy/Izod)

Course Outcomes:

On Completion of this Course, the students should be able to:

1. Analyze & prepare SC, BCC, FCC & HCP structures using balls and sticks
2. Prepare the specimens for metallographic examination with best practice and operate the optical microscope and understand, interpret, analyze the microstructure of materials
3. Understand & suggest the purpose & objectives of Heat Treatment i.e annealing, tempering, normalizing ,etc and the concept of hardenability test (Jominy test).
4. Classify the different mechanical testing methods with their inherent merits and limitations.

Fourth Semester					
Theory					
Sl. No.	Category	Course Code	Course Title	L-T-P	Credit
1	HSMC	19CM3HS01T	Humanities-1/Management-1(OB/EEC)	3-0-0	3
2	ESC	19ME4ES01T	Fluid Mechanics and Hydraulics Machines	3-0-0	3
3	PCC	19ME4PC01T	Mechanics of Solids	3-0-0	3
4	PCC	19ME4PC02T	Kinematics of Machines	3-0-0	3
5	PCC	19ME4PC03T	Manufacturing Science - I	3-0-0	3
6	PEC	19ME4PE01T/ 19ME4PE02T	CIM & FMS; IC Engines & Gas Turbines	3-0-0	3
7	MC	19CM4MC01T	Mandatory(Constitution of India/ Essence of Indian Tradition Knowledge)		0
Total Credit (Theory)					18
Practical					
1	ESC	19ME4ES01L	Fluid Mechanics and Hydraulics Machines Laboratory	0-0-2	1
2	PCC	19ME4PC01L	Mechanics of Solids Laboratory	0-0-2	1
3	PCC	19ME4PC02L	Kinematics of Machines Laboratory	0-0-2	1
4	PCC	19ME4PC03L	Manufacturing Science - I Laboratory	0-0-2	1

Total Credit (Practical)	4
Total Semester Credit	22

Course Code:19CM4HS01T	**Course Name: Engineering Economics**	**L-T-P 3- 0- 0**	**Credit 3**

Module-1: **(8 Hours)**

Introduction to Economics: Definition, scope and nature of economics, consumption laws, demand & supply analysis, elasticity of demand& supply, indifference curve analysis.

Module-2: **(10 Hours)**

Production : factors of production, production function, law of variable proportion, laws of return to scale, elasticity of factor-substitution, optimal combination of factor-inputs, production efficiency, economies of scales,Cost of Production: types of costs, economic costs: fixed cost and variable costs, short-run and long-run cost functions.

Module-3: **(10 Hours)**

Market Structure: pure competition, perfect competition, imperfect market, monopoly andoligopoly. Indian Banking System, Functions and Roles of Commercial Banks and Reserve Bank of India.

Module-4: **(12 Hours)**

Time value of money and interest formulae,Nominal and effective rate of interest, Present, Annual and Future worth analysis, Rate of Return Analysis, Cost-Benefit analysis in Public sector projects.

Module- 5: (as per choice of faculty) **(8 Hours)**

Portion covered can be tested through Internal evaluation only not to be included in University examination.

Reference Books:

1. Koutsoyiannis, A., 'Modern Microeconomics', English Language Book Society, Macmillan.
2. Pindyck, R S, Rubinfeld, D L &Mehta , 'Microeconomics', 6 th Edition, Pearson Education India.
3. Varian, H R, 'Intermediate Microeconomics', 7th Edition, East West Press India.
4. Samuelson, Paul A, 'Economics', 5th Edition, McGraw Hill New York.
5. Basics of Engineering Economy; Leland Blank and Anthony Tarquin, TMH.
6. Contemporary Engineering Economics, Chan. S Park, Pearson.
7. Engineering Economics, Paneerselvam, PHI.
8. Engineering Economics; Sasmita Mishra.

Course Code:19CM4HS02T	Course Name: Organizational Behavior	L-T-P 3- 0- 0	Credit 3

Course Objectives:

Developing an understanding of the behavior of individuals and groups inside organizations by enhancing the skills in appreciating individuals, interpersonal, and group process for increased effectiveness both within and outside of organizations is the goal of any organization. Through this course students will develop theoretical and practical insights and problem-solving capabilities for effectively managing the organizational processes.

Syllabus:

Module-1: Fundamentals of OB: (6 Hours)

Definition, scope and importance of OB, Relationship between OB and the individual, Evolution of OB, Models of OB. Learning; Theories and their applications

Module 2: Foundations of Individual Behavior: (12 Hours)

Personality and values: Definition and importance of Personality for performance, The Myers-Briggs Type Indicator and The Big Five personality model, Significant personality traits suitable to the workplace (personality and job – fit theory), Personality Tests and their practical applications. Attitude; ABC Model. Perception: Meaning and concept of perception, Factors influencing perception, Selective perception, Perceptual errors.

Motivation: Definition & Concept of Motive & Motivation, The Content Theories of Motivation (Maslow's Need Hierarchy & Herzberg's Two Factor model Theory), The Process Theories (Vroom's expectancy Theory & Porter Lawler model), Contemporary Theories – Equity Theory of Work Motivation.

Module- 3: Foundations of Group Behavior: (8 Hours)

Group Dynamics, Types of Groups, The Five – Stage Model of Group Development.

Developing Work Teams, Team Effectiveness & Team Building.

Leadership: Concept, Types & Styles of Leadership, Traditional & Contemporary theories of leadership Success stories of today's Global and Indian leaders.

Module- 4: Foundations of Organizational Behavior: (10 Hours)

Organizational Culture; creating and maintenance. Organizational Change; concept and technique and theories of change. Organizational Development; concept and methods of doing development.

Course Outcomes:

1. Students will understand the essential of maintaining the inter-personal relationships in organizations.
2. Personality factors will be effectively used to understand the communication among groups.
3. The reasons for conflict will be known and prescriptive methods can be devised to enhance higher productivity in organizations.
4. Being an employee in an organization the importance of organizational change and culture can be known to all.

Text Books:

1. Organizational Behaviour, Robbins, Judge, Sanghi, Pearson.

Reference Books:

1. Organizational Behaviour, K. Awathappa, HPH.
2. Organizational Behaviour, VSP Rao, Excel.
3. Introduction to Organizational Behaviour, Moorhead, Griffin, Cengage.
4. Organizational Behaviour,Hitt, Miller, Colella, Wiley.

5. Organizational Behaviour, Suba Rao,Mishra, Himalaya.
6. Organisational Behaviour – Uma Sekharan.
7. Understanding Organizational Behaviour, Parek, Oxford.

Course Code: 19ME4ES01T	Course Name: Fluid Mechanics and Hydraulic Machines	L-T-P: 3-0-0	Credit: 3
Note: Each and every module must practice with computer program like C, C++, Matlab, etc.			

Course Objectives:

1. Analyse fluid and its usage in flow measurement, hydraulic Machines, etc.
2. Compute pressure through manometer and design and develop marine systems with the usage of hydrostatic forces and buoyancy.
3. Differentiate velocity, acceleration, rotation and deformation etc. of fluid particles
4. Establish Euler's theorem and deduce Bernoulli's equation or a ideal fluid and real fluids and examine and evaluate energy losses in fluid transmission trough pipes
5. Do the performance analysis of different turbines and pumps

Syllabus:

Module-1: **(8 Hours)**

Introduction: Scope of fluid mechanics and its development as a science Physical property of Fluid: Density, specific gravity, specific weight, specific volume, surface tension and capillarity, viscosity, compressibility and bulk modulus, Fluid classification.

Fluid statics: Pressure, Pascal's Law, Pressure variation for incompressible fluid, atmospheric pressure, absolute pressure, gauge pressure and vacuum pressure, manometer. Hydrostatic process on submerged surface, force on a horizontal submerged plane surface, force on a vertical

submerged plane surface. Buoyancy and floatation, Archimedes' principle, stability of immersed and floating bodies, determination of metacentric height.

Module-2: **(8 Hours)**

Fluid kinematics: Introduction, description of fluid flow, classification of fluid flow. Reynold's number, Acceleration of fluid particles, flow rate and continuity equation, differential equation of continuity, Mathematical definitions of irrotational and rotational motion. Circulation, potential function and stream function. Flow net

Module-3: **(8 Hours)**

Fluid dynamics : Introduction, Introduction to N-S equation, Euler's equation along a streamline, energy equation, Bernoulli's equation and its application to siphon, venturimeter, orificemeter, pitot tube. Flow in pipes and ducts: Loss due to friction, Minor energy losses in pipes Hydraulic Gradient Line (HGL), Total Energy Line (TEL), Power transmission in the fluid flow in pipes, fluid flow in pipes in series and parallel. Flow through nozzles.

Module-4: **(8 Hours)**

Hydraulic turbines: Classification, Impulse and Reaction turbine; Tangential, Radial and axial turbine. Impulse turbine, Pelton wheel, bucket dimensions, number of buckets in pelton wheel, efficiency and performance curves.

Reaction Turbines: Francis turbine and Kaplan turbine, velocity triangle and efficiencies, performance curve. Function of draft tube and casing cavitation.

Module-5: **(8 Hours)**

Centrifugal Pump: constructional features, vane shape, velocity triangles, Efficiencies, Multi stage centrifugal pumps, Pump Characteristic, NPSH and Cavitation.

Positive displacement pumps: Reciprocating Pump, Working principle, Discharge, work done and power requirement, Slip, Indicator diagram.

Course Outcomes:

1. Apply conservation laws to fluid flow problems in engineering applications.
2. Design experimental procedure for physical model studies.
3. Design the working proportions of hydraulic machines.
4. Compute drag and lift coefficients using the theory of boundary layer flows.
5. Analyze and design free surface and pipe flows
6. Formulate and solve one dimensional compressible fluid flow problems

Suggested Books:

1. Y. A. Cengel and J. M. Cimbala, Fluid Mechanics , Tata McGraw-Hill, 3rd Edition,2017, New Delhi
2. CSP Ojha and P.N. Chandramouli, Fluid Mechanics and Machinery, Oxford University Press, 4th Edition, 2010, New Delhi
3. S. K. Som and G. Biswas, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill Education, 6th Edition, 2017, New Delhi
4. R. W. Fox, A. T. McDonald and P. J. Pritchard, Introduction to Fluid Mechanics, John Wiley, 8th Edition, 2011, New Delhi
5. Piyush Kundu, Ira Cohen & David Dowling, Fluid Mechanics, Elsevier, 6th Edition, 2016, Cambridge

Digital Learning Resources:

Course Name	Fluid Mechanics and Hydraulic Machines
Course Link	https://swayam.gov.in/nd1_noc19_me55/
Course Instructor	Dr. Sankar Kumar Som, IIT Kharagpur

Course Code: 19ME4PC01T	Course Name: Mechanics of Solids	L-T-P: 3-0-0	Credit: 03
Note: Each and every module must practice with computer program like C, C++, Matlab, etc.			

Course Objectives:

1. Understand mechanics of deformable bodies and apply them in analysis and design problems
2. Analyze bodies subjected to two dimensional stress systems
3. Understand behaviour of structural members in flexure and Torsion
4. Evaluate slope and deflection in beams subjected to loading
5. Understand stability of columns and struts
6. Predict the stress distribution in beams, pressure vessels and shafts

Syllabus:

Module-I: **(8 Hours)**

Concept of Stress: Load, Stress, Principle of St.Venant, Principle of Superposition, Strain, Hooke's law, Modulus of Elasticity, Stress-Strain Diagrams, Working Stress, Factor of safety, Strain energy in tension and compression, Resilience, Impact loads, Analysis of Axially Loaded Members: Composite bars in tension and compression - temperature stresses in composite rods, Concept of Statically indeterminate problems. Shear stress, Complimentary shear stress, Shear strain, Modulus of rigidity, Poisson's ratio, Bulk Modulus, Relationship between elastic constants

Module-2: **(8 Hours)**

Biaxial State of Stress: Analysis of Biaxial Stress. Plane stress, Principal plane, Principal stress, Mohr's Circle for Biaxial Stress. Stresses in thin cylinders and thin spherical shells under internal pressure, wire winding of thin cylinders; Biaxial State of Strain: Two dimensional state of strain, Principal strains, Mohr's circle for strain, Calculation of principal stresses from principal strains, Strain Rossette.

Module-3: **(8 Hours)**

Shear Force and Bending Moment Diagrams: Shear force and bending moment. Types of load and Types of support. Support reactions, Relationship between bending moment and shear force, Point of inflection. Shear Force and Bending Moment diagrams.

Bending of Beams: Theory of simple bending of initially straight beams, Bending stresses, Shear stresses in bending, Distribution of normal and shear stress, Composite beams

Module-4: **(8 Hours)**

Deflection of Beams: Differential equation of the elastic line, Slope and deflection of beams by integration method and area - moment method; Theory of Columns: Long columns, Euler's column formula, Lateral buckling, Critical Load, Slenderness ratio, Eccentric loading of short column

Module-5: **(8 Hours)**

Torsion: Torsion in solid and hollow circular shafts, Twisting moment, Strain energy in shear and torsion, strength of solid and hollow circular shafts. Strength of shafts in combined bending and twisting, Close - Coiled helical springs.

Course Outcomes:

After completing the course, the students will be able to

1. Identify the different engineering materials, describe their properties and predict their behaviour under different types of loading.
2. Compute the stresses, strains, moments, deflections, etc. and derive the expressions used from the fundamentals.
3. Select materials, sizes and sections for various applications such as beams, shafts, pressure vessels, columns, etc. and justify the selection.
4. Determine mechanical properties by destructive and non-destructive methods.

Suggested Books:

1. S.P.Timoshenko and D.H.Young, Elements of Strength of Materials, Affiliated East West Press, 5th Edition, 2003, New Delhi
2. G. H. Ryder, Strength of Materials by Macmillan Publishers India Limited, 3rd Edition, 2002, Chennai
3. S.S.Rattan, Strength of Materials by Tata Mc Graw Hill, 3rd Edition, 2017, New Delhi
4. R.Subramaniam, Strength of Materials, Oxford University Press, 3rd Edition, 2016, New Delhi

Digital Learning Resources:

Course Name	Mechanics of Solids
Course Link	https://nptel.ac.in/courses/112/102/112102284/
Course Instructor	Prof. Ajeet Kumar, IIT Delhi

Course Code:19ME4PC02T	Course Name: Kinematics of Machines	L-T-P:3-0-0	Credit: 03
Note: Each and every module must practice with computer program like C, C++, Matlab, etc.			

Course Objectives:

1. Describe the concept of machines, mechanisms and inversion
2. Analyze planar mechanism for displacement, velocity and acceleration both by graphical and analytic method
3. Analyze planar mechanism for displacement, velocity and acceleration both by graphical and analytic method
4. analyze the function of different types of drive
5. Understand techniques for studying motion of machines and their components.

Syllabus:

Module-1: **(8 Hours)**

Kinematic fundamental: Basic Kinematic concepts and definitions, Degrees of freedom, Elementary Mechanism : Link, joint, Kinematic Pair, Classification of kinematic pairs, Kinematic chain and mechanism, Gruebler's criterion, Inversion of mechanism, Grashof criteria, Four bar linkage and their inversions, Single slider crank mechanism, Double slider crank mechanism and their inversion. Transmission angle and toggle position, Mechanical advantage.

Kinematic Analysis: Graphical analysis of position, velocity and acceleration of four bar and Slider crank mechanisms. Instantaneous centre method, Aronhold-Kennedy Theorem, Rubbing velocity at a Pin-joint. Coriolis component of acceleration.

Module-2: (8 Hours)

Mechanism Synthesis: Graphical methods of synthesis, Chebychev spacing for precision positions, Freudenstein's equation applicable to four bar linkages.

Mechanism Trains: Gear Terminology and definitions, Analysis of mechanism Trains: Simple Train, Compound train, Reverted train, Epicyclic train and their applications.

Module-3: (8 Hours)

Combined Static and Inertia Force Analysis: Inertia forces analysis, velocity and acceleration of slider crank mechanism by analytical method, engine force analysis - piston effort, force acting along the connecting rod, crank effort. Dynamically equivalent system, compound pendulum, correction couple.

Module-4: (8 Hours)

Friction Effects: Screw jack, friction between pivot and collars, single, multi-plate and cone clutches, anti friction bearing, film friction, friction circle, friction axis.

Flexible Mechanical Elements: Belt, rope and chain drives, initial tension, effect of centrifugal tension on power transmission, maximum power transmission capacity, belt creep and slip.

Module-5: (8 Hours)

Brakes &Dynamometers: Classification of brakes, Analysis of simple block, Band and internal expanding shoe brake, Braking of a vehicle. Absorption and transmission dynamometers, Prony brake, Rope brake dynamometer, belt transmission, epicyclic train, torsion dynamometer.

Course Outcomes

Suggested Books:

1. Thomas Bevan, Theory of Machines, CBS Publications, 3rd Edition, 2005, New Delhi
2. Charles E. Wilson and J. Peter Saddler, Kinematics and Dynamics of Machinery, Pearson Education, 3rd Edition, 2008, Chennai
3. J. S. Rao and R. V. Dukipatti, Mechanism and Machine Theory, New Age International, New Delhi, 1992
4. A. Ghosh & A. K. Mallick, Theory of Mechanisms and Machines, East West Press, 3rd Edition, 2008, New Delhi

Digital Learning Resources:

Course Name	Kinematics of Machines
Course Link	https://nptel.ac.in/courses/112/105/112105268/
Course Instructor	Prof. Anirvan Dasgupta, IIT Kharagpur

Course Code: 19ME4PC03T	Course Name: Manufacturing Science - I	L-T-P: 3-0-0	Credit: 03

Course Objectives:

1. To understand basic manufacturing processes like casting, welding and metal forming.
2. To learn various aspects of different manufacturing techniques such as various casting methods, welding methods and metal forming methods
3. To decide which manufacturing technology can be implemented for a specific product

Syllabus:

Module-1: **(10 Hours)**

Foundry: Typesofpatterns,patternmaterialsandpatternallowances: MoldingMaterials: sandmolding,metalmolding,investmentmolding,shellmolding, Compositionofmoldingsand,Silicasand,Zirconsand,binders,additives,Binders-clay, bindersforCO2sand,binderforshell molding,bindersforcoresand, Propertiesofmoldingsandandsandtesting; Meltingfurnaces: cupola,resistancefurnace,inductionandarcfurnace;

Solidification of castings, design of risers and runners, feeding distance, centre line freezing resistance chills andchaplets; Degasification and inoculation ofmetals; Castingmethodslikecontinuouscasting,centrifugalcasting,disc; casting; Castingdefects.

Module-2: **(8 Hours)**

Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and Thermit welding;

Modern Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding; Edge preparation in butt welding. Brazing and soldering, welding defects; Destructive and non-destructive testing of castings and welding.

Module-3: **(8 Hours)**

Brief introduction to powder metallurgy process; Plastic deformation of metals: Variables in metal forming and their optimization. Dependence of stress strain diagram on Strain rate and temperature. Hot and cold working of metals, classification of metal forming processes; Forging: Smith Forging, Drop and Press forging, M/c forging, Forging defects;

Module-4: **(8 Hours)**

Extrusions: Direct, Indirect, Impact and Hydrostatic extrusion and their applications, Extrusion oftubes; Briefintroductiontosheetmetalworking:Bending,Forminganddeepdrawing,shearing;

Briefintroductiontoexplosiveforming,coatinganddepositionmethods;

Module-5: **(8 Hours)**

Wire drawing methods and variables in wire-drawing, Optimum dies shape for extrusion anddrawing; Rolling:PressureandForcesinrolling,typesofrollingmills,rollingdefects;

Course Outcomes:

On completion of the course, students will be able to

1. Recognize the different types of casting process.
2. Select suitable manufacturing process for typical components.
3. Describe the various welding process.
4. Explain the concept of forging, rolling process and drawing.

Suggested Books:

1. P. N. Rao, Manufacturing technology, Volume 1, Tata McGraw Hillpublication, 4th Edition, 2013, New Delhi
2. R. A. Little,Welding Technology , Tata McGraw Hill publication, 2017, New Delhi
3. A. GhoshandA.K.Malick, ManufacturingScience, EWP, 2nd Edition, 2010, New Delhi
4. P. C. Sharma,AText BooksofProductionEngineering, S. Chand Publishing, 11th Edition, 2019, New Delhi

Digital Learning Resources:

Course Name	Manufacturing Science - I
Course Link	https://nptel.ac.in/courses/112/107/112107219/
Course Instructor	Prof. D.K. Dwivedi, IIT Roorkee

Course Code: 19ME4PE01T	Course Name: Computer Integrated Manufacturing and Flexible Manufacturing System (CIM & FMS)	L-T-P: 3-0-0	Credit: 03

Course Objectives:

1. To learn the application of computers in manufacturing sectors.
2. To learn about NC part programming and robot programming
3. To learn application of computer in quality inspection, process planning, design.

Syllabus:

Module-1: (8 Hours)

FundamentalsofManufacturingandAutomation:Productionsystems,automationprinciplesand its strategies; Manufacturing industries; Types of production function in manufacturing; Automation principles and strategies, elements of automated system, automation functions and level of automation.

Module-2: (8 Hours)

Product/production relationship, Production concept and mathematical modelsforproductionrate,capacity,utilizationandavailability;Cost-benefitanalysis. Computer Integrated Manufacturing: Basics of product design, CAD/CAM, Concurrent engineering, CAPP and CIM.

Module-3: (14 Hours)

Industrial Robotics: Robot anatomy, control systems, end effectors, sensors and actuators; fundamentalsofNCtechnology,CNC,DNC,NCpartprogramming;Roboticprogramming,Robotic languages,workcellcontrol,Robotcleftdesign,typesofrobotapplication,Processingoperations, ProgrammableLogiccontrollers:PartsofPLC,OperationandapplicationofPLC,Fundamentalsof Net workings; Material Handling and automated storage and retrieval systems, automatic data capture,identificationmethods,barcodeandothertechnologies.

Module-4: (6 Hours)

Introduction to manufacturing systems: Group Technology and cellular manufacturing, Part families,Partclassificationandcoding,Productionflowanalysis,Machinecelldesign,Applications and Benefits of GroupTechnology.

Module-5: (8 Hours)

Flexible Manufacturing system: Basics of FMS, components of FMS, FMS planning and implementation, flexibility, quantitative analysis of flexibility, application and benefits of FMS. ComputerAidedQualityControl:objectivesofCAQC,QCandCIM,CMMandFlexibleInspection systems.

Course Outcomes:

1. Will be able to apply computer to manufacture industrial components.
2. Will understand the elements of an automated manufacturing environment.
3. Will able to make NC part programming and robot programming.

Suggested Books:

1. M.P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Publication, 4th Edition, 2016, Chennai
2. P. Radhakrishnan, S. Subramanyam and V. Raju, CAD/CAM/CIM, New Age International,

4th Edition, 2018, New Delhi

3. J. Talavage and R. G. Hannam, Flexible Manufacturing Systems in Practice, Marcell Decker, US, 1987

Digital Learning Resources:

Course Name	Computer Integrated Manufacturing and Flexible Manufacturing System (CIM & FMS)
Course Link	https://nptel.ac.in/courses/112/104/112104289/
Course Instructor	Prof. Janakarajan Ramkumar,Prof. Amandeep Singh IIT KAnpur

Course Code: 19ME4PE02T	Course Name: Internal Combustion Engines & Gas Turbines; (ICE & GT)	L-T-P: 3-0-0	Credit: 03
Note: Each and every module must practice with computer program like C, C++, Matlab, etc.			

Course Objectives:

1. To understand the operation and performance of internal combustion engines.
2. To perform theoretical calculations and do practical to obtain different efficiencies for internal combustion engines.
3. To analyze the combustion process of fuels (gasoline and diesel).
4. To know of the roles of coolants and lubricants in engine operation.
5. To acquire the knowledge of various alternate fuels, engine emissions, measuring and control techniques.

Syllabus:

Module-1: (8 Hours)

Introduction : Classification, Engine nomenclature, engine operating and performance parameters, Valve timing diagram of SI & CI Engines, Comparison of SI and CI engine.

Thermodynamic Analysis of cycles : Significance of Fuel-Air & Actual cycles of I.C. engines. Comparison with Air Standard Cycles. Analysis of Fuel-Air & Actual cycles (Effect of chemical equilibrium and variable specific heats. Effect of air fuel ratio and exhaust gas dilution. Time

Loss Factor, Heat Loss Factor, Exhaust Blow down, Loss Due to Gas Exchange Processes, Volumetric Efficiency, Loss due to Rubbing Friction).

Fuels :Fuels of SI and CI engine, Fuel additives, Properties, potential and advantages of alternative liquid and gaseous fuels for SI and CI engines (biofuels, LPG and CNG), Fuel Induction Techniques in IC engines : Fuel induction techniques in SI and CI engines, Mixture Requirements at Different Loads and Speeds.

Module-2: **(10 Hours)**

Carburetion: Factors Affecting Carburetion, Principle of Carburetion, Simple Carburetor and its drawbacks, Calculation of the Air–Fuel Ratio, Modern Carburetors;

Fuel Injection: Functional Requirements of an Injection System, Classification of Injection Systems, Fuel Feed Pump, Injection Pump, Injection Pump Governor, Mechanical Governor, Pneumatic Governor, Fuel Injector, Nozzle, Injection in SI Engine, Electronic Injection Systems, Multi-Point Fuel Injection (MPFI) System, Functional Divisions of MPFI System, Injection Timing, Group Gasoline Injection System, Electronic Diesel Injection System; Ignition :Energy requirement for ignition, requirements of an ignition system, conventional ignition systems, modern ignition systems (TCI and CDI), firing order, Ignition timing, Spark advance mechanism;

Module-3: **(10 Hours)**

Combustion : Stages of combustion in SI and CI engines, effects of engine variables on flame propagation and ignition delay, Abnormal combustion, Preignition & Detonation, Theory of Detonation. Effect of engine variables on Detonation, control of Detonation. Diesel Knock & methods to control diesel knock, Requirements of combustion chambers. Features of different types of combustion chambers system for S.I. engine. (I-head, F-head combustion chambers), C.I. engine combustion chambers -Open and divided type, Air swirl turbulence-M. type combustion chamber. Comparison of various types of combustion chambers.

Super Charging &Scavenging : Thermodynamics Cycles of supercharging. Effect of supercharging, Efficiency of supercharged engines. Methods of super charging, supercharging and scavenging of 2- stroke engines.

Module-4: (8 Hours)

Testing and Performances :Power, fuel & air measurement methods, Performance characteristic curves of SI & CI engines, variables affecting performance and methods to improve engine performance;

Cooling & Lubricating Systems, Engine Emission &Controls :Air cooling & water cooling systems, Effect of cooling on power output & efficiency, Properties of lubricants and different types of lubricating system;

Modern developments in IC Engines, EGR, MPFI, CRDI, GDI, HCCI, dual fuel engine, Lean burn engine, Stratified engine (basic principles);

Engine Emission and control : Mechanism of pollutant formation and its harmful effects. Methods of measuring pollutants and control of engine emission.

Module-5: (8 Hours)

Axial Flow & Centrifugal Compressor : Basic construction of centrifugal and axial flow compressor, Velocity diagram, performance characteristics of centrifugal and axial flow compressor, effects of slip, surging and stalling on compressor.

Course Outcomes:

1. Demonstrate the working and performance of IC Engines through thermodynamic cycles
2. Interpret different fuels and their inductions in internal combustion engines.
3. Describe the ignition and combustion of a fuel in a combustion chamber with supercharging and scavenging.
4. Analyze the testing, performance and emission of an IC engine.
5. Discuss the function of cooling and lubrication system of an IC engine.
6. Explain the working of axial flow and centrifugal compressor.

Text Books:

1. Mathur & Sharma, Internal Combustion Engines, 18th Edition, Dhanpat Rai Publication, 2008, New Delhi
2. V. Ganesan, Internal Combustion Engines, 4th Edition, Tata McGraw Hill Publication, ,2016, New Delhi
3. V.Ganesan, Gas Turbines, 3rd Edition,Tata McGraw Hill publication, , 2016, New Delhi

References:

1. J. B. Heywood, Fundamentals IC Engines, Indian Edition , Tata McGraw Hill Publication, 2017, New Delhi
2. H.N. Gupta, Fundamentals of Internal Combustion Engines, 2nd Edition, Prentice Hall India Learning Private Limited(PHI), 2012, New Delhi
3. K. K. Ramalngam, Internal Combustion Engines, 3rd Edition, Scitech Publications, 2007, Chennai
4. R. K. Rajput, Internal Combustion Engines, 2nd Edition, Laxmi Publication, New Delhi

Digital Learning Resources:

Course Name	Internal Combustion Engines & Gas Turbines
Course Link	https://nptel.ac.in/courses/112/103/112103262/
Course Instructor	Prof. Pranab K. Mondal, Prof. Vinayak N. Kulkarni Department of Mechanical Engineering, IIT Guwahati

Course Code: 9ME4ES01L	Course Name: Fluid Mechanics and Hydraulics Machines	L-T-P: 0-0-2	Credit: 1

Course Objectives:

The students able to

1. known about basic concept of buoyancy force with the flow device.
2. impart training on flow measuring devices such as orifice.
3. provide practice in estimating friction losses.
4. get basic information about fluid flow and its mechanism
5. gain basic knowledge about fluid machine such as pump and turbine with basic concept of impact jet.

Syllabus:

List of the Experiments:

1. Determination of Metacentric Height and application to stability of floating bodies.
2. Determination of Cv and Cd of Orifices.
3. Experiments on impact of Jets
4. Experiments on performance of Pelton Turbine.
5. Experiments on performance of Francis Turbine
6. Experiments on performance of Kaplan Turbine
7. Experiments on performance of centrifugal pump

8. Experiments on performance of reciprocating pump
9. Experiments on Reynold's Apparatus
10. Experiments on Flow through pipes
11. Experiments on performance of Gear pump
12. Verification of momentum equation

Course Outcomes:

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

1. Compute coefficients of orifice.
2. Calibrate flow discharge measuring device used in pipes channels and tanks.
3. Determine fluid and flow properties of buoyancy.
4. Characterize laminar and turbulent flows.
5. Test the performance of pumps and turbines

Course Code:19ME4PC01L	Course Name: Mechanics of Solids Laboratory	L-T-P: 0-0-2	Credit: 01

Course Objectives:

The students able to

1. Determine material properties.
2. Understand fatigue phenomena.
3. Determine Surface material properties.
4. Understand spring properties
5. Determine strain and load relationship

Syllabus:

List of the Experiments:

1. Determination of tensile strength of materials by Universal Testing Machine
2. Determination of compressive strength of materials by Universal testing Machine
3. Determination of bending strength of materials by Universal Testing Machine
4. Double shear test in Universal Testing Machine
5. Determination of Impact strength of material (Charpy and Izod)
6. Determination of Hardness strength of materials (Brinnel, Rockwell and Vickers)
7. Determination of Rigidity modulus of material
8. Determination of Fatigue strength of material
9. Estimation of Spring Constant under Tension and Compression.
10. Load measurement using Load indicator, Load Cells.

11. Strain measurement using Strain Gauge.
12. Stress measurement using strain rosette.

Course Outcomes:

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

1. Evaluate fatigue strength of materials under different loading conditions
2. Evaluate material properties under different loading conditions
3. Determine surface hardness of materials
4. Determine spring constant under different loading condition
5. Evaluate strain vs load relationship under different loading condition

Course Code:19ME4PC02L	Course Name: Kinematics of Machines Laboratory	L-T-P: 0-0-2	Credit: 01

Course Objectives:

The students will able to

1. Understand the motion resulting from a specified set of linkages and to synthesize the mechanism.
2. Understand the effect of screw jacks, bearings and clutch.
3. Understand the basic concepts of toothed gearing and kinematics of gear trains.
4. Determine friction in brakes and dynamometer.

Syllabus:

List of Experiments:

1. Radius of gyration of compound pendulum
2. Radius of gyration of connecting rod
3. TRI –FILAR / BI-FILAR System
4. Experiment on Screw Jack
5. Experiment on Journal Bearing Apparatus
6. Experiment/Study on clutches
7. Experiment on Epicyclic Gear Train
8. Experiments on Simple/Compound/Reverted Gear trains
9. Experiment on Dynamometer

10. Experiment on Brake
11. Experiment on Coriolis component of acceleration

Course Outcomes:

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

1. Analyze the velocity and acceleration of links of different mechanisms.
2. Evaluate the effect of friction in screw jacks, bearings and clutch.
3. Design and develop a gear train as per power transmission & gear terminologies and can calculate velocity of gears.

Course Code: 19ME4PC03L	Course Name: Manufacturing Science - I Laboratory	L-T-P: 0-0-2	Credit: 01

Course Objectives:

1. To determine the grain size of the sand, clay content in the sand sample, permeability of the test sample and to find out tensile, compressive and shear strength of the moulding sand
2. To familiar with foundry practices.
3. To determine the strength of brazed and soldered joint
4. To familiar with different types rolling mills and extrusion processes
5. To make job using sheet metals.
6. To learn how to make wood pattern for making mould.

Syllabus:

List of Experiments:

1. Determination of grain size, clay content, permeability and green compressive strength of molding sand. (2 to 3 experiments)
2. Foundry Practices
3. Preparation of a wood pattern.
4. Determination of strength of brazed and solders joints
5. Practice and preparation of job in sheet metal using processes like forming and deep drawing.

6. Demonstration of different rolling mills
7. Demonstration of Extrusion processes

Course Outcomes:

Students are able to

1. Determine the grain size of the sand, clay content in the sand sample, permeability of the test sample and are able to determine the tensile, compressive and shear strength of the moulding sand.
2. know the foundry practices and are able to make patterns
3. determine strength of brazed and soldered joint
4. get familiar with different types of rolling mills and extrusion process.
5. are able to make job with sheet metals

Fifth Semester					
Theory					
Sl. No.	Category	Course Code	Course Title	L-T-P	Credit
1	PCC	19ME5PC01T	Dynamics of Machines	3-0-0	3
2	PCC	19ME5PC02T	Applied Thermodynamics	3-0-0	3
3	PCC	19ME5PC03T	Manufacturing Science-II	3-0-0	3
4	PEC	19ME5PE01T/ 19ME5PE02T/ 19ME5PE03T/ 19ME5PE04T	Mechanics of Composite materials; Advanced Mechanics of Solid; Automobile Engineering; Production and Operation Management	3-0-0	3
5	OEC	19ME5OE01T/ 19ME5OE02T	Engineering Managements/ MEMS	3-0-0	3
6	OEC	19ME5OE03T/ 19ME5OE04T	Smart and Intelligent Materials/ Nano Technology	3-0-0	3
7	MC	19CM5MC01T	Mandatory(Constitution of India/ Essence of Indian Tradition Knowledge)	1-0-0	0
Total Credit (Theory)					18
Practical					
1	PCC	19ME5PC01L	Dynamics of Machines	0-0-2	1
2	PCC	19ME5PC02L	Applied Thermodynamics	0-0-2	1
3	PCC	19ME5PC03L	Manufacturing Science - II	0-0-2	1
4	PSI	19CM5MC01L	Summer Internship/Training	0-0-2	1
Total Credit (Practical)					4

Total Semester Credit	**22**

Course Code:19ME5PC01T	**Course Name:** Dynamics of Machines	**L-T-P** 3- 0- 0	**Credit** 3

Course Objective:

To make the student to:

1. Understand theory involved in the analysis of clutches, brakes and dynamometers.
2. Recognize the engineering features of flywheel and governors.
3. Develop knowledge on balancing of rotary and reciprocating masses.
4. To study the gyroscope effect and its application.
5. Understanding of vibrations and its significance on engineering design

Syllabus

Module-1: **(8 hours)**

Friction and friction clutches: Basics, inclined planes, screw thread forms (square, v), screw jack, rolling friction, journal friction. Friction axis of a link, four-bar mechanism, film friction. pivots and collars, uniform pressure, uniform wear. Types of clutches – disc, multiplate, cone and centrifugal.

Module-2: **(10 hours)**

Flywheels: Engine force analysis, turning moment of crankshaft, dynamically equivalent system, inertia of connecting rod. Turning moment diagrams, fluctuation of energy, flywheels, dimensions of flywheel rim, applications.

Governors: Watt, Porter, Proell, Hartung. Wilson-Hartnell, spring-controlled gravity governor, inertia governor. Sensitiveness, hunting, isochronism, stability, power, effort, controlling force of a governor.

Module-3: **(9 hours)**

Balancing: Static and dynamic balancing of rotating masses, force balancing of four bar linkage, Primary and Secondary balancing of reciprocating engine, balancing inline engine (2,4,6, cylinders), V-engines, W-engines and radial engines, direct and reverse crank method, balancing machines – static, dynamic theory of field balancing.

Module-4: **(9 hours)**

Gyroscopes: Angular velocity, angular acceleration, gyroscopic couple, gyroscopic effect on airplanes, ships. Static and dynamic force analysis of planar mechanisms, Stability of four-wheel and two- wheel automobiles, rigid disc at an angle fixed to a rotating shaft.

Module-5: **(10 hours)**

Vibrations: Definitions, types, basic features, degrees of freedom, free longitudinal vibration – equilibrium method, energy method, Rayleigh‘s method, displacement, velocity, acceleration, effect of mass of spring, damped vibration, logarithmic decrement. Forced longitudinal vibrations: harmonic excitation, magnification factor, vibration isolation and transmissibility. Transverse vibrations, single concentrated load, uniformly distributed load, several loads, Dunkerley‘s method, whirling of shafts. Torsional vibrations– single rotor.

Course Outcome

The student will be able to:

1. Explain the working of important machine elements like clutches, brakes.
2. Evaluate the performance of Flywheels, governors.
3. Analyze the theory involved in balancing of rotating and reciprocating members.
4. Analyze the effect of a gyroscope on ships, airplanes and automobile.
5. Understand longitudinal, transverse and torsional vibrations so as to avoid resonance.

Text Books:

1. S. S. Rattan, Theory of Machine, 3rd Edition, Tata McGraw Hill, 2009, New Delhi.
2. R. L. Norton, Kinematics and Dynamics of Machinery, 3rd Edition, Tata MacGraw Hill, 2007, India
3. John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Theory of Machines and Mechanisms, 4th Edition, Oxford University Press, 2014, New Delhi.

Reference Books:

1. J. J. Uicker , G. P. Pennock, and J. E. Shigley, Theory of Machines and Mechanisms, 4th Edition, International Version, Oxford University Press, 2009, New Delhi.
2. Thomas Bevan, The Theory of Machines: A textbook for Engineering students, 3rd Edition, Pearson, 2009, New Delhi.
3. J. S. Rao, R. V. Dukipatti, Mechanism and Machine, 3rd Edition,John Wiley & Sons, United States.

Digital Learning Resources:

Course Name	Dynamics of machines
Course Link	https://nptel.ac.in/courses/112/101/112101096/
Course Instructor	Prof. C Amarnath, Prof. K. Kurien Issac, Prof. P Seshu, Department of Mechanical Engineering, IIT Bombay

Course Name	Dynamics of machines

Course Link	https://nptel.ac.in/courses/112/104/112104114/
Course Instructor	Prof. Amitabha Ghosh, Department of Mechanical Engineering, IIT Kanpur

Course Code:19ME5PC01L	**Course Name:** Dynamics of Machines Lab	**L-T-P** 0- 0- 2	**Credit** 1

Course Objectives:

1. To study the various type of gear drives and its applications.
2. To understand the principles of gyroscope and governors.
3. Able to examine mode shapes of rotating shaft and vibration.
4. To understand the concepts of balancing of mass and cam profile.
5. To study working principle of Journal bearing.

List of Experiments:

1. Experiment on epicyclic gear train
2. Determination of gyroscopic couple using gyroscopic test rig.
3. Performance characteristics of a spring loaded governor
4. Determination of critical speed of rotating shaft
5. Experiment on static and dynamic balancing apparatus
6. Determination of natural frequencies of un-damped as well as damped vibrating systems.
7. Study of interference and undercutting for gear drives
8. Experiment on Cam Analysis Apparatus.
9. Experiment on Journal Bearing Apparatus.

Course Outcome:

1. Evaluate the velocity ration of the epicyclic gear train and study the interference and undercut of gear drives.
2. Analyze the performance of gyroscope and governor.
3. Inspect the critical speed of shaft and determine natural frequency of damped and un-damped vibrating system.
4. Able to perform the balancing of rotating system and draw the Cam profile.
5. Evaluate the pressure head in journal bearing under various speeds.

Course Code:19ME5PC02T	**Course Name:** Applied Thermodynamics	**L-T-P** 3- 0- 0	**Credit** 3

Course Objective:

The student will be able to

1. Understand thermodynamics relations and its usage in deriving properties of substances
2. Understand the behavior of ideal gas and real gas.
3. Estimate the properties of real gases.
4. Utilize the knowledge of thermodynamic cycles in design of air compressor.
5. Understand the air craft propulsion using the knowledge of gas turbine cycles.

Syllabus

Module-1: **(9 hours)**

Ideal Gas and Real Gas: Ideal gas, relation among the specific heats, internal energy, enthalpy. Analysis of isochoric, isobaric, isothermal, isentropic, isenthalpic processes, representation of the above processes on P-v, T-s planes. Determination of work, heat, entropy and enthalpy changes during the above processes, problems. Characteristic gas equations of a real gas, virial coefficients, law of corresponding states, compressibility factor, generalized compressibility chart, problems

Module-2: **(9 hours)**

Properties of Gases and Gas Mixtures: Equations of State, changes in internal energy, enthalpy and entropy for an ideal gas, Equations of state for a real gas, Virial Expansions, Law of Corresponding States, Generalized Compressibility Chart, Reduced coordinates, Other Equations of state, Dalton's Law of Partial Pressures, Internal Energy, Enthalpy and Entropy and Specific Heats of Gas Mixtures, Gibbs Function of a Mixture.

Module-3: **(9 hours)**

Thermodynamic Relations:

Some Mathematical Theorems, Maxwell's Relations, T-ds Equations, Difference in Heat Capacities, Ratio of Heat Capacities, Energy Equation, Claussius-Clapeyron Equation, Joule-Thomson Coefficient, Evaluation of Thermodynamic Properties from Equation of State, Mixtures of Variable Composition, Conditions of Equilibrium for a Heterogeneous System, Gibbs Phase Rule, Types of Equilibrium, Conditions of Stability, Third Law of Thermodynamics

Module-4: **(8 hours)**

Reciprocating Air Compressors: Introduction (Uses of compressed air), The reciprocating cycle neglecting and considering clearance volume, Volumetric efficiency and its effect on compressor performance, Limitations of single stage compression, Multistage compression and intercooling, Optimum intercooler pressure, Performance and design calculations of reciprocating compressors, Air motors.

Module-5: **(9 hours)**

Gas Turbines: Introduction, Open and closed cycle gas turbines, Analysis of practical gas turbine cycle.

Air Craft Propulsion: Analysis of Turbo Jet, Turbo Prop, Turbo fan & Ram jet engines.

Course Outcome

Students will able to

1. Derive different properties using the thermodynamic relations.

2. Use the ideal gas and real gas effects in solving real life problems
3. Compute the thermodynamic properties of gas mixture..
4. Design the air compressor based on the thermodynamics analysis of compressor
5. Use the knowledge of gas turbine cycles in analyzing the air-craft propulsion.

Text Book

1. P. K. Nag, Basic and Applied Thermodynamics, 2nd Edition, Tata McGraw Hill Education Private Limited, 2009, New Delhi
2. Claus Borgnakke, Richard E. Sonntag, Gordon J. Van Wylen, Fundamentals of Thermodynamics, 6th Edition, John Wiley & Sons, 2002
3. E. Rathakrishnan, Fundamentals of Engineering Thermodynamics, 2nd Edition, PHI Learning Pvt. Ltd., 2005, New Delhi

Reference Book

1. S. Domkundwar, C. P. Kothandaraman, Anand Domkundwar, A Course in thermal Engineering, Dhanpat Rai & Co., 2016, India
2. P. L. Ballaney, Engineering Thermodynamics and Energy Conversion Techniques, 5th Edition, Khanna Publishers, 2010, New Delhi
3. Y. A. Cengel, M.A. Boles, Thermodynamics: An Engineering Approach, 8th Ed, McGraw Hill Education, 2017, India
4. D. A. McQuarrie, J. D. Simon, Molecular Thermodynamics, 1999th Edition, University Science Books, 1999
5. H. Cohen, H. I. H. Saravanamuttoo, G. F. C. Rogers, Paul Straznicky, A. C. Nix, Gas Turbine Theory, 7th Edition, Pearson, 2019, India

Digital Learning Resources:

Course Name	Applied Thermodynamics

Course Link	https://nptel.ac.in/courses/112/103/112103275/
Course Instructor	Prof. Dipankar N. Basu, Department of ME, IIT Guwahati

Course Code:19ME5PC02L	**Course Name:** Applied Thermodynamics Lab	**L-T-P** 0- 0-2	**Credit** 1

Course Objective:

1. Able to get brief knowledge about Compressor
2. Understand the basic concept of expansion of a gas through Joule experiment.
3. Basic knowledge of gas turbine and jet propulsion system.
4. Gaining knowledge about load carrying system of petrol and diesel engine.
5. Understand about various performance analysis of load test, heat balance and Morse test of various engine.

Syllabus

1. Performance analysis of reciprocating air-compressor.
2. Performance analysis of Centrifugal / Axial Flow compressor.
3. Verification of Joule-Thomson coefficient.
4. Performance analysis of gas turbine.
5. Model study of Jet propulsion system
6. Abel's apparatus: Determination of flash and fire points of a given oil sample
7. Redwood Viscometer: Determination of kinematic and absolute viscosities of an oil sample given.
8. Load test on 4-stroke single cylinder C.I. engine.

9. Load test on 4-stroke single cylinder S.I. engine.
10. Morse Test on multi-cylinder S.I. or C.I. engine.
11. Load test on variable compression ratio S.I. engine.
12. Load test and Heat balance on 2 stroke S.I. Engine.

Course Outcome

1. Brief description about various types of compressor and its components with characteristics analysis.
2. Describe about aircraft system and its working principle.
3. Determine the properties of gases, mixture.
4. Evaluate the performance of petrol and diesel engine.
5. Evaluate the various accept of load test, heat balance of a variable 2-stroke and 4-stroke engine.

Course Code:19ME5PE01T	**Course Name:** Manufacturing Science - II	**L-T-P** 3- 0- 0	**Credit** 3

Course Objective:

The students will able to

1. learn basic metal removal processes and different tools used in them
2. learn mechanics and mechanism of machining, tool life, tool materials, heating effect in machining, machining time and economy of machining process
3. Learn about different machine tools.
4. Learn about Jigs and fixtures and their application in different machine tools.
5. learn about non- traditional machining processes and their application in machining specific material

Syllabus

Module-1: **(12 hours)**

Machine Tools: Geometry of cutting tools in ASA and ORS, Mechanics of chip formation, Merchant's theory, Force relationship and velocity relationship, Cutting tool materials.

Flank wear, Crater wear, Wear measurement, Cutting fluid and its effect; Machinability Criteria, Tool life and Taylor's equation, Effect of variables on tool life and surface finish, Measurement of cutting force, Lathe tool dynamometer, Drill tool dynamometer.

Module-2: **(9 hours)**

Conventional machining process and machine tools: Turning, Drilling, Shaping, Planning, Milling, Grinding. Machine tools used for these processes, their specifications and various techniques used. Principles of machine tools: Kinematics of machine tools, speed transmission from motor to spindle, speed reversal mechanism, mechanism for feed motion, Tool holding and job holding methods in different Machine tools.

Module-3: **(9 hours)**

Mechanism in machining: Indexing mechanism and thread cutting mechanism, Quick return mechanism.

Production Machine tools: Engine lathe, Speed lathe**,** Capstan and turret lathes, single spindle and multi spindle semiautomatics, Gear shaper and Gear hobbing machines, Copying lathe and transfer machine

Module-4: **(8 hours)**

Non-traditional Machining processes: Ultrasonic Machining, Laser Beam Machining, Plasma Arc Machining, Electro Chemical Machining, Electro Discharge Machining, Wire EDM , Abrasive Jet Machining

Course Outcome

1. Explain the features and applications of lathe, milling, drilling and broaching machines.
2. Discuss features and applications of reciprocating machine tools like shaper, planer and slotting machine.
3. Explain economics of machining.
4. Explain Jigs and fixtures and their application.
5. Explain different types of non- traditional machining processes.

Text Book

1. G.Boothroyd and W.A.Knight, Fundamentals of Machining and Machine Tools, 3rd Edition, CRC Press, 2005, Florida
2. M.C.Shaw, Metal Cutting Principles, 2nd Edition, Oxford University Press, 2004, Kolkota

3. A.Bhattacharya, Metal Cutting Theory and Practice, 2nd Edition,Central Book Publishers, 2012, Hyderabad.

Reference Book

1. P.N. Rao, Manufacturing Technology, 4th Edition, Tata McGraw Hill publication, 2018, New York City.
2. G. Boothroyd and W.A. Knight, Fundamentals of Machining and Machine Tools,3rd Edition,CRC Press, 2005,Florida.
3. Ghosh and Mallik, Manufacturing Science, 2nd Edition, East West Press, 2010, New Delhi.
4. P. C. Pandey, H. S. Shan, Modern Manufacturing Processes, 45th Edition, Tata McGraw Hill, 2012, New Delhi
5. D. A. Stephenson and J. S. Agapiou, Metal Cutting Theory and Practice, 3rd Edition, CRC Press,2018, Florida

Digital Learning Resources:

Course Name	Manufacturing Science-II
Course Link	https://nptel.ac.in/courses/112/105/112105126/
Course Instructor	A. B. Chattopadhyay, Department of Mechanical Engineering, IIT Khadagpur

Course Code:19ME5PE01L	Course Name: Manufacturing Science – II Lab	L-T-P 0- 0- 2	Credit 1

Course Objective:

1. Learn about the different types of cutting tools & its geometry
2. Get the knowledge about various types of conventional machining operation, principle of machine tools
3. Learn to calculate cutting forces during machining.
4. Learn about the CNC lathe and milling machines.
5. Learn about the various non-traditional machining processes and their importance.

List of Experiments:

1. Job on lathe with tapper turning, thread cutting, knurling and groove cutting (3 experiments).
2. Gear cutting (with index head) on milling machine
3. Working with shaper, Planner and slotting machine.
4. Working with surface and cylindrical grinding.
5. Determination of cutting force using Lathe tool dynamometer.
6. Determination of cutting force in drilling using drill tool dynamometer.
7. Study of Non-traditional machining processes.(USM, AJM, EDM, ECM)

8. Study of CNC Lathe and demonstration of making job in CNC lathe.
9. Study of CNC Milling machine and demonstration of making job in CNC Milling machine

Course Outcomes:

1. Students have learned about the use of cutting tools for various operations
2. Students have learned to conduct various machining operations on conventional machining
3. Students were able to calculate cutting forces during machining using dynamometer
4. Students were able to operate and conduct the machining on CNC machines
5. Students have learned the importance of the non-conventional machining processes.

Course Code:19ME5PE01T	**Course Name:** Composite materials	**L-T-P** 3- 0- 0	**Credit** 3

Course Objective:

The objective of the course is to

1. understand the concept of composite material
2. know the processes involved in the manufacturing of composite materials
3. understand the various types of composite materials and their compositions
4. know the micro and macro mechanical properties of composite materials
5. Know the concept of lamination theory.

Syllabus

Module-1: **(7 hours)**

Introduction to Composite Material: Classification and characteristics of composite materials, mechanical behavior of composites, constituents, Reinforcements, Matrices, Fillers, Additives, Applications and advantages of composites.

Module-2: **(7 hours)**

Manufacturing Procedures of composites: Constituent Materials, Initial form of constituent materials,. Testing of Composites, Evaluation of Engineering Constants and Strengths.

Module-3: **(7 hours)**

Macro-mechanical behavior of composites: Stress strain relations of anisotropic materials - Engineering constants for orthotropic materials, Stress strain relations for specially orthotropic lamina. Transformation relationships for a lamina of arbitrary fibre orientation.

Module-4: **(7 hours)**

Micromechanical Analyses of orthotropic lamina: Evaluation of Engineering Constants using Micromechanical principles, Rules of Mixtures, Kelly Davis Model for Minimum and Critical Volume Fractions.

Module-5: **(7 hours)**

FRP Composite: Laminate designation and codes, Macro-mechanical Behaviour of FRP Composite Laminates, Classical Lamination Theory. General Design Consideration and Suitable laminating Scheme.

Course Outcome

The student will be able to

1. Understand and describe the basic concept and classification of the composite.
2. Acquire the knowledge in polymer matrix composites and its processing methods.
3. Understand the micromechanical properties of composites.
4. Understand the macro mechanical of composites.
5. Use of Mathematical techniques to predict the macroscopic properties of different Laminates

Text Book

1. R.M. Jones, Mechanics of Composite Materials, 2nd Edition , Mc. Graw Hill Book Co.- 1999

2. Matthews and Rawlings, Composite Materials: Engineering and Science, 1st Edition , CRC Press-1999
3. M Mukhopadhay, Mechanics of composite materials and structures, 1st Edition, Universities Press-2000

Reference Book

1. P. K. Mallick, Fibre - Reinforced composites: - Materials, manufacturing and Design, 2nd Edition, CRC Press-1993.
2. I.. M. Danel, O.Issai, Engineering Mechanics of Composite Materials, 2nd Edition, Oxord University Press-2006
3. R. F. Gibson, Principles of Composite Material Mechanics, 1st Edition , CRC Press-1993
4. D. Hull and T.W. Clyne, An Introduction to composite material, , Cambridge University press-1996
5. S. Suresh, A. Martensen, and A. Needleman, Fundamentals of Metal Matrix Composites, 1st Edition, Butterworth Heinemann-1993

Digital Learning Resources:

Course Name	Advanced Composites
Course Link	https://nptel.ac.in/courses/112/104/112104249/
Course Instructor	Prof. Nachiketa Tiwari Department of Mechanical Engineering, IIT Kanpur

Course Code:19ME5OE01T	Course Name: Advanced Mechanics of Solid	L-T-P 3- 0- 0	Credit 3

Course Objective:

1. To solve solid mechanics problems using theory of Elasticity.
2. Understand the advanced concept of stress-strain behavior of materials.
3. To solve solid mechanics problems using energy methods.
4. To estimate the stress and strain in thick cylinders.
5. Recognize the basics mode of failure criteria and fracture analysis.

Syllabus

Module-1: **(9 hours)**

Concept of elasticity: stresses in three dimensions, Principal Stresses, Stress Invariants, Mohr's Circle for 3-D state of stress, Octahedral Stresses, State of pure shear. Differential equations of equilibrium, compatibility conditions, plane stress.

Module-2: **(8 hours)**

Analysis of strain: State of strain at a point, Strain Invariant, Principal Strains, Plane state of strain, Strain measurements. Theories of Failure, Various yield criteria

Module-3: **(10 hours)**

Energy Methods: Work done by forces and elastic strain energy stored. Reciprocal relations, Theorem of virtual work, Castigliano's theorems, Bending of beams: Asymmetrical bending, Shear centre, Bending of curved beams, Stress distribution in beam with rectangular, circular and trapezoidal cross section, stresses in crane hooks, ring and chain links. Deflection of thick curved bars.

Module-4: **(8 hours)**

Thick cylinder: Thick walled cylinder subjected to internal and external pressures, Compound cylinders, Shrink fit.

Module-5: **(9 hours)**

Fatigue and Fracture Analysis: Repeated stresses and fatigue in metals, Fatigue tests and fatigue design theory, Goodman, Gerber and Soderberg criteria, Concept of stress concentration, Notch sensitivity.

Introduction to Fracture Mechanics: Basic modes of fracture, Fracture toughness evaluation.

Course Outcome

1. To understand the elastic and plastic behavior of material and evaluate stress invariants, principal stresses and their directions.
2. Develop constitutive relationships between stress and strain for linearly elastic solid.
3. Analyze solid mechanics problems using energy methods
4. Examine the properties of ideally plastic solid and apply the concepts of energy methods in solving structural problems.
5. Analyze theories of failure and design components for safe operation.

Text Book

1. S P Timoshenko and D H Young, Elements of Strength of Materials, 5th Edition, Affiliated East West Press, 2003, India.
2. G. H. Ryder, Strength of Materials, 3rd Edition, Palgrave Macmillan Press, 1965, India.

3. S S Rattan Strength of Materials, 3rd Edition, Tata Mc Graw Hill, 2008, India.
4. L.S. Srinath, Advanced Mechanics of Solids, 3rd Edition, Tata McGraw Hill, 2010, India.

Reference Book

1. Egor P Popov, Engineering Mechanics of Solids, 2nd Edition, Prentice Hall of India, 2015, India.
2. P. Boresi, and Richard J. Schmidtt, Advanced Mechanics of Materials, 5th Edition, Willey, 2019, India.
3. Beer and Johnston, Mechanics of Materials, 5th Edition, Tata McGraw Hill, 2008, India.
4. Russell C. Hibbeler, Mechanics of Materials, 9th Edition, Pearson Education, 2014, India

Digital Learning Resources:

Course Name	Advanced Mechanics of Solid
Course Link	https://nptel.ac.in/courses/105/106/105106049
Course Instructor	Dr. U. Saravanan, Department of Civil Engineering, IIT Madras.

Course Code:19ME5PC01T	Course Name: Automobile Engineering	L-T-P 3- 0- 0	Credit 3

Course Objective:

1. Identify the different parts of engine & know the construction of chassis & amp body.
2. Calculate different resistances act upon the vehicle & amp; power related to it.
3. Know the steering geometry & amp; related mechanism.
4. Know about electrical vehicle & amp; electrical circuit diagram of electrical system of vehicle.
5. Apply their ideas on Automobile project work & amp; related industrial sector for future development of Automobile.

Syllabus

Module-1: **(8 hours)**

Introduction

Main Modules of automobile chassis and body, different systems of the automobile, description of the main parts of the engine, motor vehicle act.

Alternative Energy Sources- Use of Natural Gas, LPG, Biodiesel, Gasohol and Hydrogen in Automobiles, Electric and Hybrid Vehicles, Fuel Cells.

Module-2: **(8 hours)**

Types of Resistance

Resistance to motion, rolling resistance, air resistance, gradient resistance, power required for propulsion, tractive effort and traction, road performance curves.

Hydraulic braking system, braking of vehicles when applied to rear, front and all four wheel, theory of internal shoe brake, design of brake lining and brake drum, different arrangement of brake shoes, servo and power brakes.

Module-3: **(8 hours)**

Transmission Systems

Layout of the transmission system, main function of the different components of the transmission system, transmission system for two wheels and four wheel drives. Hotchkiss and torque tube drives.

Module-4: **(8 hours)**

Gear box: Sliding mesh, constant mesh and synchromesh gearbox, design of 3 speed and 4 speed gear box, over drive, torque converter, semi and fully automatic transmission.

Hookes joint, propeller shaft, differential, rear axles, types of rear axles, semi floating, there quarter floating and full floating types.

Front wheel Geometry and steering systems : Camber, castor, kingpin inclination, toe-in and toe-out, centre point steering condition for true rolling, components of steering mechanism, power steering.

Module-5: **(8 hours)**

Electrical system of an automobile: Starting system, charging system, ignition system, other electrical system.

Electrical vehicles: History, electrical vehicles and the environment pollution, description of electric vehicle,operational advantages, present EV performance and applications, battery for EV, Battery types and fuel cells, Solar powered vehicles, hybrid vehicles.

Course Outcome

1. Understand the basic lay-out of an automobile.
2. Understand the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
3. Understand the principles of transmission, suspension, steering and braking systems.
4. Understand automotive electronics.
5. Study latest developments in automobiles.

Text Book

1. N. K. Giri, Automobile Mechanics , 8th Edition, Khanna publishers, 2008, New Delhi
2. K. M. Gupta, Automobile Engineering (Vol. 1 & 2), 1st Edition, Umesh Publication, 2007, New Delhi
3. Kirpal Singh, Automobile Engineering (Vol. 1 & 2), 14th Edition, Standard Publisher Distributors, 2018, New Delhi

Reference Book

1. W. H. Crouse, D. L. Anglin, Automotive mechanics, 10th Edition, Tata McGraw Hill Publishers, 2007, New Delhi
2. K. Newton, W. Steeds, The Motor Vehicle, 12th Edition, Society of Automotive Engineers U.S., 1996
3. J. Heitner, Automotive Mechanics, 2nd Edition, East West Press, 2004, New Delhi
4. K. K. Jain, R. B. Asthana, Automobile Engineering, Tata McGraw Hill Publishers, 2002, New Delhi
5. K. K. Ramalingam, Automobile Engineering, 2nd Edition, Scitech Publications, 2001, New Delhi

6. R. K. Rajput, A Text Book of Automobile Engineering, 2nd Edition, Laxmi Publishers, 2014, New Delhi

Course Name	Fundamentals of Automotive Systems
Course Link	https://nptel.ac.in/courses/107/106/107106088/
Course Instructor	Prof. C. S. Shankar Ram, Department of Design Engineering, IIT Madras

Course Code:19ME5PC01T	**Course Name:** Production and Operation Management	**L-T-P** 3- 0- 0	**Credit** 3

Course Objective:

1. Acquire a working understanding of the roles/functions of production management in the context of business enterprise.
2. Develop skills in solving production management problems.
3. Recognize, appreciate, and perform the job of a competent production or operation manager

Syllabus

Module-1: **(8 hours)**

Introduction: Operations Function in an Organization, Manufacturing Vs. Service Operations, System view of Operations, Strategic Role of Operations, Operations Strategies for Competitive Advantage, Operations Quality and Productivity Focus, Meeting Global Challenges of Production and Operations Imperatives.

Designing Products, Services and Processes: New Product Design- Product Life Cycle, Product Development Process, Process Technology: Project, Job shop, Batch, Assembly Line,

Continuous Manufacturing; Process Technology Life Cycle, Process Technology Trends, FMS, CIM, CAD, CAM; Design for Services, Services Process Technology.

Module-2: **(8 hours)**

Work Study: Methods Study- Techniques of Analysis, recording, improvement and standardization; Work Measurement: Work Measurement Principles using Stopwatch.

Time Study: Predetermined Motion Time Standards and Work Sampling, Standard Time Estimation.

Module-3: **(8 hours)**

Location and Layout Planning: Factor Influencing Plant and Warehouse Locations, Impact of Location on cost and revenues.

Facility Location Procedure and Models: Qualitative Models, Breakeven Analysis, location Model, centroid method.

Layout Planning: Layout Types : Process Layout, Product Layout, Fixed Position Layout Planning, block diagramming, line balancing, computerized layout planning- overview.

Forecasting: Principles and Method, Moving Average, weighted Moving Average, Exponential, Smoothing, Winter's Method for Seasonal Demand, Forecasting Error.

Module-4: **(8 hours)**

Manufacturing Planning and Control: The Framework and Components: Aggregate Planning, Master Production Scheduling, Rough-cut-Capacity Planning, Material Requirements Planning, Capacity Requirements Planning.

Sequencing and Scheduling: Single Machine Sequencing: Basics and Performance Evaluation Criteria, Methods for Minimizing Mean Flow Time, Parallel Machines: Minimization of Makespan, Flowshop sequencing: 2 and 3 machines cases: Johnson's Rule and Jobshop Scheduling: Priority dispatching Rules.

Module-5: **(8 hours)**

Inventory Control: Relevant Costs, Economic Batch Quantity, Basic EOQ Model, Model with Quantity discount, Periodic and Continuous Review Systems, Safety Stock, Reorder Point and Order Quantity Calculations. ABC Analysis.

Modern Trends in Manufacturing: Just in Time (JIT) System: Shop Floor Control By Kanbans, Total Quality Management, Total Productive Maintenance, ISO 9000, Quality Circle, Kaizen, Poka Yoke, and Supply Chain Management, Group Technology.

Course Outcome:

1. Identify the elements of operations management and various transformation processes to enhance productivity and competitiveness.
2. Analyze and evaluate various facility alternatives and their capacity decisions, develop a balanced line of production & scheduling and sequencing techniques in operation environments
3. Develop aggregate capacity plans and MPS in operation environments.
4. Plan and implement suitable materials handling principles and practices in the operations.
5. Plan and implement suitable quality control measures in Quality Circles to TQM.

Text Book

1. R. Paneerselvam, Production and Operations Management, 2nd Edition, Prentice Hall of India, 2006, India.
2. K Aswathappa, Shridhara Bhatt, Production & Operations Management, 1st Edition, Himalaya Publising House, 2010, Mumbai.
3. S. N. Chary, Production and Operations Management, 5th Edition, Tata McGraw Hill, 2012, New Delhi.

Reference Books

1. Norman Gaither, Greg Frazier, Operations Management, 9th Edition, Cengage Publication, 2004, New Delhi.
2. Roberta S Russell, Bernard W Taylor, Operations Management, 10th Edition, PHI Publication, 2019, New Delhi.

3. E. E. Adam and R.J. Ebert, Production and Operations Management, 2nd Edition, Prentice Hall of India, 2009, India.

Digital Learning Resources:

Course Name	**Industrial Engineering**
Course Link	https://nptel.ac.in/courses/112/107/112107143/
Course Instructor	Prof. P K Sinha Department of Mechanical Engineering, IIT Roorkee

Course Name	Principles of Industrial Engineering
Course Link	https://nptel.ac.in/courses/112/107/112107292/
Course Instructor	Prof. D K Dwivedi Department of Mechanical Engineering, IIT Roorkee

Course Code:19ME5OE01T	Course Name: Engineering Management	L-T-P 3- 0- 0	Credit 3

Course Objective:

1. To provide an introduction to Engineering Management and exposure to forecasting methods, namely qualitative & quantitative methods .
2. .Impart knowledge on the Aggregate Planning and Materials Requirement Planning?
3. Understand the principles/methods of Scheduling and Sequencing.
4. Understand the Maintenance Planning and Control and the methods for reliability improvement?
5. Impart knowledge on the Modern concepts/ techniques in operations management and Supply Chain management

Syllabus

Module – 1 **(8 hours)**

Management and Organizations, Management process: Definition, planning organizing, directing, controlling, coordinating, types of management. Organization Definition, planning, design and development, types of organizations. Management planning and control: Classical, new classical and modern principles. General Management, scientific management, engineering, management, systems management. Planning: Procedures, resources and constraints, objectives,

goals, policies and procedures. Control: Setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.

Module – 2 **(7 hours)**

Human resource planning and management: selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining, Management of Physical Resources Plant: site selection procedures, factors affecting selection. Layout-types and relative merits and demerits, Maintenance-Objectives, different types of associated decisions, strategies for effective maintenance, computer applications. Material: Functions, objectives, planning and control including inventory models with or without storage costs, price break (excluding dynamic and probabilistic considerations). Different classes of inventory. Material Requirement Planning (MRP).

Module – 3 **(8 hours)**

Financial management: Introduction to standard forms of financial statements, i.e., balance-sheet, profit and loss, and income statement. Fixed and current asset items. Fixed and current liability items. Linkage of two successive balance-sheets through income or profit and loss statement. Funds flow statement. Financial ratios and their implications. Managerial economics: Concepts, theory of production, marginal productivity and cost. Introduction to theory of firm.

Module – 4 **(7 hours)**

Quality management: Quality definition, quality planning, quality control and quality management, Total quality management, ISO 9000 systems, simple quality control techniques like control charts and acceptance sampling. Marketing management consumer behavior, market research, product design and development pricing and promotion.

Module – 5 **(10 hours)**

Project management: Introduction. Concept of a project, project management concepts, project simulation, cost or project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing). Project evaluation.

Information technology and management. Role of information, management information system and decision support system, Information technology-introduction to e-business, e-commerce and integration tools like enterprise resource planning (ERP).

Course Outcome:

1. Acquire a sound knowledge on the principles of Operations Management .
2. Use forecasting methods, principles/methods of scheduling and Sequencing, methods of maintenance planning and control, concepts/ technique supply chain management for Engineering Management .
3. Select and use an appropriate principles/methods/ techniques/ modern concepts with reference to given application/situation in the mechanical systems/ project management and finance
4. Develop and implement new ideas/ modern concepts with reference to given application/situation for best manufacturing practices.
5. Preparation and ability to engage in independent and lifelong learning in the context of technological change in Engineering Management

Text Books

1. A K Gupta, Engineering Management, 2nd Edition, S. Chand Publishing, 2007, New Delhi.
2. C. M. Chang, Engineering Management: Meeting the Global Challenges, 2nd Edition, CRC Press, Taylors & Francis Group, 2016,Boca Raton.

Reference Books

1. S. Chauhan, R. S. Vaishwanar, Engineering Management, 2nd Edition, Jain Brothers Publications, 2016, New Delhi.
2. Fraidoon Mazda, Engineering Management, 3rd Edition, Pearson Edition, 1998, New Delhi.
3. Patrick D. T. O'Connor, The Practice of Engineering Management, 1st Edition, Wiley–Blackwell, 1994, India.

Digital Learning Resources:

Course Name	Project and Engineering Management
Course Link	https://nptel.ac.in/courses/112/102/112102106/
Course Instructor	Prof. Arun Kanda Department of Mechanical Engineering, IIT Delhi

Course Name	Project and Production Management
Course Link	https://nptel.ac.in/courses/112/102/112102107/
Course Instructor	Prof. S.G.Deshmukh and Prof. Arun Kanda Department of Mechanical Engineering, IIT Delhi

Course Code:19ME5OE03T	Course Name: Micro Electro-Mechanical Systems (MEMS)	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1. Learning fundamental concepts for design of micro-electromechanical devices (MEMS), including mechanical and thermal behavior of materials and structures, transduction principles, transducer design, and modeling.
2. Learn about the current and future trends of MEMS in the industry. Types of MEMS devices, their application areas.
3. Acquire comprehensive knowledge of microfluidic devices.
4. Learn different techniques for fabrication of MEMS devices, materials used and their properties.
5. Learn analytical/mathematical modeling of a MEMS device. Gain knowledge on capabilities of different tools used in the industry.

Module-1 **(7 hours)**

Introduction to MEMS

History of micro system technology, overview of commercial MEMS products, future trends, Case study, Micro-fabrication basics and materials used. Miniaturization : Moore's law, Effects of scaling: on mechanical strength, heat transfer, vibrational and magnetic characteristics. Benefits and limitations of the materials and miniaturization.

Module-2 **(8 hours)**

MEMS types, application areas

Mechanical Transducer: Inertial Sensors (Accelerometer, Gyroscope), Pressure Sensors, Flow Sensors, Force Sensors (SPM), Magnetic Transducers: Magnetic Field Sensors, Magnetic Actuators, Proximity sensor; Chemical/Biological Transducers : Gas sensor, Thermal Transducers: Thermometers, IR Sensors; Applications of MEMS: smart homes, electrical systems, material transport, condition monitoring, biomedical prosthesis. Packaging of MEMS devices : Standard Packages, Packaging Concepts, Packaging Examples.

Module-3 **(7 hours)**

Microfluidics:

Fundamentals of fluid mechanics, Basic components of a micro-fluidic system, Micro flows, Micro pumps, Capillarity and Surface Tension, Micro pumping methods, Micro dispensers, Micro nozzles

Module-4 **(7 hours)**

Materials and Fabrication techniques of MEMS

Properties of materials used in MEMS fabrication : silicon, polymers, metals, ceramics. Their structure and properties. Structure of silicon and other materials (polymers), Silicon wafer processing, Bulk micro machining and Surface micro machining, Wafer-bonding. Thin-film deposition, Lithography, wet etching and dry etching.

Module-5 **(9 hours)**

Modeling of MEMS structures

System modeling of MEMS : Analytical vs Numerical Modeling, Lumped Element modeling, Finite element modeling; MEMS simulation packages : MEMS pro, MEMS+, SUGAR, Coventor, SoftMEMS, COMSOL etc. Demonstration of MEMS pro-Ansys integration

Course Outcomes:

1. Understand the operation of micro devices, micro systems and their applications.
2. Select whether the particular situation requires the use of a MEMS device. If required, select an appropriate device.
3. Analyze a chemical/biological system to select the right microfluidic device.
4. Apply knowledge of physical, chemical and biological principles to engineer MEMS devices using different materials and techniques. Select appropriate MEMS fabrication techniques for a particular design and application.
5. Apply knowledge of MEMS analysis to evaluate suitability of MEMS designs for particular applications. Select a suitable tool for a

Text Books:

1. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS:Design and Development Methodologies, 1st Edition, Wiley, 2006, England
2. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture", 1st Edition, Tata McGraw Hill, 2002, New Delhi
3. Chang Liu, "Foundations of MEMS", Indian Edition, Pearson Education (Dorling Kindersley India Pvt. Ltd.), 2012, New Delhi

Reference Books:

1. Mohamed Gad-el-Hak, "MEMS : Design and Fabrication", CRC Press, 2005, London,
2. Mohamed Gad-el-Hak, "MEMS : Introduction and Fundamentals", CRC Press, 2005,London
3. Stephen D. Senturia**, "**Microsystem Design", Springer US, 2013, US

Digital Learning Resources

Course Name	Fabrication Techniques for MEMs-based sensors : clinical perspective
Course Link	https://onlinecourses.nptel.ac.in/noc21_ee60/preview
Course Instructor	Prof. Hardik Jeetendra Pandya, Department of Electronic Systems Engineering, IISc Bangalore

Course Name

MEMS and Microsystems

Course Link

https://nptel.ac.in/courses/117/105/117105082/

Course Instructor

Prof. Santiram Kal,

Department of Electronic & communication Engineering, IIT Kharagpur

Course Name

NOC: BioMEMS and Microsystems

Course Link

https://nptel.ac.in/courses/112/104/112104181/

Course Instructor

Dr. Shantanu Bhattacharya,

Department of Mechanical Engineering, IIT Kanpur

Course Code:19ME5OE02T

Course Name: Smart and Intelligent Materials

L-T-P 3- 0- 0

Credit 3

Course Objective:

1. To study different type of smart material and its application.
2. Understand in details on the shape memory material and Chromogenic materials.
3. Understand the details of smart polymer and its application.
4. To study about smart hydrogels and its properties.
5. Understanding of smart material and its application in aerospace engineering.

Syllabus

MODULE – 1 **(7 hours)**

Smart materials and structures: System intelligence- components and classification of smart structures, common smart materials and associated stimulus-response, Application areas of smart systems **Ferroelectric materials:** Piezoelectric materials- piezoelectric effect, Direct and converse, parameter definitions, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs

MODULE – 2 **(7 hours)**

Shape memory materials: Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs

Chromogenic materials: Thermochromism, Photochromism, Electrochromism, Halochromism, Solvatochromism- principle and design strategies

MODULE – 3 **(7 hours)**

Smart polymers: Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers, Approaches to molecular imprinting, Drug delivery using smart polymers

MODULE – 4 **(7 hours)**

Smart hydrogels: Synthesis, Fast responsive hydrogels, Molecular recognition, Smart hydrogels as actuators, Controlled drug release, Artificial muscles, Hydrogels in microfluidics

MODULE – 5 **(7 hours)**

Smart systems for space applications: Elastic memory composites, Smart corrosion protection coatings, Self-healing materials, Sensors, Actuators, Transducers, MEMS, Deployment devices, Molecular machines

Course Outcomes:

1. On successful completion of this course students will be able:
2. Characterize and evaluate smart materials for specific applications.
3. Inspect the theory of shape memory alloy material and chromogenic materials.
4. Understand the structure of smart polymer and its application to engineering problems.
5. Examine the properties of smart hydrogels.
6. Design advanced materials for aerospace, biological, nuclear and high temperature applications.

Text Books:

1. D. J. Leo, Engineering Analysis of Smart Material Systems, 1st Edition, Wiley 2007.
2. M. Addington, D. L. Schodek, Smart Materials and New Technologies in Architecture, 1st Edition, Elsevier 2005.
3. K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, 1st Edition, Cambridge University Press, 1998.
4. M. V. Gandhi, B. S. Thompson, Smart Materials and Structures, 1st Edition, Chapman & Hall, 1992

Reference Books:

1. M. Schwartz, New Materials, Processes, and Methods Technology, 1st Edition, CRC Press, 2006.
2. P. Ball, Made to Measure: Materials for the 21st Century, 1st Edition, Princeton University Press, 1997.
3. Galaev, B. Mattiasson (Eds.), Smart Polymers: Applications in Biotechnology and Biomedicine, 2nd Edition, CRC Press, 2008.
4. N. Yui, R. J. Mrsny, K. Park (Eds.), Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, 1st Edition, CRC Press, 2004.

Digital Learning Resources:

Course Name	Smart Materials and Intelligent System Design
Course Link	https://nptel.ac.in/courses/112/104/112104251/
Course Instructor	Prof. Bisakh Bhattacharya Department of Mechanical ENigneering, IIT Kanpur

Course Code:19ME5OE04T	Course Name: Nanoscience and Technology	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1. Learn about the background on Nanoscience and nanomaterials.
2. Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
3. Recognize the different functionalities of nanomaterials.
4. Understand the fundaments of Biomimetic nanomaterials and its application.
5. Understand the different applications of nanomaterials.

MODULE – 1 **(10 hours)**

General introduction and theory of nanomaterials- History of nanomaterials; Size and shape dependant properties and their uniqueness; Energy at nanoscale - surface characteristics and electrostatic and steric stabilization - Quantum confinement - zero dimensional, one dimensional and two dimensional nanostructures

MODULE – 2 **(8 hours)**

Synthesis of nanomaterials- Introduction to nanoparticle synthesis – top-down and bottom up approaches - physical nanofabrication techniques (PVD, MBE, CVD, self-assembly, lithographic techniques etc.) and wet chemical methods for the synthesis of zero dimensional one dimensional and two dimensional nanostructures-metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films

MODULE – 3 **(12 hours)**

Functional nanomaterials- Synthesis, properties and applications of organic, inorganic, hybrid nanomaterials – core-shells, nanoshells, self-assembled nanostructures, superlattices, nanoceramics metallic, polymeric and ceramic nanocomposites, nanoporous materials, nanofluids, nanolayers and carbon based nano materials - Occurrence, production, purification,

properties and applications of fullerene, carbon nanotube, graphene, carbon onion, nanodiamond and films

MODULE – 4 **(8 hours)**

Biomimetic nanomaterials - introduction to biomimetics, mimicking mechanisms found in nature, synthesis and applications of bioinspired nanomaterials and self-assemblies

MODULE – 5 **(8 hours)**

Applications of nanomaterials- Application of nanomaterials in healthcare, biosenors, coatings environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors.

Course Outcomes:

1. To develop a foundational knowledge of the Nanoscience and related fields.
2. Apply their learned knowledge to develop Nanomaterial's.
3. Evaluate the different functional properties of nanomaterials.
4. Understand the details about Biomimetic nanomaterials and its application.
5. Utilize the knowledge of nanomaterial in solving engineering problems.

Text Books:

1. K. J. Klabunde and R.M. Richards (Eds.), Nanoscale Materials in Chemistry, 2nd Edition, John Wiley & Sons, 2009.
2. T. Pradeep, Nano: The Essentials, 1st Edition, McGraw-Hill (India) Pvt Limited, 2008.
3. Bharat Bhushan, (Ed.), Handbook of Nanotechnology, 3rd Edition Springer, 2010.

Reference Books:

1. Carl C. Koch (Ed.), Nano structured Materials: Processing Properties and Applications, 2nd Edition , William Andrew Inc., 2007.
2. Anke Krueger, Carbon Materials and Nanotechnology, 1st Edition , Wiley-VCH Verlag GmbH & Co. KGaA, 2010.

3. Cao G. and Wang Y., Nanostructures and Nanomaterials Synthesis, Properties, and Applications, 2nd Edition, World Scientific Publishing Company, 2010.
4. Wang, Z. L., (Ed.), Characterization of nanophase materials, 1st Edition, Wiley-VCH Verlag GmbH, 2000.
5. Garcia-Martinez, J., (Ed.), Nanotechnology for the Energy Challenge, 2nd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2013.
6. Goddard III W.A., et. al.,(Ed.), Handbook of Nanoscience, Engineering, and Technology, 3rd Edition,CRC Press, 2012.
7. B.P.S. Chauhan **(**Ed**)**, Hybrid Nanomaterials: Synthesis, Characterization, and Applications, 1st Edition , Wiley-VCH Verlag GmbH, 2011.
8. J. Lei and F. Lin, Bioinspired Intelligent Nanostructured Interfacial Materials, 1st Edition, World Scientific Publishing Company, 2010.
9. Challa S. S. R. Kumar (Ed.), Biomimetic and Bioinspired Nanomaterials, 1st Edition, Wiley-VCH Verlag GmbH, 2010.

Digital Learning Resources:

Course Name	Nanotechnology, Science and Applications
Course Link	https://nptel.ac.in/courses/113/106/113106093/
Course Instructor	Dr. Prathap Haridoss Department of Metallurgy and Material Science, IIT Madras