B.Tech. - Mechanical Engineering

Course Description

Course Name: Engineering Mathematics-I **Course Code: MA102**
L-T-P scheme: 3-1-0 **Credits: 4**

Prerequisite: Students should have basic knowledge of Algebra and calculus.

Objective: This course is aimed:

- To introduce the calculus of functions of two variables and applicability of derivatives and integrals of vector functions to Analytical geometry and physical problems.
- To make students aware of the basic mathematical concepts and methods which will help them in learning courses in engineering and Technology.

Learning Outcomes:

Course Outcome	Description
CO1	Understand the rank, eigen values, eigen vectors, diagonalization of matrix; compute inverse of matrix by Caley-Hamilton theorem.
CO2	Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, and solve it by Gauss elimination method.
CO3	Interpret derivatives and integrals of multivariable functions geometrically and physically; implement multivariable calculus tools in engineering, science, optimization, and understand the architecture of surfaces in plane and space etc.
CO4	Know about piecewise continuous functions, Laplace transforms and its properties; use of Laplace transform and inverse transform for solving initial value problems.
CO5	Realize importance of line, surface and volume integrals, Gauss and Stokes theorems and apply the concepts of vector calculus in real life problems.
CO6	Formulate mathematical models in the form of ordinary differential equations and learn various techniques of getting solutions of linear differential equations of second order.

Course Contents:
Unit 1: Algebra of matrices, Determinants, Rank, Gauss elimination method, Eigen values and vectors. Quadratic forms.
Unit 2: Partial differentiation. Taylor's series. Maxima and minima. Jacobians**,** Double integrals,
Unit 3: Differential Equations with constants coefficients.

Unit 4: Gradient, divergence and curl. Line and surface integrals, Normal and tangent to a surface. Gauss and Stokes theorems, Equations to a line, plane, curve and surfaces.

Unit 5: Laplace transforms.

Methodology:

The course will be covered through lectures supported by tutorials. There shall be 3 Lectures per week where the teacher will explain the theory, give some examples supporting the theory and its applications. About 12 Tutorial Sheets covering whole of the syllabus shall be given. Difficulties and doubts shall be cleared in tutorials. Apart from the discussions on the topics covered in the lectures, assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials, lecture slides and books on mathematics-1 will be available on the JUET server.

Books

1. Erwin Kreyszig: Advanced Engineering Mathematics, Wiley Publishers.
2. Lipshuts, S., Lipsom M.: Linear Algebra, 3rd Ed, Schaum series 2001.
3. B. V. Raman: Higher Engineering Mathematics, McGraw-Hill Publishers.
4. R.K. Jain, S.R.K. Iyenger: Advanced Engineering Mathematics, Narosa Publishing House, New Delhi.
5. Thomas, G.B., Finney, R.L.: Calculus and Analytical Geometry, 9th Ed., Addison Wesley,1996.
6. Grewal, B.S. : Higher Engineering Mathematics, Khanna Publishers Delhi.

Title of Course: Engineering Physics-I **Course Code: PH101**
L-T-P Scheme: 3-1-0 **Course Credits: 4**

Objective: Broadly, the study of Physics improves one's ability to think logically about the problems of science and technology and obtain their solutions. The present course is aimed to offer a broad aspect of those areas of Physics which are specifically required as an essential background to all engineering students for their studies in higher semesters. The course intends to impart sufficient scientific understanding of different phenomena associated with Special relativity, Modern Physics, Statistical physics, atomic physics, and lasers.

Course Outcomes:

Course Outcome	Description
CO1	Describe the limitations of Newton's laws and explain when special relativity become evant, Learn to Apply the principles of Special Relativity to an extended range of oblems involving particle kinematics
CO2	Demonstrate the ability to explain the concepts related to the consequences of Special Relativity, the nature of space-time and related dynamic observables
CO3	Acquired a profound understanding of inadequacy of classical mechanics regarding phenomena related to microscopic level, Become well versed with the experimental developments, historical account and importance of probabilistic interpretation
CO4	Understand the basic quantum mechanical ideas and relevant mathematical framework, approach the solution of one dimensional time independent Schrodinger equation
CO5	Appreciate the importance of applying statistical ideas to explore thermodynamic variables, Developed ability to identify and apply appropriate statistical method for describing the assembly of microscopic particles, comprehend basic properties and working of Laser systems

Course Contents:

Unit-I (Theory of Special Relativity): Frames of reference, Galilean transformation, Michelson Morley Experiment, Postulates of special theory of relativity, time dilation and length contraction, twin paradox, Lorentz transformations, addition of velocities, Relativistic Doppler effect, Mass variation with velocity, Mass-energy relation.

Unit-II (Introduction to Modern Physics):

Quantization of Radiation, Black body radiation, Rayleigh-Jeans law, Planck's law of radiation Wien's law, Stefan's law, Photoelectric effect Compton scattering, Atomic spectra, Bohr model

of hydrogen atom, Frank hertz experiment, Matter waves, de Broglie hypothesis, Davisson Germer experiment

Unit III Quantum Mechanics

Wave packets, phase and group velocity, Heisenberg's uncertainty principle, Schrödinger wave equation and its applications to the free particle in a box, potential barrier and Harmonic oscillator

Unit-IV (Statistical Mechanics): Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions and their applications.

Unit- VLaser Physics & Applications

Fundamental ideas of stimulated and spontaneous emission, Einstein's coefficients, Principle and working of laser, Different types of lasers (He-Ne Laser, Ruby Laser, Semiconductor Laser), Applications of Lasers

Text Books and References:

1. A. Beiser, Perspectives of Modern Physics, Tata McGraw Hill.
2. J R Taylor, C D Zafiratos, M A Dubson, Modern Physics for Scientist &
1. Engineers, Pearson Education.
2. K Krane, Modern Physics, Wiley India
3. J Bernstein, P M Fishbane, S. Gasiorowicz, Modern Physics, Pearson
4. Education.
5. B. B. Laud, Laser and Non-Linear Optics, New Age International (P) Ltd.
6. R. Resnick, Relativity, New Age.

Title: English **Code: HS101**

L-T-P scheme: 2-1-0 **Credit: 3**

Prerequisite: None

Objective:

1. To enable understanding of basics of communication in Business environment.
2. To provide insight into structural aspect of communication in business.
3. To impart knowledge about communication theory and develop skills in oral and non verbal communication.
4. To improve skills as critical readers, thinkers, listener and writer.

Learning Outcomes:

Course Outcome	Description

CO1	Outline the basic concept of verbal/ nonverbal skills to understand the role of effective communication in personal & professional success.
CO2	Describe drawbacks in listening patterns and apply listening techniques for specific needs.
CO3	Develop the understanding to analyze, interpret and effectively summarize a variety of textual content
CO4	Discuss a given technical/non-technical topic in a group setting and arrive at generalizations/consensus.
CO5	Create effective presentations
CO6	Create professional and technical documents that are clear and adhering to all the necessary convention.

Course Content:

Unit-1: Concept and Nature of Communication : Definition of Communication, Process & Stages of Communication, Barriers to Communication, Channels of Communication.

Unit-2: Listening Skills: The listening process**,** Importance of listening,Purpose and types of listening**,** Hearing and listening, Listening with a purpose, Barriers to listening.

Unit-3: Speaking/Oral Skills: Importance of acquiring oral skills, Visual aids, Body Language, Delivery, Pronunciation, Use of connectives Organization of matter: Metadiscourse features, Textual organization, 7 C'S of effective communication , Improving vocabulary by learning Root words in English, Some foreign words, Reading comprehension, Some important synonyms and antonyms, commonly confused words, Etiquettes & grooming.

Unit-4: Reading Skills: Skimming and Scanning, Intensive and extensive reading, SQ3R Technique

Unit-5: Writing Skills: Business letters, Memo, Circulars, Notices, Report writing, resume writing, Agenda & Minutes writing, Tips on clear writingTranslation- Hindi to English, Translation -English to Hindi.

Unit-6: Introduction to Modern Communication Media: Technology based communication tools, Committee types, Advantages, Conferences, Audio-video conferencing, Barriers and overcoming negative impact.

Unit-7: Public Speaking and Interviewing Strategies: Speech Preparation, Theory of group discussion, Participation in Group discussion, Oral presentation, Power point presentation ,Tips for successful job interview, Do's and don'ts while appearing for interview, Mock interview, Some interview questions, Telephonic interview tips, Resume writing

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3,& Unit-4 and around 30%

		from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Teaching Methodology:

The course will be taught with the aid of lectures, handouts, case studies, Task-based language learning, and comprehensive language learning through language lab.

Learning Resources:

Lecture slides and e-books on ENGLISH (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. K.K. Sinha- Business Communication (Galgotia Publications)

Reference Books:

1. R.C. Bhatia- Business Communication (Ane Books Pvt. Ltd.)
2. P.D. Chaturvedi – Business Communication (Pearson Education, 1st Edition 2006).
3. Lesikar RV & Pettit Jr. JD – Basic Business Communication: Theory & Application (Tata Mc Graw Hill, 10thEdition)
4. Wren & Martin, High School English Grammar & Composition – S. Chand & Co. Delhi.
5. Raman Meenakshi & Sharma Sangeeta, Technical Communication-Principles & Practice –O.U.P. New Delhi. 2007.
6. Mitra Barum K., Effective Technical Communication – O.U.P. New Delhi. 2006.
7. Better Your English- a Workbook for 1st year Students- Macmillan India, New Delhi.
8. Raymond Murphy,' Essential English Grammar', Cambridge University Press.

Title: Computer Programming **Code: CS101**
L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: There is no prerequisite in this course; however, students having any prior experience of programming are desirable.

Objective:

1. To provide exposure to problem-solving through programming.
2. To provide students with understanding of code organization and functional hierarchical decomposition with using complex data types.

Learning Outcomes:

Course Outcome	Description
CO1	Makes students gain a broad perspective about the uses of computers in engineering industry.
CO2	Develops basic understanding of computers, the concept of algorithm and algorithmic thinking.
CO3	Develops the ability to analyze a problem, develop an algorithm to solve it.
CO4	Develops the use of the C programming language to implement various algorithms, and develops the basic concepts and terminology of programming in general.
CO5	Introduces the more advanced features of the C language

Course Content:

Unit-1: Introduction to Programming: Basic computer organization, operating system, editor, compiler, interpreter, loader, linker, program development. Variable naming, basic function naming, indentation, usage and significance of comments for readability and program maintainability. Types of errors, debugging, tracing/stepwise execution of program, watching variables values in memory. Constants, Variables and data Types Character Set, C tokens, Keywords and Identifiers, Constants, Variables, Data types, Declaration of Variables, assigning values to variables, typedef, and Defining symbolic constants. printf & scanf function.

Unit-2:Operators and Expression: Introduction, Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operators, Special Operators, Evaluation of expressions, Precedence of arithmetic operators, Type conversions in expressions, Operator precedence and associativity.

Management Input and Output Operators: Introduction, reading a character, writing a character, formatted input, formatted output.

Unit-3: Decision Making Branching: Introduction, Decision making with IF statement, the IF-ELSE statement, nesting of IF-ELSE statement, ELSE-IF ladder, SWITCH statement, ternary operator, and the GOTO statement.

Looping: Introduction, the WHILE statement, the DO statement, The FOR statement, Break and Continue.

Unit-4: Array: Introduction, One-dimensional arrays, Two-dimensional arrays, arrays, Concept of Multidimensional arrays.

Handling of Character strings: Introduction, Declaring and initializing string variables, reading string from terminal, writing string to screen, String, Operations: String Copy, String Compare, String Concatenation and String Length (using predefined functions & without using them), Table of strings.

Unit-5: User-Defined Functions (UDF): Introduction, need for user-defined functions, the form of C function, elements of UDF, return values and their types, Calling a function, category of functions, Nesting of functions, Recursion, Functions with arrays, The scope and Lifetime of variables in functions, multi file program.

Structures and Unions: Introduction, Structure definition, declaring and initializing Structure variables, accessing Structure members, Copying & Comparison of structures, Arrays of structures, Arrays within structures, Structures within Structures, Structures and functions, Unions.

Unit-6: Pointers: Introduction, understanding pointers, Accessing the address of variable, Declaring and initializing pointers, accessing a variable through its pointer, Pointer expressions, Pointer increments and scale factor, Pointers and arrays, Pointers & character strings, Pointers & Functions, Function returning multiple values, Pointers and structures.

File Management in C and CONSOLE I/O: Introduction, Defining files and its Operations, Error handling during I/O operations, Random access files, Command line arguments. Types of files, File vs. Console, File structure, File attributes, Standard i/o, Formatted i/o, Sample programs.

Teaching Methodology:

This course is introduced to help students understand the discipline of programming. The programming language used to teach this course is C. Starting from the basic computer architecture, the student will slowly be exposed to program designing and later to programming fundamentals. The entire course is broken down into six separate units, from fundamentals of programming to some complex programming structures like pointers. This theory course is well complemented by a laboratory course under the name Software Development Fundamentals Lab in the same semester that helps a student learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2

Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 20-30% from coverage till Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage till Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Software Development Fundamentals (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Programming in ANSI C by E. Balguruswamy, Tata Mc-Graw Hill.

[2] Programming With C, Schaum Series.

Reference Books/Material:

[1] The 'C' programming language by Kernighan and Ritchie, Prentice Hall

[2] Computer Programming in 'C' by V. Rajaraman, Prentice Hall

[3] Programming and Problem Solving by M. Sprankle, Pearson Education

[4] How to solve it by Computer by R.G. Dromey, Pearson Education

Web References:

[1] http://www2.its.strath.ac.uk/courses/c/

Notes on C programming by University of Strathclyde Computer Centre. This tutorial was awarded the NetGuide Gold Award during the 1990s.

[2] http://www.princeton.edu/~achaney/tmve/wiki100k/docs/C_%28programming_language%29.html

This site contains notes on C programming from Princeton University, USA.

These are very useful for students who are learning C as their first programming Language.

[3] http://www.stat.cmu.edu/~hseltman/Computer.html

Online reference material on Computers and Programming from Carnegie Mellon University, Pittsburgh, USA

[4] http://projecteuler.net/

Collection of mathematical problems which make you use your programming skills

Title: Engineering Physics Lab-I **Code: PH201**
L-T-P scheme:0-0-2 **Credit: 1**

Learning Outcomes

Course Outcome	Description
CO1	Demonstrate ability to collect experimental data and understanding the working procedures within the precautionary limits
CO2	Acquired the ability to analyze the experimental data and related errors in a reflective, iterative and responsive way
CO3	Developed understanding of the basic concepts related to Modern Physics, Basic Solid State Physics and Optics
CO4	Acquired a first hand and independent experience of verifying Kirchoff's circuit laws and related concepts e.g. resistivity, measurement of resistance
CO5	Appreciate the importance of the laboratory work culture and ethics that is intended to impart features like regularity, continuity of self evaluation and honesty of reporting the data

List of Experiments

1. To study the variation of magnetic field along the axis of Helmholtz Galvanometer and to determine its reduction factor.
2. To determine the resistance per unit length of a Carey Foster's bridge and to obtain the specific resistance of a given wire.
3. To determine the wavelengths of spectral lines Red, Green and Violet of mercury using plane transmission grating.
4. To determine the specific rotation of cane sugar solution using Bi-quartz polarimeter.
5. To observe Newton's rings and to determine the wavelength of sodium light.
6. To study the CRO and function generator by producing the following waveforms.
   i. 10kHz, 8Vp-p(sine wave, square wave, triangular wave)
   ii. 4kHz, 6Vp-p(sine wave, square wave, triangular wave)
   iii. 10kHz, 8Vpeak(sine wave, square wave, triangular wave)
   iv. 4kHz, $6V_{peak}$(sine wave, square wave, triangular wave)
7. To verify the Kirchhoff's current law.
8. To verify the Kirchhoff's voltage law.

Title: Computer Programming Lab **Code: CS201**
L-T-P scheme: 0-0-4 **Credit: 2**

Prerequisite: Experience in programming is desirable.

Objective:

1. To provide exposure to problem-solving through programming.
2. To provide students with understanding of code organization and functional hierarchical decomposition with using complex data types.
3. To give the student hands-on experience with the concepts.

Learning Outcomes:

Course Outcome	Description
CO1	Makes students gain a broad perspective about the uses of computers in engineering industry.
CO2	Develops basic understanding of computers, the concept of algorithm and algorithmic thinking.
CO3	Develops the ability to analyze a problem, develop an algorithm to solve it.
CO4	Develops the use of the C programming language to implement various algorithms, and develops the basic concepts and terminology of programming in general.
CO5	Introduces the more advanced features of the C language

Course Content:

The following assignments will be carried out in synchronization with the theory classes.

Unit-1: Introduction to programming Environment (Linux commands, editing tools such as vi editor, sample program entry, compilation and execution). Development of programs using multiple arithmetic and logical operators. Programs for Roots of quadratic equation, conversion of units etc.

Unit-II: Programs using simple control statements such as if else, while, do while etc. Making a program for a calculator for example. Extracting the digits of an integer, reversing digits, finding sum of digits etc.

Unit-III: Programs using For loop, switch statement etc. For example, Finding average of numbers, printing multiplication tables etc. Checking for primes, generation of Armstrong numbers. Generation of the Fibonacci sequence, Finding the square root of a number, calculation of factorials, printing various patterns using for loop. The greatest common divisor of two integers, Raising a number to large power.

Unit-IV: Programs using Arrays: declaring and initializing arrays. Program to do simple operations with arrays. Strings – inputting and outputting strings. Using string functions such as strcat, strlen etc. Writing simple programs for strings without using string functions.Finding the

maximum number in a set, Array order reversal, Finding maximum number from an array of numbers Removal of duplicates from an ordered array,

Unit-V: Selection/ Bubble/ Insertion sort, create a linked list, traverse a linked list, insert a node and delete a node form the list. Recursion and related examples such as Tower of Hanoi, computing factorial etc. Practice sessions and sessions for missed labs

Units to Lab Mapping:

Unit	**Labs**
I	1, 2, 3
II	4, 5
III	6, 7, 8
IV	9, 10, 11
V	12, 13, 14

Teaching Methodology:

This course is introduced to help students understand the discipline of programming. The programming language used to teach this course is C. Starting from the programming environment setup, the student will slowly be exposed to program designing and later to programming fundamentals. The entire course is broken down into six separate units, from fundamentals of programming to some complex programming structures like pointers. This theory course is well complemented by a laboratory course under the name Software Development Fundamentals Lab in the same semester that helps a student learn with hand-on experience.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-6**
P-2		15 Marks	**Based on Lab Exercises: 7-13**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Software Development Fundamentals Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

1. Programming in ANSI C by E. Balguruswamy, Tata Mc-Graw Hill.
2. Programming With C, Schaum Series.

Reference Books/Material:

1. The 'C' programming language by Kernighan and Ritchie, Prentice Hall
2. Computer Programming in 'C' by V. Rajaraman, Prentice Hall
3. Programming and Problem Solving by M. Sprankle, Pearson Education
4. How to solve it by Computer by R.G. Dromey, Pearson Education

Web References:

1. http://www2.its.strath.ac.uk/courses/c/
   a. Notes on C programming by University of Strathclyde Computer Centre. This tutorial was awarded the NetGuide Gold Award during the 1990s.
2. http://www.princeton.edu/~achaney/tmve/wiki100k/docs/C_%28programming_language%29.html
   a. This site contains notes on C programming from Princeton University, USA. These are very useful for students who are learning C as their first programming Language.
3. http://www.stat.cmu.edu/~hseltman/Computer.html
   a. Online reference material on Computers and Programming from Carnegie Mellon University, Pittsburgh, USA
4. http://projecteuler.net/
   a. Collection of mathematical problems which make you use your programming skills

Title: Workshop Practices **Code: ME201**
L-T-P scheme: 0-0-3 **Credit: 1.5**

Prerequisite: Students must have the knowledge of fundamental principles of Physic and Chemistry upto class 12^{th} which helps them to understand the various process of Workshop Lab.

Objective:

1. To demonstrate students, the basic manufacturing processes of Workshop lab: Carpentry, Fitting, Welding, Machining and Casting Processes.
2. To develop effective skills in students to identify the manufacturing process with its applications
3. To be able to perform basic manufacturing processes safely.

Learning Outcomes:

Course Outcome	Description
CO1	Identify the various processes of manufacturing.
CO2	Capable to explain the use of various holding, measuring, marking and
CO3	Prepare a useful job by performing the various processes in proper
CO4	Apply Bernoulli's theorem to analyze the liquid metal velocity in
CO5	Develop the skills to join two metallic specimen using welding
CO6	Work as a team on a project

Course Content:

Carpentry Shop

1. To study about various tools/equipments used in carpentry shop
2. To make Cross lap /T joint as per given specification
3. To make Cross lap /T joint as per given specification

Foundry Shop

1. To study about various tools used in foundry shop.
2. To prepare a green sand mould with the help of a given pattern.
3. To perform permeability test on moulding sand

Machine Shop

1. To study various machine tools such as lathe, milling, shaper, drilling, grinding, EDM drill and cutting tools used by them.

2. To perform turning, step turning and taper turning operations on lathe machine
3. To perform threading operation on the lathe machine

Fitting Shop

1. To study about various tools used in fitting shop.
2. To make a fitting job as per given drawing.

Welding Shop

1. To study various types of welding processes available in the workshop such as Electric arc welding, TIG and MIG welding, gas welding and spot resistance welding,
2. To prepare welding joint by using Electric arc welding/gas welding
3. To prepare welding joint by using Spot Resistance welding

Teaching Methodology:

This Lab course has been introduced to help a student to learn with hand-on experience on machines. The entire course is broken down into fourteen experiments. Experiments are performed different shop wise by taking the proper safety precautions. Workshop lab includes five shops namely: Carpentry, Foundry, Machining, Fitting and Welding. Basic principles of manufacturing processes are applied to prepare a job. Students learn here how to handle the real world problems by using technical skills. The way of experimentation here realizes the students that they are now moving on an Engineering path. This Lab course will enable a student to learn with hand-on experience.

Evaluation Scheme:

<table>
<tr><th colspan="2">Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Experiments: 1-7</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Experiments: 8-14</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:

Laboratory Manual available in Lab. Study material of Workshop Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Books:

[1] "Workshop Technology Volume- I & II", B.S. Raghuvanshi, Dhanpat Rai & Co.
[2] "Workshop Technology Volume-I & II", Khanna Publisher.

Reference Books:

[1] "Workshop Technology Vol.- 1, 2, 3 & 4", Butterworth-Heinemann.
[2] "Material Science & Engineering", W. D. Callister, John Wiley

Web References:

- https://nptel.ac.in/courses/112/107/112107219/
- https://nptel.ac.in/courses/112/107/112107144/

Course Title: Engineering Mathematics-2 **Code: MA103**
L-T-P scheme: 3-1-0 **Credits: 4**
Prerequisite: Students should have basic knowledge of differential equations and calculus.
Objective: This course is aimed

- To introduce the fundamental ideas of the functions of complex variables and developing a clear understanding of fundamental concepts of Complex Analysis.
- To equip students with the concepts of ordinary and partial differential equations and how to solve them with different methods.

Learning Outcomes:

Course Outcome	This course will enable the students to:
CO1	Understand the concepts of limit, continuity, differentiability, analyticity, singularities, contour integration, Taylor and Laurent's series expansion of function complex variable.
CO2	Learn various techniques of getting solutions of linear ordinary and partial differential equations of second order,
CO3	Visualize complex numbers as points of $\mathbb{R}^2$, two path test for non-existence of limit, orthogonal trajectories, connected domain, conformal mapping.
CO4	Use Laurent series to evaluate complex integrals and classify the singularities of a function, conformal mapping in modeling and solving boundary value problems, power series method to solve linear differential equations.
CO5	Apply Cauchy residue theorem in evaluation of real integrals and separation of variables method in the solution of heat, wave and Laplace equation
CO6	Formulate mathematical models in the form of ordinary and partial differential equations to problems arising in mechanical, chemical and physical disciplines.

Course Content:

Unit-1: Functions of complex variable, analytical functions and Cauchy-Riemann equations, Conformal mapping, Poles and singularities, complex integration, Taylor's and Laurent's series, Cauchy residue theorem, contour integration and their application.

Unit-2: Second order linear differential equations, Convergence of series, convergence tests, solution of D.E. in series, Bessel functions; Legendre and Chebyshev polynomials, Orthogonality.

Unit-3: Second order partial differential equations and classification, one dimensional wave and diffusion equations with their applications. Laplace and Poisson equations. Use of Green's function.

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures, assignments and quizzes in the form of questions will also be given for practice.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials, lecture slides and books on mathematics-2 will be available on the JUET server.

Books

1. Kreyszig, Erwin : Advanced Engineering Mathematics, John Wiley & Sons, Inc.
2. Simmons, G.F. : Differential Equations with Applications, 2nd Ed., McGrawHill, 1991.
3. Brown, J.W., Churchill, R.V. : Complex Variables and Applications, 6th Ed., McGrawHill, 1996.
4. Prasad, C : a) Mathematics for Engineers
   b) Advanced Mathematics for Engineers, Prasad Mudranalaya, 1982.
5. Grewal, B. S. : Higher Engineering Mathematics, Khanna Publishers Delhi.

Title: Electrical Circuit Analysis **Code: EC102**

L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Not Applicable

Objective:

1. To learn the basic concepts of electrical engineering.
2. To analyze the various electrical circuit with the help of practical.

Learning Outcomes:

Course Outcome	Description
CO1	Be aware of basic essentials of electrical circuit
CO2	Apply theorems for finding the solutions of network problems
CO3	Analysis the behavior of direct current transients
CO4	Realize the performance of two port network parameters
CO5	Be familiar with the role of alternating current in home and industry
CO6	Evaluate the performance of various alternating current circuits

Course Content:

Unit I: Basic Electrical Circuit: Electromotive Force , Terminal Voltage; Resistance (R), Inductance (L) and Capacitance (C) from (i) Circuit, (ii) Energy, and (iii) Geometrical Points of View; Voltage Divider, Current Divider; Star-Delta Transformation; Voltage Source and Current Source, Source Transformation, Combination of Sources; Controlled (Dependent) Sources.

Unit II: Network Analysis and Network Theorems: Kichhoff's Circuit Law (KCL), Kichhoff's Voltage Law (KVL), Loop-Current Analysis, Mesh Analysis, Node-Voltage Analysis, Choices of Method of Analysis. Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem, Millman's Theorem, Reciprocity Theorem.

Unit III: DC Transients: Simple RL Circuit, Time Constant, Decay and Growth of Current; Simple RC Circuit, Discharging of a Capacitor, Charging of a Capacitor.

Unit IV: Two Port Networks: Impedance parameters, Admittance parameters, Hybrid parameters, Equivalent circuits of all the parameters, Symmetry and Reciprocity conditions.

Unit V: Alternating Voltage and Current: Physical Model for a Sinusoid, Phase and Phase Difference; Average Value, Effective Value, Form Factor and Peak Factor; Concept of Phasors, Addition of Phasors Using Complex Numbers; Non sinusoidal Waveforms; Power and Power Factor; Behaviour of R, L and C in AC Circuits.

Unit VI: AC Circuits: Series RL Circuit, Complex Impedance; Series RC Circuit, Complex Power; Parallel RL Circuit; Parallel RC Circuit; Series RLC Circuit and its Phasor Diagram; Parallel RLC Circuit and its Phasor Diagram, Q factor, Resonance in series parallel RLC circuits.

Teaching Methodology:

This course is introduced to help students for understanding the basic concept of electricl engineering. Initially an overview of basic terminology of electrical circuit along with various component needed for circuits will be discussed briefly. In the first part, Direct Current (DC) related issued are elaborated through various theorems. Later on DC transient is evaluated on various circuits. In the second

part, Alternating Current (AC) is described by different parameters and phasor diagrams. At the end, ac circuits and resonance condition has been evaluated.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15	Based on Unit-1 & Unit-2
Test-2	25	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10	Based on all Units
Tutorials	5	Based on all Units
Quiz	5	Based on all Units
Attendance	5	Based on attendance in the theory classes
Total	**100**	

Learning Resources:

Tutorials and lecture slides on theory course will be added from time to time and a digital copy of study material will be available on the JUET server.

Text Books:

[1] "Basic Electrical Engineering", D.C. Kulshreshtha, McGraw Hill Education, 2009.
[2] "Engineering Circuit Analysis", W.H. Hayt, J. E. Kemerlay and S.M. Durbin, 6th edition, McGraw Hill, 2006.
[3] "Introduction to Electric Circuits", R.C. Dorf & J.A. Svoboda, John Wiley, 2004.

Reference Books:

1. "Network Analysis", V. Valkenburg, Prentice-Hall India Ltd., 2001.
2. "Basic Electrical Engineering", A. Chakrabarti, S. Nath, C. K.Chanda, Tata McGraw Hill Publishing Co, 2008.
3. "Principles of Electrical Engineering", V. D. Toro, Prentice Hall of India.

Web References:

[1] https://www.rapidtables.com/electric/index.html
[2] https://library.automationdirect.com/basic-electrical-theory/

Journals References:

[1] International Journal of Circuit Theory and Application Wiley publication
[2] International Journal of Circuits and Electronics

Title: Engineering Mechanics **Code: ME101**

L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "Basic Mathematics" and "Physics"
Objective:

4. Enable students to apply their knowledge of mathematics, science, and engineering in order to expand this knowledge into the vast area of "Rigid Body Mechanics".
5. To enhance students' ability to design by framing the solution of open ended problems.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the various laws of mechanics
CO2	Describe the equivalent force systems
CO3	Develop the equations of equilibrium for various force systems
CO4	Identify and use various methods for analyzing the forces in machines and structures
CO5	Apply concepts of kinematics and kinetics of particles to analyze practical problems.
CO6	Demonstrate and deployment basic knowledge of engineering mechanics for solving real-world problems

Course Content:

Unit-1: Introduction: Idealization of mechanics, Concept of rigid body, External forces (body forces & surface forces), Laws of mechanics.

Unit-2:Force Systems and Equilibrium: Introduction to vector, Statically equivalent force systems (planar and spatial), Free body diagram, Equations of equilibrium and their applications to various system of forces, Variational mechanics.

Unit-3: Structures and Machines: Plane trusses, Space trusses, Method of joints, Method of section, Graphical method, Frames and machines.

Unit-4: Distributed Forces and Moment of Inertia: Centroid of composite figures, Area moment of inertia, Mass moment of inertia, Principal axes and principal moment of inertia.

Unit-5:Friction: Introduction of friction, Laws of friction, Wedge, Screw, Belt, and Rolling friction.

Unit-6:Beams: Different support & loading conditions of Beam, Shear force diagram (SFD), Bending moment diagram (BMD).

Unit-7:Kinematics and Kinetics of Rigid Bodies: Velocity and acceleration, Rotation of rigid bodies, Rolling motion, Plane motion of rigid bodies, Effective forces on a rigid body,

D'Alembert's principle, Force, Mass and Acceleration, Work and energy, Impulse and momentum.

Teaching Methodology:

This course is introduced to help students in applying their knowledge of mathematics, science and engineering in order to explore the vast area of rigid body mechanics and to enhance students' ability to design machines and mechanisms by framing the solution of open ended problems. The entire course is divided into seven separate units: Introduction, Force Systems and Equilibrium, Structures and Machines, Distributed Forces and Moment of Inertia, Friction, Beams and Kinematics and Kinetics of Rigid Bodies. These sections have been framed to impart a systematic understanding of the basic laws of forces, static and dynamic equilibrium conditions and finally implement these laws to solve the real-world problems. This theory course is well complemented by a laboratory course under the name Engineering Mechanics Lab in the same semester. This Lab course will enable a student to learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 and Unit-3
Test-2	25 Marks	Based on Unit-4, Unit-5, Unit-6 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Engineering Mechanics (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Engineering Mechanics Vol. I-Statics, by J. L. Meriam and L.G. Kraige, John Wiley & Sons Inc. 6th Edition.

[2] Engineering Mechanics Vol. II-Dynamics, by J. L. Meriam and L.G. Kraige, John Wiley & Sons Inc. 6th Edition.

Reference Books/Material:

[1] Engineering Mechanics: Statics and Dynamics, Hibbeler, R.C. (2007), Pearson Prentice Hall, Upper Saddle River, NJ, 13th Edition.

[2] Engineering Mechanics, S.Timoshenko, D.H.Young, McGraw Hill Book Co.

Web References:

- https://nptel.ac.in/courses/112103109/
- https://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/
- https://freevideolectures.com/course/2264/engineering-mechanics
- https://www.coursera.org/learn/engineering-mechanics-statics-2

Journals References:

- Journal of Engineering Mechanics - ASCE
- Mechanical Engineering & Mechanics, Springer
- International Journal for Theoretical and Applied Mechanics, Association for Engineering Mechanics
- Probabilistic Engineering Mechanics, Elsevier
- International Journal of Mechanics and Materials in Design, Springer
- Journal of Engineering Mechanics and Machinery, Clausius Scientific Press

Title: Engineering Chemistry **Code: CH101**

L-T-P Scheme:3-1-0 **Credit: 4**

Prerequisite: The students must be aware of basic Chemistry upto class 12^{th}. Basic knowledge of chemistry helps them to correlate in various division of Engineering during this course.

Objective:

The purpose behind this course is to make the students familiar with the concepts of the Chemistry and to understand the significance of Chemistry in various field of the Engineering (Chemical, Mechanical and Civil Engineering).

Course Learning Outcomes:

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in still deep interests in learning chemistry; develop broad and balanced knowledge and understanding of key chemical concepts, principles, and theories related to chemistry; and equip students with appropriate tools of analysis to tackle issues and problems in the field of chemistry.
CO2	Describe the real world problems, challenges with application of the Chemistry in various fields of engineering (Chemical, Mechanical and Civil Engineering).
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in chemistry.
CO4	Identify and use of various analytical techniques in the Chemical, Mechanical and Civil Engineering project management.
CO5	Apply experimental demonstration and validation by using various analytical techniques given in theorem, principles as explained in lectures.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in chemistry and related areas or in multidisciplinary areas that involve chemistry and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

COURSE CONTENT

Unit 1: Alloys

Purpose of making alloys; Types of alloys; Alloy steels; Light alloys; Cast alloys; Copper alloys; Nickel alloys; Nickel iron alloys; Nickel chromium alloys; Super alloys; Lead alloys; Bearing alloys; Modes of formation of alloys; Preparation of alloys; Treatment of alloys.

Unit 2: Corrosion

Types of corrosion; Dry and wet corrosion; Chemical corrosion; Factors promoting corrosion; Galvanic corrosion; Atmospheric corrosion; Open air corrosion; Water corrosion; Pitting

corrosion; Inter granular corrosion; Waterline corrosion; Corrosion fatigue; Prevention of corrosion.

Unit 3 : Protective / Metallic Coatings

Coating processes; Hot dipping; Metal cladding; Electroplating; Displacement or immersion plating; Cementation; Metal spraying or metalized coatings; Organic coating.

Unit 4: Adhesives

Introduction; Classification & preparation of adhesives; Animal glue; other protein adhesives; Starch adhesive; Synthetic resin adhesives; Rubber based adhesives; Cellulose and silicate adhesives; Uses of adhesives.

Unit 5: Paints and Pigments

White pigments; white lead; Characteristics of pigments; Zinc oxide; Physical properties of pigments; Characteristics of pigments; Blue pigments; Ultramarine blue; Cobalt blue and iron blue; Red pigments; Red lead; Yellow pigments; Paints; Distempers; Manufacture; Emulsion paint; Varnishes; Lacquers.

Unit 6: Lubricants

Properties of lubricants; Classification of lubricants; Substances used as lubricants; Additives for lubricating oil; Lubricants of mineral origin; Synthetic lubricants; Lubricating greases; Chemical properties of greases; Selection of lubricants.

Teaching Methodology:

This course comprises 3 lectures and 1 tutorial per week. The course content is divided into 42 lectures and 14 tutorials. The lectures will be conducted in both, white board and PowerPoint presentation, modes. At the end of this course student will be able to understand the significance of the basic Chemistry in various field of engineering such as paints, lubricants, adhesives etc.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 (70 %) and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-1 and Text-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] P.C Jain & M. Jain 'Engineering Chemistry'. Dhanpat Rai & Co.(pvt.) Ltd.

[2] Puri Sharma & Pathania " Physical Chemistry" Vishal Publishing Co. 2002

[3] Puri Sharma & Pathania " Inorganic Chemistry" Vishal Publishing Co. 2002

Reference Book:

[1] Shashi Chawala 'Theory and Practical of Engineering Chemistry'. Dhanpat Rai & co.(pvt.) Ltd.

[2] S.S. Dara "A Text book of Engineering Chemistry". S.Chand & Company Ltd. 2008

Title: Engineering Mechanics Lab **Code: ME202**

L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied the course, "Engineering Mechanics"

Objective:

1. To demonstrate students, the basic principles of Engineering Mechanics: Statics and Dynamics.
2. To develop effective skills in students to observe experimental data and to analyze the results.

Learning Outcomes:

Course Outcome	Description
CO1	Verify the various laws of mechanics
CO2	Determine mechanical advantage, velocity ratio and efficiency of various lifting machines
CO3	Evaluate co-efficient of friction between two mating surfaces
CO4	Estimate the forces in machines and structures
CO5	Apply concepts of kinematics and kinetics of particles to analyze practical problems.
CO6	Work as a team on a project

Course Content:

Experiment-1: To verify the triangle law of forces

Experiment-2: To verify the parallelogram law of forces

Experiment-3: To verify the polygon law of forces

Experiment-4: To verify Lami's theorem

Experiment-5: To determine the co-efficient of friction between wood and other surfaces

Experiment-6: To find the moment of inertia of flywheel

Experiment-7: To determine the mechanical advantage, velocity ratio and efficiency of a screw jack

Experiment-8: To determine the mechanical advantage, velocity ratio and efficiency of Worm and Wheel

Experiment-9: To determine the mechanical advantage, velocity ratio and efficiency of the Winch Crab

Experiment-10: To find the forces in a member of a Triangular Truss

Experiment-11: To find the forces in a member of a Warren Truss

Experiment-12: To find the forces in a member of a Pratt Truss

Experiment-13: To find the forces in a member of a Joint Roof Truss

Teaching Methodology:

This Lab course has been introduced to help a student to learn with hand-on experience on machines. The entire course is broken down into thirteen experiments. Each experiment includes engineering mechanics principles applied to various machines in order to help a student gain more experience as Mechanical Engineer. This lab course is well complemented by a theory course under the name Engineering Mechanics in the same semester in order to enable the student to get acquainted, learn and discuss the technical details of the underlying principles of mechanics and mechanisms in machines and structures. This Lab course will enable a student to learn with hand-on experience.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-13**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:
Laboratory Manual available in Lab. Study material of Engineering Mechanics Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Engineering Mechanics Vol. I-Statics, by J. L. Meriam and L.G. Kraige, John Wiley & Sons Inc. 6th Edition.

[2] Engineering Mechanics Vol. II-Dynamics, by J. L. Meriam and L.G. Kraige, John Wiley & Sons Inc. 6th Edition.

Reference Books/Material:

[1] Engineering Mechanics: Statics and Dynamics, Hibbeler, R.C. (2007), Pearson Prentice Hall, Upper Saddle River, NJ, 13th Edition.

[2] Engineering Mechanics, S.Timoshenko, D.H.Young, McGraw Hill Book Co.

Web References:

[1] https://nptel.ac.in/courses/112103109/

[2] https://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/

[3] https://freevideolectures.com/course/2264/engineering-mechanics

[4] https://www.coursera.org/learn/engineering-mechanics-statics-2

Journals References:

[1] Journal of Engineering Mechanics - ASCE

[2] Mechanical Engineering & Mechanics, Springer

[3] International Journal for Theoretical and Applied Mechanics, Association for Engineering Mechanics

[4] Probabilistic Engineering Mechanics, Elsevier

[5] International Journal of Mechanics and Materials in Design, Springer

[6] Journal of Engineering Mechanics and Machinery, Clausius Scientific Press

Title: Engineering Drawing & Design Lab **Code: ME203**
L-T-P scheme: 0-0-1 **Credits: 1.5**

OBJECTIVE

[1] Enables students to learn the concepts of graphic communication, their role in sanitary construction.
[2] Make familiar with different drawing equipment, technical standards and procedures for construction of geometric figures.
[3] Equipped with the skill that enables them to convert pictorial to orthogonal representations.

Course Content:

Unit-1: Study and construction of lines, lettering, dimensioning, plane scales, diagonal scales, construction of different methods used for the construction of conic curves.

Course Outcome	Description
CO1	Outline the objectives of scale and develop the imagination and mental visualization capabilities for correlating the geometrical details of objects.
CO2	To develop the constructional ability for a different curve.
CO3	ToDescribe BIS rules for orthogonal projection andunderstand the fundamental concept of orthogonal projection for point, line, plane and solids.
CO4	Understand and apply orthogonal projection for solids, section and intersection of solid objects/structures
CO5	To apply the skill of development of surfaces of three dimensional objects for evaluation of black size of the components.
CO6	Demonstrate computer aided drafting tools and techniques using CAD software's

Unit-2: Study and construction of geometrical construction, cycloidal curves, involutes and helix etc.

Unit-3: Orthogonal projection of point in all possible positions, Study and construction of projection of line and its applications (inclined to both planes), and projection of planes (inclined to both planes).

Unit-4: Study and construction of projection of solids (right circular cone, prism, pyramid and cylinders), and true shape of sections,

Unit-5: Study and construction of oblique projection and development of surface, isometric view using orthogonal projection on isometric scales.

Unit-6: Introduction to basic and editing command of CAD software, 2-D drafting, surface modeling, and 3-D geometrical model.

Teaching Methodology:

This course is introduced to build the imagination and established the correlation between the real object and engineering drawing and CAD developed by the design engineers and the requirement of the production engineers of the different units.

Evaluation Scheme:

<table>
<tr><td colspan="2">Exams</td><td>Marks</td><td>Coverage</td></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-7</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 8-14</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:

The study material of engineering drawing & design lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

1. Bhatt, N.D., Engineering Drawing,

Reference Books:

2. Gill, PS, A Text Book of Engineering Drawing (Geometrical Drawing)
3. Dhananjay A J, Engineering Drawing with an introduction to Auto CAD, Mc Graw Hill

Title: Electrical Circuit Analysis Lab **Code: EC202**
L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Not applicable

Objective:

3. To analyze the various dc network theorem.
4. To learn the ac fundamental concepts.

Learning Outcomes: In reference to Electrical Circuit Analysis (18B11EC212), the students will be able to:

Course Outcome	Description
CO1	Be aware of basic laws of electrical circuit
CO2	Apply theorems for finding the solutions of network problems
CO3	Calculate the power from electrical circuits
CO4	Analysis the behavior of direct current transients
CO5	Realize the performance of two port network parameters
CO6	Evaluate the performance of various alternating current circuits

Course Content:

Unit-1; Lab exercises based on basic law's of electrical circuits
Unit-2; Lab exercises based on various dc theorems such as superposition, Thevenin's
Unit-3; Lab exercises based on power calculation with the help of maximum power transfer
Unit-4; Lab exercises based on transient analysis of electrical circuits
Unit-5; Lab exercises based on different two-port network
Unit-6; Lab exercises based on ac fundamental circuits

Teaching Methodology:

This lab course is introduced to help students for understanding the basic concept of electrical engineering. Initially an overview of basic terminology of electrical circuit along with various component needed for circuits will be discussed briefly. In the first part, Direct Current (DC) related issued are elaborated through various theorems. Later on DC transient is evaluated on various circuits. In the second part, Alternating Current (AC) is described by different parameters and phasor diagrams. At the end, ac circuits and resonance condition has been evaluated.

Evaluation Scheme:

Exams	Marks		Coverage
P-1	15 Marks		**Based on Lab Exercises: 1-7**
P-2	15 Marks		**Based on Lab Exercises: 8-14**
Day-to-Day Work	Viva	20 Marks	**70 Marks**

	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:
Study material of Electrical Circuit Analysis Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Books:
[4] "Basic Electrical Engineering", D.C. Kulshreshtha, McGraw Hill Education, 2009.
[5] "Engineering Circuit Analysis", W.H. Hayt, J. E. Kemerlay and S.M. Durbin, 6th edition, McGraw Hill, 2006.
[6] "Introduction to Electric Circuits", R.C. Dorf & J.A. Svoboda, John Wiley, 2004.

Reference Books:
4. "Network Analysis", V. Valkenburg, Prentice-Hall India Ltd., 2001.
5. "Basic Electrical Engineering", A. Chakrabarti, S. Nath, C. K.Chanda, Tata McGraw Hill Publishing Co, 2008.
6. "Principles of Electrical Engineering", V. D. Toro, Prentice Hall of India.

Web References:
[3] https://www.rapidtables.com/electric/index.html
[4] https://library.automationdirect.com/basic-electrical-theory/

Journals References:
[3] International Journal of Circuit Theory and Application Wiley publication
[4] International Journal of Circuits and Electronics

Title: Engineering Chemistry Lab **Code: CH201**

L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: The students must be aware of basic Chemistry Experiment upto class 12^{th}. Basic knowledge of chemistry helps them to correlate in various division of Engineering during this lab.

Objective:

The purpose behind this course is to make the students familiar with the concepts of the Chemistry Experiment and to understand the significance of Chemistry in various field of the Engineering (Chemical, Mechanical and Civil Engineering).

Course Learning Outcomes:

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in still deep interests in learning chemistry; develop broad and balanced knowledge and understanding of key chemical concepts, principles, and theories related to chemistry; and equip students with appropriate tools of analysis to tackle issues and problems in the field of chemistry.
CO2	Describe the real world problems, challenges with application of the Chemistry in various fields of engineering (Chemical, Mechanical and Civil Engineering).
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in chemistry.
CO4	Identify and use of various analytical techniques in the Chemical, Mechanical and Civil Engineering project management.
CO5	Apply experimental demonstration and validation by using various analytical techniques given in theorem, principles as explained in lectures.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in chemistry and related areas or in multidisciplinary areas that involve chemistry and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

LIST OF EXPERIMENT

1. To determine the dissolve oxygen (DO) in the given water samples.
2. To determine the pH and conductivity of the given water samples.
3. To determine the relative viscosity of given unknown liquids.
4. To determine the relative surface tension of the given unknown liquid.
5. To determine the equivalence point by using pH metric titration of strong acid and weak base.
6. To determine the alkalinity of a given water sample.
7. Determination of total hardness of water by complexmetric titration using EDTA.
8. To find out the strength of unknown solution of oxalic acid & sodium hydroxide with the help of N/20 oxalic acid solution by double titration.
9. Confirmation of hetro-elements e.g. N, S, Cl, Br and I by Lassaigne's test.

10. Detection of functional groups e.g. aldehyde, alcohol, carboxylic and ketone in the given organic compound.
11. To prepare urea formaldehyde resin by condensation reaction. (Bakelite).
12. Evaluation of physical properties of oils e.g. saponification value and acid value.
13. Separation of pigments/colored ions by paper/column chromatography.
14. Separation of parameter by using TLC.

Teaching Methodology:

This course planned in 14 lab experiment and each experiment having 2 hours practical exposure in Chemistry lab. Their continuous evaluation will be performed in each week and weightage given during finalizing of the grade sheet. At the end of this course student will be able to: Understand the significance of the basic Chemistry in various field of engineering.

Evaluation Scheme:

<table>
<tr><td colspan="2">Exams</td><td>Marks</td><td>Coverage</td></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-7</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 8-14</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:

Study material of Web Technology Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book

1. Organic Chemistry Lab Technique, Lisa Nichols Publisher, by Lisa Nichols, Butte Community College.
2. Practical Chemistry Labs, by Leonard Saland, **Manufacturer:** Walch Education 015116

Reference Book

1. Green Chemistry, by Sally A. Henrie, CRC Press Published March 18, 2015.
2. Drinking Water Chemistry: A Laboratory Manual by Barbara Hauser, CRC Press Published August 21, 2001.

Title: Basic Thermodynamics **Code: ME102**
L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "*Partial Differential Equations*".

Objective:

1. To learn Basic principles and equations of fluid mechanics so that intuitive understanding of subject can be developed.
2. He will study numerous and diverse real-world engineering examples, so that his understanding of fluid mechanics principles strengthens more.

Learning Outcomes:

Course Outcome	**Description**
CO1	Outline the concepts of system (open and closed), thermodynamic properties and equilibrium, work and heat.
CO2	Apply the laws of thermodynamics real life problems like refrigeration, engines, compressors, turbines, nozzles etc.
CO3	Understand the properties of pure substances and can evaluate Rankine cycle.
CO4	Describe the concept of available energy along with the development of Maxwell's and thermodynamic relations of gas mixtures.
CO5	Identify air standard cycles applied in real engines.
CO6	Describe the basic concept of Heat transfer & VCS and solve real life problem

Course Content:

Unit-1:BASIC CONCEPTS: Macroscopic and microscopic approaches, Property, Equilibrium, State, Process, Quasi-static processes, Cycle, Laws of thermodynamics, Steady and unsteady flow processes.

Unit-2: FIRST LAW OF THERMODYNAMICS: Energy and its forms, Energy and first law of thermodynamics, Boundary work, Work done in different processes, Specific heat, Internal energy and enthalpy, PMMI, Steady flow energy equation, First law applied to non- flow process, flow process (steady and unsteady).

Unit-3:SECOND LAW OF THERMODYNAMICS AND EXERGY: Limitations of first law, Thermal reservoir, Heat source and heat sink, Heat engine, Refrigerator and heat pump, Kelvin - Planck and Clausius Statements and their equivalence, Carnot's theorem, Carnot's cycle, Entropy, Entropy change for ideal gas, T-S diagrams, Availability and irreversibility, Loss of available energy, Dead state of a system, Availability of a non-flow and steady flow system, Helmholtz and Gibb's functions.

Unit-4: PURE SUBSTANCE, AIR-STANDARD CYCLES & THERMODYNAMICS RELATIONS : Phase and phase transformation, Saturated and superheat steam, Solid – liquid – vapour equilibrium, T-V, P-V and P-T Plots during steam formation, Property changes during steam processes, Throttling and measurement of dryness fraction of steam, Two stroke and four stroke engines, Otto cycle, Diesel cycle, Brayton cycle, PVT relationship, Mixture of ideal gases, Properties of mixture of ideal gases, T-ds relations, Maxwell equations, Joule-Thomson coefficient, Clapeyron equation.

Unit-5: BASIC HEAT TRANSFER MECHANISM: Definition of Heat Transfer, Modes of heat flow, Combined heat transfer system and law of energy conservation, Steady state heat conduction through a plane wall, cylinder and sphere, Conduction with heat generation, Basic mechanism of convection (free and forced), The Stephen-Boltzmann law, The black body radiation.

Unit-6: **REFRIGERATION AND REFRIGERANTS:** Refrigeration & air conditioning, Refrigerants and their Classification, Carnot refrigeration cycle, Brayton refrigeration or the Bell Coleman air refrigeration cycle, Simple vapour compression (VC) refrigeration systems-Limitations of reversed carnot cycle with vapour as the refrigerant, Analysis of VC cycle, Effects of operating conditions on COP.

Teaching Methodology: This course is one of the foundation course in the Mechanical discipline. The knowledge gained in this course will help the student to understand not only the industrial processes but, they will also be able to do some small applied research. The course is divided into six units which have to be followed one after the other i.e. no unit should be skipped. This course has to discussed in great depth as, it covers a very large part of GATE and ESE examinations syllabus. After every broader topic an assignment will be given to students which has to submitted in due time. In tutorials the students will work collectively to understand the concepts with the help of practical problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2

Test-2	25 Marks	Based on Unit-3 and Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and assignments on Basic Thermodynamics (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1]"Engineering Thermodynamics", P. K. Nag , Tata McGraw Hill.
[2]"Refrigeration and Air conditioning", C. P. Arora, Tata McGraw Hill.
[3]"Fundamentals of Heat and Mass transfer", P. F. Incropera and D. P. DeWitt, Wiley

Reference Books/Material:

[1] "Introduction to Thermodynamics", D. C. Spanner, Academic Press
[2] "Principle of Engineering Thermodynamics", Moran, Shapiro, Boettner, Bailey, whiley.
[3] "Heat Transfer", P. S. Ghoshdastidar, Oxford.
[4] "Engineering thermodynamics", E. Fermi, Dover book
[5] "Engineering Thermodynamics", Y. A. Cengel, Cimbala, Tata McGraw Hill.

Web References:

- pdumka.blogspot.com/
- www.youtube.com/channel/UCgY8X2rJciN3DvIHp0ysNKg

Title: Strength of materials **Code: ME103**
L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "Engineering Mechanics".

Objective:

1. To learn and be able to analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.
2. To learn and be able to perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.

Learning Outcomes:

Course Outcome	Description
CO1	Understand statically determinate and indeterminate problems.
CO2	Determine the resistance and deformation in structural members subjected to various loading.
CO3	Apply knowledge of materials and structural elements to the analysis of simple structures.
CO4	Undertake problem identification, formulation and solution using a range of analytical methods.
CO5	Evaluate principal stresses, strains and apply the concept of failure theories for design.
CO6	Analyze and design thin, thick cylinders and springs.

Course Content:

Unit-1: Simple Stresses & Strains: Elasticity and plasticity – Types of stresses & strains–Hooke's law– stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Elastic moduli & the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain energy – Resilience – Gradual, sudden, impact and shock loadings.

Unit-2: Shear Force and Bending Moment: Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

Unit-3: Bending and shear stress in beams: Bending of beams with symmetric cross-section, shearing stress variation in beam cross-section (shear centre and plastic analysis not to be discussed)

Unit-4: Torsion of shafts: Torsion of solid and hollow circular shafts and thin-walled tubes (plastic analysis and rectangular shafts not to be discussed), shaft in series and parallel.

Unit-5: Thin cylinders & spheres: Introduction, difference between thin walled and thick walled pressure vessels, thin walled spheres and cylinders, hoop and axial stresses and strain, volumetric strain. Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures.

Unit-6: Deflection of beams: Deflection of beams, deflection by Double Integration, Macaulay's method, Moment area method, Castigliano's theorem.

Unit-7: Columns and Struts: Columns and Struts: Buckling and stability, slenderness ratio, combined bending and direct stress, middle third and middle quarter rules, struts with different end conditions, Euler's theory for pin ended columns, effect of end conditions on column buckling, Ranking Gordon formulae, examples of columns in mechanical equipment's and machines.

Unit-8: Helical and Leaf Springs: Deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.

Unit-9: Principal stresses and strains: Analysis of biaxial state of stress with and without shear stress. Mohr's circle.

Teaching methodology:

The aim of introducing this course is to give aexposure to the students on the important and fundamental concept in the extensive area of Materials and its behavior under different loading conditions. The concepts, ideas and techniques developed in SOM are indispensable in machine and structural design. The main focus of this course is to introduce fundamental concepts in SOM with special emphasis on practical problems.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 &Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4& Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-9 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and referred video lecture on Strength of materials is available on JUET server.

Text Book:

1. "Mechanics of materials"; Timoshenko and Gere, CBS Publishers. 2011.
2. "Engineering Mechanics of Solids"; E.P.Popov, PHI,2009
3. "Mechanics of materials"; B. C. Punamia.and A.K. Jain, Laxmi publication.

Reference Books:

1. Nag and Chanda, Fundamentals of Strength of Materials, Wiley India.
2. Bansal R.K., Strength of Materials, Laxmi Publications.
3. Gere J. M., Mechanics of Materials, Thomson Press.
4. Pytel A. and kiusalaas J., Mechanics of Materials, Thomson Press.
5. Hearn E. J., Mechanics of Material Vol. I & II, Butterworth-Heinemann Publication.
6. Bedi D. S., Strength of Materials, S. Chand & Co. Ltd

Title: Manufacturing Technology-1 **Code: ME104**

L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: It is a foundation course of manufacturing.

Objective:

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

Learning Outcomes:

CO1	Outline various manufacturing processes such as metal casting, welding and metal forming and their types
CO2	Describe various casting, welding and metal forming techniques
CO3	Develop the knowledge of casting, welding and metal forming processes and their practical use
CO4	Identify and use the proper technique required for the production process of any metallic product
CO5	Apply various manufacturing processes as per the requirement of the product
CO6	Demonstrate the practical exposure of casting, welding and metal forming

Course Content

Unit 1: Casting:

Introduction to Casting: Requirements of casting, Basic principle of casting

Sand Moulding and Core Making: Pattern materials, Pattern types, Allowances on pattern Types and properties of moulding sand, Sand conditioning, Sand moulding methods and types, Types of core, Core sand and core making, Moulding and core making machines, Special Sand Moulding Processes(based on sodium silicate and organic binders), Investment casting, Full mould casting, Plaster moulding, Vacuum moulding, VRH process

Permanent Mould Casting and Other Casting Methods: Permanent mould casting, Pressure die casting, Low pressure die casting, Squeeze casting, Centrifugal casting, Continuous casting.

Gating System design, Melting, Pouring and Shakeout : Requirement of gating system and risers in casting, Components of gating system, Types of gates and risers, Design of gating system and riser, Use of chaplets, chills, pads and exothermic materials in sand casting, Various melting furnaces, Solidification of casting (nucleation and grain growth), Casting shakeout, Casting defects and their remedy.

Unit 2: Welding:

Introduction to Welding: Requirement of welding, Classification of welding

Gas Welding and Allied Process: Gas welding, Gas cutting, Brazing

Arc Welding: Welding arc, Power source for arc welding, Arc welding consumables, Metal transfer in arc welding, Principles, setup, metallurgy, position, variants and application of different arc welding techniques: SMAW, SAW, GTAW, GMAW, Electroslag welding

Other Welding Techniques: Resistance welding, Friction welding, Thermit welding, Cold pressure welding.

Unit 3: Metal Forming Processes:

Bulk metal deforming: Elastic and plastic deformation, Yield and flow criteria, Concept of strain hardening, Hot and cold working, classification of metal deforming processes -rolling, forging, extrusion, wire and tube drawing. Machine and equipments for the metal deforming processes, Parameters and force calculations for different processes.

Sheet metal deforming and cutting: Role of sheet components, Shearing mechanism, Various press working operations. Presses for sheet metal working; Part feeding systems; Elements of die, punch and die clearances, Progressive, compound and combination dies; Forming processes like bending, cup drawing, coining, embossing, etc.

Teaching Methodology:

In foundry technology the student will have a broad knowledge of sand casting: Pattern making: requirement of pattern materials, different pattern materials and designing of the pattern; Moulding and core making: Moulding sand, sand conditioning, moulding and core making processes and machines and special moulding methods; permanent mould casting: requirement of permanent mould casting, design requirement of permanent moulds and types of permanent mould casting; designing of gating system and risers, cupola furnace and defects in metal casting.

In welding technology students will have a generalized knowledge on various welding technology used in manufacturing. They are going learn about arc welding processes, resistance welding, gas welding and brazing processes. In arc welding they are going to learn about the welding arc, arc welding power source, arc welding consumables and metal transfer. Also they are going to learn about shielded metal arc welding, submersed arc welding, gas tungsten arc welding, gas metal arc welding, electro-slag welding, electro-gas welding, resistance welding, oxy-acetylene welding and brazing processes.

In metal forming processes the students will have knowledge on stress and strain analysis and various yielding methods to understand the analysis of metal forming processes. They will have knowledge on classification of different metal forming processes and analysis on metal forging, metal rolling, metal drawing, metal extrusion, sheet metal bending and sheet metal deep drawing processes. In each process they will also learn about the machines used, the processes to be followed, defects in them and their remedies.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit 1
Test-2	25 Marks	Based on Unit 2 and Unit 1 (20%)
Test-3	35 Marks	Based on Unit 3, Unit 2 (15%) and Unit 1 (15%)

Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials on manufacturing technology 1 (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. Jain P L, Principles Foundry Technology, Tata McGraw Hill
2. Parmar R.S., Welding Process and Technology, Khanna Publishers.
3. Kumar Surendra, Technology of Matal Forming Processes, Prentice Hall of India

References Books/Materials:

1. Pandey P. C. and Singh C. K., Production Engineering Sciences, Standard Publisher.
2. Jain R.K., Production Technology, Khanna Publisher.
3. Kalpakjian S., Schemid S., Manufacturing, Engineering and Technology, Addison Wesley.
4. De Garmo, E. P., Black, J. T. and Kohser, R.A., Materials and Processes in Manufacturing, Prentice Hall of India Pvt. Ltd.
5. Rao P. N., Manufacturing Technology I, Tata McGraw Hill.
6. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *Journal of Manufacturing Science and Engineering*
2. Journal of Manufacturing Processes

Title: Theory of Machines **Code: ME105**
L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: Students must have already studied course, "*Engineering Mechanics*".

Objective:

1. To provide the knowledge of different mechanisms, degree of freedom and kinematic analysis of mechanism and to explain different types of gears, gear trains.
2. To provide the concepts of static and dynamic mass balancing, knowledge of turning moment diagram and to provide the knowledge of the application of flywheels & Governors.
3. To provide the concepts of gyroscope and the vibration analyses of rigid body systems.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the knowledge of different mechanisms, degree of freedom, kinematic and dynamic analysis of mechanism.
CO2	Describe different types of gears, gear trains.
CO3	Develop the mathematical methods to analyze the static & dynamical forces acting on mechanical systems and balancing of single slider crank mechanism.
CO4	Identify the fluctuations in the speed of the engine and provide the concepts static and dynamic mass balancing, knowledge of turning moment diagram and the knowledge of the application of flywheels & Governors.
CO5	Apply the concept of Free, damped & forced vibration to determine the natural frequency, to find the damping coefficient and to find the effect of whiling of shaft.
CO6	Demonstrate the Gyroscopic effects on naval ships, on stability of four wheels and two wheels vehicle moving on curved path, Gyroscopic effects on an Aero plane.

Course Content:

Unit-1:Mechanisms and machines

Introduction to mechanism and machine, Kinematic link, Kinematic Pairs, Chains, Grashof's Criterion, Kinematic mechanisms, Inversions, Constrained motion, Degrees of freedom, Equivalent linkages, Mechanisms with lower pairs.

Unit-2: Velocity and acceleration analysis

Displacement analysis, Relative velocity, Instantaneous centre, Aronhold-Kennedy's theorem, Velocity and acceleration diagram, Coriolis component of acceleration, Klien's construction.

Unit-3: Gear and Gear trains

Introduction to gear, Types of gear, Different types of gear trains: Simple Gear Train, Compound Gear Train, Epicyclic Gear Train. Torque calculation.

Unit-4: Flywheel

Turning-moment diagrams, Fluctuations of energy, Fluctuations of speed, Coefficient of fluctuation of energy, Coefficient of fluctuation of speed, Energy stored in Flywheel, Flywheel in punching machine.

Unit-5: **Governor**

Types of governors, Characteristics of centrifugal governors, Stability of governor, Isochronous governor, Sensitiveness, Hunting, Governor Effort and power, Coefficient of insensitiveness.

Unit-6: Balancing

Balancing of rotating and reciprocating masses, Partial balancing of primary unbalanced force of reciprocating engine, Tractive force, Swaying couple, Hammer blow.

Unit-7: Gyroscope

Gyroscopes, Gyroscopic forces and couples, Gyroscopic stabilization, Gyroscopic effects on naval ships, Steering, pitching and rolling, Ship stabilization, Stability of four wheels and two wheels vehicle moving on curved path, Gyroscopic effects on an Aero plane.

Teaching Methodology:

This course is introduced to help students to understand the relative motion between the various parts of a machine and the forces which act on them. The knowledge of this subject is very essential for an engineer in designing the various parts of a machine.

The entire course is broken down into seven separate units: Mechanisms and machines, Velocity and acceleration analysis, Gear and Gear trains, Flywheel, Governor, Balancing and Gyroscope. Each section includes the different aspects of the machine which help a student to gain more experience as a mechanical engineer. This theory course is complemented by a laboratory course under the name “Theory of Machine Lab” in the same semester that helps a student learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6& Unit-7 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

[1] Theory of Machine by SS Ratan

[2] Theory of Mechanisms and Machines by CS Sharma & Purohit

Reference Books/Material:

[6] Theory of Machine by R.S. Khurmi

Web References:

- https://nptel.ac.in/courses/112104121/
- https://nptel.ac.in/courses/112101096/#

Journals References:

- Mechanism and Machine Theory : Elsevier

Title: Managerial Economics **Code: HS102**
L-T-P scheme: 2-1-0 **Credit: 3**
Prerequisite: None
Objectives:

1. The course is concerned with the application of economic principles and methodologies to key management decisions within organizations.
2. It provides principles to foster the goals of the organization, as well as a better understanding of the external business environment in which an organization operates.
3. It is fundamentally a unique way of thinking about problems, issues and decisions that managers face in each of the functional areas of the organization as well as the strategic ones faced by general managers.

Learning Outcomes:

Course Outcome	Description
CO1	Outline what managerial economics is and how micro and macro economics differ from each other.
CO2	Describe basic concepts & elasticities of demand.
CO3	Develop an understanding of factors of production.
CO4	Identify different types of cost.
CO5	Apply logic to understand different market structures viz Perfect Competition; Monopoly; Monopolistic Competition; and Oligopoly.
CO6	Deploy and be proficient in contribution and break even analysis

Course Content :

Unit-1 : Introduction to Managerial Economics & Macro-economic Concepts: Definition of Economics, Meaning & Scope of Managerial Economics, Micro & Macro Economics concepts – National income, GDP, Inflation, Monetary Policy, Fiscal Policy, SLR, CRR, Concept of economic profit, Opportunity Cost, Discounting principle, time value of money, Equi marginal utility

Unit-2 : Demand Analysis: Law of demand**,** Individual & market demand, Determinants of market demand, Marginal Utility theory, Elasticity of demand – Price, Income, Cross, Advertising ,Theory of Consumer choice using Indifference Curve analysis, Demand forecasting techniques – Delphi , Survey , Time series analysis, Correlation, Regression analysis

Unit-3: Production Theory and Analysis: Production with one variable, optimal employment of a factor of production, Cobb Douglas production function, Productionwith two variable inputs, Production Isoquants, Production Isocosts, Optimal employment of two inputs, the expansion path, Basics of Supply, Market Equilibrium

Unit-4: Cost Theory and Analysis : Cost concepts – Opportunity, Explicit, Marginal, Incremental and Sunk, Relation between Production & Cost, Short run cost function, Long run cost function, Special topics -Profit contribution analysis, Break Even analysis

Unit-5 :Pricing under Different Market Structures : Perfect Competition - Determination of Price output relationship in short run, long run, Monopoly - Determination of Price output relationship in short run & long run , Price discrimination, Monopolistic Competition - Determination of Price output relationship in short run & long run , Product Differentiation ,Oligopoly -Types ,Determination of Price output

relationship ,Kinky demand curve {Stickiness of Price},Price leadership model, Collusive and Non Collusive Oligopoly

Teaching Methodology:

Teaching methodology in this course involves classroom lectures as well tutorials. The tutorials allow a closer interaction between the students and the teacher as each student gets individual attention. In tutorials, the teacher will be keeping track of each student's progress and address her/his individual difficulties. Written assignments and projects submitted by students as part of the course will also discussed in tutorials.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Reference Books/Material:

[1] Osborne, M. (2004), An introduction to game theory. Oxford University Press.

[2] Snyder, C., Nicholson, W. (2010), Fundamentals of microeconomics. Cengage Learning.

[3] Varian, H. (2010), Intermediate microeconomics: A modern approach, 8th ed. W. W. Norton.

[4] Bergstrom, T., Varian, H. (2014),Workouts in intermediate microeconomics. W. W. Norton

[5] Bernheim, B., Whinston, M. (2009). Microeconomics. Tata McGraw-Hill.

[6] Mankiw, N. (2007). Economics: Principles and applications, 4th ed. Cengage Learning.

[7] Snyder, C., Nicholson, W. (2010). Fundamentals of microeconomics. Cengage Learning.

Title: Introduction to Materials and Metallurgy **Code: ME001**
L-T-P scheme: 3-0-0 **Credit: 0**

Prerequisite: Students must have already studied courses "Physics and Chemistry" upto 12th standard.

Objective:

1. To learn the importance of materials and their applications in engineering domain.
2. To learn and be able to identify metals and alloys based on their compositions and structures.
3. To know about heat treatment processes to improve the properties of metals.

Learning Outcomes:

Course Outcome	Description
CO1	Understands the different categories of engineering materials
CO2	Determine the atomic packing factors and density of the crystal structure
CO3	Apply the fundamental concepts of material science to find the properties of materials
CO4	Estimate the amount of liquid and solid phase using phase diagrams
CO5	Identify the corrosion and wear phenomenon in metals
CO6	Develop the skills to modify the properties of metals

Course Content:

Unit-1: Introduction to engineering materials: Importance of materials, Classification of materials, Properties of materials– Mechanical, electrical, thermal, magnetic, optical, decorative and its applications, Modern materials – Smart materials, Bio and Nano materials.

Unit-2: Crystallography: Concept of unit cell space lattice, Bravais lattices, Common crystal structures, Atomic packing factor and density, Miller indices.

Unit-3: Diffusion in metals: Diffusion mechanism, steady-state diffusion, nonsteady-state diffusion, Diffusion in metals:Diffusion mechanism, steady-state diffusion, nonsteady-state diffusion

Unit-4: Phase Diagrams: Solid-solutions, Gibb's solid phase rule, Uniary and binarySystem, Lever rule, Iron-Carbon Equilibrium-Diagram.

Unit-5: Phase transfer: Definition, concept, solidification, classification of heat treatment processes e.g. Annealing, Normalizing, Quenching, Tempering, and Case hardening, Time-Temperature-Transformation (TTT) diagram, types of steel, cast iron.

Unit-6: Mechanical Behavior of Metals: Stress straindiagram, Properties of metals, Deformation of metals, Mechanism of deformation.

Unit-7: Non-Ferrous Metals and Alloys: Non-ferrous metals such as Cu, Al, Zn, Cr, Ni etc. and its applications.

Unit-8: Wear and Corrosion of metals: Mechanism, factors, methods of testing of wear, principle, factors, types of corrosion, protection against wear and corrosion.

Teaching methodology:

This course covers the engineering materials, properties, treatments and their applications. The entire course is broken into Introduction of materials, crystallography, diffusion in metals, phase diagram, phase transfer, mechanical behavior of metals, and wear and corrosion of metals. This course is introduced as an audit courses to aware the students about engineering materials.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3 to Unit-5 and around 30%
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30%
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and referred video lecture on Introduction to Materials and Metallurgy is available on JUET server.

Text Books:

[1] William D. Callister, Jr., Fundamentals of material science and engineering- An interactive, John willey & Sons, Inc.

[2] Donald R. Askeland, P.P Fulay and W.J. Wright, The science and engineering of materials, sixth edition, Cengage Learning.

[3] V. Raghvan, Material science and engineering, prentice hall of India (PHI) Pvt. Ltd.

[4] S. H. Avner, Introduction to physical metallurgy, Mc Graw Hill Education

Reference Books:

[1] George E. Dieter, Mechanical metallurgy, Tata Mcgraw Hill education.

[2] H. Van Vlack, Elements of material science and engineering, Addision-wesley.

Web links: https://nptel.ac.in/courses/113/102/113102080

Title: Basic Thermodynamics Lab **Code: ME204**
L-T-P scheme:0-0-1 **Credit: 1**

Prerequisite: Students should be studying "Basic Thermodynamics"

Objective:

1. To learn and be able to measure flow, velocity, and losses in open and closed channel flows.
2. To develop the abilities to understand the flow behavior and its impacts on industrial and daily life precesses.

Learning Outcomes:

Course Outcome	Description
CO1	Identify the working and construction of 2 and 4 stroke Petrol and Diesel engines.
CO2	Describe the working and construction of water tube and fire tube boilers along with the knowledge of modern boilers
CO3	Develop the magnitude of dryness fraction of wet steam
CO4	Understand the working and construction of refrigerator and air conditioner along with its COP calculations.
CO5	Calculate the thermal conductivity of given sold and liquid.
CO6	Able to calculate the numerical value of Stefan-Boltzmann constant.

Course Content:

Experiment-1: Study of simple vertical, Locomotive, Babcock Wilcox Boiler.
Experiment-2: Study of two stroke Petrol and Diesel Engine.
Experiment-3: Study of four stroke Petrol and Diesel engine.
Experiment-4: To determine the dryness fraction by separating calorimeter.
Experiment-5: To determine different efficiencies and performance of a double acting reciprocating compressor
Experiment-6: To study the vapour compression Refrigeration System and determine its C.O.P. and draw P-H and T-S diagrams.
Experiment-7 To study the Ice- plant, its working cycle and determine its C.O.P and capacity.
Experiment-8: To Study the Mechanical and Air and Water heat pump and find its C.O.P.
Experiment-9: To determine the thermal conductivity of a metallic rod and insulating power.
Experiment-10: To determine the thermal conductivity of a solid by the guarded hot plate method.
Experiment-11: To verify the Stefan-Boltzmann constant for thermal radiation.
Experiment-12: Draw the characteristic curves for Francis turbine.
Experiment-13: Study of positive displacement and rotary pumps

Teaching Methodology:

This lab is run in conjunction with the theory course 18B11ME311 (Fluid Mechanics). It is an introductory course where basic aspects of thermodynamics, heat transfer, and refrigeration are explained through practical demonstrations and models. The goals of the experiments include study of basic boiler and engine study, dryness fraction calculation, COP calculations, thermal conductivity calculations, and Stefan Boltzmann constant evaluations. Experimental setups and models such as boilers models, engine models, separating and throttling apparatus, compressor apparatus, refrigeration and air conditioning test rigs, and heat transfer apparatus are made available to the students. The lab experiments utilize U-tube manometer, piezometers, theromocouples, digital temperature indicators and stop watches. The lab runs closely with the lectures in such a way that experiments support the text covered in the class room.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-6**
P-2		15 Marks	**Based on Lab Exercises: 7-13**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Basic Thermodynamics Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[4]"Engineering Thermodynamics", P. K. Nag , Tata McGraw Hill.

[5]"Refrigeration and Air conditioning", C. P. Arora, Tata McGraw Hill.

[6]"Fundamentals of Heat and Mass transfer", P. F. Incropera and D. P. DeWitt, Wiley

Reference Books/Material:

[7] "Introduction to Thermodynamics", D. C. Spanner, Academic Press

[8] "Principle of Engineering Thermodynamics", Moran, Shapiro, Boettner, Bailey, whiley.

[9] "Heat Transfer", P. S. Ghoshdastidar, Oxford.

[10] "Engineering thermodynamics", E. Fermi, Dover book

[11] "Engineering Thermodynamics", Y. A. Cengel, Cimbala, Tata McGraw Hill.

Web References:

[1] http://vlab.co.in

Title: Strength of Materials Lab **Code: ME205**
L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied courses, "Engineering Mechanics lab".

Objective:

1. To learn and be able to analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.
2. To learn and be able to perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.

Learning Outcomes:

Course Outcome	Description
CO1	Understand statically determinate and indeterminate problems.
CO2	Determine the resistance and deformation in structural members subjected to various loading.
CO3	Apply knowledge of materials and structural elements to the analysis of simple structures.
CO4	Undertake problem identification, formulation and solution using a range of analytical methods.
CO5	Evaluate principal stresses, strains and apply the concept of failure theories for design.
CO6	Analyze and design thin, thick cylinders and springs.

Course Content:

1. To study the Rockwell hardness testing machine & perform the Rockwell hardness test.
2. To study the Brinell hardness testing machine & perform the Brinell hardness test.
3. To study the Vickers hardness testing machine & perform the Vickers hardness test.
4. To study the Impact testing machine and perform the Izod test.
5. To study the Impact testing machine and perform the Charpy test.
6. To study the Universal Testing Machine (UTM) and perform the tensile test.
7. To perform compression test on UTM.
8. To perform the shear/bending test on UTM.
9. To study the torsion testing machine and perform the torsion test.
10. To perform the fatigue test on fatigue testing machine.
11. To determine the deflection of simply supported beams.
12. To perform the spring test in tension and compression.
13. To study the Erichsen sheet metal testing machine & perform the Erichsen sheet metal test.

Teaching methodology:

The aim of introducing this course is to give aexposure to the students on the important and fundamental concept in the extensive area of Materials and its behavior under different loading conditions. The concepts, ideas and techniques developed in SOM are indispensable in machine and structural design. The main focus of this course is to introduce fundamental concepts in SOM with special emphasis on practical problems.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-13**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Strength of materials lab (will be added time to time): digital copy will be available on the JUET server

Text Book:

1. Laboratory Manual Available in Lab
2. Study material available in related folder of server
3. “Mechanics of materials”; Timoshenko and Gere, CBS Publishers. 2011.
4. “Engineering Mechanics of Solids”; E.P.Popov, PHI,2009
5. “Mechanics of materials”; B. C. Punamia.and A.K. Jain, Laxmi publication.

Reference Books:

1. Nag and Chanda, Fundamentals of Strength of Materials, Wiley India.
2. Bansal R.K., Strength of Materials, Laxmi Publications.
3. Gere J. M., Mechanics of Materials, Thomson Press.
4. Pytel A. and kiusalaas J., Mechanics of Materials, Thomson Press.
5. Hearn E. J., Mechanics of Material Vol. I & II, Butterworth-Heinemann Publication.
6. Bedi D. S., Strength of Materials, S. Chand & Co. Ltd

Title: Manufacturing Technology Lab-1 **Code: ME206**
L-T-P scheme: 0-0-1 **Credit: 1**
Prerequisite: Basics of workshop
Objective:

1. To study different testing methods for silica sand, moulding sand and design of pattern
2. To study SMAW, GMAW, GTAW, Oxy-acetylene welding and resistance spot welding processes
3. To study different sheet metal operations such as bending of sheet metal and press working operations

Learning Outcomes:

CO1	Outline different casting, welding and sheet metal forming processes
CO2	Describe each process with their practical aspects
CO3	Develop the practical knowledge to manufacture products using casting, welding and sheet metal forming
CO4	Identify the required process for a product
CO5	Apply the knowledge to improve the methods
CO6	Demonstrate the skill of metal forming for practical use in the industry

Course Content

1. To test the moisture content of green sand.
2. To determine the grain fineness number.
3. Design and making of pattern for a desired casting (containing hole).
4. To find the clay content of the supplied moulding sand
5. To find the permeability number of the standard sand specimen of the moulding sand
6. Press work experiment such as blanking/piercing, washer making etc.
7. Wire drawing on soft material.
8. To perform Sheet bending operation.
9. Hand forging experiments.
10. Gas welding experiment
11. Shielded Metal Arc Welding (SMAW) experiment
12. Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW) experiments
13. Resistance Spot welding experiment.
14. Soldering & Brazing experiment

Teaching Methodology:

In this lab the students will learn the requirement of different testing of moulding sand and design of pattern for a casting. They are going to learn GFN test, Moisture content test, Clay content test. And they are going to learn the design of pattern and manufacturing the designed pattern and use that pattern to get a casting for the designed one.

In welding techniques they are going to learn various safety aspects in welding. After that they will start learning different welding processes like SMAW, GMAW, GTAW, Oxy-acetylene welding and Resistance spot welding. In those processes they are going to learn the welding process, their compatibility, limitations and developments in them.
In metal forming section they are going to learn various bulk metal forming and sheet metal forming techniques. They are going to learn about those requirements of the processes to get a specific product, how to choose the tooling required for a process and how to get the required product with least errors in them.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-14**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Digital copy of study material and videos will be available on the JUET server.

Text Book:

1. Jain P L, Principles Foundry Technology, Tata McGraw Hill
2. Parmar R.S., Welding Process and Technology, Khanna Publishers.
3. Kumar Surendra, Technology of Matal Forming Processes, Prentice Hall of India

References Books/Materials:

1. Rao P. N., Manufacturing Technology I, Tata McGraw Hill.
2. Hajra S. K. and Chaudhary, Workshop Technology, Vol. I, Khanna Publisher.
3. Jain R.K., Production Technology, Khanna Publisher.
4. Kalpakjian S., Schemid S., Manufacturing, Engineering and Technology, Addison Wesley.
5. Parmar R.S., Welding Process and Technology, Khanna Publishers.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *Journal of Manufacturing Science and Engineering*
2. Journal of Manufacturing Processes

Title: Theory of Machines Lab **Code: ME207**
L-T-P scheme: 0-0-2 **Credit: 1**

List of experiment:

1. To study mechanism and various inversions of single slider crank chain.
2. To study mechanism and various inversions of double slider crank chain.
3. To study exact straight line motion mechanisms and approximate straight line motion mechanisms.
4. Determination of Coriolis component of acceleration of a slider crank mechanism.
5. To study various types of cam and follower arrangements.
6. To perform experiments on Watt and Porter governors to prepare performance characteristic curves.
7. To perform experiments on Hartnell governor to prepare performance characteristic curves.
8. To perform experiments on static and dynamic balancing system.
9. Determination of gyroscopic couple on Motorized Gyroscope.
10. To determine the natural frequency of vibration theoretically and experimentally of two rotor system.
11. To find the damping coefficient ofdamped torsional oscillation.
12. To verify the Dunkerley's rules.
13. To determine whiling speed of shaft in given different cases.

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-7**
P-2	15 Marks	**Based on Lab Exercises: 8-13**
Day-to-Day Work	40 Marks	**70 Marks**
Lab Record	15 Marks	
Attendance & Discipline	15 Marks	
Total	**100 Marks**	

Title of Course: Programming in Python **Course Code: XXXXX**
L-T-P scheme: 0-0-2 **Course Credits: Audit**

Prerequisite: No explicit prerequisite course work is required, but students are expected to have a fundamental understanding of basic computer principles and previous experience using a personal computer.

***Objective*:** To emphasize object-oriented programming. Problem decomposition and principles of programming are stressed throughout the course. Advance aspects of programming may be taken care off through Python.

Learning Outcomes:

Course Outcome	Description
CO1	Installation and understanding features of Python.
CO2	Describe Python data types to handle programming problems
CO3	Develop understanding looping to handle new data types
CO4	Identify appropriate methods to solve challenging problems.
CO5	Apply programming knowledge to solve real world problems in the form of Project

Course Contents:

An Introduction to Python: Introductory Remarks about Python, Strengths and Weaknesses, A Brief History of Python, Python Versions, Installing Python, Environment Variables, Executing Python from the Command Line, IDLE, Editing Python Files, Getting Help, Dynamic Types, Python Reserved Words, Naming Conventions.

Basic Python Syntax: Introduction, Basic Syntax, Comments, String Values, String Operations, The format Method, String Slices, String Operators, Numeric Data Types, Conversions, Simple Input and Output, The print Function.

Language Components: Introduction, Control Flow and Syntax, Indenting, The if Statement, Relational Operators, Logical Operators, True or False, Bit Wise Operators, The while Loop, break and continue, The for Loop.

Collections: Introduction, Lists, Tuples, Sets, Dictionaries, Sorting Dictionaries, Copying Collections, Summary.

Functions: Introduction, Defining Your Own Functions, Parameters, Function Documentation, Keyword and Optional Parameters, Passing Collections to a Function, Variable Number of Arguments, Scope Functions- "First Class Citizens", Passing Functions to a Function, Mapping Functions in a Dictionary, Lambda, Closures.

Text Book

1. Programming Python /Mark Lutz.

Reference Books

1. Think Python / Allen B Downey
2. Python 101 / Dave Kuhlman

Evaluation scheme:

<table>
<tr><th colspan="2">Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-7</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 8-14</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Course Title: Numerical methods **Code: MA105**
L-T-P scheme: 3-1-0 **Credits: 4**

Prerequisite: Students should have basic knowledge of calculus, differential equations and matrix algebra.

Objectives:

To make students aware of the concepts of numerical methods necessary for solving complicated mathematical problems numerically.

Learning Outcomes:

Course Outcome	This course will enable the students to:
CO1	Understand the concepts of finite differences, interpolation, extrapolation and approximation.
CO2	Learn various techniques of getting numerical solutions of system of linear equations and check the accuracy of the solutions.
CO3	Obtain numerical solutions of algebraic and transcendental equations.
CO4	Solve initial and boundary value problems in differential equations using numerical methods.
CO5	Work out numerical differentiation and integration whenever and wherever routine methods are not applicable.
CO6	Apply numerical methods to diverse situations in physics, engineering and in other mathematical contexts.

Course Content:

Unit-1: Solution of linear system of equations- Direct and iterative methods. Eigen values and Eigen vectors, Jacobi and Householder methods. Solution of a single and a system of non-linear equations

Unit-2: Interpolation and Approximation

Unit-3: Numerical differentiation, Numerical Integration, Gauss quadrature

Unit-4: Initial and boundary value problems in ODE, Numerical solution of PDE by finite difference method, Method of weighted residuals (MWR).

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures, assignments and quizzes in the form of questions will also be given for practice.

Evaluation Scheme:

Exams	Marks	Coverage

Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials, lecture slides and books on numerical methods will be available on the JUET server.

Text Books

1. "Applied Numerical Analysis", Gerald C.F., Wheatley P.O.,Pearson Education India; 7e, 2007.
2. "Numerical Methods", Jain, Iyengar &Jain, New age Int. Publication (P) Ltd, 6e.
3. "Numerical Methods", Grewal, B. S., Khanna Publisher; Eleventh edition, 2013.
4. "Advanced Engineering Math.", Erwin Kreyszig, John Wiley & Sons, INC.
5. "Introductory Methods of Numerical Analysis", S.S. Sastry, Prentice Hall India Ltd.

Title: Environnemental Science **Code: GE101**

L-T-P Scheme:2-0-0 **Credit: 0**

Prerequisite: The students must be aware of basic Environmental Science upto class 12th. Basic knowledge of Environmental Science helps them to correlate in various division of Engineering during this course.

Objective:

The purpose behind this course is to make the students familiar with Environment (surrounding) and to understand the significance/importance of natural resource, biodiversity, environment pollution and impact of intervention of human being in the Ecosystem. This course is mandatory for all branches of the Engineering and Sciences.

Course Learning Outcomes:

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in learning the significance and importance of environment in their life.
CO2	Describe the real world problems, challenges with the suitable case study based on conservation (natural resource and biodiversity), ecosystem, socio-economic development and remedial measure of the various pollutions (air, water, soil, noise and radiation).
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in their surrounding (the Environment).
CO4	Identify and use of various techniques for solving the Environmental Problems.
CO5	Apply filed visit and justification by using various analytical techniques.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in the Environmental Science and related multidisciplinary areas that involve Environmental Science and help to develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

COURSE CONTENT

Modules	Description
Unit 1:	**Introduction to Environmental Science:** Multidisciplinary nature of environmental science; components of environment –atmosphere, hydrosphere, lithosphere and biosphere. Scope and importance; Concept of sustainability and sustainable development.
Unit 2:	**Ecosystems:** What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chain, food web and ecological succession. Case studies of the following ecosystems:

a) Forest ecosystem
b) Grassland ecosystem
c) Desert ecosystem
d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: **Natural Resources:** Renewable and Non-renewable Resources

• Land Resources and land use change; Land degradation, soil erosion and desertification.

• Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.

• Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).

• Heating of earth and circulation of air; air mass formation and precipitation.

• Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4: **Biodiversity and its conservation:** Levels of biological diversity: genetic, species and ecosystem diversity; Biogeography zones of India; Biodiversity patterns and global biodiversity hot spots. • India as a mega-biodiversity nation; Endangered and endemic species of India. • Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ

Conservation of biodiversity. • Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5: **Environmental Pollution:** Environmental pollution: types, causes, effects and controls; Air, water, soil, chemical and noise pollution. • Nuclear hazards and human health risks. • Solid waste management: Control measures of urban and industrial waste. • Pollution case studies.

Unit 6: **Environmental Policies & Practices:** Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture. Environment Laws : Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; International agreements; Montreal and Kyoto protocols and conservation on Biological Diversity (CBD). The Chemical Weapons Convention (CWC).

• Nature reserves, tribal population and rights, and human, wildlife conflicts in Indian context.

Unit 7: **Human Communities and the Environment** Human population and growth: Impacts on environment, human health and welfares.

• Carbon foot-print.

• Resettlement and rehabilitation of project affected persons; case studies.

• Disaster management: floods, earthquakes, cyclones and landslides.

• Environmental movements: Chipko, Silent valley, Bishnios of Rajasthan.

• Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.

• Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

Unit 8: **Field Work:** Visit to a local area to document assets-river / forest / grassland /hill / mountain. polluted sites(Urban, rural ,industrial, agriculture), plants, insects, bird, Ecosystem (pond, river, hill slopes etc)

Teaching Methodology:

The core module Syllabus for Environment Science includes class room teaching and Field Work. The syllabus is divided into eight units covering lectures. The first seven units will cover 28 lectures, which are class room based to enhance knowledge skills and attitude to environment. Unit eight is based on field activities which will be covered in 4 lecture hours and would provide student firsthand knowledge on various local environmental aspects. Field experience is one of the most effective learning tools for environmental concerns. This moves out of the scope of the text book mode of teaching into the realm of real learning in the field, where the teacher merely acts as a catalyst to interpret what the student observes or discovers in his/her own environment. Field studies are as essential as class work and form an irreplaceable synergistic tool in the entire learning process. Course material provided by UGC for class room teaching and field activities is utilized.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 Unit 2 and Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 (70 %) and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-7 and around 30% from coverage of Test-1 and Text-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book

[1] Bharucha Erach, 2003. The Biodiversity of India, Mapin Publishing Pvt. Ltd, Ahmadabad – 380013, India.
[2] De Anil Kumar, Environmental Chemistry, Wiley Eastern Ltd, 2007.
[3] Agarwal KC, 2001. Environmental Biology, Nidhi Publishers Ltd. Bikaner.

Reference Book

[1] 3. Brunner RC, 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480pgs.
[2] Clark R B, Marine Pollution, Clanderson Press, Oxford (TB).2001.
[3] Cunningham WP, Cooper TH, Gorhani E & Hepworth MT, 2001. Environmental Encyclopedia, Jaico Publishing House, Mumbai, 1196 pgs.

[4] Gleick HP, 1993. Water in Crisis, Pacific Institute for Studies in Development, Environment and Security. Stockholm Environmental Institute, Oxford University Press, 473pgs.
[5] Heywood VH, and Watson RT, 1995. Global Biodiversity Assessment. Cambridge University Press 1140pgs.
[6] Jadhav H and Bhosale VM, 1995. Environmental Protection and Laws. Himalaya Publishing House, Delhi 284pgs.
[7] Mckinney ML and Schoch RM, 1996. Environmental Science Systems and Solutions. Web enhanced edition, 639pgs.

Title: Fluid Mechanics **Code: ME106**

L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "*Engineering Mechanics, Partial Differential Equations, Vector Calculus*".

Objective:

1. To learn Basic principles and equations of fluid mechanics so that intuitive understanding of subject can be developed.
2. He will study numerous and diverse real-world engineering examples, so that his understanding of fluid mechanics principles strengthens more.

Learning Outcomes:

Course Outcome	Description
CO1	Understand basic fluid mechanical properties.
CO2	Outline the basic concepts of hydrostatics.
CO3	Apply conservation laws to real life fluid problems.
CO4	Should be able to analyze and design pipe flows
CO5	Formulate and solve one dimensional incompressible fluid flow problems
CO6	Describe the boundary layer phenomenon.

Course Content:

Unit-1:FUNDAMENTAL CONCEPTS AND FLUID STATICS: Definition of stress, definition of fluid, distinction between solid and fluid, concept of continuum. Fluid properties: Density, Specific weight, Viscosity, Dynamic and kinematic viscosity, no slip condition of viscous fluids, Compressibility, distinction between an incompressible and a compressible flow, surface tension of liquids, capillarity. Forces on fluid elements, normal stresses in a stationary fluid (pressure and Pascal's law), fundamental equation of fluid statics, pressure measuring devices, Hydrostatic thrusts on submerged surfaces (Both plane and Inclined surfaces), Buoyancy, Floatation, Stability of floating bodies.

Unit-2: FLUID KINEMATICS: Scalar and vector fields, flow field and description of fluid motion (Lagrangian and Aurelian approaches), variation of flow parameters in time and space, material derivative and acceleration, stream line , path lines and streak lines, one two and three dimensional flows, Translation, rate of deformation and rotation, vorticity, Concept of flow existence, concept of flow potential.

Unit-3: FLUID DYNAMICS: (Conservation equations and analysis of finite control volume)

System and control volume concept, conservation of mass-the continuity equation (both in differential and integral form) for system and control volume, stream function and its physical significance, Conservation of momentum (Reynolds transport theorem, application of RTT to conservation of mass and momentum), Analysis of finite control volumes (both inertial and non-inertial control volumes), Euler's equation(both for infinitesimal control volume and along a stream line), conservation of energy and its reduced form i.e. Bernoulli's equation

Unit-4: APPLICATIONS OF EQUATION OF MOTIOIN AND MECHANICAL ENERGY: Bernoulli's equation in irrotational flow, plane circular vortex flows, fluids in relative equilibrium, principles of hydraulic siphon, losses due to geometric chances, flow measurement through pipes, flow through orifices and mouthpieces.

Unit-5: PRINCIPLES OF PHYSICAL SIMILARITY AND DIMENSIONAL ANALYSIS: Concept and types of physical similarity, dynamic similarity of flows governed by viscous, pressure, inertia, gravitation, surface tension and elastic forces (Reynolds, Euler, Froude, Weber, Cauchy, Mach numbers).Dimensional analysis: Buckingham's theorem, Rayleigh's indicial method and Ipsen method.

Unit-6 : VISCOUS INCOMPRESSIBLE FLOWS AND FLOWS THROUGH PIPES: General viscosity law, Navier-Stokes equation, exact solutions of Navier-Stokes equation: Couette flow, Plane Poiseuille flow and Hagen Poiseuille flow and flow between two concentric rotating cylinders. Low Reynolds no, flows and theory of hydraulic lubrication.

Concept of friction factor in pipe flow, variation of friction factor (Moody's diagram), concept of flow potential and flow resistance, flow through branched pipes(pipes in series and parallel), introduction of Hardy Cross method, flow through pipes with side tappings, losses in pipe bends and fittings, power transmission by through a pipeline.

Unit-7: LAMINAR BOUNDARY LAYER AND INTRODUCITON TO TURBULENCE: Prandtl's boundary layer equations (order of magnitude analysis), Blasius flow over a flat plate, wall shear and boundary layer thickness, Momentum-Integral equation for boundary layer, separation of boundary layer, Karman-Pohlhausen approximate method for flat plate, entry flow in a duct, control of boundary layer separation. Characteristics of turbulent flows, laminar-turbulent transition, correlation functions, mean motions and fluctuations, governing equations for turbulent flow, Prandtl's mixing length hypothesis, universal velocity distribution law and friction factor in duct for large Reynolds number.

Teaching Methodology:

This course is one of the foundation course in the Mechanical discipline. The knowledge gained in this course will help the student to understand not only the industrial processes but, they will also be able to do some small applied research. The course is divided into seven units which have to be followed one after the other i.e. no unit should be skipped. Unit-1, 2, 3, 5, and 6 are to be explained in great depth as, these are the most valuable topics in terms of GATE and ESE examinations. After every broader topic an assignment will be given to students which has to

submitted in due time. In tutorials the students will work collectively to understand the concepts with the help of practical problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 and Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and assignments on Fluid Mechanics (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[7] "Introduction to fluid mechanics and fluid machines", S. K. Som, G. Biswas, McGraw-Hill Education

Reference Books/Material:

[12] "Fluid Mechanics", Frank M. White, McGraw-Hill Education

[13] "Fluid Mechanics", Yunas A. Cengel, Cimbala, McGraw-Hill Education

[14] "Advanced Engineering Fluid Mechanics", K. Muralidhar, G. Biswas, Narosa

[15] "Fluid mechanics", Sishadri and Patankar, Elsevier

Web References:

[1] pdumkafm.blogspot.com/http://www.techtutorials.info/ecommerce.html

[2] www.slideshare.net/pankajdumka1/solution-of-introductoin-to-fluid-mechanics-and-machinesprof-som-and-prof-biswas

[3] https://www.youtube.com/watch?v=fa0zHI6nLUo&list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Title: Manufacturing Technology-2 **Code: ME107**

L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: It is a foundation course of manufacturing.

Objective:

1. To learn basic metal removal processes and different tools used in them
2. To learn mechanics and mechanism of machining, tool life, tool materials, heating effect in machining, machining time and economy of machining process
3. To learn different machine tools and gigs and fixtures used in them

Learning Outcomes:

CO1	Outline various machining processes such as turning, milling, drilling, shaping and grinding techniques
CO2	Describe each machining process and their behavior on the product quality
CO3	Develop the knowledge of chip formation in various machining processes to understand the behavior of the process and the metal
CO4	Identify the requirement of the machining process for various products and their sequence of operations
CO5	Apply the knowledge of machining for various product development
CO6	Demonstrate the skill of practical exposure of various machining processes

Course Content

Unit 1: Introduction: Introduction to Manufacturing processes and Machining, Importance of manufacturing, Classification of Metal Removal Processes, Needs of machining, limitations of Machining.

Geometry of Cutting Tools: Geometry of Single point cutting tools and multi-point cutting tools, ASA, ORS, NRS and WRS systems for single point tools and Milling cutters, SRS, DRS and WRS systems for drill bits, conversion of angles from one system to the others

Unit 2: Metal Cutting: Mechanics of Machining (Metal Cutting), Mechanism of chip formation, Orthogonal and oblique cutting, Machining forces and Merchant's Circle Diagram (MCD), Analytical determination of cutting forces, Cutting temperature – causes, effects, and assessment, Control of cutting temperature and cutting fluid application.

Machinability and Tool Life: Concept of Machinability and its Improvement, Failure of cutting tools, flank wear and crater wear, Tool life, concept of chatter, Cutting Tool Materials of common use , Advanced Cutting Tool Materials, Economics of metal machining.

Unit 3: Classification of milling machines, classification of milling cutters, types of milling operations, Principles and types of broaches

Jigs and Fixtures: Methods of mounting of jobs and cutting tools in machine tools, Purposes of jigs and fixtures and their Design principles, indexing in machining.

Abrasive Processes (Grinding): Basic principle, purpose and application of grinding, Selection of wheels and their conditioning, Classification of grinding machines and their uses
Super finishing processes: Honing, Lapping and burnishing, polishing and super finishing

Teaching Methodology:

In this subject the students basically going to learn machining processes and machine tool. In machining portion they are going to learn about geometry of cutting tool: ASA, ORS, NRS and WRS systems for a single point cutting tool and multipoint tools i.e. milling cutters. SRS, DRS and WRS for a twist drill and conversion equations from one system to the other; mechanism of machining: chip formation methods, geometrical features of chip formed by turning, milling and drilling operations; mechanics of machining: different forces in turning, milling and drilling, MCD for conversion of forces from one reference to the other and equipments used to measure forces in turning, milling, drilling and grinding processes; heat generation in machining: source, cause and effect of heat generation in machining, determination of cutting temperature by analytical and experimental methods and control of cutting temperature in machining; tool failure methods tool life and tool materials; estimation of machining time and aspects of machinability so that economy of machining can be analyzed; grinding process: grinding wheels, grinding machines, chip formation in grinding and grindability aspect; super finishing processes: laping, honing and buffing; jigs and fixtures: methods of mounting of jobs and tools and design of jig and fixtures for machining operations.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit 1
Test-2	25 Marks	Based on Unit 2 and Unit 1 (20%)
Test-3	35 Marks	Based on Unit 3, Unit 2 (15%) and Unit 1 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials on manufacturing technology 2 (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. Chattopadhyay A B, Machining and Machine Tools, Wiley India
2. Rao P. N., Manufacturing Technology II, Tata McGraw Hill.
3. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.
4. Pandey P. C. and Singh C. K., Production Engineering Sciences, Standard Publisher

References Books/Materials:

1. HMT, Production Technology, Tata McGraw Hill.
2. Serope Kalpakjian, Steven R Schmid, Manufacturing Engineering and Technology, Pearson Education
3. Chapman W. A. J., Workshop Technology Vol. 1, 2, 3 & 4, Butterworth-Heinemann.
4. Sharma P. C., Production Technology: Manufacturing Processes, S. Chand and Sons.
5. Roy A. Lindberg, Materials and manufacturing technology, Allyn and Bacon
6. Jain R.K., Production Technology, Khanna Publisher.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *Journal of Manufacturing Science and Engineering*
2. Journal of Manufacturing Processes

Title: Fluid Mechanics Lab **Code: ME208**
L-T-P scheme: 0-0-1 **Credit: 1**

Prerequisite: Students must have already studied the course, "Engineering Mechanics" and should be studying "Fluid Mechanics"

Objective:

1. To learn and be able to measure flow, velocity, and losses in open and closed channel flows.
2. To develop the abilities to understand the flow behavior and its impacts on industrial and daily life processes.

Learning Outcomes:

Course Outcome	Description
CO1	Outline procedures for standardization of experiments.
CO2	Apply the principle of discharge and velocity measurement in open and close channel.
CO3	Identify laminar and turbulent flows.
CO4	Describe and demonstrate the principle of Bernoulli's and metacentric height.
CO5	Compute the losses in fluid flow
CO6	Develop the performance characteristics and test the performance of pumps and turbines

Course Content:

Experiment-1: To determine the coefficient of discharge of venturimeter.
Experiment-2: To verify the Bernoulli's Theorem.
Experiment-3: To find critical Reynolds number for a pipe flow.
Experiment-4: To determine the friction factor for pipes.
Experiment-5: To determine the coefficient of velocity of Pitostatic tube.
Experiment-6: To determine coefficient of discharge of an orificemeter.
Experiment-7 To determine the coefficient of discharge of Notch (V and Rectangular types).
Experiment-8: To determine the coefficient of discharge, contraction & velocity of an orifice.
Experiment-9: To determine the minor losses due to sudden enlargement, sudden contraction and bends.
Experiment-10: To determine the meta-centric height of a floating body.
Experiment-11: Draw the characteristic curves for pelton wheel.
Experiment-12: Draw the characteristic curves for Francis turbine.
Experiment-13: Study of positive displacement and rotary pumps

Teaching Methodology:

This lab is run in conjunction with the theory course 18B11ME411 (Fluid Mechanics). It is an introductory course where flow behaviour, fluid forces and analysis tools are introduced. The goals of the experiments include determination of discharge in open and closed channel, applications of the control volume approach, demonstration of the momentum and energy equations. Intricate flow phenomena such as separations and transition to turbulence are demonstrated. Experimental setups such as flow through a tube and open channel, Bernoulli's apparatus, orifice meter, venture meter, Pitot tubes and metacentric height apparatus are made available to the students. The lab experiments utilize U-tube manometer, piezometers, and stop watches. The lab runs closely with the lectures in such a way that experiments support the text covered in the class room.

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-14**
Day-to-Day Work	Viva on mini Project	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Fluid Mechanics Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Laboratory Manual available in Lab

[2] Study material available in related folder of Server

[3] "Introduction to fluid mechanics and fluid machines", S. K. Som, G. Biswas, McGraw-Hill Education

Reference Books/Material:

[1] "Fluid Mechanics", Frank M. White, McGraw-Hill Education

[2] "Fluid Mechanics", Yunas A. Cengel, Cimbala, McGraw-Hill Education

[3] "Advanced Engineering Fluid Mechanics", K. Muralidhar, G. Biswas, Narosa

[4] "Fluid mechanics", Sishadri and Patankar, Elsevier

Web References:

[1] http://eerc03-iiith.vlabs.ac.in/

Title: Manufacturing Technology Lab-2 **Code: ME209**

L-T-P scheme: 0-0-1 **Credit: 1**

Prerequisite: Basics of workshop

Objective:

1. To learn different machine tool in details
2. To learn different cutting tool in details
3. To do the alignment test of the machine tools, calculate the shear angle of a chip in shaping operation and measure the turning forces and drilling forces using different dynamometers.

Learning Outcomes:

CO1	Outline different machining processes such as turning, milling, drilling, shaping and grinding operations
CO2	Describe different machines used in different machining processes
CO3	Develop the knowledge to get the required quality of the product
CO4	Identify the processes required and their sequence of operations
CO5	Apply the knowledge to improve the methods
CO6	Demonstrate the skill of metal forming for practical use in the industry

Course Content

1. Introduction to Lathe machines and lathe operations
2. To study about the nomenclature of single point cutting tool
3. Alignment tests of lathe bed and spindle with chuck
4. Practice of thread cutting on Lathe machine.
5. To measure the cutting forces using lathe dynamometer during turning operation.
6. To study different types of milling machines, milling cutters and work holding and tool holding devices
7. To make a job on milling machine by performing different operations such as end milling and slot cutting on a single workpiece.
8. Alignment test horizontal milling machine work table and arbor
9. To study the various methods of gear cutting and practice for making gears on milling machine.
10. To study the quick return mechanism and types of shapers, slotters and Planners.
11. To find out the shear plane angle of a chip formed while shaping a workpiece at different process parameters.
12. To study the nomenclature of drill and find out the drilling torque and thrust force required in solid drilling and pilot drilling..

13. To study about grinding wheels and perform the grinding operations on grinding machine.

Teaching Methodology:

To study single point, bi-point and multi point cutting tools used in different machining processes like turning, drilling and milling processes. They are going to learn different machine tools like lathe, milling machine, shaper, drilling machine and surface grinder. They are going to check whether the machine tools are in their proper alignment or not. They are going to learn turning processes, drilling, shaping, milling and grinding processes. They are going to calculate the shear plane angle of a chip formed in shaping operation to know about the mechanism of chip formation in machining processes. They are also going to learn the cutting forces in machining and measuring them by using dynamometers to analyze the processes. They are also going to learn requirement of grinding processes, grinding wheel and the ginding process in details.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-14**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Digital copy of study material and videos will be available on the JUET server.

Text Book:

1. Chattopadhyay A B, Machining and Machine Tools, Wiley India
2. Rao P. N., Manufacturing Technology II, Tata McGraw Hill.

References Books/Materials:

1. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.
2. Pandey P. C. and Singh C. K., Production Engineering Sciences, Standard Publisher

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *Journal of Manufacturing Science and Engineering*
2. Journal of Manufacturing Processes

Title: Applied Thermodynamics **Code: ME108**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Thermodynamics, Heat and Mass transfer" and "Fluid Mechanics".

Objective:

1. To learn and be able to implement the thermal design analysis of RapidCooling Systems and its demand in industrial application.
2. To know the application of thermodynamics and heat transfer in a heat exchanger.

Course Outcome	Description
CO1	*Outline of various of* Applied Thermodynamics with respect to Heat transfer and Refrigeration..
CO2	*Description of real application of applied thermodynamics due to* Heat transfer in extended surfaces, unsteady-state conduction, convection and thermal radiation.
CO3	*Experimental study of forced convection, natural convection, heat exchanger used in various industries.*
CO4	*Experimental study of radiation heat transfer and* Radiation shields, Boiling condensation and Mass transfer.
CO5	Experimental and theoretical study of Vapour absorption systems and refrigerants, Psychrometry and air conditioning, types of air conditioning systems, positive displacement air compressors.
CO6	Demonstrate deployment of Psychrometry and air conditioning system. Work Types of air conditioning systems, positive displacement air compressors

Course Content:

Unit-I: INTRODUCTION OF HEAT TRANSFER AND REFRIGERATION: heat transfer in extended surfaces and unsteady-state conduction.

Unit-II: CONVECTION: Forced convection-Thermal and hydro-dynamic boundary layers, Equation of continuity, Momentum and energy equations, Empirical relations for free convection from vertical and horizontal planes & cylinders,

Unit-III: RADIATION HEAT TRANSFER: Shape factors and their relationships. Heat exchange between non black bodies, Electrical network for radiative exchange in an enclosure of two or three gray bodies, Radiation shields.

Unit-IV: Boiling condensation and mass transfer.

Unit-V: REFRIGERATION AND AIR CONDITIONING: Vapour absorption systems and refrigerants, Psychrometry and air conditioning, types of air conditioning systems, positive displacement air compressors.

Teaching Methodology: This course is introduced to teach Heat and mass transfer and Refrigeration and air conditioning. The entire course is broken down into five separate units: i.e. Introduction of Heat transfer and Refrigeration, Forced and Free Convection and thermal radiation, Radiation heat transfer, Shape factors, Boiling condensation, mass transfer and vapour absorptionrefrigeration systems and refrigerants, Psychrometry and air conditioning

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2& Unit-3
Test-2	25 Marks	Based on Unit-4& Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources: Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

1. Arora C. P., Refrigeration & Air conditioning, TMH, New Delhi.
2. Incropera P. F. and DeWitt D. P., Fundamentals of Heat and Mass transfer, Wiley

Reference Books:

1. Yunus A. Cengel and AfshinJ.Ghajar, Heat and mass transfer: Fundamentals and applications, McGraw Hill Education
2. Jones J. W. and Stocker W. F., Refrigeration& Air conditioning, TMH, New Delhi.
3. Prasad M. Refrigeration& Air conditioning, Wiley Estern limited, New Delhi.
4. Priester G. B., Jordan R. C. Refrigeration & Air conditioning, Prentice Hall of India.
5. Yunus A. Cengel, and Cimbala, Engineering Thermodynamics, Tata McGraw Hill.

NPTEL -https://nptel.ac.in/courses/112/105/112105129/ - IIT Khargpur

Title: Computer Aided Design and Manufacturing (CAD/ CAM) Code: ME109

L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses like "Manufacturing Technology-II", "Machine Drawing" and "Strength of materials."

Objectives

1. The objective of this course is to impart knowledge about mathematical elements of CAD, 2D and 3D transformations of objects for display as well as to make them aware about importance of synthetic parametric curve, surfaces and solids in design
2. To make students learn the important theoretical concepts, and the state-of-the-art technological developments in the area of modern manufacturing.
3. Various topics to be covered are basics of automation, NC programming (Manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics.

Learning Outcome

Course Outcome	Description
CO1	Outline basic fundamentals and scope of CAD, CAM and related technologies in industr environment and their relationship with product life cycle.
CO2	Describe concepts of transformations, types of modeling, parametric curves, surfaces a solids, NC, CNC and DNC machines and automation.
CO3	Develop ability to understand geometric modeling and execute the steps required in CA software for developing 2D and 3D models and perform transformations.
CO4	Identify the configurations of CAD modeling software, CNC machines, robots or Compu integrated system in any industry.
CO5	Apply acquired knowledge to write CNC part programs for industrial components as well as operate CNC machines, robots and CIM system.
CO6	Demonstrate skill to work in any automated manufacturing system.

Course Content

Introduction : Introduction to types of production and plant layout; introduction to terms like CAD, CAM, CIM, CAE, CAPP, CAIQC; scope of CAD/CAM; product life cycle and CAD/CAM; product design and manufacturing in conventional and CIM environment. (4)

CAD: Software and hardware in CAD; Introduction to 2D and 3D transformations: scaling, rotation and translation; introduction to wireframe, surface and solid modeling; analytic and synthetic curves and their representation; parametric representation of curves; introduction to parametric synthetic curves such as Hermite, Bezier, cubic spline and B-spline curves. Surface entities and surface representation, surface of revolution, sweep surfaces, quadric surface, ruled surface, coons patch etc.; solid entities and solid representation, fundamentals of solid modeling –Boundary Representation (B-rep), Constructive Solid Geometry (CSG), other representations.

CAM: Introduction to mechanization and automation; building block of automation; types, strategies and levels of automation; advantages, disadvantages and applications of automation; introduction and components of NC and CNC machines, classification of NC machines, special features of CNC over NC; direct numeric control (DNC) and its advantages, adaptive control and its types; CNC part programming methods; manual part programming using G and M codes; concept of canned cycle; computer aided part programming: introduction to APT language; simple problems on APT programming; Introduction to Group Technology; composite part concept; machine cell design; benefits of GT.

CAD/CAM Data Exchange Formats: ISO standard; STEP, DXF, IGES, STL and PDES formats – a brief introduction.

FMS and CIM : Flexible Manufacturing System (FMS); components of FMS: FMS workstations, automated material handling and storage systems, automated storage and retrieval system and industrial robots; FMS layout and benefits; concept of computer integrated manufacturing (CIM) through CIM wheel; benefits CIM.

TEACHING METHODOLOGY:This course is introduced to help students learn and understand the computer assisted design and manufacturing processes. The course is divided into two major parts namely, CAD and CAM. Students will be taught fundamentals of computer assisted design, modeling and analyses. Then they will be taught about CNC machines and their part programming. Finally, they will be made aware about FMS and CIM systems. This theory course is well complemented by a laboratory course under the name CAD/CAM Lab in the same semester that helps students learn with hand-on experience.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-2 and Unit-3 and around 30% from coverage Test-1
Test-3	35 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text Books:

1. Zeid, Ibrahim, CAD/CAM Theory and Practice, McGraw-Hill, Inc.
2. Groover and Zimmers, CAD/CAM: Computer Aided Design and Manufacturing, PHI
3. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.

4. Kundra, Rao and Tiwari., Computer Aided manufacturing, Tata McGraw Hill Publishers,

References:

1. Rooney, J. and Steadman P., Principles of Computer-aided Design, Affiliated East-West Press Pvt Ltd.
2. Mortenson, Michael E., Geometric Modeling, John Wiley & Sons.
3. Steve Krar, Arthur Gill, CNC technology and programming, McGraw-Hill, 1990
4. James Madison, CNC machining hand book, Industrial Press Inc., 1996
5. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall.

Title: Advanced Manufacturing Processes **Code: ME303**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Manufacturing Technology-I*" and "*Manufacturing Technology-II*".

Objective:

1. To understand the working principles/mechanisms involved in different manufacturing processes
2. To learn and know about the applications of advanced manufacturing processes.
3. To encourage the students for doing their projects in the area of Advanced Manufacturing Processes

Learning Outcomes:

Course Outcome	Description
CO1	Outline various advanced manufacturing process based on energy sources and mechanism employed.
CO2	Describe the industrial or real world problems using advanced manufacturing concepts and systems.
CO3	Develop an idea to fabricate or modify the laboratory setups to find out the solution of industrial problems.
CO4	Identify the most influencing process parameters to manufacture a defect free product.
CO5	Apply most appropriate advanced technique to manufacture a product economically.
CO6	Demonstrate and deployment the mechanism of advanced manufacturing processes for solving real-world problems.

Course Content:

Unit-1:INTRODUCTION: Limitations of Conventional Manufacturing Processes, Need And Classification of Unconventional or Advanced Manufacturing Processes .

Unit-2:MECHANICAL ENERGY BASED UNCONVENTIONAL MACHINING PROCESSES: Process Principle, Analysis and Applications of Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultra-Sonic Machining.

Unit-3: UNCONVENTIONAL FINISHING PROCESSES: Need, classification, process principle and applications of Abrasive Flow Finishing, Magnetic Abrasive Flow Finishing, Magneto-Rheological Finishing.

Unit-4: THERMAL ENERGY BASED UNCONVENTIONAL MACHINING PROCESSES: Electric Discharge Machining, Laser Beam Machining, Electron Beam

Machining, Ion Beam Machining, Plasma Beam Machining, and Electro Discharge Abrasive Grinding.

Unit-5: CHEMICAL ENERGY BASED UNCONVENTIONAL MACHINING PROCESSES: Process Principle, Analysis and Applications of Electrochemical Machining, Chemical Machining, Electrochemical Discharge Machining, Electro-Chemical Abrasive Grinding,

Unit-6: **UNCONVENTIONAL WELDING PROCESSES:**Need, process principle, advantages and applications ofLaser Beam Welding, Electron Beam Welding, Ultra-Sonic Welding, Plasma Arc Welding, and Explosive Welding.

Unit-7: UNCONVENTIONAL FORMING PROCESSES: Need, process principle, advantages and applications ofExplosive Forming, Electro Hydraulic Forming, Electromagnetic Forming, and Laser Bending.

Unit-8: Powder Metallurgy: Metal Powder Production, Treatment, Compaction, and Sintering.

Teaching Methodology:

This course is introduced to help students to understand the various non-traditional manufacturing processes with their applications. The entire course is broken down into eight separate units: Introduction, Unconventional machining processes, Hybrid machining processes, unconventional finishing processes, unconventional welding processes, unconventional forming processes, and powder metallurgy. Students are motivated to do their projects in the area of advanced manufacturing processes using the laboratory facilities.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures and lecture notes on Advanced Manufacturing Processes are available on JUET server.

Text Book:

[1] Ghosh and Mallik, Manufacturing Science, EWP Private Ltd.

[2] Jain V. K., Advance Machining Processes, Allied Publisher.

[3] Pandey P. C., Modern Machining Processes, TMH Publication.

[4] Benedict G.F., Non Traditional Manufacturing Processes, Marcel Dekker.

Reference Books/Material:

[1] El-Hofy, H., Advanced Machining Processes-Non-traditional and Hybrid Machining Processes, McGraw-Hill, NewYork.

[2] McGough J. A., Advanced Methods of Machining, Chapman and Hall Ltd., London.

Web References:

- www.nptel.com
- https://nptel.ac.in/courses/112/107/112107077/

Journals References:

- Journal of Manufacturing Processes: Elsevier
- Materials and Manufacturing Processes: Taylor & Francis
- Journal of Materials Processing Technology: Elsevier
- Advances in Manufacturing: Springer

Title: Advanced Metal Casting and NDT **Code: ME304**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Workshop*" and "*Manufacturing Technology-I*".

Objective:

4. To understand the working principles involved in different non-destructive testing processes
5. To learn and know about the design of feeder, Gates and selection of appropriate casting process.
6. To encourage the students for doing minor projects in the area of non-destructive testing of materials.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various mechanism and principles involved in metal casting and non-destructive testing methods.
CO2	Describe the industrial or real world problems related to non-destructive testing methods.
CO3	Identify the most appropriate method of metal casting economically.
CO4	Develop the skills of product design for castability.
CO5	Apply most appropriate NDT method for testing a particular component or material.
CO6	Demonstrate and deployment the mechanism of non-destructive methods for solving real-world problems.

Course Content:

Unit-1:METAL CASTING-OVERVIEW: Applications and production, historical perspective, casting processes. Solid modeling of castings: casting features, modeling techniques, graphical user interface, model representation model exchange formats, model verification, mould cavity layout.

Unit-2:FEEDER DESIGN AND ANALYSIS: Casting solidification, solidification time and rate, feeder location, feeder and neck design, feed aid design, solidification analysis, vector element method, optimization and validation.

Unit-3: GATING CHANNEL LAYOUT: optimal filling time, gating element design, mould filling analysis, numerical simulation, optimization and validation, Process planning and costing: Casting process selection, process steps and parameters, tooling cost estimation, material cost estimation, and conversion cost estimation.

Unit-4: DESIGN FOR CASTABILITY: Product design for castability, process friendly design, and castability analysis.

Unit-5: NON-DESTRUCTIVE TESTING: Liquid penetrant test: Physical Principles, Procedure for penetrant testing, Penetrant testing methods, sensitivity, Applications and limitations.

Unit-6: **ULTRASONIC TESTING:** Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Thermography: Basic principles, Detectors and equipment, techniques, application, Magnetic particle testing.

Unit-7: RADIOGRAPHY: Basic principle, Electromagnetic radiation sources, radiographic imaging Inspection techniques, applications, limitations, typical examples. Eddy current test: Principles, instrumentation for ECT, techniques.

Unit-8:ACOUSTIC EMISSION: Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection, Visual inspection and its importance in inspection, Infra-red imaging-methodology and applications.

Teaching Methodology:

This course helps students to understand the various mechanisms and principles involved in metal casting and non-destructive testing methods. The entire course is broken into eight separate units: Introductory part of metal casting, Feeder design, Gating layout, optimal mould filling time, and design for castability, non-destructive testing methods, radiography, and acoustic emission. Some experimental classes has been conducted for the NDT methods.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures and lecture notes on Advanced Metal Casting and NDT are available on JUET server.

Text Book:

[5] “Production Engineering Sciences”, P.C. Pandey, C. K. Singh, Standard Publisher.
[6] “Manufacturing Science”, A. Ghosh A, A. K. Mallik, EWP Pvt. Ltd
[7] “Nondestructive Testing Techniques”, R. Prakash, New Age Science, 2009.
[8] “Nondestructive Testing Methods and New Applications”, M. Omar, Ed, InTech, 2012.

Reference Books

[3] “Materials and Processes in Manufacturing”, E. P. De Garmo, J. T. Black, R. A. Kohser, Prentice Hall of India Pvt. Ltd.
[4] “Materials Science and Engineering: An Introduction”, William D. Callister , David G. Rethwisch, Wiley
[5] “Nondestructive Testing: Radiography, Ultrasonics, Liquid Penetrant, Magnetic Particle, Eddy Current”, Louis Cartz, ASM International, 1995.
[6] **“**Introduction to Non-destructive Testing: A Training Guide”, Paul E. Mix, Second Edition, *Wiley*, 2005

Title: Maintenance Engineering **Code: ME305**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "Mathematics-1 and Mathematics-ii".
Objective:

1. To understand the needs and types of maintenance. And to develop skill for keep asset in availability state based on requirement level of reliability and effectiveness.
2. To understand methods for evaluating maintenance cost in relation to achieve the availability and effectiveness of equipments.

Learning Outcomes:

Maintenance Engineering	
Course Outcome	**Description**
CO1	Outline the scope and concepts of maintenance engineering
CO2	Describe the tools, principles of maintenance.
CO3	Develop the skill needed for analysis of friction, wear and science of interacting surface.
CO4	Identify the engineering issues and tools for condition monitoring of equipments.
CO5	Apply reliability, availability, and maintainability (RAM) analysis for engineering system
CO6	Demonstrate application of maintenance managements and analysis tools.

Course Content:

UNIT-1 INTRODUCTION: Fundamentals of Maintenance Engineering, Maintenance engineering its importance in material & energy conservation, Inventory control, Productivity, Safety, Pollution control, Safety Regulations, Pollution problems, Human reliability.

UNIT-II MAINTENANCE MANAGEMENT: Types of maintenance strategies, Planned and unplanned maintenance, Breakdown, Preventive & Predictive maintenance their comparison, Computer aided maintenance, Maintenance scheduling, Spare part management, inventory control.

UNIT-III TRIBOLOGY IN MAINTENANCE: Friction wear and lubrication, Friction & wear mechanisms, Prevention of wear, Types of lubrication mechanisms, Lubrication processes. Lubricants types, general and special purpose, additives, testing of lubricants, Degradation of lubricants, Seal & packing.

UNIT-IV MACHINE HEALTH MONITORING: Condition based maintenance, Signature analysis, Oil analysis, Vibration, Noise and thermal signatures, online & off line techniques, Instrumentation & equipment used in machine health monitoring. Instrumentation in

maintenance, Signal processing, Data acquisition and analysis, Application of intelligent systems, Data base design.

UNIT-V RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM) ANALYSIS: Introduction to RAM failure mechanism, Failure data analysis, Failure distribution, Reliability of repairable and non-repairable systems, Improvement in reliability, Reliability testing, Reliability prediction, Utilization factor, System reliability by Monte Carlo Simulation Technique.

Teaching Methodology: This course is introduced to help students to understand the need and type of maintenance in production industry. The entire course is broken down into five major sections: Introduction and Definitions , management principle, tribology, condition monitoring and reliability & maintainability.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit -2 and unit -3 around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

TEXT BOOKS:

1. Krishnan Gopal and Banerji S. K., Maintenance & Spare parts Management, PHI
2. Mishra R. C. and Pathak K., Maintenance Engineering and Management, PHI
3. Anthony Kelley , Maintenance Planning & Control: East West Press.

REFERENCE BOOKS:

1. Shrivastava S.K., Industrial Maintenance Management, S. Chand Publications.
2. B.K.N. Rao, Handbook of Condition Monitoring,. Elsevier Science;
3. Higgins L., Mobley R. K. and Mobley K., Maintenance Engineering Hand Book. McGraw hill
4. Banga and Sharma, Industrial Engineering & Management Science, Khanna Publishers.

Title: Engineering Data Analytics **Code: ME306**
L-T-P scheme: 3-0-0 **Credit:** 3

Prerequisite: Students must have already studied course, "Engineering Mathematics"
Objective:

1. To provide the concepts of data analytics and analyzing data to convert information to useful knowledge
2. To impart a wide range of data analytic techniques namely, descriptive, inferential, predictive and prescriptive analytics.

Learning Outcomes:

Course Outcome	*Description*
CO1	Outline various concepts, principles and governing equations of data analytics
CO2	Demonstrate the ability to interpret complex data in various engineering domain
CO3	Illustrate analytical, experimental and computational tools needed to analyze these engineering data
CO4	Use these solutions to guide a corresponding design, manufacture or failure analysis
CO5	Describe the independent judgment required to interpret the results of these solutions
CO6	Demonstrate and deployment of the knowledge of advanced data analytics in practical engineering applications

Course Content:

Unit-1: Introduction: Introduction to the course, Descriptive Statistics, Probability Distributions (Nakagami, Chi square, Gamma, Gaussian etc)

Unit-2: Inferential Statistics: Inferential Statistics through hypothesis tests, Permutation and Randomization Test

Unit–3: Regression and ANOVA: Regression ANOVA (Analysis of Variance)

Unit-4: Machine Learning: Differentiating algorithmic and model based frameworks,

Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression and Classification

Unit- 5: Supervised Learning with Regression and Classification techniques -1: Bias-Variance Dichotomy, Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis Quadratic Discriminant Analysis, Regression and Classification Trees, Support Vector Machines

Unit-6: Supervised Learning with Regression and Classification techniques -2: Ensemble Methods: Random Forest, Neural Networks, Deep learning

Unit-7: Unsupervised Learning and Challenges for Big Data Analytics: Clustering, Associative Rule Mining, Challenges for big data analytics

Unit- 8: Prescriptive analytics: Creating data for analytics through designed experiments, Creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning

Teaching Methodology: Data Analytics is the science of analyzing data to convert information to useful knowledge. This knowledge will help students to understand the world better and in many contexts enable them to make better decisions. This course seeks to present students with a wide range of data analytic techniques and is structured around the broad contours of the different types of data analytics, namely, descriptive, inferential, predictive, and prescriptive analytics. The entire course is divided into eight separate units: Introduction, Inferential Statistics, Regression and ANOVA, Machine Learning: Differentiating algorithmic and model based frameworks, Regression, Supervised Learning with Regression and Classification techniques -1, Supervised Learning with Regression and Classification techniques -2, Unsupervised Learning and Challenges for Big Data Analytics and Prescriptive analytics. These sections have been framed to impart a systematic understanding of the basic and advanced principles of data analytics and finally implement these principles to convert information to useful knowledge. This course is intended to enable the students to apply the knowledge of data analytics in practical engineering problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4, Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7, Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Tutorials and lecture slides on Data Analytics (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:
[1] Anil Maheshwari; Data Analytics, McGraw Hill Education; First edition, 2017
[2] Bharti Motwani: Data Analytics using Python, Wiley, 2020

Reference Books:

[1] Montgomery, Douglas C., and George C. Runger.; Applied statistics and probability for engineers. John Wiley & Sons, 2010
[2] V. K. Jain; Data Science and Analytics, Khanna Publishing; First edition, 2018

Web References:

[1] https://nptel.ac.in/courses/106/107/106107220/
[2] https://nptel.ac.in/courses/106/106/106106212/

Journals References:

[1] International Journal of Data Science and Analytics, Springer
[2] Journal of Big Data, Springer
[3] Big Data Analytics, Springer
[4] Big Data Research, Elsevier
[5] Computational Statistics & Data Analysis, Elsevier

Title: Verbal & non Verbal Reasoning-I **Code: ME002**
L-T-P scheme: 3-0-0 **Credit: 0**

Prerequisite: None

Objective:

[1] To develop the ability to solve problems of general intelligence and reasoning.
[2] To develop wide range of psychometric ability.
[3] To solve quantitative aptitude.
[4] Logically work through concepts and problems expressed in words.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the basic concepts of quantitative ability.
CO2	Describe basic concepts of logical reasoning skills.
CO3	Develop satisfactory competency in use of verbal reasoning.
CO4	Identify aptitude papers covering quantitative ability, logical reasoning and verbal ability.
CO5	Apply general intelligence and reasoning.
CO6	Demonstrate verbal and non-verbal reasoning ability through mock test.

Course Content:

Unit-1:General intelligence and reasoning:

- Seating arrangement
- Blood relation
- Directions
- Judgement
- Statement and assumptions
- Ranking
- Number and letter series problems

Unit-2: English language:

- Synonyms and antonyms
- Fill in the blanks
- Active/passive voice
- Verbs
- Idioms & phrases
- Facts-inferences-judgments
- Vocabulary

Unit-3: Quantitative aptitude:

- Number system
- Time and distance
- Time and work
- Averages
- Ratio & proportion
- Percentages
- Simple and compound interest
- Discount
- Partnership business
- Mensuration
- Logarithm

Unit-4: Data interpretation:

- Bar graphs
- Line charts
- Column graphs
- Pie chart
- Calendars
- Clocks
- Venn diagrams
- Cubes

Teaching Methodology:

This course is introduced with an explanation and example, followed by further interactive worked examples, emphasizing specific techniques to deal with each question type in the most efficient manner. Key tips and advice are presented throughout the lesson. Finally, there are a number of practice questions for students to try themselves to reinforce and consolidate what they have learnt.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	30% from all units
Test-2	25 Marks	Next 30 % from all units and around 30% from coverage of Test-1
Test-3	35 Marks	Next 40 % from all units and around 30% from coverage of Test-1 and Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes, problem sheets and solutions.

Text Book:

[1] Verbal and Non-Verbal Reasoning by Dr. RS Aggarwal

[2] Reasoning Book for Competitive Examinations by Pearson

Reference Books/Material:

[1] A new approach to Reasoning By B.S. Sijwali & S. Sijwali Arihant

[2] Analytical Reasoning by M.K Pandey

Web References:

[1] https://www.indiabix.com/non-verbal-reasoning/questions-and-answers/

[2] https://www.fresherslive.com/online-test/logical-reasoning-test/questions-and-answers

TITLE: Applied Thermodynamics Lab **CODE: ME210**
L-T-P scheme: 0-0-2 **Credit:** 1

SCOPE AND OBJECTIVES

- This course is designed to measure/calculate the properties related with heat transfer and compare them with standard values.
- The topics covered in this course include the basics of heat transfer, refrigeration and air-conditioning and machines and components used for them.
- The objective of this course is to show the students the practical applications of heat transfer, refrigeration and air-conditioning.

Learning Outcomes:

Course Outcome	Description
CO1	Verify various laws of heat transfer
CO2	Determine, thermal conductivity, heat transfer coefficient, effectiveness of heat exchanger and fin
CO3	Determine the effectiveness of heat exchanger and its industrial application
CO4	Measure emissivity of surfaces
CO5	Determine sensible heat factor and bypass factor
CO6	Work as a team on a project.

LIST OF EXPERIMENTS

1. To find the effectiveness of a pin fin in a rectangular duct natural convective condition and plot temperature distribution along its length.
2. To determine average heat transfer coefficient for an externally heated horizontal pipe under forced convection & plot Reynolds and Nusselt numbers along the length of pipe. Also compare the results with those of the correlations.
3. To measure the emissivity of the gray body (plate) at different temperature and plot the variation of emissivity with surface temperature.
4. To find overall heat transfer coefficient and effectiveness of a heat exchange under parallel and counter flow conditions. Also plot the temperature distribution in both the cases along the length of heat of heat exchanger.
5. To measure thermal conductivity of a copper rod. Also plot temperature variation along the length with time for three pipes.
6. To determine the water side overall heat transfer coefficient on a cross-flow heat exchanger.
7. To study the cut- sectional models of Reciprocating and Rotary Refrigerant compressor.
8. To study the various controls used in Refrigerating & Air Conditioning systems.

9. To study the humidification, heating, cooling and dehumidification processes and plot them on Psychrometric charts.
10. To determine the By-pass factor of Heating & Cooling coils and plot them on Psychrometric charts on different inlet conditions.
11. To determine sensible heat factor of Air on re-circulated air-conditioning set up.
12. To study the chilling plant and its working cycle.
13. To study the cold storage.
14. To Study the reciprocating compressor

Teaching Methodology:

This lab course is introduced where students can conduct different heat transfer experiment for conduction, convention and Radiation and Refrigeration and Air Conditioning. The entire course is broken down into four separate parts: thermal conductivity, heat transfer coefficient, effectiveness of heat exchanger and fin, heat exchanger and its industrial application, Refrigeration system sensible heat factor and bypass factor for air-conditioning.

This lab course is well complemented by a theory course under the name Applied thermodynamics in the same semester that helps a student learn and discuss the technical details of the underlying technologies.

Evaluation Scheme:

<table>
<tr><th colspan="2">Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-7</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 8-13</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">Day-to-Day Work</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:

Laboratory Manual is available in Lab. Study material of Heat Transfer, Refrigeration and Air-Conditioning Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Books:

3. Arora C. P., Refrigeration & Air conditioning, TMH, New Delhi.
4. Incropera P. F. and DeWitt D. P., Fundamentals of Heat and Mass transfer, Wiley

Reference Books:

6. Yunus A. Cengel and AfshinJ.Ghajar, Heat and mass transfer: Fundamentals and applications, McGraw Hill Education
7. Jones J. W. and Stocker W. F., Refrigeration& Air conditioning, TMH, New Delhi.
8. Prasad M. Refrigeration& Air conditioning, Wiley Estern limited, New Delhi.
9. Priester G. B., Jordan R. C. Refrigeration & Air conditioning, Prentice Hall of India.
10. Yunus A. Cengel, and Cimbala, Engineering Thermodynamics, Tata McGraw Hill.

Title: Machine Drawing and Drafting Lab **Code: ME212**
L-T-P scheme: 0-0-4 **Credits: 2**

Objectives:

1. To learn the basic concepts and to draw the views of section of solids, orthographic projections and threaded fasteners.
2. This course will give the insight into the design, creation of assembly and get the detailed drawing of machine components.
3. This course will also introduce students to draw riveted joints, threaded fasteners and couplings.

Learning Outcomes:

Course Outcome	**Description**
CO1	Outline scope of machine drawing in various manufacturing processes.
CO2	Describe various terminologies used in machine drawing.
CO3	Develop skills of using various drawing instruments for drawing machine elements and their sectional views in orthographic projection.
CO4	Identify various types of thread forms, joints, keys, couplings and IS codes applicable to them.
CO5	Apply dimensional and geometric tolerances on various machine components.
CO6	Demonstrate the assembly drawings of various machine components and joints

Syllabus and list of exercises:

1. Introduction, IS Code of Practice for General Engineering Drawings; Lines, scales, sectioning and dimensioning;
2. Limits, fits and tolerances (dimensional and geometrical tolerances),
3. Drawing of machine elements in orthographic projection.
4. Screw threads – definitions, forms and conventional representation.
5. Drawing of screwed (or threaded) fasteners.
6. Methods of preventing rotation of a bolt while screwing a nut on or off it; Set screws, free-hand sketching of some threaded fasteners and simple machine components
7. Drawing of assembly of Nut and Bolts.
8. Drawing of locking arrangements for nuts.
9. Drawing of different types of keys.
10. Drawing of the assembly of cotter and knuckle joint.
11. Drawing of rigid coupling.
12. Drawing of flexible coupling.
13. Drawing of riveted joints.

14. Drawing of engine sub-assemblies.
15. Drawing of complete assembly of the stuffing box.

Teaching Methodology:

The students will draw various sectional drawings, drawings of fasteners, keys, cotters and riveted joints. The students will learnt to draw and interpret the drawing for shop floor and assembly shop. The students also will understand the standards used in drawing their importance and applications

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-15**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

TEXT BOOKS:

1. Bhatt N.D. and Panchal, V.M., Machine Drawing, Charotar Publishing House Pvt Ltd, 2014.

REFERENCES:

1. Sidheswar, N., Kannaiah P. and Sastry, V.V.S., Machine Drawing, Tata McGraw Hill Publishing Pvt. Ltd.

Title: CAD/CAM LAB **Code: ME211**
L-T-P scheme: 0-0-2 **Credit: 1**

Objectives:

- To make students practice feature-based, parametric CAD software package such as SolidWorks or Pro/ENIGINEER (now PTC Creo Element) and learn surface and solid modeling. It is also aimed at getting the students practice the CAD fundamentals like transformations and design of curves and surfaces.
- To provide practical experience to students with an opportunity of hands-on training on modern CNC machines and CIM system. Student will make part programs for CNC Lathe and Milling machines. They will also perform Robot programming.

Learning Outcome:

Course Outcome	Description
CO1	Outline basic fundamentals and scope of CAD, CAM and related technologies in industrial environment and their relationship with product life cycle.
CO2	Describe concepts modeling, types of modeling, parametric curves, surfaces and solids, NC, CNC and DNC machines and automation.
CO3	Develop ability to understand geometric modeling and execute the steps required in CAD software for developing 2D and 3D models and perform transformations.
CO4	Identify the configurations of CAD modeling software, CNC machines, robots or Computer integrated system in any industry.
CO5	Apply acquired knowledge to write CNC part programs for industrial components as well as to operate CNC machines, robots and CIM system.
CO6	Demonstrate skill to work in any automated manufacturing system.

List of Experiments:

1. Introduction to basic commands in Solidworks.
2. Introduction to advanced commands in Solidworks.
3. To make CAD models of a given parts in Solidworks.
4. Introduction to assembly and drawing module of Solidworks.
5. Announcement of a CAD project in Solidworks (to be completed in two labs)
6. CAD project continued…
7. Introduction to solid modeling software Pro/Engineer.
8. To write and simulate a part program for CNC Lathe for a given part.
9. To write and simulate a part program for CNC Lathe for a given part and perform machining operations on XLTURN CNC Lathe machine.
10. To write and simulate a part program for CNC Milling for a given part.
11. To write and simulate a part program for CNC Milling for a given part and perform machining operations on XLMILL CNC milling machine.

12. To introduce students with CAM software and generate word address format (G and M codes) using Pro/Manufacturing (Module of Pro/E) and EdgeCAM software.
13. To make a program for pick and place of a ball for 5-axis mini robot.
14. To demonstrate the working of Flexible Manufacturing System (FMS) to the students.

Teaching Methodology:

This course is introduced to help students learn and understand the computer assisted design and manufacturing processes. The course is divided into two major parts namely, CAD and CAM. Students will take hands-on experience on design software such as SolidWorks, Pro/Engineer, Abacus etc. They will also make and simulate part programs for CNC Lathe and Milling machines and perform machining on these machines. They will also do Robot programming. Finally, they will be performing automatic operations on FMS and CIM systems. This lab course is well complemented by a theory course under the name CAD/CAM in the same semester that helps students learn with hand-on experience.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
P-1	15 Marks	Based on Lab Exercises: 1-7
P-2	15 Marks	Based on Lab Exercises: 8-14
Day-to-Day Work	Viva	70 Marks
	Demonstration	
	Lab Record	
	Attendance & Discipline	
Total	**100 Marks**	

Text Books:

1. Zeid, Ibrahim, CAD/CAM Theory and Practice, McGraw-Hill, Inc.
2. Rogers, David F. and Adams, J. Alan, Mathematical Elements for Computer Graphics, McGraw-Hill Publishing Company.
3. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
4. HELP files of SolidWorks and Pro/Engineer
5. CNC XLTURN Manual by MTAB, Chennai
6. CNC XLMILL Manual by MTAB, Chennai

Reference Books:

1. Faux, I.D. and Pratt, M.J., Computational Geometry for Design and Manufacture, Ellis Horwood Limited (a division of John Wiley & Sons).
2. Rooney, Joe and Steadman Philip, Principles of Computer-aided Design, Affiliated East-West Press Pvt Ltd.
3. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi
4. Jha, N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc.

Title: Minor Project Part-1 **Code: ME213**

L-T-P scheme:0-0-4 **Credit: 2**

Prerequisite: Students must have already studied the fundamental courses, **"Mechanical Engineering"** and "**Mechanical Engineering Lab**".

Objective:

1. To learn and be able to implement the Mechanical Engineering in different industry.

Course Content:

Course Outcome	*Description*
CO1	Introduction to practical course requirement under the guidance of a faculty supervisor member to understand the respective design project to do innovative work with the application
CO2	Students are expected to do a literature survey and carry out development and/or experimentation in their respective design projects. Interaction with existing work of current researchers of their respective project work.
CO3	Development of the theoretical model and computational analysis of the existing working design project model.
CO4	Preparation of theoretical analysis for an innovative technique to overcome the current troubles of industrial applications related to their design project work.
CO5	Verification and validation techniques of their respective design project
CO6	Demonstrate deployment and basic maintenance skills of the respective design project.

UNIT-I IDENTIFICATION OF INNOVATIVE WORK: ,based upon Literature survey

UNIT-II student is required doing an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study.

UNIT-III The student is expected to do literature survey and carry out development and/or experimentation.

UNIT-IV Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

UNIT-V *Demonstrate deployment and basic maintenance skills of the* respective design project

Project is a course requirement wherein under the guidance of a faculty member, a final year student is required to do an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study. The student is expected to do literature survey and carry out development and/or experimentation. Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

Exams		Marks	Coverage
P-1		20 Marks	**Based on :** *Literature survey and Interaction with existing work of current researchers of their respective project work.*
P-2		15 Marks	**Based on:** *Development of the theoretical model and computational analysis of the existing working design project model.*
P3		20 Marks	**Based on:** *Demonstrate deployment and basic maintenance skills of the* respective design project.
Day-to-Day Work	Supervisor Marks [**Day- to- Day Marks**] [Attendance, Performance, Discipline]	35 Marks	**45 Marks**
	Thesis	10 Marks	
Total		**100 Marks**	

Learning Resources: Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. **As prescribed by respective project supervisor.**

Title: Material Science **Code: ME301**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: It is a foundation course.

Objective:

1. Primary objective is to present the basic fundamentals of materials science and engineering.
2. Help students to possess a solid foundation in materials science and engineering, with emphasis on the fundamental engineering principles that govern the microstructure, properties, processing.
3. Help students to understand the broad issues relevant to materials, including professional and ethical responsibilities, impact of materials engineering on society and environment.

Learning Outcomes:

COURSE OUTCOME	DESCRIPTION
CO1	ANALYZE THE STRUCTURE OF MATERIALS AT DIFFERENT LEVELS, BASIC CONCEPTS OF CRYSTALLINE MATERIALS LIKE UNIT CELL, FCC, BCC, HCP, APF (ATOMIC PACKING FACTOR), CO-ORDINATION NUMBER ETC.
CO2	DESCRIBE DIFFUSION TECHNIQUES ALONG WITH VARIOUS MICROSCOPIC PROCEDURE
CO3	UNDERSTAND CONCEPT OF MECHANICAL BEHAVIOR OF MATERIALS AND CALCULATIONS OF SAME USING APPROPRIATE EQUATIONS
CO4	EXPLAIN THE CONCEPT OF PHASE & PHASE DIAGRAM &UNDERSTAND THE BASIC TERMINOLOGIES ASSOCIATED WITH METALLURGY. CONSTRUCTION AND IDENTIFICATION OF PHASE DIAGRAMS AND REACTIONS
CO5	UNDERSTAND AND SUGGEST THE HEAT TREATMENT PROCESS & TYPES. SIGNIFICANCE OF PROPERTIES VS MICROSTRUCTURE. SURFACE HARDENING & ITS TYPES. INTRODUCE THE CONCEPT OF HARDENABILITY & DEMONSTRATE THE TEST USED TO FIND HARDENABILITY OF STEELS
CO6	EXPLAIN FEATURES, CLASSIFICATION, APPLICATIONS OF NEWER CLASS MATERIALS LIKE SMART MATERIALS, PIEZOELECTRIC MATERIALS, BIOMATERIALS, COMPOSITE MATERIALS ETC.

Course Content

Unit 1: Introduction:

Introduction to Material: Historical perspective, Importance of materials, Classification of materials, Properties of materials– Mechanical, electrical, thermal, magnetic, optical, decorative and its applications, Modern materials – Smart materials, Bio and Nano materials; Atomic models and Chemical bonding.

Crystallography: Concept of unit cell space lattice, Bravais lattices, Common crystal structures, Atomic packing factor and density, Miller indices, Volume, Planar and Linear density, X-ray Crystallography techniques.

Imperfection in Solids: Types of imperfections, point Imperfections, line defects (Dislocations), planar defects, volume defects, Experimental techniques for identification of microstructure and defects.

Diffusion: Diffusion is solids, Diffusion mechanism, Steady-state diffusion, non-steady state diffusion, effects of temperature on diffusion

Unit 2: Phase Diagram:

Phase Diagrams: Phase diagram for pure substances, Gibbs phase rule, cooling curves, binary isomorphous alloy systems, the lever rule, the invariant reactions, Iron-Carbon Equilibrium-Diagram and its importance, Concept of solidification of metals.

Mechanical Behavior of Metals: Stress straindiagram, Properties of metals, Deformation of metals, Mechanism of deformation, Mechanical testing of materials (destructive and non-destructive testing).

Ferrous Materials: Iron and steel manufacture, Furnaces, Various types of carbon steels, Alloy steels and Cast irons, its properties and uses.

Heat Treatment Processes: Definition, purpose and classification of heat treatment processes such as Annealing, Normalizing, Quenching, Tempering, and Case hardening, Time-Temperature-Transformation (TTT) diagram**.**

Non-Ferrous Metals and Alloys: Non-ferrous metals such as Cu, Al, Zn, Cr, Ni etc. and its applications, Various types Brass, Bronze, Bearing materials, its properties and uses, Aluminum alloys such as Duralumin, Other advanced materials/alloys

Unit 3: Ceramics, Polymers and other Materials:

Ceramics, Polymers and other Materials: Structure types, properties, and applications of ceramics. Mechanical/Electrical behaviour and processing of Ceramics. Various types of polymers/plastics and its applications. Mechanical behaviour and processing of plastics. Future of plastics. Composite Materials and its uses. Brief description of other materials such as Magnetic, Dielectric, Optical, Thermal materials and concrete.

Teaching Methodology:

In introduction to material science the student will have a broad knowledge on the types of material and their application in the real life. Students will have concept of unit cell space lattice, bravais lattices, common crystal structures, atomic packing factor and density, miller indices, volume, planar and linear density, x-ray crystallography techniques, types of imperfections, point imperfections, line defects (dislocations), planar defects, volume defects, experimental techniques for identification of microstructure and defects.

In second unit of the course student will learn about the phase diagram for pure substances, Gibbs phase rule, cooling curves, binary isomorphous alloy systems, the lever rule, the invariant reactions, iron-carbon equilibrium diagram and its importance, concept of solidification of metals, stress strain diagram, properties of metals, deformation of metals, mechanism of deformation, mechanical testing of materials (destructive and non-destructive testing). Iron and steel manufacture, Furnaces, Various types of carbon steels, Alloy steels and Cast irons, its properties and uses. Non - ferrous metals and alloys, purpose and classification of heat treatment processes such as annealing, normalizing, quenching, tempering, and case hardening, time-temperature-transformation (TTT) diagram.

In third unit students will have a generalized knowledge on structure types, properties, and applications of ceramics. mechanical/electrical behavior and processing of ceramics, various types of polymers/plastics and its applications, mechanical behavior and processing of plastic, future of plastics, composite materials and its uses, brief description of other materials such as magnetic, dielectric, optical, thermal materials and concrete.

Evaluation Scheme:

EXAMS	MARKS	COVERAGE
TEST-1	15 MARKS	BASED ON UNIT 1
TEST-2	25 MARKS	BASED ON UNIT 2 AND UNIT 1 (20%)
TEST-3	35 MARKS	BASED ON UNIT 3, UNIT 2 (15%) AND UNIT 1 (15%)
ASSIGNMENT	10 MARKS	
TUTORIALS	5 MARKS	
QUIZ	5 MARKS	
ATTENDANCE	5 MARKS	
TOTAL	**100 MARKS**	

Learning Resources:

Tutorials on Material Science (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[5] William D. Callister, Jr., Fundamentals of material science and engineering- An interactive, John willey & Sons, Inc.

[6] Donald R. Askeland, P.P Fulay and W.J. Wright, The science and engineering of materials, sixth edition, Cengage Learning.
[7] V. Raghvan, Material science and engineering, prentice hall of India (PHI) Pvt. Ltd.

References:

[3] George E. Dieter, Mechanical metallurgy, Tata Mcgraw Hill education.
[4] H. Van Vlack, Elements of material science and engineering, Addision-wesley.

Web References:

2. www.youtube.com/user/nptelhrd

Journals References:

3. *Journal of Material Science*

Title: Design of Machine Elements **Code: ME110**
L-T-P scheme: 3-0-0 **Credit:** 3

Prerequisite: Students must have already studied courses, "Engineering Mechanics", "Strength of Materials" and "Theory of Machines"

Objective:

3. To familiarize the various steps involved in the design process
4. To know the principles involved in evaluating the shape, size and dimensions of machine components to satisfy functional and strength requirements
5. To learn to use standard practices and standard data

Learning Outcomes:

Course Outcome	Description
CO1	Outline various concepts of design and select commonly used machine components
CO2	Demonstrate understanding of various design consideration
CO3	Illustrate basic principles of machine design
CO4	Design machine elements for static as well as dynamic loading
CO5	Design machine elements on the basis of strength and rigidity concepts
CO6	Demonstrate and deployment of computer based techniques in the analysis, design and selection of machine components

Course Content:

Unit-1: DESIGN AGAINST STATIC LOAD: Modes of failure, Theories of failure, Graphical representation and comparison, Introduction to fracture mechanics, Stress concentration factor.

Unit-2: DESIGN AGAINST FLUCTUATING LOAD: Different types of fluctuating stresses, S-N Curve, Notch sensitivity, Fatigue strength considering stress concentration factor, surface factor, size factor, reliability factor etc., Fatigue design for finite and infinite life against combined variable stresses using Goodman and Soderberg's Criterion, Fatigue design using Miner's equation. Design for Manufacturing (DFM), Role of processing in design.

Unit-3: MATERIAL SELECTION: Material and Manufacturing in design, Material selection.

Unit-4: BELT, ROPE AND CHAIN DRIVES: Design of belt drives: Flat and V-belt drives, Geometrical factors, Mechanics of belt drives, Condition for transmission of maximum

power, Selection of flat and V-belts, Design of rope drives, Design of chain drives with sprockets.

Unit-5: SHAFTS, KEYS AND COUPLINGS: Design of shaft under bending, twisting and axial loading, Shock factors, Rigidity considerations, Design of shaft under fluctuating loads, Critical speed of shafts, Keys, Couplings.

Unit-6: WELDED AND RIVETED JOINTS: Design of welded and riveted joints.

Unit-7: SPRINGS: Types of springs, Design of helical springs against tension, compression and fluctuating loads and their uses, Design of leaf springs, Surging phenomenon in springs.

Unit-8: CLUTCHES AND GEARS: Types of clutches, Design of plate clutch, conical clutch, centrifugal clutch. Types of gears, Nomenclature and Working of gears, Design of straight and helical spur gears.

Unit-9: BEARINGS: Selection of ball and roller bearings based on static and dynamic load carrying capacity using load-life relationship, Selection of bearings from manufacturer's catalogue. Types of lubrication, lubricants and their properties, Selection of suitable lubricants, Design of journal bearings.

Teaching Methodology:

This course is introduced to help students in applying their knowledge of Engineering Mechanics, Strength of Materials and Theory of Machines in order to explore the vast area of design in mechanical engineering and to enhance students' ability to design machines and mechanisms by framing the solution of open ended problems. The entire course is divided into nine separate units: Design against Static Load, Design against Fluctuating Load, Material Selection, Belt, Rope and Chain Drives, Shafts, Keys and Couplings, Welded and Riveted Joints, Springs, Clutches and Gears and Bearings. These sections have been framed to impart a systematic understanding of the basic principles of machine design and finally implement these principles to evaluate the shape, size and dimensions of machine components to satisfy functional and strength requirements. This theory course is well complemented by a laboratory course under the name Design of Machine Elements Lab in the same semester. This Lab course will enable a student to learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 and Unit-3
Test-2	25 Marks	Based on Unit-4, Unit-5, Unit-6 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-7, Unit-8, Unit-9 and around 30% from coverage of Test-2
Assignment	10 Marks	

Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Design of Machine Elements (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Design of Machine elements by V. B. Bhandari, McGraw Hill Education, 4th Edition, 2017.

[2] Mechanical Engineering Design by J. E. Shigley and L. D. Mitchell, McGraw-Hill Education; 10th Edition, 2014.

Reference Books/Material:

[1] Machine Design by Robert L. Norton, Pearson, 5th Edition, 2013.

[2] Design Data Book Compiled by PSG College of Engineering & Technology, Coimbatore

Web References:

- https://nptel.ac.in/courses/112105124/
- https://nptel.ac.in/courses/112106137/
- https://ocw.mit.edu/courses/mechanical-engineering/2-72-elements-of-mechanical-design-spring-2009/
- https://pe.gatech.edu/courses/machine-design-part-1

Journals References:

- Journal of Mechanical Design (JMD), ASME
- Materials & Design, Elsevier
- Design Studies, Elsevier
- Trends in Machine Design, STM Journals
- Finite Elements in Analysis and Design, Elsevier

Title: Industrial Engineering **Code: ME111**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, “mathematics”.

Objective:

The objectives of the Industrial Engineering course are to produce graduates who, are able to:

1. be employed as a practicing engineer in fields such as design, research, development, testing, manufacturing, operations and service systems;
2. Function on multidisciplinary teams, and to identify, formulate, and solve engineering problems.

Learning Outcomes:

Industrial Engineering	
Course Outcome	**Description**
CO1	Outline various role and scope of industrial engineering in manufacturing and service industry.
CO2	Describe the types of production systems and evaluate the system, tools.
CO3	Develop the understanding of techniques, skills, and industrial engineering tools for planning of resources needed in production system.
CO4	Identify economic issues, safety issues and disaster management of production system.
CO5	Apply the learned tools of analysis in production industry.
CO6	Demonstrate problem solving skill for quality improvement and productivity enhancement.

Course Content:

UNIT-1 INTRODUCTION AND PRODUCTION SYSTEM

Introduction to industrial engineering, scope of industrial engineering, industrial engineering and production management, Types of Production Systems, flexible manufacturing system, Introduction to supply chain management, concept of value chain. Productivity measurement in International, National and Industrial level – Total Productivity Model– Productivity measurement in Manufacturing and Service sectors – Performance Objective Productivity (POP) model – Need for Productivity Evaluation – Evaluation Methodology.

UNIT –II PLANT LOCATION AND LAYOUT

Introduction to plant location and layout, Urban Vs rural site, factors affecting plant location, types of plant layout, Numerical methods for plant location and layout.

UNIT III QUALITY AND RELIABILITY ENGINEERING

Japanese contribution to world class manufacturing, meaning of quality in product and service, Introduction TQM, Six sigma.

UNIT –IV WORK STUDY AND ERGONOMICS
Meaning and benefits of work study, Time & motion study, Micro-motion study, P.M.T.S Work sampling, standard time, Ergonomics. Introduction Plant layout, Industrial material handling system, human factor engineering

UNIT V-STATISTICAL QUALITY CONTROL
Introduction to SQC, attribute and discrete data, causes of variation, various types of charts for attributes and variables and numerical based on them.

UNIT-VI ACCEPTANCE SAMPLING
Introduction to sampling inspection, types of sampling plans, OC curve, consumer and supplier's risk and numerical based on them.

UNIT VII JOB EVALUATION AND MERIT RATING
Concept of job evaluation, objectives, methods etc. Introduction to Merit rating and method of merit rating

Teaching Methodology:

This course is introduced to help students to understand the management and engineering decision issues in production industry. The entire course is broken down into four major sections: Scope and definitions, Fundamental of productivity, Tools and methodology and organizational structures.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit -2
Test-2	25 Marks	Based on, Unit-3, Unit -4 and Unit -5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit- 6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Digital copy of important material will be available on the JUET server.

Text book

1. Dr. Ravi shanker , Industrial engineering and management, , Galgotia , New delhi
2. Evertte E. Adam, Jr. Ronald J. Ebert Production and operation management , PHI
3. M. Mahajan , Industrial engineering and production management, Dhanpat rai and company pub

Reference

4. Sumanth, D.J, "Productivity Engineering and Management", TMH, New Delhi, 1990.
5. Edosomwan, J.A, "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.
6. Premvrat, Sardana, G.D. and Sahay, B.S, "Productivity Management - A systems Approach", Narosa Publications, New Delhi, 1998.

TITLE: INTERNAL COMBUSTION ENGINE AND ELECTRICAL POWER PLANTS FOR AUTOMOBILES **CODE :** ME112

L-T-P SCHEME: 3-1-0 **CREDITS:** 4

Prerequisite: Student must have already studied courses, "Engineering Thermodynamics, Manufacturing process, Applied chemistry, Kinematic of Machine and Dynamics of machine".

Objective:

1. To make aware of the basics of automobile history & its development and Bharat stage requirement in India.
2. To make aware of the role of the internal combustion engines in automobile industry.
3. To learn the different types of internal combustion engine.
4. To make able to do the experimental and theoretical evaluation of the performance characteristic of the internal combustion engines.
5. To develop an understanding of environmental aspect associated with the internal combustion engines.

Learning Outcome:

Course Outcome	Description
CO1	**Outlin**e basis for the categorization of internal combustion engines
CO2	**Demonstrate** working principals of the auxiliaries associated with the inlet manifold
CO3	**Describe** working principals of the auxiliaries associated with the exhaust manifold
CO4	**Demonstrate** and understand different auxiliary associated with the cooling and lubrication system
CO5	**Develop** skill for the performance analysis of CI and SI Engines
CO6	**Describe** rotary, sterling, and hybrid engines.

COURSE CONTENT

Unit-1: Internal Combustion Engines: S.I. and C.I. engines of two and four stroke cycles, , Scavenging, Introduction to ideal cycles: carnot cycle, otto cycle, diesel cycle, brayton cycle: applications of gas turbines, real cycle analysis of SI and CI engines, Determination of engine dimensions, speed, fuel consumption, output, mean effective pressure, efficiency, Factors effecting volumetric efficiency, Valve timing diagram ,Heat balance, Performance characteristics of SI and CI engines, Cylinder arrangement, Firing order, Power balance for multi-cylinder engines.

Unit-2: Engine Testing and Performance: Performance parameters: BHP, IHP, Mechanical-efficiency, Brake mean effective pressure and indicative mean effective pressure, Torque, Volumetric efficiency, Specific fuel consumption (BSFC, ISFC), Thermal efficiency; Heat balance, Basic engine measurements, Fuel and air consumption, Brake power, Indicated power and friction power, Heat lost to coolant and exhaust gases, Performance curves.

Unit-03: Various Types of Fuels: Fuels for SI and CI engine, Important qualities of SI and CI engine fuels, Rating of SI engine and CI engine fuels, Gaseous fuels, LPG, CNG and other alternative fuels, Carburetion, Mixture requirements,

Unit-04: Mechanism of Carburetion and Injection: Theory of carburetor, MPFI, Fuel injection in CI engines, Requirements, Fuel pumps, Fuel injectors, Injection timings.

Unit-05: Combustion in S.I. & C.I. Engines **:** Flame development and propagation, Ignition lag, Effect of air density, Temperature, Engine speed, Turbulence and ignition timings, Physical and chemical aspects of detonation, Effect of engine and fuel variables on knocking tendency, Knock rating of volatile fuels, Octane number, H.U.C.R., Action of dopes. Pre-ignition, Its causes and remedy, Abnormal combustion, Theory, effect and control of detonation, Super-charging and turbo-charging of engines.

Unit-06: Cooling and lubrication systems**:** Functions of a lubricating system, Types of lubrication system, Mist, Wet sump and dry sump systems. Properties of lubricating oil, Classification of lubricating oil, SAE rating of lubricants, Engine performance and lubrication, Necessity of engine, Cooling, disadvantages of overcooling, Cooling systems, Air-cooling, Water cooling, Radiators

Unit-07: Introduction to the renewable energy based power plants: Battery, green hydrogen etc. based power generation units.

Teaching Methodology:

This is introduced to make the student capable of utilizing skills developed as an outcome from their above-mentioned pre-requisite subjects, various constructional parameters of the child parts and their requirement. Course contain deals within this internal combustion engines subject is categorized in seven different units (viz. Introduction, engine testing and performance parameters, types of fuel used, Carburetors and injectors, Combustion in SI and CI Engines, Engine cooling and lubrication). A well equipped advance laboratory of internal combustion engines will helps student to examine the performance of internal combustion engines of different capacity and type.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Total	100 Marks	

Learning Resources:

Tutorials and lecture slides of an internal combustion engines subject (will be added from time to time): Digital copy will be available on the JUET server.

TEXT BOOKS:

1. Ganeshan V., Internal Combustion Engines, Tata McGraw-Hill.
2. Pulkrabek, W. W., Engineering fundamental of the I.C. Engine, PHI, India.
3. Ganeshan V., Gas Turbines, Tata McGraw-Hill.

REFERENCE BOOKS:

4. Obert E.F., Internal Combustion Engines & Air pollution, Hopper & Row Pub., New York.
5. Heywood J. B., Internal Combustion Engines Fundamentals, McGraw Hill, New York

Web References:

1. https://www.saeindia.org
2. http://www.oica.net
3. https://uia.org

Journals References:

1. https://www.sciencedirect.com/journal/transportation-research-part-a-policy-and-practice
2. https://www.sciencedirect.com/journal/journal-of-cleaner-production
3. https://www.sciencedirect.com/journal/advances-in-engineering-software
4. https://www.sciencedirect.com/journal/materials-today-proceedings
5. https://www.sciencedirect.com/journal/travel-behaviour-and-society
6. https://www.sciencedirect.com/journal/neurocomputing

Title: Design of Machine Elements Lab **Code: ME214**

L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied the course, "Design of Machine Elements"

Objective:

1. To familiarize with the various steps involved in the design process
2. To know the principles involved in evaluating the shape, size and dimensions of machine components to satisfy functional and strength requirements
3. To learn to use standard practices and standard data

Learning Outcomes:

Course Outcome	Description
CO1	Apply concepts of design and select commonly used machine components
CO2	Demonstrate understanding of various design consideration
CO3	Practice systematic approaches to mechanical design and analysis procedures
CO4	Understand, formulate and implement standards in the design of machine components in engineering practice
CO5	Produce analysis briefs, design sketches, assembly and detail drawings that clearly communicate machine element design and analysis
CO6	Demonstrate and deployment of computer based techniques in the analysis, design and selection of machine components

Course Content:

Experiment-1: Design of belts and pulleys

Experiment-2: Design of chain and rope drives

Experiment-3: Design of a shaft

Experiment-4: Design of keys and coupling

Experiment-5: Design of knuckle and cotter joint

Experiment-6: Design of welded and riveted butt joint

Experiment-7: Design of welded and riveted lap joint

Experiment-8: To Design of helical spring

Experiment-9: Design of leaf spring

Experiment-10: Design of spur gears

Experiment-11: Design of journal bearing

Experiment-12: Design of roller bearings

Experiment-13: Design of connecting rod

Experiment-14: Design of Piston

Teaching Methodology:

This Lab course has been introduced to help a student to learn with hand-on experience on design of machine element. The entire course is divided into fourteen experiments. Each experiment includes mechanical design principles applied to various machine elements in order to help a student gain more experience as Mechanical Engineer. This lab course is well complemented by a theory course under the name Design of Machine Elements in the same semester in order to enable the student to get acquainted, learn and discuss the technical details involved in the design and selection of machine components. This Lab course will enable a student to learn with hand-on experience.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-14**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Laboratory Manual available in Lab. Study material of Design of Machine Elements Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Design of Machine elements by V. B. Bhandari, McGraw Hill Education, 4th Edition, 2017.

[2] Mechanical Engineering Design by J. E. Shigley and L. D. Mitchell, McGraw-Hill Education; 10th Edition, 2014.

Reference Books/Material:

[1] Machine Design by Robert L. Norton, Pearson, 5th Edition, 2013.

[2] Design Data Book Compiled by PSG College of Engineering & Technology, Coimbatore

Web References:

[1] https://nptel.ac.in/courses/112105124/

[2] https://nptel.ac.in/courses/112106137/

[3] https://ocw.mit.edu/courses/mechanical-engineering/2-72-elements-of-mechanical-design-spring-2009/

[4] https://pe.gatech.edu/courses/machine-design-part-1

Journals References:

[1] Journal of Mechanical Design (JMD), ASME

[2] Materials & Design, Elsevier

[3] Design Studies, Elsevier

[4] Trends in Machine Design, STM Journals

[5] Finite Elements in Analysis and Design, Elsevier

Title: Value Added Course-II (Verbal & non Verbal Reasoning-II) Code: ME003
L-T-P scheme: 3-0-0 Credit: 0

Prerequisite: None

Objective:

[1] To develop the ability to solve problems of general intelligence and reasoning.
[2] To develop wide range of psychometric ability.
[3] To solve quantitative aptitude.
[4] Logically work through concepts and problems expressed in words.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the basic concepts of quantitative ability.
CO2	Describe basic concepts of logical reasoning skills.
CO3	Develop satisfactory competency in use of verbal reasoning.
CO4	Identify aptitude papers covering quantitative ability, logical reasoning and verbal ability.
CO5	Apply general intelligence and reasoning.
CO6	Demonstrate verbal and non-verbal reasoning ability through mock test.

Course Content:

Unit-1: General intelligence and reasoning:

- Syllogism
- Coding-decoding
- Analogy
- Non-verbal reasoning

Unit-2: English language:

- Passage and cloze test
- Improving sentences
- Spotting errors
- One word substitution
- Jumbled paragraph
- Misspell word
- Vocabulary

Unit-3: Quantitative aptitude:

- Probability
- Profit and loss
- Mixture
- Algebra and geometry
- Trigonometry
- Permutation and combination
- Complex numbers
- Sequences and series
- In-equations quadratic and linear equations algebra

Unit-4: Data interpretation:

- Discrimination
- Spatial visualization
- Spatial orientation
- Binary logic
- Logical matching
- Logical sequence
- Logical connectives
- Tables
- Caselets

Teaching Methodology:

This course is introduced with an explanation and example, followed by further interactive worked examples, emphasizing specific techniques to deal with each question type in the most efficient manner. Key tips and advice are presented throughout the lesson. Finally, there are a number of practice questions for students to try themselves to reinforce and consolidate what they have learnt.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	30% from all units
Test-2	25 Marks	Next 30 % from all units and around 30% from coverage of Test-1
Test-3	35 Marks	Next 40 % from all units and around 30% from coverage of Test-1 and Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on on JUET server. This can include eBook, lecture material, supplementary course notes, problem sheets and solutions.

Text Book:

[3] Verbal and Non-Verbal Reasoning by Dr. RS Aggarwal

[4] Reasoning Book for Competitive Examinations by Pearson

Reference Books/Material:

[3] A new approach to Reasoning By B.S. Sijwali & S. Sijwali Arihant

[4] Analytical Reasoning by M.K Pandey

Web References:

[3] https://www.indiabix.com/non-verbal-reasoning/questions-and-answers/

[4] https://www.fresherslive.com/online-test/logical-reasoning-test/questions-and-answers

Title: Minor Project-2 **Code: ME216**

L-T-P scheme: 0-0-6 **Credit: 3**

Prerequisite: Students must have already studied the courses, "Fluid Mechanics, Thermodynamics, Heat and Transfer" and "Engineering Mechanics, Machine dynamics, Machine Design, Manufacturing Technology, Industrial Technology".

Objective:

1. To learn and be able to implement the front-end and back-end web-technologies.
2. To develop the abilities to call oneself full-stack web developer.

Course Outcome	Description
CO1	Introduction to practical course requirement under the guidance of a faculty supervisor member to understand the respective design project to do innovative work with the application
CO2	Interaction with existing work of current researchers of their respective project work.
CO3	Development of the theoretical model and computational analysis of the existing working design project model.
CO4	Preparation of theoretical analysis for an innovative technique to overcome the current troubles of industrial applications related to their design project work.
CO5	Verification and validation techniques of their respective design project
CO6	student is expected to do literature survey and carry out development and/or experimentation

UNIT-1 Identification of Innovative work, based upon Literature survey

UNIT- 2 student is required doing an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study.

UNIT-3 The student is expected to do literature survey and carry out development and/or experimentation.

UNIT-4 Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

UNIT-5 Verification and validation techniques of their respective design project

Teaching Methodology:A topic or problem will be allotted to the student after that relevant literature survey will be done by the student. Based upon the literature survey, it is expected from

the student to find the solution experimentally/theoretically to arrive at some concrete conclusion. . The student is expected to do literature survey and carry out development and/or experimentation

Evaluation Scheme:

Exams	Marks	Coverage
P-1	20 Marks	Based on Unit-1, Unit-2 & Unit-3
P-2	15 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
P-3	20 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
supervisor Marks for performance and Attendance	35 Marks	
Report	10 Marks	
Total	**100 Marks**	

Learning Resources:

1. Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

2. https://nptel.ac.in/course.html

3. https://scholar.google.com/

Text Book: As prescribed by respective supervisor faculty member

Title: Advanced Mechanics of Solids **Code: ME307**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Engineering Mechanics" and "Strength of Materials"

Objective:

1. To provide the fundamental concepts and principles in the analysis of solids in three dimensions
2. Comparison of the 3D elasticity solutions to boundary value problems and frame simplified solutions

Learning Outcomes:

Course Outcome	*Description*
CO1	Outline various concepts, principles and governing equations of mechanics of solid in three dimensions
CO2	Demonstrate the ability to interpret complex three dimensional problems
CO3	Illustrate analytical, experimental and computational tools needed to solve the idealized three dimensional problems
CO4	Use these solutions to guide a corresponding design, manufacture or failure analysis
CO5	Describe the independent judgment required to interpret the results of these solutions
CO6	Demonstrate and deployment of the knowledge of advanced mechanics of solids in practical engineering structures

Course Content:

Unit-1: INTRODUCTION: Review of basic concepts and equations in mechanics, Classification of materials, Outline of general techniques to solve boundary value problems.

Unit-2: STRESS AND STRAINS IN 3-D: Cauchy formula, Principal Stress, hydrostatic stress, deviatoric stress, stress transformations, Mohr circle, octahedral shear stress, strain energy densities, etc.

Unit-3: STRAIN ENERGY AND IMPACT LOADING: Definitions, expressions for strain energy stored in a body when load is applied: (i) gradually, (ii) suddenly and (iii) with impact, strain energy of beams in bending, beam deflections, strain energy of shafts in twisting, energy methods in determining spring deflection, Castigliano's & Maxwell's theorems.

Unit-4: UNSYMMETRICAL BENDING: Properties of beam cross section, product of inertia, ellipse of inertia, slope of the neutral axis, stresses and deflections, shear center and the flexural AXIS.

UNIT-5: BENDING OF CURVED BARS: Stresses in bars of initial large radius of curvature, bars of initial small radius of curvature, stresses in crane hooks, rings of circular & trapezoidal sections, deflection of curved bars and rings, deflection of rings by Castigliano's theorem stresses in simple chain link, deflection of simple chain links.

Unit-6: THICK PRESSURE VESSELS: Derivation of Lame's equations, radial & hoop stresses and strains in thick and compound cylinders and spherical shells subjected to internal fluid pressure only, wire wound cylinders, hub shrunk on solid shaft.

Unit-7: ROTATING MEMBERS: Stresses in uniform rotating rings and discs, stresses in rotating rims, rotating cylinders, hollow and solids cylinders.

Unit-8: COLUMNS AND STRUTS: Straight and initially curved columns and struts, Rankine's formula.

Teaching Methodology: This course is introduced to help students in applying their knowledge of Engineering Mechanics and Strength of Materials in order to explore the vast area of applied mechanics and to enhance students' ability to solve problems related to theory of elasticity and plasticity. The entire course is divided into eight separate units: Introduction, Stress and Strains in 3-D, Strain Energy and Impact Loading, Unsymmetrical Bending, Bending of Curved Bars, Thick Pressure Vessels, Rotating Members and Columns and Struts. These sections have been framed to impart a systematic understanding of the basic and advanced principles of mechanics of materials and finally implement these principles to evaluate design, manufacture or failure analysis to satisfy functional and strength requirements. This course is intended to enable the students to apply the knowledge of advanced mechanics of solids in practical engineering problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4, Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7, Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Tutorials and lecture slides on Advanced Mechanics of Solids (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[3] Advanced Mechanics of Solids by L. S. Srinath, McGraw Hill Education, 2010.

[4] Advanced Mechanics of Materials by Kamal Kumar and R. C. Ghai, 7th Edition, Khanna Publishers

Reference Books:

[3] Advanced Strength of Materials by J. P. Den Hartog Dover Publications, 2014.

[4] Advanced Mechanics of Materials and Applied Elasticity, Saul K. Fenster and Ansel C. Ugural, 5th Edition, Prentice Hall, 2011.

Web References:

- https://nptel.ac.in/courses/112101095/
- https://ocw.mit.edu/courses/mechanical-engineering/2-002-mechanics-and-materials-ii-spring-2004/

Journals References:

- Mechanics of Materials, Elsevier
- Strength of Materials, Springer
- Applied Mechanics and Materials, Scientific.Net
- Mechanics of Advanced Materials and Structures, Taylor & Francis
- JSME international journal. Ser. 1, Solid mechanics, strength of materials

Title: Measurement and Metrology **Code: ME308**
L-T-P scheme: 3-0-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "Engineering Mechanics".

Objective:

1. To know Indian standards and International standards of measurement
2. To learn different measuring equipment's used for various measurement system along with their capability
3. To learn various instruments and their methods of used in engineering metrology
4. To know Indian standards and International standards of measurement
5. To learn different measuring equipments used for various measurement system along with their capability
6. To learn various instruments and their methods of used in engineering metrology

Learning Outcomes:

Course Outcome	Description
CO1	Outline different measuring instruments to measure the qualitative and quantitative characteristics.
CO2	Describing the fits and tolerances to improve the existing performance.
CO3	Develop an idea to evaluate quality of job, machine and instruments.
CO4	Identify the most influencing measuring device to measure surface properties.
CO5	Apply the concept of measuring and metrology to solve the industrial or real world problems.
CO6	Demonstrate various measuring instrument and their basic principles of working.

Course Content:

Unit-1: Introduction to metrology: Definition, types, need of inspection, terminologies, and methods of measurement, selection of instruments, measurement errors, units, measurement standards, calibration.

Unit-2: Limits, fits and gauges: Limits, fits, tolerance and allowance, theory of limits and fits and their selection, hole based and shaft based systems, Indian standard system of limits and fits. Interchangeability, selective assembly, limit gauges, Taylor's principle of limit gauging, plug gauges, ring gauges.

Unit-3: Measurement and measurement system: Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy,

precision, calibration, threshold, sensitivity, hysteresis, and repeatability, linearity, loading effect, system response-time and delay, errors in measurements.

Unit-4: Pressure and Temperature measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, bridge man gauge. Vacuum measurement: vacuum gauges viz. McLeod gauge. Electrical methods of temperature measurement: resistance thermometers, thermistors and thermocouples, pyrometer.

Unit-5: Measurement of surface finish: Introduction, terminology, specifying roughness on drawings, surface roughness parameters, factors affecting surface roughness, ideal surface roughness, roughness measurement methods, precautions in measurement, surface microscopy, surface finish software. Measurement of straightness, flatness, squareness, parallelism, roundness, non-contact profiling systems Taper measurement, angle measurement, radius measurement.

Unit-6:Measurement of screw threads and gears and Interferometry: Measurement of various elements of threads, major, minor and effective diameter, measurement of pitch, gear inspection, measurement of tooth thickness, gear tooth caliper, Parkinson's gear tester. Principle of interference, interference bands, interference patterns, flatness interferometer, Gauge length interferometer

Teaching methodology:

The aim of introducing this course is to give aexposure to the students on the important and fundamental concept in the extensive area of Materials and its behavior under different loading conditions. The concepts, ideas and techniques developed in SOM are indispensable in machine and structural design. The main focus of this course is to introduce fundamental concepts in SOM with special emphasis on practical problems.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 &Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 & Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Measurement & Metrology (will be added from time to time): Digital copy will be available on the JUET server.

REFERENCES:

Text Books:

1. Beckwith Marangoni and Lienhard, Mechanical measurements, Pearson Education, 6th Ed
2. R.K.Jain, Engineering Metrology, Khanna Publishers
3. A K Sawhney, A course in Mechanical Measurements and Instrumentation, J.C Kapur Publishers, 3rd Ed

Reference Books:

1. I.C.Gupta, Engineering Metrology, DhanpatRai Publications, Delhi
2. Ernen O Dobeblein, Measurements Systems, Applications & Design, 5th Ed
3. Alsutko, Jerry. D.Faulk, Industrial Instrumentation, Thompson Asia Pvt. Ltd.
4. R.S. Shirohi& H.C. Radhakrishna, Mechanical Measurements, New Age Intl. Pvt, 3rd Ed

Title: Turbomachinery **Code: ME309**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Thermodynamics" and "Fluid Mechanics"

Objectives:

3. The course aims at giving an overview of different types of turbo-machines used for energy transformation, such as pumps, fans, compressors, hydraulic, steam and gas-turbines.
4. To focus on applications in power generation, transport, refrigeration and the built environment.

Learning Outcomes:

Course Outcome	Description
CO1	Outline typical design and applications of turbomachines
CO2	Describe the working principles of turbomachines and apply it to various types of machines
CO3	Identify the preliminary design of turbomachines (pumps, compressors, turbines) on one dimensional basis
CO4	Use design parameters for characterizing turbomachinery stages
CO5	Explain the limits of safe operation of turbomachines
CO6	Demonstrate the ability to start any turbo machine independently

Course Content:

Unit-1: Introduction: Definition of a Turbomachine; parts of a Turbomachine; Comparison with positive displacement machine; Classification: based on direction of energy conversion, based on principle of operation and based on fluid used.

Unit-2: Energy Transfer and Principles of Similarity and Dimensional Analysis in Rotodynamic Machines: Basic equation of energy transfer in rotodynamic machines (Euler's equation), components of energy transfer, energy transfer in axial and radial flow machines.

Unit-3: Centrifugal Pumps: Definition of terms used in the design of centrifugal pumps like manometric head, suction head, delivery head, pressure rise, manometric efficiency, hydraulic efficiency, volumetric efficiency, overall efficiency, multistage centrifugal pumps, minimum starting speed, slip, priming, cavitations, NPSH.

Unit-4: Axial Flow or Propeller Pumps: Introduction, matching of pump and system characteristics, effect of speed and diameter variation, specific speed calculation.

Unit-5: Reciprocating Pumps: Introduction, analytical expression of accelerating heads during suction and delivery strokes, single acting and double acting piston pumps, multi-cylinder pumps, air vessel and its working principle.

Unit-6: Hydraulic Turbines: Classification; Pelton Turbine-velocity triangles, Design parameters, turbine efficiency, volumetric efficiency; Francis turbine – velocity triangles, runner shapes for different blade speeds, Design of Francis turbine; Function of a Draft tube, types of draft tubes; Kaplan and Propeller turbines – Velocity triangles and design parameters.

Unit-7: Hydraulic Systems: Hydrostatic and hydrodynamic systems, hydraulic coupling and hydraulic torque converter.

Teaching Methodology:

This course is introduced to acquaint the students with working principles of turbomachines and apply it to the various types of machines. The students will be able to recognize and discuss today's and tomorrow's use of turbomachines for enabling a sustainable society. The entire course is divided into seven separate units: Introduction, Energy Transfer and Principles of Similarity and Dimensional Analysis in Rotodynamic Machines, Centrifugal Pumps, Axial Flow or Propeller Pumps, Reciprocating Pumps, Hydraulic Turbines, Hydraulic Systems. These sections have been framed to impart a systematic understanding of the typical designs and main applications of turbomachines.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 and Unit-3
Test-2	25 Marks	Based on Unit-4, Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Engineering Mechanics (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[5] Introduction to Fluid Mechanics and Fluid Machines by S. K. Som, G. Biswas and S. Chakraborty, TMH, 2009.

Reference Books/Material:

[5] Principles of Turbo Machinery by D. G. Shepherd, The Macmillan Company, 1964.

[6] Fundamentals of Turbomachinery by William W Perg, John Wiley & Sons, Inc., 2008.

[7] A Text book of Turbomechanics by M. S. Govindgouda and A. M. Nagaraj, M. M. Publications, 4th Edition, 2008.

[8] Fundamentals of Turbomachinery by B. K. Venkanna, PHI, 2009.

Web References:

- https://nptel.ac.in/courses/101/101/101101058/
- https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-540-internal-flows-in-turbomachines-spring-2006/

Journals References:

- Journal of Turbomachinery, ASME.
- International Journal of Turbomachinery, Propulsion and Power, European Turbomachinery society, MDPI.

Title: Computational Fluid Dynamics **Code: ME310**
L-T-P scheme:3-0-0 **Credit: 3**
Prerequisite: Students must have already studied courses, "Thermodynamics, Heat and Mass transfer" and "Fluid Mechanics".
Objective:

1. To introduce the student to widely used techniques in the numerical solution of fluid equations, issues that arise in the solution of such equations, and modern trends in CFD.

2. To Emphasis will be on 'learning by doing', as students will work on programming projects for assignments.

Course Outcome	**Description**
CO1	Get an induction to Fluid Equations and their properties (Physical and Mathematical)
CO2	Study of Convergence, Stability, Resolution and Accuracy. Grid Generation – General
CO3	Gives knowledge related to Time stepping in CFD
CO4	Students can solve CFD problems using various CFD technique
CO5	Knowledge of different types grid; such as Collocated vs. Staggered grids
CO6	*Understanding of* Compressible flows, Shock handling Visualization and Interpreting

Course Content:
Unit-I: Introduction to Fluid Equations and their properties (Physical and Mathematical) Basics of Discretization – Finite Differences, Finite Volume.
Unit-II: Issues – Convergence, Stability, Resolution and Accuracy. Grid Generation – General transformations and mapping techniques, Adaptive grid refinement.
Unit-III: Time stepping – ADI, Runge-Kutta, the SIMPLE methods.
Unit-IV: Pressure Correction – Solution techniques for the pressure Poisson equation, collocated vs. Staggered grids. Other topics – Compressible flows, Shock handling Visualization and Interpreting results Recent Trends – Parallelization, Multiscale techniques, newer methods (molecular dynamics, Lattice Boltzmann).

Teaching Methodology: This course is introduced to make students familiar with CFD. The entire course is broken down into four separate units: i.e. Introduction, CFD, Issues – Convergence, Stability, Resolution and Accuracy, Pressure Correction technique in CFD.

Learning Resources: Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. Patankar, S., 2018. *Numerical heat transfer and fluid flow*. Taylor & Francis.
2. Anderson, J.D., 2009. Basic philosophy of CFD. In *Computational Fluid Dynamics* (pp. 3-14). Springer, Berlin, Heidelberg.

Reference Book:

1. Grady II, M.L., 2004. CFD analysis of full-scale steam generator inlet plenum mixing during a PWR severe accident.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2& Unit-3
Test-2	25 Marks	Based on Unit-4& Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Title: Operations Research **Code: ME311**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "Mathematics".

OBJECTIVES

The course aims at building capabilities in the students for analyzing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the scope and applications of operations research methods
CO2	Describe the problem formulations in operations research.
CO3	Develop the Operations research model for decision problems.
CO4	Identify the operation research tools useful for industrial problems and key issues in linear programming, sequencing decision problem in industry.
CO5	Apply the tools learned for better material management and efficient utilization of resources in industry
CO6	Demonstrate the problem solving skills in production, project managements and maintenance.

Course Content:

UNIT-I INTRODUCTION – Definition– Characteristics and Phases – Types of models – Operation Research models – applications.

Linear Programming Problem Formulation – Graphical solution – Simplex method – Artificial variables techniques -Two–phase method, Big-M method – Duality Principle.

UNIT-II TRANSPORTATION PROBLEM – Formulation – Optimal solution, unbalanced transportation problem –Degeneracy. Assignment problem – Formulation – Optimal solution - Variants of Assignment Problem

UNIT-III SEQUENCING – Introduction – Flow –Shop sequencing – n jobs through two machines – n jobs through three machines – Job shop sequencing – two jobs through 'm' machines.

THEORY OF GAMES : Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games – dominance principle – m X 2 & 2 X n games -graphical method.

UNIT-IV WAITING LINES: Introduction – Single Channel – Poisson arrivals – exponential service times –with infinite population and finite population models– Multichannel – Poisson arrivals – exponential service times with infinite population single channel Poisson arrivals.

UNIT-V PROJECT PLANNING AND SCHEDULING: Introduction to project planning. PERT/ CPM network components. PERT & CPM analysis. Project schedule with uncertain activity times. Project time-cost trade off.

UNIT-VI INVENTORY CONTROL:
Meaning of inventory Control. Inventory costs. Deterministic inventory models. Static economic order quantity models. Introduction to probabilistic Inventory models.
UNIT-VII REPLACEMENT AND MAINTENANCE MODELS:
Introduction and types of failure. Replacement of item whose efficiency deteriorates with time. Replacement of item that completely fail. Replacement problems.

Teaching Methodology:

This course is introduced to help students to understand the scope of operations research. The entire course is broken down into four major sections: Introduction, linear programming, sequencing and waiting line, Project planning and inventory control, and Replacement And Maintenance. Each section includes numerical problems and methodology to analyze the problem.
The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit -3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

Text Books:

1. Taha. H.A, Operations research: An Introduction, Pearson educ.
2. Sharma J.K., Operations research, Trinity press

References:

1. Schaum's Outline of Operations Research.
2. Kapoor . V.K. , Operations Research (Quantitative Techniques for Management)
3. JainK.C. Industrial Engineering & Operations Research.

Title: Laser Material Processing **Code: ME312**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied conventional material processing courses, "*Manufacturing Technology-I*" and "*Manufacturing Technology-II*".

Objective:

1. To learn about the basic knowledge of the laser beam generation and different types of lasers and their characteristics.
2. To learn the capabilities of laser for different advanced materials processing.
3. To study about the laser micro machining and different laser hybrid machining processes.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various laser material processes based on their mechanisms.
CO2	Describe the industrial applications using LASER as processing tool.
CO3	Develop an idea to process the difficult to process materials using different classes of LASERS.
CO4	Identify the most influencing process parameters to fabricate a defect free product using Electromagnetic radiation.
CO5	Apply most appropriate LASER processing technique to process a product economically.
CO6	Demonstrate and deployment the different laser processing techniques for solving real-world problems.

Course Content:

Unit-1: Introduction: Light and Laser – Historical background, Generation of laser beam, Classification/ Types of lasers, Characteristics and application of lasers. Applications of Lasers in Material Processing, Lasers in Engineering.

Unit-2: Laser Materials Processing: Introduction, classification of laser materials processing methods, Laser beam material Interaction, Temperature distribution during laser heating, melting and vaporization, Melt depth, fractional melt depth, Variation of temperature gradient.

Unit-3: Laser Beam Machining: Process capabilities of laser, Laser beam machining (LBM), Process principle, analysis and applications of laser Drilling, Cutting, Turning, and Milling processes.

Unit-4: Laser Forming: Process principle, analysis and applications of Laser forming processes such as Laser Bending, Mechanism of Laser Bending.

Unit-5: Laser Welding and Surface Treatment: Process principle of Laser Welding, analysis and applications of laser welding, cladding, surface alloying and heat treatment processes

Unit-6: Laser Based Rapid Prototyping: Process principle and analysis of laser based rapid prototyping such as Stereolithography, Selective laser sintering

Unit-7: Laser Assisted Material Processing: Laser assisted machining (LAM), Laser hybrid machining processes, Laser Micromachining, and Latest developments in laser material processing.

Teaching Methodology:

This course is introduced to help students to understand the various material processing techniques using lasers and their applications. The entire course is broken down into seven separate units: Introduction, laser materials processing, laser machining processes, laser forming processes, laser welding and heat treatment processes, rapid prototyping, laser micromachining, and laser assisted processes. Students are motivated to do research work in the area of laser material processing.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures and lecture notes on Laser Material Processing are available on JUET server.

Text Book:

[1] Pandey P. C., Modern Machining Processes, TMH Publication.

[2] Steen W. M., Laser Material Processing, Springer, 2003.

[3] Chryssolouris G., Laser Machining- Theory and Practice (Mechanical Engineering Series), Springer, 1991.

Reference Books/Material:

Luxton J.T., Parker D.E, Industrial lasers and their applications, Prentice Hall, 1987.

Web References:

[1] www.nptel.com

[2] https://nptel.ac.in/courses/112/104/112104028/

Journals References:

[1] Journal of Manufacturing Processes: Elsevier

[2] Materials and Manufacturing Processes: Taylor & Francis

[3] Journal of Materials Processing Technology: Elsevier

[4] Optics and Lasers in Engineering: Elsevier

[5] Optics and Laser Technology: Elsevier

Title: Power Plant Engineering **Code: ME313**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Thermodynamics, Heat transfer, Fluid Mechanics*".

Objective:

1. In this course the student will learn a great depth of how a Thermal, Nuclear and Hydro power plant work.
2. He will learn all the thermodynamic aspects of a thermal power plant along with hands on experience of 660 MW PPS.

Learning Outcomes:

CourseOutcome	Description
CO1	Outline the basic concept of power plant economics based on load.
CO2	Describe the working and all variants of Rankine Cycle
CO3	Develop the design of boiler circuit based on the understanding of plant process
CO4	Apply the knowledge of fluid and thermodynamics to analyze steam turbines
CO5	Demonstrate the ability to handle the basic problems in thermal power plant
CO6	Identify the components of hydro and thermal power plants.

Course Content:

Unit-1:INTRODUCTION Energy resources and their availability, Types of power plants, Selection of the plants. Load curve, Different terms and definitions, Cost of electrical energy, Tariffs methods of electrical energy, Performance & operating characteristics of power plants-incremental rate theory

Unit-2: ANALYSIS OF STEAM CYCLES: Steam power plant, Rankine cycle, Mean temperature of heat addition,effect of variation of steam condition on thermal efficiency of steam power plant, Reheating and Regeneration, geed water heaters, optimum degree of regeneration, supercritical power plant, Deaerator, , Arrangements of combined plants (steam & gas turbine power plants), Re-powering systems with gas production from coal, Using PFBC systems with organic fluids, Parameters affecting thermodynamic efficiency of combined cycles.

Unit-3: FUELS AND COMBUSTION: Coal, coal analysis, Fuel oil, mass and energy balance of steam generator, Draught system, fans, orsat analyzer, combustion reactions.

Unit-4: STEAM GENERATORS Basic types of steam generators, water-tube boilers, economizers, superheaters, reheaters, steam generator control, air preheaters, ESP, Boiler blowdown, evaporators.

Unit-5: STEAM TURBINES Classification, Impulse Turbine- flow through blades, Velocity diagram, Power output and efficiency, Maximum blade efficiency of single stage impulse turbine, Blade friction, Compounding of impulse turbine, Reaction Turbine-flow through impulse reaction blades, Degree of reaction, Velocity diagram, Power output, Efficiency and

blade height, Comparison of impulse and impulse reaction turbines, Losses in steam turbines, Stage efficiency, Overall efficiency and reheat factor, Governing of steam turbines.

Unit-6 : NUCLEAR POWER PLANTS Principles of nuclear energy, Basic nuclear reactions, Nuclear reactors-PWR, BWR, CANDU, Breeder reactors.

Unit-7: HYDRO ELECTRIC POWER PLANT Rainfall and run-off measurements power plants design, Site selection, optimization of hydro thermal mix, Hydrographs, Classification of Hydro Electric power plants, Hydraulic turbines, Comparison with other types of power plants.

Teaching Methodology:

This course is one of the applied course in the Mechanical discipline. The knowledge gained in this course will help the student to understand how a thermal, nuclear, and hydro power plant works. The course is divided into seven units. First five units have to be studied one after the other i.e. no unit should be skipped. Unit-1, 2, 4, and 5 are to be explained in great depth as; these are the most valuable topics in terms of GATE and ESE examinations. After every broader topic an assignment will be given to students which has to submitted in due time. Along with this every week two hours should be devoted to 660 MW simulator which will help the students to understand how a thermal power plant works.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2, and Unit-3
Test-2	25 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 and Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
OTS Lab	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Assignments on Power Plant (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] “Power Plant Engineering”, P. K. Nag, McGraw-Hill Education

Reference Books/Material:

[1]“Power plant engineering”, Black, Veatch, CBS

[2]“Power Plant Technology”, M. M. Wakil, McGraw-Hill Education

Web References:

[1] www.youtube.com/watch?v=iWWyI8CZhUw

[2] ww.youtube.com/watch?v=EahFPHMukxM

Title: Major Project Part-1 **Code: ME217**
L-T-P scheme: 0-0-8 **Credit: 4**
Prerequisite: Students must have already studied the fundamental courses, **"Mechanical Engineering"** and "**Mechanical Engineering Lab**".
Objective:

1. To learn and be able to implement the Mechanical Engineering in different industry.

Course Outcome	Description
CO1	Introduction to practical course requirement under the guidance of a faculty supervisor member to understand the respective design project to do innovative work with the application
CO2	Students are expected to do a literature survey and carry out development and/or experimentation in their respective design projects. Interaction with existing work of current researchers of their respective project work.
CO3	Development of the theoretical model and computational analysis of the existing working design project model.
CO4	Preparation of theoretical analysis for an innovative technique to overcome the current troubles of industrial applications related to their design project work.
CO5	Verification and validation techniques of their respective design project
CO6	Demonstrate deployment and basic maintenance skills of the respective design project.

Course Content:

UNIT-I Identification of Innovative work, based upon Literature survey

UNIT-II student is required doing an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study.

UNIT-III The student is expected to do literature survey and carry out development and/or experimentation.

UNIT-IV Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

UNIT-V *Demonstrate deployment and basic maintenance skills of the* respective design project

Project is a course requirement wherein under the guidance of a faculty member, a final year student is required to do an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study. The student is expected to do literature survey and carry out development and/or experimentation. Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

Exams	Marks	Coverage

P-1	20 Marks		**Based on :** *Literature surveyand Interaction with existing work of current researchers of their respective project work.*
P-2	15 Marks		**Based on:** *Development of the theoretical model and computational analysis of the existing working design project model.*
P3	20 Marks		**Based on:** *Demonstrate deployment and basic maintenance skills of the* respective design project.
Day-to-Day Work	Supervisor Marks [**Day- to-Day Marks**] [Attendance, Performance, Discipline]	35 Marks	**45 Marks**
	Thesis	10 Marks	
Total		**100 Marks**	

Learning Resources: Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

2. **As prescribed by respective project supervisor.**

Title: Finite Element Technique **Code: ME314**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, " *Strength of Materials, Design of Machine Elements and Advanced Mechanics of Solids* ".

Objective:

1. The main objective of this subject is to provide a practical training in engineering design using finite element methods. When components have complex construction, shape, and general boundary conditions (loading and restraint) the designer will often use finite element methods to determine their structural integrity.
2. The first half of the module aims at introducing the fundamental principles of the modeling for statics and dynamics analyses.
3. In the second half of the module the students will be taught how to use the method in practice, to critically assess and evaluate the results.

Learning Outcomes:

Course Outcome	Description
CO1	Outline of this subject is to provide a practical training in engineering design using finite element methods.
CO2	Describe the use of finite element methods to determine their structural integrity when components have complex construction, shape, and general boundary conditions (loading and restraint).
CO3	Develop the fundamental principles of the modeling for statics analysis.
CO4	Identify the important stress analysis technique and how it may be used to design components.
CO5	Apply the finite element methods for small displacement linear elastic analysis, develop good models and interpret the numerical results in design.
CO6	Demonstrate the method in practice, critically assess and evaluate the results.

Course Content:

Unit-1:Fundamental concepts

Introduction, Stresses and equilibrium equations, Boundary conditions, Strain-displacement, Relations, Stress- strain relations, The Rayleigh-Ritz method, Galerkin's method,Application: Axial deformation of bars, Axial spring element, Matrix algebra, Gaussian elimination.

Unit-2: One-dimensional problems

Finite element modeling, Coordinates and a shape functions, Galerkin approach treatment of boundary conditions, Quadratic shape functions, Temperature effects.

Unit-3:Two-dimensional problems

Finite element modeling, Constant strain triangle, Axis symmetric solids subjected to axis symmetric loading, Axis symmetric formulation, Triangular element, Four- node quadrilateral,

Numerical integration stress calculations, High order element, Nine-node quadrilateral, Eight-node quadrilateral, Six-node triangle.

Unit-4: Beams, frames & truss element

Introduction, Finite element formulation, Load vector, Boundary considerations, Shear force and bending moment, Beams on elastic supports, Plane frames. 2D & 3D Truss element.

Unit-5:**Three-dimensional problems**

Introduction, Finite element formulation, Stress calculations, Mesh preparation, hexahedral elements and Higher- order elements, Heat transfer Problem.

Teaching Methodology:

This course is introduced to provide a numerical method for solving problems of engineering and mathematical physics, which include structural analysis, heat transfer analysis, thermal analysis etc. This course is introduced to help students to understand a method which can reduce the degrees of freedom from infinite to finite with the help of discretization or meshing. The entire course is broken down into six units: Fundamental concepts, One-dimensional problems, Two-dimensional problems, Beams, frames & truss element, Three-dimensional problems and Dynamic considerations.

Each section helps a student to gain detail knowledge of the subject to solve different types of engineering problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5& Unit-6 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

[1] Finite Element Analysis by P.Seshu

Reference Books/Material:

[1] Finite Element Method for Engineering by C.V. Girija Vallabhan

[2] The Finite Element Method for Engineers by Kenneth H. Huebner

Web References:

[1] https://nptel.ac.in/courses/112/104/112104116/

[2] https://ocw.mit.edu/resources/res-2-002-finite-element-procedures-for-solids-and-structures-spring-2010/

Journals References:

[1] Finite Elements in Analysis and Design: Elsevier

[2] Computer-Aided Engineering: IET

TITLE: Production Planning and Control **CODE: ME315**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: The students must have knowledge of basic mathematical operations
Objectives:

1. To understand the planning of the production facilities in the best possible manner along with the proper systematic planning of production activities.
2. To learn the Planning of men, machines, materials etc. of right quality, quantity and also providing them at the right time forms a very important factor.
3. To understand, about the difficulties or the various awkward positions expected to crop up later, to the management beforehand.

Course Outcome	Description
CO1	Outline objectives of production planning and control functions in manufacturing and service industry.
CO2	Describe economic order quantity and forecasting methods.
CO3	Develop master production schedule, sequencing and scheduling for engineering products.
CO4	Identify types of inventory and the role of industrial engineer.
CO5	Apply appropriate inventory model and project management techniques.
CO6	Demonstrate capacity planning and line balancing for mass production industry.

COURSE CONTENTS

Unit 1: PRODUCTION PLANNING AND CONTROL- INTRODUCTION

Objective of PPC, Function of PPC, steps in production planning and control. Effectiveness of PPC. Role of Industrial engineer, application of industrial engineering, industrial engineering & production management.

Unit 2: MATERIAL MANAGEMENT AND FORECASTING

Inventory: Function and types of inventory, ABC analysis, EOQ of deterministic inventory model (single item). Forecasting: Simple moving average method, weighted moving average, simple exponential smoothing method, break even analysis.

Unit 3: PLANNING ACTIVITIES

Aggregate planning, Master production schedule (MPS), Material requirement planning (MRP), MRP-II, Enterprise resource planning (ERP), Facility Layout (Plant Layout), Productivity &

types of productivity.

Unit 4: CONTROL ACTIVITIES
Capacity Planning, Assembly line Balancing, Sequencing, scheduling, dispatching. Production system &Types of production system, Just in Time (JIT) in production system, Introduction and object of value engineering.

Unit 5: PROJECT MANAGEMENT
Gantt chart, CPM and PERT, basic difference between CPM and PERT, Terminology in project management, Phase of project management

Unit 6:QUEUING THEORY
Introduction, Structure of queuing system, characteristic of queuing system, performance measure of queuing system

Teaching Methodology:
The student will learn to do forecasting, inventory management, apply project management, scheduling techniques, line balancing techniques, and solve the queuing problems. The course will help him understand his job in industry and job of an Industrial Engineer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and 2,
Test-2	25 Marks	Based on Unit-3 & 4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 &6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text Books: 1. Industrial Engineering and Management by Dr. Ravi Shankar
2. Operation Research by J K Sharma

References: 1. Production Planning and control by Seetharama L. Narasimhan Dennis W. McLeavey

TITLE: Additive Manufacturing **CODE: ME316**

L-T-P scheme: 3-0-0 **CREDITS: 3**

Objectives:

4. The objective of the course is to make the students aware about the additive manufacturing (AM) technology used for conceptual modeling, prototyping and rapid manufacturing.
5. Students will know about wide range of materials and applications of AM in industry and society.
6. Students will also know about file formats, rapid tooling and metal additive manufacturing processes.

Learning Outcome:

Course Outcome	Description
CO1	Outline the additive manufacturing process. Introduction, definition, Process chain, Strength and weakness of AM compared to conventional subtractive manufacturing processes.
CO2	Describe the working procedure of various AM processes. Classification and detail descriptions of various rapid prototyping and rapid tooling processes.
CO3	Develop understanding to differentiate rapid prototyping from rapid manufacturing, rapid manufacturing processes and various file formats.
CO4	Identify the strength and limitations of various file formats, errors and repair of files. AM process to be used for a particular application in industry.
CO5	Apply acquired knowledge in new product development and mass customization of products in various industries such as automobile, aerospace, medical, construction, fashion, electronics etc.
CO6	Demonstrate skill to build AM part by preparing CAD model, pre processing, part building and post processing the part.

COURSE CONTENT

INTRODUCTION: Overview, history, concept, definition and process chain of additive manufacturing.

CLASSIFICATION: Liquid based, solid based, and powder based AM processes; Fused Deposition Modeling of polymers, ceramics and metals, Laminated Object Manufacturing , Shape Deposition Manufacturing, Stereolithography and other liquid based systems, Laser sintering based technologies and their related details, 3D printing, Direct Metal Deposition, laser and Electron Beam melting based technologies.

DATA EXCHANGE FORMATS: Data formats for AM and associated details, Data conversion for AM and associated difficulties, Data validity checks for AM, Data repair procedures for AM, Slicing algorithms and related details, Direct slicing, Standard data formats for translation, Relevant AM file formats, STEP data format and its details.

APPLICATIONS: Applications of AM in different industries

RAPID TOOLING: Direct and indirect tooling processes.

RAPID MANUFACTURING: Different applications of AM for directly making end-use parts; Medical RP- dental, hearing aid, medical devices, bone-transplant, surgical planning and tissue engineering; Mass customization – production of customized products in mass scale.
REVERSE ENGINEERING: Definition of Reverse Engineering (RE), Need for RE, Three phases in the generic RE process – scanning (contact and non-contact scanners), point processing and geometric modeling.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4 and around 30% from coverage Test-1
Test-3	35 Marks	Based on Unit-5, Unit-6, Unit-7 and around 30% from covera of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

TEXT BOOK:

1. Chua, C K, Leong, K F and Lim CS, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2003.
2. Gibson, I., Rosen, D.W. and Stucker, B., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, 2010.

REFERENCES:

1. Hopkinson, N, Hague, R, and Dickens, P, Rapid Manufacturing: An Industrial Revolution for a Digital Age: An Industrial Revolution for the Digital Age, Wiley, Jan 2006.
2. Raja, V. and Fernandes K.J., Reverse Engineering – An Industrial Perspective, Springer-Verlag London Ltd, 2008.
3. Kamrani, A.K. and Nasr, E.A., Rapid Prototyping – Theory and Practice, Springer Science and Business Media Inc., New York, NY 10013, USA, 2006.
4. Bartolo, P J (editor), Virtual and Rapid Manufacturing: Advanced Research in Virtual and Rapid Prototyping, Taylor and Francis, 2007.
5. Cooper K. G., Rapid Prototyping Technology: Selection and Application, CRC Press.

Title: Statistical Quality Control **Code: ME317**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Basics of statistics and production

Objective:

1. To establish the desired quality standards which are acceptable to the customers?
2. To discover flaws or variations in the raw materials and the manufacturing processes in order to ensure smooth and uninterrupted production.
3. To evaluate the methods and processes of production and suggest further improvements in their functioning.
4. To study and determine the extent of quality deviation in a product during the manufacturing process.
5. To analyze in detail the causes responsible for such deviation.
6. To undertake such steps which are helpful in achieving the desired quality of the product?

Learning Outcomes:

CO1	Outline of statistical methods such as distributions, control charts, process and measurement system, design of experiments and optimization.
CO2	Describe various statistical methods used to understand the quality control of a production process.
CO3	Develop the knowledge of online and offline quality control of a production process. Able to construct the control charts
CO4	Able to do capability analysis of process.
CO5	Able to analyze the design of experiments and understanding of different types of design of experiments methods.
CO6	Demonstrate the skill of statistic for various processes and able to apply the acceptance sampling.

Course Content

Unit 1:

Quality Improvement in the Modern Business Environment: Meaning of quality, quality improvement, Japanese contribution to world class manufacturing, managing for quality. Quality cost, legal aspect of quality.

Statistical Methods Useful in Quality Improvement: Describing variation, discrete and random distributions, probability plots, statistics and sampling distributions, statistical inference of a single sample and two samples, hypothesis testing

Unit 2:

Methods and Philosophy of Statistical Process Control: A statistical basic of control chart, control charts for variables, control charts for attributes .

Process and Measurement System Capability Analysis: Process capability analysis using histogram or a probability plot, using control chart, using designed experiments with attribute data, setting specification limits, estimating natural tolerance limits

Unit 3:

Process Design and Improvements with Designed Experiments: Experimental design, 2k factorial design, response surface methods and design

Acceptance Sampling: The acceptance sampling problem, Single sampling, double sampling, multiple sampling, sequential sampling, AOQL, LTPD, chain sampling.

Teaching Methodology:

First the basic concept of quality is to be discussed followed by introduction to statistical terminologies. Different variety of distributions under the category of discrete and continuous distribution will be discussed. Along with different probability plots will be discussed to analyze the process. Then the concept of sampling distribution is to be discussed. After that the inference will be discussed. Then after different tools used for quality checking will be discussed including control charts. Then the design and implication of control charts will be discussed for manufacturing, production and service industries. Quality can be controlled before running the process and looking to the control chart by using design of experiments and optimization of the process through optimizing the experiment. Hence different design of experiments will be discussed. Along with DOE, ANOVA and linear regression models will be developed to characterize the process.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit 1
Test-2	25 Marks	Based on Unit 2 and Unit 1 (20%)
Test-3	35 Marks	Based on Unit 3, Unit 2 (15%) and Unit 1 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Learning resources at library, book, and journals.

Text Book:

1. Statistical quality control by *Douglas C. Montgomery*
2. Production and operation management by Everett E. Adam,

References Books/Materials:

1. Quality Management: A Process Improvement Approach by *Mark Fryman*

2. Quality Management by *O.N. Pandey, Bhupesh Ahuja*
3. Industrial Engineering and Management by *Dr. Ravi Shankar*

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. Journal of Quality Technology
2. International Journal of Production Research

Title: Gas Turbine and Jet Propulsion **Code: ME318**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Thermodynamics, Heat transfer, Fluid Mechanics*".

Objective:

3. In this course the student will learn fundamentals and operation of Rockets, ramjets, turbojets, turbofans, turboprops, and piston propeller engines.
4. The will focus on applications thermodynamic and fluid mechanics principles to the aircraft jet-propulsion system.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the control volume analysis and the integral momentum equation to estimate the forces produced by aerospace propulsion systems
CO2	Describe to describe the principal design parameters and constraints that set the performance of gas turbine engines and to apply ideal-cycle analysis to a gas turbine engine to relate thrust and fuel burn to component-level performance parameters and flight conditions.
CO3	Develop the aerodynamic and propulsion system performance and to estimate the power required for flight, the range, the endurance, and the time-to-climb for an aircraft.
CO4	Apply the knowledge of heat transfer to describe the principal figures of merit for aircraft engine and rocket motor performance and explain how they are related to vehicle performance.
CO5	Demonstrate the ability to handle the calculations based on mass fractions, and propulsion system performance and to be able to estimate the range and velocity of single-stage rockets.
CO6	Identify and discuss the energy exchange processes that underlie the workings of multistage compressor or turbine, and to be able to use velocity triangles and the Euler Turbine Equation to estimate the performance of a compressor or turbine stage.

Course Content:

Unit-1:INTRODUCTION Classification, Application. Gas turbine and its components, Gas turbine power plants. Optimum pressure ratio for maximum specific and thermal efficiency in actual gas turbine cycle, Effect of operating variables on thermal efficiency, Air rate and work ratio.

Unit-2: COMBUSTION CHAMBER DESIGN Basic equation of energy transfer in rotodynamic machines(Eulers equation), components of energy transfer, energy transfer in axial and radial flow machines.
Unit-3: CENTRIFUGAL COMPRESSORS Prewhirling, Adiabatic efficiency, Performance characteristics, Pressure coefficient and slip factor, Losses, surging, Compressor design calculations, Mach number.
Unit-4: AXIAL FLOW COMPRESSORS Principles of operation, Simple design method, Blade design, calculation of stage, Overall performance, Compressor characteristics, Mach number, Reynolds Number.
Unit-5: JET PROPULSION Turbo jet, Turbo Prop, Ram jet, Rocket engines thrust power, propulsive efficiency and thermal efficiency, Jet propulsion performance, Specifying thrust and specific fuel consumption in each case for turbo jet and turbo propulsion units.

Teaching Methodology: This course is one of the applied course in the Mechanical discipline. The knowledge gained in this course will help the student to understand how rocket and aircraft engine works. The course is divided into five units. First two units have to be studied one after the other i.e. no unit should be skipped. Unit-3 and 4 are to be explained in great depth as; these are the most valuable topics in terms of GATE and ESE examinations. After every broader topic an assignment will be given to students which has to submitted in due time.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 andUnit-2
Test-2	25 Marks	Based on Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage of Test-2
Assignment	15 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources: Assignments on Gas Turbine and Jet Propulsion (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] "**Gas Turbine Theory**", H. I. H. Saravanamuttoo, Gordon Frederick Crichton Rogers, Henry Cohen, Wiley,

Reference Books/Material:

1. **"Gas Turbine", V. Ganesh,** Tata McGraw-Hill Education
2. **"Introduction to fluid mechanics and fluid machines",** S. K. Som, G. Biswas, McGraw-HillEducation

Web References:

[1]https://www.youtube.com/watch?v=JxZHlCEdoyg&list=PLwdnzlV3ogoWEYkr5o3OD4cv5v7ba10Lm

Title: Introduction to Design of Experiments **Code: MME319**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Higher Engineering Mathematics (*Probability and Statistics)"*.

Objective:

1. To learn and be able to use the designed matrices for experimentation.
2. To develop the abilities to create a functional relationship between input and output parameters.

Learning Outcomes:

Course Outcome	Description
CO1	Get familiar with various Design of Experiments techniques.
CO2	Have a good foundation of Design of Experiments and analysis methods like response surface methodology, Factorial design.
CO3	Possess demonstrative skills in using statistical software (Minitab, Design expert, and R).
CO4	Identify the influencing parameters of the process using analysis of experiments
CO5	Apply analysis of variance (ANOVA) to obtain the significant variables in the process
CO6	Work as a team on a project.

Course Content:

Unit-1:Basic concepts, fundamentals of experimental design, selection of an appropriate design, criteria for evaluation, factors and levels, importance of optimized design, single factor experiments, introduction to one parameter at a time study.
Unit-2: Factorial design, introduction to factorial design, types of factorial design, two way analysis of variance, fixed, random and mixed models, expected mean square rules.
Unit-3: Response surface methodology (RSM), central composite designs (CCD), central composite rotary design (CCRD), number of experiments required in RSM, Box-Behnken design, the method of steepest ascent, response surface designs, statistical regression techniques, fitting of regression models.
Unit-4: Robust parameter design, steps in designing performance in to a product, Taguchi's definition of quality, loss functions in quality, orthogonal arrays, graphic evaluations of main effects, selecting factors for Taguchi experiments, concept of s/n ratios – its significance in robust design.
Unit-5: Analysis of variance (ANOVA)- significance of parameters

Unit-6: Applications of RSM in engineering, case studies of S/N ratios in optimization, identifying control and noise factors, applications of robust parameter design methodology.

Teaching Methodology:

This course is introduced to help students for designing the experiments in scientific way so that they can save the time, money and materials while conducting the experiments. The methods of experiments help them to build an empirical model to predict the process behavior.

The entire course is broken down into six separate units: introductory or fundamentals of design of experiments, factorial design, response surface methodology, Taguchi method, analysis of variance, and the applications of techniques.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Design of Experiments (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

3. D. C. Montgomery, "Design and Analysis of Experiments", D. C. Montgomery, John Wiley & Sons.
4. "Quality Engineering using robust design", M. S. Phadke, Prentice-Hall.
5. "Taguchi Techniques for quality engineering", P. J. Ross, McGraw-Hill.

Reference Books/Material:

[1] "Fundamental concepts in design of experiments", C. R. Hicks, Holt, Rinehort and Winston.

[2] “Methods Explained: Practical steps to Robust Design”, T. P. Bagchi, Prentice-Hall.
[3] “Experimental Designs”, W.G. Cochran, and G.M. Cox, Asia Publishing House

Web References:

- https://nptel.ac.in/courses/110/105/110105087/
- https://nptel.ac.in/courses/102/106/102106051/

Journals References:

- Journal of Materials Processing Technology
- Materials and Manufacturing Processes

Title: Production and Operation Management **Code: ME320**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "mathematics".

Objective:

The objectives of the course are to produce graduates who are able to:

1. manage and plan various activities related to plant design, manufacturing as well as carrying out new projects
2. be a part of multidisciplinary teams to identify, formulate, and solve engineering problems.

Learning Outcomes:

Industrial Engineering	
Course Outcome	**Description**
CO1	Outline various role and scope of production and operation management in industry
CO2	Describe the concept of forecasting, planning and control of various manufacturing activities
CO3	Develop the understanding of Inventory, its control and management in industries
CO4	Identify scope of applying project mgmt techniques and improvement in productivity of the production system
CO5	Apply various techniques, like forecasting, capacity planning, MRp, project evaluation etc. in production industry.
CO6	Demonstrate problem solving skill for overall improvement and productivity enhancement.

Course Content:

UNIT-1 INTRODUCTION
Introduction to production and operation management, types of production and production system, scope of production management, plant layout, organization structure, types of decisions in organization, product life cycle, horizontal and vertical integration, value engineering and value analysis. Cost concept and break even analysis.
UNIT –II DEMAND FORECASTING
Prediction v/s forecasting, need of forecasting, long term and short term forecasting, classification of forecasting methods and numerical based on them.
UNIT III PRODUCTION PLANNING
Need and objectives of production planning, capacity planning, aggregate planning, MRP, CRP, MRP-II, process planning

UNIT –IV PRODUCTION CONTROL
Introduction, Loading, assignment, sequencing and scheduling and numerical based on them, line balancing and line of balance.
UNIT V-INVENTORY CONTROL
meaning and need for inventory, types of inventory, inventory management techniques, cost associated with inventory, simple inventory models. UNIT-VI PROJECT MANAGEMENT
Introduction, importance of project planning, concept of network and its analysis, CPM and PERT and their comparison, time-cost trade off (network crashing), Numericals.

Teaching Methodology:

This course is introduced to help students to understand the management and engineering decision issues in production industry. The entire course is broken down into four major sections: Scope and definitions, Fundamental of productivity, Tools and methodology and organizational structures.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit -2
Test-2	25 Marks	Based on, Unit-3, Unit -4 and Unit -5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit- 6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

Text book

7. S N Cherry, Production and Operation Management,Tata McGraw Hill
8. S. Panneerselvam, Production and Operation Management,PHI Learning Pvt. Ltd.

Reference

9. Elwood Buffa and Sarin, Modern production/ operations management, Wiely Publication

Title: Fracture Mechanics **Code: ME321**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of material and Material science*".

Objective:

4. The objective of this course is to introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design to develop the ability in students to compute the stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and non linear materials.
5. It will also expand the students' knowledge on experimental methods to determine the fracture toughness and develop the students understanding on the design principle of materials and structures using fracture mechanics approaches.

Learning Outcomes:

Course Outcome	Description
CO1	Identify and describe the basic fracture and fatigue mechanisms. Correctly apply fracture mechanics to predict brittle fracture.
CO2	Understand crack resistance and energy release rate for crack criticality.
CO3	Application of Linear Elastic Fracture Mechanics on brittle materials.
CO4	Identify the plane stress and plane strain conditions based on the shape and size of plastic zones.
CO5	Correctly identify the cause of failure of a material based on fracture surface observations.
CO6	Understand the relationship between crack tip opening displacement, SIF and ERR and application of such parameters for ductile and brittle materials.

Course Content:

Unit-1: Introduction to Fracture Mechanics

Stress-Strain Curve, Elements of dislocation theory, Historical perspective, Stress Concentration effect of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Cleavage, Brittle and Ductile fracture, ductile brittle transition, modes of fracture failure, Fatigue and stress corrosion cack growth, Damage tolerance.

Unit-2: Linear Elastic Fracture Mechanics

An atomic view of fracture, Griffith Energy Balance, Energy release rate, instability and the R Curves, compliance, tearing modulus, Stress and Displacement field in isotropic elastic materials, Airy stress function, Westergard approach for different modes of fracture, Stress analysis of crack, Stress intensity factor (SIF), relation between K and global behaviour, Effect of finite size.

Unit-3: Elastic-Plastic Fracture Mechanics

Crack tip deformation and plastic zone size, plane stress vs plane strain, effective crack length, Irwin plastic zone correction, Dugdale approach, effect of plate thickness

J Contour Integral: Relevance and scope, J as a path-independent line integral, J as a stress intensity parameter, Stress-Strain relations, J-Controlled fracture, Laboratory measurement of J, Crack Tip Opening Displacement (CTOD), Relationship between CTOD, K and G, Equivalence between CTOD and J, Determination CTOD from strip yield model, HRR Singularity

Unit-4: Fatigue Fracture

Introduction to fatigue, factors affecting fatigue performance, fatigue loading, constant and variable amplitude loading, some characteristics of fatigue crack, Paris Law

Unit-5: **Experimental and Finite Element Estimates of Fracture Mechanics**

Experimental determination of J-Integral, Critical Stress intensity factor and CTOD, Photoelasticity techniques, strain gage measurements, Fatigue crack initiation and propagation testingPreprocessing in Finite Element Method, Element selection and meshing of crack, Load application, constraints, preprocessing checks, processing the model, post-processing

Teaching Methodology:

Fracture Mechanics is a challenging subject containing a series of new concepts, theories and solution methods, which are linked like a chain. Since the subject is concept and theory intensive, the most effective way to understand the new concepts and theories is to attend the lectures. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

Anderson T.L., Fracture Mechanics Fundamentals and Applications, CRC Press, Second edition, 1994

Janssen, M., Zuidema, J., Wanhill, R. Fracture Mechanics. Spon Press.

Reference Books/Material:

1. Kumar Prashant, Elements of Fracture Mechanics, Wheelers Publishing Co. Ltd India, Second edition, 2010

Web References:

- https://www.fracturemechanics.org/
- https://nptel.ac.in/courses/112106065

Journals References:
https://www.sciencedirect.com/topics/materials-science/fracture-mechanics

Title: Smart Manufacturing **Code: ME322**
L-T-P scheme: 3-0-0 **Credit: 3**

CO-PO to be added

Unit 1: Introduction- Computer Integrated Manufacturing (CIM) Systems, Structure and functional areas of CIM system, advantages and disadvantages of CIM, differences between smart and conventional manufacturing, requirements of smart manufacturing.

(6)

Unit 2: Advanced manufacturing technologies: additive, subtractive and forming processes.

(8)

Unit 3: Basic Concepts of embedded systems and microprocessors, electrical drives and controls, introduction to sensors, digital control and drive applications.

(10)

Unit 4: Smart manufacturing tools- design and development of jigs and fixtures, automated material transfer systems and guided vehicles, flexible manufacturing systems.

(8)

Unit 5: Machine Learning – concept, artificial neural networks, applications in manufacturing; use of probability and fuzzy logic for machine thinking, examples in manufacturing systems.

(10)

Reference Books:

1. Vijay. K. Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd., 2004.
2. G.F. Benedict, Nontraditional Manufacturing Processes, Marcel Dekker Inc. , 2019
3. A. Nagoor Kani, Microprocessors and Microcontrollers 2nd Edison – McGraw-Hill Companies, 2015.
4. S. Kalpakjian, Manufacturing Engineering and Technology (SI Edition) Pearson Education 2016.
5. M.P. Groover, Automation, Production Systems and CIM, Prentice-Hall, New Delhi, 2009.
6. T., Mitchell, Machine Learning, Mc-Graw Hill, 2012.

Title: Composite Materials **Code: ME323**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Material Science*" and "*Manufacturing Technology*".

Objective:

1. To explain the fundamental concepts of mechanical behavior of composite materials.
2. To explore the applications of composite materials in modern manufacturing industries.

Learning Outcome:

Course Outcome	Description
CO1	Outline various types of composite materials.
CO2	Describe the fabrication and applications of composite materials.
CO3	Develop an idea to fabricate the advanced composite material using the concept of sustainable manufacturing.
CO4	Identify the most influencing process parameters to fabricate the composites.
CO5	Apply most appropriate processing technique to fabricate the polymer matrix composites.
CO6	Demonstrate the applications of composite materials in real-world.

Course Content:

Unit-1: General introduction and concept, Historical development, Concept of composite materials, Material properties of a composite material & engineering potential, Basic definition, and Advantages of composites materials.

Unit-2: Types of Reinforcements/Fibers, Matrix materials. Classification based on matrix material: Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC)

Unit-3: Carbon matrix composites or Carbon-Carbon Composites, Classification based on reinforcements: Fiber reinforced composites; Fiber reinforced polymer (FRP) composites, laminar composites, and Particulate composites.

Unit-4: Mechanics of composites: Fiber–Matrix Interactions in a Unidirectional Lamina, Tensile Testing, Characteristics of a Fiber-Reinforced Lamina

Unit-5: Elastic Properties of a Lamina, Stress–Strain Relationships for a Thin Lamina, Compliance and Stiffness Matrices, Laminated Structure

Unit-6: Fabrication of polymer, metal and ceramic matrices composites, application of important composite materials such as Metal matrix, Ceramic matrix, and Polymer matrix in various fields of engineering.

Unit-7: Performance of composites: static mechanical properties- tensile, compressive, and flexural properties, fatigue properties and other properties.

Teaching Methodology:

This course is introduced to help students to understand the various types of composite materials and their applications. The entire course is broken down into six separate units: Introduction to composites, Future aircraft structure and polymer based composite applications, processing of fibers and fabrication of composites, Mechanical properties of composites, Multifunctional polymer based structures, and developments in Characterizing the Structural Behavior of Composites in Fire.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4, Unit 5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 & Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures on Processing of non-metals are available on JUET server.

TEXT BOOKS-

1. Mallick P. K., Fiber reinforced composites: Materials, manufacturing and design, CRC press, 2007
2. Hull, D. and Clyne, T.W., Introduction to composite materials, Cambridge University press, 1996.
3. Kaw.A. K, Mechanics of Composite materials, CRC Press (Taylor & Francis), 2006.

REFERENCE BOOKS-

1. Bunsell, A, R. and Renard, J., Fundamentals of fiber reinforced composite materials, Institute of Physics Pub, 2005.
2. Gibson, Ronald F**., Principles of composite material mechanics,** CRC Press (Taylor & Francis Group), 2012.
3. Luigi Nicolais., Eva Milella, Michele Meo, Composite materials – A vision for future, Springer, 2011.

Web References:

[1] www.nptel.com

[2] https://nptel.ac.in/courses/112/104/112104229/

Journals References:

[1] Journal of Manufacturing Processes: Elsevier

[2] Materials and Manufacturing Processes: Taylor & Francis

[3] Journal of Materials Processing Technology: Elsevier

[4] Composite Part A: Elsevier

[5] Composite Part B: Elsevier

Title: Vibration And Noise Control **Code: ME324**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Engineering Mechanics", "Strength of Materials" and "Theory of Machines"

Objective:

1. To enable the students to apply their knowledge of mathematics, science, and engineering into the analysis of vibrations of machine structures
2. To understand the degrees of freedom in vibration
3. To represent the vibration as vector and understand the phenomenon of resonance

Learning Outcomes:

Course Outcome	***Description***
CO1	*Outline the various laws of vibration in machines*
CO2	*Describe the various degrees of freedom in vibration*
CO3	*Develop the equations of free and forced vibrations in systems*
CO4	*Identify and use various methods for analyzing the dynamical vibrations in machines and structures*
CO5	*Apply concepts of vibration to devise methods of industrial noise control*
CO6	*Demonstrate and deployment basic knowledge of vibration for solving real-world problems*

Course Content:

Unit-1: Introduction: Periodical motion, harmonic motion, vector method of representing vibrations, displacement, velocity and acceleration in harmonic motion, work done in harmonic motion, superposition of simple harmonic motion, beat phenomenon, non harmonic periodic motions. system having single degree of freedom, free vibration of systems without damping, equilibrium and energy method for determining natural frequency, Rayleigh's method, equivalent systems, free vibration of systems with viscous, coulomb and structural damping.

Unit-2: Electrical Analogies: Electric circuit principles, equivalent circuits.

Unit-3: Damping: Forced vibrations of systems with and without damping (viscous and coulomb), Method of complex algebra, equivalent viscous damping, impressed force due to unbalance, inadmissibility, support motion, Vibration isolation, commercial isolators.

Unit-4: Degrees of Freedom and Critical Speed: System with two-degree of freedom: Normal mode vibrations, Torsional systems, Coupled vibrations, General solution in terms of normal mode, vehicle suspension, Undamped dynamic vibration absorber, Centrifugal absorber, friction damper. Whirling of shafts : Whirling of light flexible shaft with an

unbalance disk at the centre of its length with and without damping, discussion of the speeds above and below the critical speed, uniform shaft with and without unbalanced masses attached along its length (by Rayleigh Method) for simply supported and fixed ends.

Unit-5:Noise Control: Noise Control : Noise and its causes, sound pressure / intensity / power level and their interrelation, Decibel scale, Loudness and equal loudness contours, Effect of machine / process noise on operators, employees and local residents. Standards of noise level and exposure limits. Methods of industrial noise control.

Unit-6:Vibration and Noise Measurement: Principle of frequency, amplitude, velocity and acceleration measuring instruments, frequency response plots, phase shift plots, analysis of vibration records. Sound spectra and octave band analysis. Background noises, weighted networks, measurement of noise.

Teaching Methodology:

This course is introduced to help students in applying their knowledge of Engineering Mechanics, Strength of Materials and Theory of Machines in order to explore the vast area of Mechanical Vibration by framing the solution of open ended problems. The entire course is divided into six separate units: Introduction, Electrical Analogies, Damping, Degrees of Freedom and Critical Speed, Noise Control, Vibration and Noise Measurement. These sections have been framed to impart a systematic understanding of the basic laws of vibration and finally implement these laws to solve the real-world problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5, Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Vibration and Noise Control (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Mechanical Vibrations by G. K. Grover, Nem Chand & Brothers, 2009.
[2] Mechanical Vibrations by Singiresu S. Rao, Pearson; 5th Edition, 2010.

Reference Books:

[1] Mechanical Vibrations Theory And Applications by TseMorse & Hinkle, CBS Publication, 2004
[2] Theory of Vibrations with Applications by William T. Thomson and Marie Dillon Dahleh, 5th Edition, Pearson, 1997.

Web References:

- https://nptel.ac.in/courses/112103112/
- https://online.stanford.edu/courses/aa242b-mechanical-vibrations
- https://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/mechanical-vibration/
- https://www.udemy.com/course/complete-mechanical-vibration-online-course-rahme301-rahsoft/

Journals References:

- Journal of Vibration and Acoustics, ASME
- Journal of Sound and Vibration, Elsevier
- Journal of Vibration and Control, Sage
- Shock and Vibration, Hindawi
- Journal of Vibration Engineering & Technologies, Springer
- Journal of Vibroengineering. JVE Journals

TITLE: Automobile Engineering **CODE : ME325**
L-T-P SCHEME: 3-0-0 **CREDITS: 3**

Prerequisite: Student must have already studied courses, "Internal combustion engines, Manufacturing process, Machine design, Kinematic of machine and Dynamics of machine".

Objective:

6. To make aware of the basics of automobile history & its development and Bharat stage requirement in India.
7. To make aware of the role of the automobile in national growth.
8. To learn the construction and assembly of chassis of LTV, MTV and HTV.
9. To learn about the features of the auxiliaries associated with sprung and unsprung.
10. To make able to understand the basics of the drive train of the automobile.

Learning Outcomes:

AUTOMOBILE ENGINEERING	
Course Outcome	**Description**
CO1	To **describe** the requirement of the automobile body, drive systems, and safety consideration of the automobile.
CO2	**Outline** clutch mechanisms and mechanical and hydraulic power transmission systems.
CO3	To **develop** a skill for utilization of the drive lines, universal joint, differential, and drive axles.
CO4	To **demonstrate** the requirement and utilization of suspension and steering system for an automobile.
CO5	To **demonstrate** knowledge of automotive brakes, tyres & wheels.
CO6	To **describe** different methods for emission control and automotive electrical.

Course Content:

Unit-1: Introduction: Classification, Components, Requirements of automobile body, Vehicle frame, Separate body & frame, Unitised body, Front engine rear drive & Front engine four-wheel drive vehicles, Safety considerations.

Unit-2: Clutches: Principle of Clutches: Friction, Cone, Single Plate, Diaphragm Spring, Multi-plate, Centrifugal, Electromagnetic, Overrunning of Clutches, Clutch linkages.

Unit-3: Power Transmission: Requirements of the transmission system, General arrangement of the power transmission system, Gearbox, Different types of gearboxes, Epi-cyclic gearbox, Flywheel unit, Overdrive unit-principle of overdrive, Advantage of overdrive, Transaxle, Transfer cases.

Unit-4: Drive Lines, Universal Joint, Differential and Drive Axles: Effect of driving thrust and torque reactions, Hotchkiss drive, Torque tube drive and radius rods, Propeller shaft, Universal joints, Slip joint, Constant velocity universal joints, Construction & operation of differential, Rear axles, Types of load coming on rear axles, Full floating, Three quarter floating and semi-floating rear axles.

Unit-5: Suspension & Steering Systems: Need of suspension system, Types of suspension, Factors influencing ride comfort, Suspension spring, Constructional details and characteristics of leaf springs, Front wheel geometry & wheel alignment, Different types of steering gearboxes, Steering linkages and layout, Power steering.
Unit-6: Automotive Brakes, Tyres & Wheels: Classification of brakes, Principle and constructional details of drum brakes, Disc brakes, Brake actuating systems, Factors affecting brake performance, Power & power-assisted brakes, Antilock and Sensotronic Brakes. Tyres of wheels, Types of tyre & their constructional details, Wheel balancing, Tyre rotation, Types of tyre wear & their causes.
Unit-7: Automotive Electrical: Construction & operation of lead-acid battery, Capacity, rating & maintenance of batteries, Purpose and operation of charging systems, Purpose, and operations of the starting system, Vehicle lighting system.

Teaching Methodology:
This is introduced to make the student capable of utilizing skills developed as an outcome from their above-mentioned pre-requisite subjects, various constructional parameters of the child parts and their requirement. Course contain deals within this automobile engineering subject is catergroiesed in seven different units (viz. Introduction, clutches, power transmission, drive lines, universal joint, differential and drive axles, suspension & steering systems, brakes, tyres & wheels, and electrical system). A well equipped advance laboratory of automobile engineering will helps student to understand and gives hands on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides of an automobile engineering subject (will be added from time to time): Digital copy will be available on the JUET server.
Text Books

1. Automobile Nomenclature: Including Names of Car Parts and Items of Terminology-by Society Of Automotive Engineers
2. Automobile Engineering Vol 1- by Singh K.
3. Automobile Engineering Vol 2- by Singh K.

Reference Books/Material:

1. Engineering Materials Being A Thoroughly Revised Edition Of Aircraft And Automobile Materials - Ferrous - Vol. 1: 1- by Arthur William Judge
2. Engineering Materials Being A Thoroughly Revised Edition Of Aircraft And Automobile Materials - Ferrous - Vol. 2: 1- by Arthur William Judge

Web References:

4. https://www.saeindia.org
5. http://www.oica.net
6. https://uia.org

Journals References:

7. https://www.sciencedirect.com/journal/transportation-research-part-a-policy-and-practice
8. https://www.sciencedirect.com/journal/journal-of-cleaner-production
9. https://www.sciencedirect.com/journal/advances-in-engineering-software
10. https://www.sciencedirect.com/journal/materials-today-proceedings
11. https://www.sciencedirect.com/journal/travel-behaviour-and-society
12. https://www.sciencedirect.com/journal/neurocomputing

Title: Bio-fluid Mechanics **Code: ME326**
L-T-P scheme: 3-0-0 **Credit: 3**

OBJECTIVES:
• To characteristicsvarious fluids, such as Newtonian and Non-Newtonian fluids.
• To study the impact of pressure and flow patterns in blood vessels.
• To apply this understanding in studying various important systems, such as cardiac system.

Course Outcome	Description
CO1	Outline scope of bio-fluid mechanics as a very important extension of classical fluid dynamics.
CO2	To understand the anatomy and physiology of the systems under consideration.
CO3	To analyze fluid mechanics based models, currently being used for clinical applications.
CO4	To integrate engineering fluid dynamics based concepts to understand and model flow of biological fluids in human body.
CO5	To identify specific organs and corresponding diseases and how they are related to fluid dynamics.
CO6	Apply mathematical modeling approach to carry out a biofluid dynamics design project.

Course Contents:
Introduction: Introduction to fluid mechanics, and human physiology in relation to heart, lungs and blood vessels.
Cardiovascular structure and function: Electro-cardiogram, heartvalves, cardiac cycles, heart sounds, coronary circulation, microcirculation, lymphatic circulation.Pulmonary Anatomy.
Pulmonary physiology and Respiration: Respiratory system, alveolar ventilation, mechanics of breathing, air way resistance, gas exchange and transport, pulmonary pathophysiology, respiration in extreme environment.
Hematology and Blood Rheology: Elements of blood, blood characteristics, viscosity measurement, erythrocytes, leukocytes; blood types, plasma.
Anatomy and Physiology of Blood vessels: General structure &types of arteries, mechanics of arterial walls, compliance, vascular pathologies, stents, coronary artery bypass grafting.
Mechanics of Heart Valves: Aortic and pulmonic valves; Mitral andTricuspid valves; Pressure gradients across a stenotic heart valve;Prosthetic mechanical valves; Prosthetic tissue valves.
Pulsatile flow in large arteries: Introduction to blood flow in largearteries, pulsatile flow in tubes, instability in pulsatile flow.
Mathematical modeling: Introduction to finite difference, finite volume &finite element methods, non-Newtonian flow models, modeling of flowthrough Mitral valve, modeling of blood flow in vascular system.

Textbooks:
1. C.Ross Ethier and Craigg A. Simmons, Introductory Biomechanics, Cambridgetexts in Biomedical Engineering, 2007.

2. C. Kleinstreuer, Biofluid Dynamics: Principles and Applications, CRC Press,Taylor&Francis Group, 2006.
3. M. Zamir, The Physics of pulsatile flow, Springer-Verlag NY, 2000.
4. J. N. Mazumdar, Biofluid Mechanics, World Scientific, 2004.
5. Y.C. Fung, Biodynamics: Circulation, Springer-Verlag NY, 1997.
6. L. Waite, Applied Biofluid Mechanics, McGraw Hill, 2007
7. L. Waite, Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , 2006.

A general fluid mechanics textbook will be useful (Such as

1. Fluid Mechanics 9th Edition, Frank M. White and Henry Xue, McGraw Hill; Standard Edition (16 June 2022); McGraw Hill Education (India) Private Limited, B-4, Sector-63, Dist. Gautam Budh Nagar, Noida – 201 301, UP.
2. S K Som and Gautam Biswas, McGraw Hill Education; 3rd edition (1 July 2017).

Title: Smart Material **Code: ME340**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Material science".

Objective:

1. To learn and be able to analyze and design smart material MEMS.
2. To learn and be able to perform engineering work in accordance with ethical and economic constraints related to the design of MEMS.

Learning Outcomes:

Course Outcome	Description
CO1	Understand different materials for sensor applications based on required properties
CO2	Determine various opportunities in the emerging field of Smart material.
CO3	Apply the principles of operation of optical fibers, actuators, and methods of analyses employed in smart materials.
CO4	Undertake problem identification, formulation and solution using a range of Smart material.
CO5	Evaluate shape memory materials, electro rheological fluids for newer applications
CO6	Analyze and design fabrication and testing the Smart material based components

Course Content:

Unit-1: OVERVIEW OF SMART MATERIALS: Introduction to smart material, application of smart material. Smart systems using smart materials, smart actuators, Direct and reverse effect, Principles of Piezoelectricty, history of piezoelectricity, piezoelectric materials, Piezoceramic actuators, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Magnetostrictive smart materials, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Ionic Polymer Metal Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro active polymer, Electro-rheological Fluids, Magneto Rhelological Fluids

Unit-2: SMART SENSORS: Introduction to smart sensors, Piezeoelctric Strain Sensors, Bulk micromachining, wafer bonding, surface micromachining, LIGA and SLIGA process, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors

Unit-3: SMART ACTUATORS: Modelling Piezoelectric Actuators Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators,

IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control.

Unit-4: SMART COMPOSITES: Review of Composite Materials, behaviour of unidirectional composites, Modelling Laminated Composites based on Classical Laminated Plate Theory, Predictive models for transverse stiffness and strength, predictive models for longitudinal stiffnes and strength, predictive models for coefficient of thermal expansion, thermal conductivity, failure mechanism in unidirectional composites, Analysis of orthotropic ply, Effect of Shear Deformation, and Dynamics of Smart Composite Beam.

Teaching methodology:

The aim of introducing this course is to give aexposure to the students on the important and fundamental concept in the extensive area of Smart Materials. The concepts, ideas and techniques developed in Smart materialare indispensable in Mechanical and electronic devices. The main focus of this course is to introduce fundamental concepts in smart material with special emphasis on practical problems.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2, half Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on remaining half Unit-3, Unit-4 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and referred video lecture on Smart material is available on JUET server.

Text Book:

1. Meirovitch L., Dynamics and Control of Structures, John Wiley, 1992
2. Brian Culshaw, “Smart Structures and Materials”, Artech House, 2000.
3. Gauenzi, P., “Smart Structures”, Wiley, 2009.

Reference Books:

1. Cady, W. G., “Piezoelectricity”, Dover Publication.
2. Gandhi, M.V., and Thompson, B.S., “Smart materials and sturctures”, chapman & Hall publication.
3. Randy Frank, “Understanding Smart Sensors”, Artech House, 2013.
4. Bob Tucker, “handbook of smart actuators and smart sensors”, NY Research Press, 2015.

Title: Agile and Lean Manufacturing **Code: ME342**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course "Industrial engineering".

Objective:
To describe the principles of lean and agile manufacturing
To recognize the potential applications of lean and agile manufacturing

Learning Outcomes:

Agile and lean manufacturing	
Course Outcome	**Description**
CO1	Outline the meaning and objectives of agile and lean manufacturing.
CO2	Describe the principles of agile and lean manufacturing.
CO3	Develop the skills of lean manufacturing, skills for mapping people in agile manufacturing and strategies for agility
CO4	Identify the value added activities, non value added activities and types of wastages in manufacturing industry.
CO5	Apply lean rules, leanness assessment in manufacturing operations.
CO6	Demonstrate the assessment of agility and leanness

Course Content:
Unit- 1 Introduction to world class manufacturing, historical development of lean manufacturing, agile definition and historical context, Introduction to Lean Manufacturing, Comparison of Mass Manufacturing and Lean Manufacturing, Lean Principles, Types of Wastes – Seven basic categories, Types of activities – Value Added, Non Value Added and Necessary but Non Value Added activities, Examples
Unit II Primary Tools of Lean Manufacturing- 5S, Process Mapping and Value Stream Mapping, Work Cells, Total Productive Maintenance – Principle, Procedural steps and Advantages- Secondary Lean Tools.
Unit –III Lean rules, Training and Implementation for lean systems, How to succeed with lean manufacturing, Leanness assessment – Indicators, methods and illustrative example. (8)
UNIT-IV Fundamentals of Agile Manufacturing, Agile Principles, Conceptual models of Agile Manufacturing, Product Development Strategies for agility, Developing the agile enterprise, Managing People in agile organizations.

Unit –V Strategic approach to agile manufacturing, Information Technology applications in Agile Manufacturing, Assessment of agility – Activity Based Costing - Application Case studies on Lean and Agile Manufacturing.

Teaching Methodology:

This course is introduced to help students to understand the agile and lean manufacturing concept. Starting from use of basic engineering skill to understand wastages and non value added activities in manufacturing. The entire course is broken down into four major sections: introduction, tools and philosophy of agility, lean manufacturing, and people's involvement in agile and lean manufacturing.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit -2,and Unit 3 around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

Text Books

1. Montgomery, J.C and Levine, L. O., "The transition to agile manufacturing – Staying flexible for competitive advantage", ASQC Quality Press, Wisconsin, 1996.
2. Gopalakrishnan "Simplified Lean Manufacture – Elements, Rules, Tools and Implementation", PHI Learning Private Limited, New Delhi, India, 2010.
3. Hobbs, D.P. "Lean Manufacturing Implementation", Narosa Publisher, 2004.
4. Devadasan, S.R., Sivakumar, V., Mohan Murugesh, R., Shalij, P, R. "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities", Prentice Hall India, 2012.

Title: Micro Electro-Mechanical Systems (MEMS) **Code: ME344**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied courses, "Engineering Mechanics".
Objective:

7. To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices
8. To introduce principle of microsystems
9. To educate on the rudiments of Micro fabrication techniques.
10. To introduce various sensors and actuators
11. To introduce different materials used for MEMS
12. To educate on the applications of MEMS to disciplines beyond Electrical and Mechanical engineering.

Learning Outcomes:

Course Outcome	Description
CO1	Outline different field of application of micro/nanosystems
CO2	Describing the functions of different type of sensors
CO3	Develop an idea to basic approaches for micro/nanosystem design
CO4	Identify the most influencing micro fabrication technique.
CO5	Apply the concept of linear and digital electronic devices
CO6	Demonstrate various microsystems design

Course Content:

Unit-1: OVERVIEW OF MEMS AND MICRO SYSTEM: MEMS and microsystems, evolution of microfabrication, microsystems and micro electronics, laws of scaling, the multi disciplinary nature of MEMS, microsystems and miniaturization, Survey of materials central to micro engineering, Applications of MEMS in various industries

Unit-2: MICRO SENSORS AND ACTUATORS: Working principle of Microsystems, micro actuation techniques, micro sensors, MEMS with microactuators i.e.; micropump – micromotors – microvalves – microgrippers – microaccelerometers – microfluids.

Unit-3: FABRICATION PROCESS: Substrates - single crystal silicon wafer formation – Photolithography – Ion implantation – Diffusion – Oxidation – CVD - Physical vapor deposition - Deposition epitaxy - etching process.

Unit-4: MICRO SYSTEM MANUFACTURING: Bulk Micro manufacturing, surface micro machining, LIGA and SLIGA process, Micro system packaging, interfaces in microsystem packaging, packaging techniques – die preparation – surface bonding - wire bonding - sealing.

Unit-5: MICROSYSTEMS DESIGN AND PACKAGING: Design considerations, Mechanical Design, Process design, Realization of MEMS components using intellisuite, Micro system packaging, Packing Technologies, Assembly of Microsystems, Reliability in MEMS.

Teaching methodology:

The aim of introducing this course is to give an exposure to the students on the important and fundamental concept in the extensive area of Mechanical and electronics systemsby emphasizing the state of the art science and technology in fabrication and materials of MEMS..

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 &Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on MEMS (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

1. "MEMS and Microsystems Design and Manufacture" by Tai-Ran Hsu. Tata McGraw-Hill Publishing Company Ltd.
2. "Foundation of MEMS" by Chang Liu. Pearson Education.
3. "MEMS Handbook" by Mohamed Gad – el – Hak, CRC Press, 2002.
4. "MEMS and MOEMS Technology and Applications" by P. Rai – Choudhury, PHI Learning Private Limited, 2009.

Reference Books:

1. "Sensors Handbook" by Sabrie Solomon, "McGraw Hill, 1998.
2. "Fundamentals of Micro Fabrication" by Marc F Madou, CRC Press, 2nd Edition, 2002.

3. “Micro fluidics and Bio mems application” by Francis E.H. Tay and Choong .W.O, IEEE Press New York, 1997.
4. “Micromechanics and MEMS” by Trimmer William S., Ed., IEEE Press New York, 1997.
5. “An introduction to Micro electro mechanical Systems Engineering” by Maluf, Nadim, AR Tech house, Boston 2000.
6. “Micro sensors MEMS and Smart Devices” by Julian W.Gardner, Vijay K.Varadan, Osama O. AwadelKarim, John Wiby& sons Ltd., 2001.

Title: Major Project (Part-II) **Code: ME218**

L-T-P scheme: 0-0-2 **Credit: 8**

Prerequisite: Students must have already studied the courses, " Fluid Mechanics, Thermodynamics, Heat and Transfer" and "Engineering Mechanics, Machine dynamics, Machine Design, Manufacturing Technology, Industrial Technology".

Objective:

1. To learn and be able to implement the front-end and back-end web-technologies.
2. To develop the abilities to call oneself full-stack web developer.

Course Outcome	Description
CO1	Introduction to practical course requirement under the guidance of a faculty supervisor member to understand the respective design project to do innovative work with the application
CO2	Students are expected to do a literature survey and carry out development and/or experimentation in their respective design projects. Interaction with existing work of current researchers of their respective project work.
CO3	Development of the theoretical model and computational analysis of the existing working design project model.
CO4	Preparation of theoretical analysis for an innovative technique to overcome the current troubles of industrial applications related to their design project work.
CO5	Verification and validation techniques of their respective design project
CO6	Demonstrate deployment and basic maintenance skills of the respective design project.

Course Content

UNIT-1 Identification of Innovative work, based upon Literature survey

UNIT-2 student is required doing an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study.

UNIT-3 The student is expected to do literature survey and carry out development and/or experimentation.

UNIT-4 Through project work the student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

UNIT-5 *Demonstrate deployment and basic maintenance skills of the* respective design project

Teaching Methodology:

Project is a course requirement wherein under the guidance of a faculty member, a final year student is required to do an innovative work with application of knowledge earned while undergoing various courses and laboratories in the course of study. The student is expected to do literature survey and carry out development and/or experimentation. Through project work the

student has to exhibit both analytical and practical skills. The project is done in two semesters, i.e. 7th and 8th, on a continuous problem.

Evaluation Scheme:

Exams	Marks	Coverage
P-1	20 Marks	Based on Unit-1, Unit-2 & Unit-3
P-2	15 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
P-3	20 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
supervisor Marks for performance and Attendance	35 Marks	
Report	10 Marks	
Total	**100 Marks**	

Learning Resources:

1. Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

2. https://nptel.ac.in/course.html

3. https://scholar.google.com/

Text Book: As prescribed by respective supervisor faculty member

Course Name: Biofluid Mechanics **Course Code: ME326**
L T P: 3 0 0 **Credits: 3**

OBJECTIVES:
• To characteristicsvarious fluids, such as Newtonian and Non-Newtonian fluids.
• To study the impact of pressure and flow patterns in blood vessels.
• To apply this understanding in studying various important systems, such as cardiac system.

Course Outcome	Description
CO1	Outline scope of bio-fluid mechanics as a very important extension of classical fluid dynamics.
CO2	To understand the anatomy and physiology of the systems under consideration.
CO3	To analyze fluid mechanics based models, currently being used for clinical applications.
CO4	To integrate engineering fluid dynamics based concepts to understand and model flow of biological fluids in human body.
CO5	To identify specific organs and corresponding diseases and how they are related to fluid dynamics.
CO6	Apply mathematical modeling approach to carry out a biofluid dynamics design project.

Course Contents:
Introduction: Introduction to fluid mechanics, and human physiology in relation to heart, lungs and blood vessels.
Cardiovascular structure and function: Electro-cardiogram, heartvalves, cardiac cycles, heart sounds, coronary circulation, microcirculation, lymphatic circulation.Pulmonary Anatomy.
Pulmonary physiology and Respiration: Respiratory system, alveolar ventilation, mechanics of breathing, air way resistance, gas exchange and transport, pulmonary pathophysiology, respiration in extreme environment.
Hematology and Blood Rheology: Elements of blood, blood characteristics, viscosity measurement, erythrocytes, leukocytes; blood types, plasma.
Anatomy and Physiology of Blood vessels: General structure &types of arteries, mechanics of arterial walls, compliance, vascular pathologies, stents, coronary artery bypass grafting.
Mechanics of Heart Valves: Aortic and pulmonic valves; Mitral andTricuspid valves; Pressure gradients across a stenotic heart valve;Prosthetic mechanical valves; Prosthetic tissue valves.
Pulsatile flow in large arteries: Introduction to blood flow in largearteries, pulsatile flow in tubes, instability in pulsatile flow.
Mathematical modeling: Introduction to finite difference, finite volume &finite element methods, non-Newtonian flow models, modeling of flowthrough Mitral valve, modeling of blood flow in vascular system.

Textbooks:
1. C.Ross Ethier and Craigg A. Simmons, Introductory Biomechanics, Cambridgetexts in Biomedical Engineering, 2007.

2. C. Kleinstreuer, Biofluid Dynamics: Principles and Applications, CRC Press,Taylor&Francis Group, 2006.
3. M. Zamir, The Physics of pulsatile flow, Springer-Verlag NY, 2000.
4. J. N. Mazumdar, Biofluid Mechanics, World Scientific, 2004.
5. Y.C. Fung, Biodynamics: Circulation, Springer-Verlag NY, 1997.
6. L. Waite, Applied Biofluid Mechanics, McGraw Hill, 2007
7. L. Waite, Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , 2006.

A general fluid mechanics textbook will be useful (Such as

3. Fluid Mechanics 9th Edition, Frank M. White and Henry Xue, McGraw Hill; Standard Edition (16 June 2022); McGraw Hill Education (India) Private Limited, B-4, Sector-63, Dist. Gautam Budh Nagar, Noida – 201 301, UP.
4. S K Som and Gautam Biswas, McGraw Hill Education; 3rd edition (1 July 2017).

Title: Design of Heat Exchangers **Code: ME327**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Thermodynamics, Heat and Mass transfer" and "Fluid Mechanics".

Objective:

1. To learn and be able to implement the thermal design analysis of heat exchanger for industrial application.
2. To know the application of thermodynamics and heat transfer in a heat exchanger.

Course Outcome	Description
CO1	Get an induction to types of heat exchanger and its industrial application
CO2	Study of Fouling of Heat Exchangers and fouling resistance, cleanliness factor, techniques to control fouling
CO3	Gives knowledge related to Design of Shell & Tube Heat Exchangers and pressure drop analysis in heat exchanger
CO4	Students can do thermal design heat exchanger with help of different design methods , like Bell-Delaware method
CO5	*Students can design can analysis various types of Design procedure for different types of heat exchanger*
CO6	Work as a team on a design project of heat exchanger

Course Content:

Unit-1: Basic Design Methodologies. Classification of heat exchanger, selection of heat exchanger, Thermal-Hydraulic fundamentals, Overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multipass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, Fouling, Rating and sizing problems, heat exchanger design methodology

Unit-2: Fouling of Heat Exchangers. Basic consideration, effect of fouling on heat transfer and pressure drop, cost of fouling, design of heat exchangers subject to fouling, fouling resistance, cleanliness factor, techniques to control fouling

Unit-3: Design of Double Pipe Heat Exchangers. Thermal and Hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop.

Unit-4: Design of Shell & Tube Heat Exchangers. Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method, Kern method.

Unit-5: Design of Compact Heat Exchanger Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop.

Teaching Methodology: This course is introduced to help students to examine the classification, application, design, and analysis of different types of Heat Exchangers in industries. The entire course is broken down into five separate units: i.e. Basic Design Methodologies. Classification of the heat exchanger, Study of Fouling of Heat Exchangers and fouling resistance, design analysis of various types of a Design procedure for different types of heat exchanger.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

1. Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.
2. https://nptel.ac.in/course.html, https://nptel.ac.in/courses/112/104/112104159/

Text Book: 1. Shah, Ramesh K., and Dusan P. Sekulic. Fundamentals of heat exchanger design. John Wiley & Sons, 2003.

TITLE: Flexible Manufacturing System (FMS) **CODE : ME328**
L-T-P scheme: 3-0-0 **CREDITS: 3**

Objectives:

- This course introduces students with computer assisted modern manufacturing technologies.
- The topics covered in this course include basics production, flexible automation, concepts of group technology and Flexible Manufacturing system.
- The objective of this course is to make students acquainted with state-of-the-art technological developments in the area of modern manufacturing.

Learning Outcome:

Course Outcome	Description
CO1	Outline basic concepts related to FMS like types of production, plant layout, sequencing and scheduling, group technology and types of automation.
CO2	Describe types FMS, part classification and coding schemes, various components of FMS like, CNC workstation, robots, ASRS, AGV etc., concurrent engineering and computer aided process planning (CAPP).
CO3	Develop ability to form part families; pick and place programs for robot, CNC part programs.
CO4	Identify the sequence of operation, generate process plan and simulate the FMS operation in off-line mode.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in CIM lab of the department.
CO6	Demonstrate ability to work in automated manufacturing system in an organization.

Course Contents:

Production System: Types of production, Plant layouts, overview of sequencing and scheduling, Introduction to flexible automation.
Group Technology: Introduction, formation of part families, part classification and coding system, production flow analysis, composite part concept, clustering methods, modern algorithms for machine cell design, benefits of GT.

Flexible Manufacturing System (FMS): Introduction, evolution, need for FMS and flexibility, economic justification of FMS application, components of FMS, types of FMS, Components of FMS, FMS layouts and benefits, FMS installation and implementation.

FMS components: Automated Material Handling and AS/RS- Introduction, types of material handling equipment, automated guided vehicle system (AGVs), applications, vehicle guidance and routing, traffic control and safety system management, Basic components of AS/RS, types of AS/RS, AS/RS controls, special features.

Industrial robots -Definition, robot anatomy and related attributes, robot configuration, work volume, types of control systems, end effectors, industrial applications of robot, introduction to robot programming.

Automated assembly system - Fundamentals of automated assembly system, design for automated assembly and various line balancing algorithms.

Automated Inspection & Testing- Automated inspection principles, off-line and on-line inspection, contact and noncontact inspection techniques, Co-ordinate measuring machine (CMM): Introduction and types of CMM.

Manufacturing Support System: Product design and CAD, concurrent engineering and Computer aided process planning (CAPP).

Teaching Methodology:

This course is introduced to help students learn and understand the components of automated manufacturing system. The course is divided into eight units which covers basic concepts of FMS as well as group technology, components of FMS in detail. They will be made aware about FMS and CIM systems

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-2 and Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

TEXT BOOK:

1. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
2. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

REFERENCES:

1. Parrish D. J, "Flexible manufacturing", Butterworth – Heinemann Ltd, 1990
2. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi
3. Jha, N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc.

Title: Mechatronics and Automation **Code: ME329**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Basic of electrical and electronics engineering, fluid mechanics, kinematics, thermiodynamics.

Objective:

1. This course is a combination of mechanics, electronics and computing.
2. To impart interdisciplinary knowledge to study modern CNC m/c tools, robots etc.
3. The aim of the course is to make a bridge among various engineering disciplines such as Mechanical, Electronics, Instrumentation, Computer and Control.

Learning Outcomes:

CO1	Outline of Mechatronics system to understand the requirement of automation
CO2	Describe various sensors, microcontrollers, signal processing, actuators, PLC, pneumatic and hydraulic systems
CO3	Develop the knowledge of automation to improve the performance of manufacturing, maintenance and assembly units
CO4	Identify the type of sensors, microcontrollers, communication methods and actuators required for specific problem of automation
CO5	Apply the knowledge to develop and maintain various automation systems
CO6	Demonstrate the skill in the field of requirement

Course Content

Unit 1:

Mechatronics and its scope:

Sensors and transducers-Displacement, position & proximity, velocity, force, pressure and level. Signal conditioning amplification, Filtering, analogue to digital converter, digital to analogue converter, multiplexer & data acquisition systems

Unit 2:

Pneumatic and hydraulic actuation systems:

Air Compressors- type of compressors, dryers, after coolers, mainline filters, oil removal, air receivers and air distribution systems

Pneumatic actuators- mechanical requirements, classification according to action and duty; pneumatic valves- classification, graphical representation, 3/2 DCVs, none return valves, check valves, flow control valves, speed control of a actuator, 5/2 DCV, logic controls, quick exhaust valve, time delay valve, pressure sequence valve and pneumatic counters. Multi-actuator circuit-positional layout, displacement step diagram, displacement time diagram, sequence control, elimination of signal conflict; Hydraulics

Electro-pneumatics- fundamentals of solenoid valves, 3/2 and 5/2 types of valves, push button switch, relays, logic controls, memory function, dominant OFF and ON circuits, electronic sensors, limit switches, time delay relays, electrical counters, pressure switches, multi actuator circuits

Unit 3: PLC:

Introduction to PLC system, ladder programming, instruction list, logic operations using PLCs, applications of PLC in machines, industries and various purpose

Elements of microprocessors & microcontrollers:

Close loop controls- two step, proportional, derivative, integral, PID and digital controls

Microcontroller- microprocessor systems, buses, ALU, registers, control units, memory, input/output, Motorola M68HC11, Intel 8051and programming

Interfacing- requirement, PIA, SCI, display adapters, motor drives for dc motors, stepper motors and servo motors

Teaching Methodology:

The course will start from the architect of Mechatronics systems such as inputs and outputs of any physical system. It includes different variety of sensors and the processing of the signals to the microcontroller. Also different variety of actuators used in Mechatronics system to get the required output of the system. There will be some problem to interface the sensors and actuators to the microcontroller so interfaces are most important parts of the Mechatronics system. It also includes different microcontrollers and their architect.

In the field of automation pneumatics and hydraulics have their importance. Hence, in this subject different compressor, oil pumps introduction will be given. Different varieties of direction control valves are to be talked to achieve the required action by the actuators. It also includes different architect of the circuits to achieve the required job done. To further enhance the performance of the automation electro-pneumatics will come in action. Further it can be done to the electro-pneumatics system by incorporating programmable logic controller.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit 1
Test-2	25 Marks	Based on Unit 2 and Unit 1 (20%)
Test-3	35 Marks	Based on Unit 3, Unit 2 (15%) and Unit 1 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	

Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials on manufacturing technology 2 (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. HMT Ltd, Mechatronics, Tata McGraw Hill.

References Books/Materials:

1. Isermann R., Mechatronics Systems: Fundamentals, Springer.
2. Bradley, D. A., Dawson, D., Buru, N. C. and Loader, A. J., Mechatronics, Chapman and Hall.
3. Bolton W., Mechatronics, Pearson Education.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. Mechatronics: The Science of Intelligent Machines
2. International Journal of Mechatronics and Automation

Title: Optimization Methods in Engineering **Code: ME330**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "Mathematics".

OBJECTIVES

Introduce methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods.

Learning Outcomes:

Optimization methods in engineering	
Course Outcome	**Description**
CO1	Outline the scope and applications of optimization in engineering industry
CO2	Describe tools and methods of optimizations for engineering industry
CO3	Develop the problem solving skills for optimizations
CO4	Identify the useful modern tools for optimization in production industry
CO5	Apply the learned tools for industrial optimization.
CO6	Demonstrate the skills by developing software programme for optimization problem.

Course Content:

Unit 1 INTRODUCTION –

Introduction, Historical Development, Engineering Applications of Optimization, Classification of optimization problems, Statement of an Optimization Problem

CLASSICAL OPTIMIZATION TECHNIQUES

Single-Variable Optimization, Multivariable Optimization with No Constraints, Multivariable Optimization with Equality Constraints, Convex Programming Problem.

Unit-II LINEAR PROGRAMMING

Simplex Algorithm, MATLAB Solution of LP Problems, Duality in Linear Programming, Sensitivity or Postoptimality Analysis.

Unit-III NONLINEAR PROGRAMMING

Elimination Methods, Interpolation Methods, MATLAB Solution of One-Dimensional Minimization Problems.

GEOMETRIC PROGRAMMING

Introduction, Polynomial, Unconstrained Minimization Problem, Unconstrained Geometric Programming Problem Using Arithmetic–Geometric Inequality, Constrained Minimization, Geometric Programming with Mixed Inequality Constraints, Applications of Geometric Programming

Unit IV DYNAMIC PROGRAMMING

Multistage Decision Processes, Concept of Suboptimization and Principle of Optimality, Computational Procedure in Dynamic Programming, Conversion of a Final Value Problem into an Initial Value Problem, Continuous Dynamic Programming.

Unit V STOCHASTIC PROGRAMMING

Basic Concepts of Probability Theory, Random Variables and Probability Density Functions, Jointly Distributed Random Variables, Central Limit Theorem, Stochastic Linear Programming, Stochastic Nonlinear Programming.

Unit VI MODERN METHODS OF OPTIMIZATION

Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, Optimization of Fuzzy Systems, Neural-Network-Based Optimization

Teaching Methodology:

This course is introduced to help students to indentify needs of optimization in production or engineering industry. The entire course is broken down into four major sections: linear programming, geometric programming, dynamic programming, stochastic programming and modern method of optimization. Each section includes numerical problems and methodology to analyze the problem. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit -3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

Text Books:

1. Singiresu S. Rao (2009) , Engineering Optimization Theory and Practice , Wiley. New Jersey
2. J K Sharma(2013) , Operations Research, Trinity, New Delhi
3. H A Taha (2005) Operations Research : An Introduction, Pearson,

Reference Books:

1. RV Rao, Advanced Modeling and Optimization of Manufacturing Processes , Springer

TITLE: Supply Chain Management **CODE: ME331**
L-T-P: 3-0-0 **CREDITS: 3**
Prerequisite: Nothing specific
Objectives

- SCM involves movement and storage of all materials including raw material, work-in progress and finished goods.
- The objective of the supply chain management (SCM) is to improve the overall organization performance and customer satisfaction by improving product or service delivery to consumer.

Learning Objectives

Course Outcome	Description
CO1	Outline scope, importance and evolution of SCM, opportunities and difficulties in supply Chain.
CO2	Describe critical management skills such as negotiating, make or buy decision, product development, purchasing, logistics design, and inventory management, ethical decision making and use of information technology.
CO3	Develop a sound understanding of the important role of supply chain management in today's business environment.
CO4	Identify the supply chain management (SCM) related business processes, problems encountered in practice, and the new challenges facing SCM practices.
CO5	Apply the current supply chain theories, practices and concepts utilizing case problems and problem-based learning situations
CO6	Demonstrate the use of effective written and oral communications, critical thinking, team building and presentation skills as applied to business problems.

Course contents

Introduction: Scope, importance and evolution of SCM, Decision phases in supply chain, integration of inbound, outbound logistics and manufacturing to SCM, opportunities and difficulties in supply Chain, Bull-whip effect, IT in SCM.

Supply chain network design: Plant and warehouse-network configuration, data collection and aggregation, transportation and mileage costs, warehouse capacity, costs and potential locations, Service level requirements, variance reduction by pooling demands, cross docking and trans shipments distribution.

Inventory models: Concept of inventory, inventory in progress (WIP) andsafety stock, problem of excess inventory and cycle time, concept of JIT and lean mfg, EOQ and basic inventory models, lead time variance and safety stock, ABC, VED and other analysis based on shelf life,

MRP technique and calculations, lot sizing in MRP, linking MRP with JIT, evolution of MRP to ERP to SCM and e-business.

Strategic Decisions: make/ buy decision, Outsourcing: benefits and risks, dependency on capacity and knowledge, modular and integral products, strategic alliance issues, analysis of third party (3PL) logistic, push, pull and push-pull based supply chains, coordination and leadership issues, change of purchasing role and vendor rating, variability from multiple suppliers, supply contracts and revenue sharing, Effect of lack of co-ordination in supply chain and obstacles.

Information Technology in SCM: The role IT in supply chain, supply chain IT frame work, interface devices, communication and databases, decision support systems for SCM**, c**ustomer relationship management, internal supply chain management, supplier relationship management, future of IT in supply chain, E-Business in supply chain.

Teaching Methodology:

This course is introduced to help students learn and understand the movement and storage of materials including raw material, work-in progress and finished goods. The course is divided into five chapters. Initially they will be taught about basic fundamentals of SCM with suitable examples. Various inventory models will be explained with realistic examples. Emphasis will be given on problem based learining.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 and Unit-3 and around 30% from coverage Test-1
Test-3	35 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text book:

1. Chopra, S., and Meindle, P., Kalra D.V. “Supply chain Management: Strategy, Planning and Operation”. Sixth edition, Pearson Education, 2016.
2. Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E., and Ravishankar “Designing & managing supply chain: concept, Strategies & case studies. Third Edition”, Tata McGraw-Hill Edition.
3. oebler, D.W. and Burt, D.N. Purchasing and Supply Chain Management: Text Cases, McGraw-Hill Publishing Company Limited, New Delhi, 1996.

References Books:

1. Tersine, R.J., Principle Of inventory And Material Management 4th Edition Prentice-hall Inc., New Jercy, 1994.
2. Chistopher, M., Logistic And Supply Chain Management, Pearson Publishing House, London 2011.
3. Narasimhan, S.L., McLeavy, D.W. and Billington, P.J., Production Planning and Inventory Control, 2nd Edition, Prentice-Hall India, New Delhi 1995.
4. Star, M.K. And Miller, D.W., Inventory Control: Theory and Practice, Prentice-Hall India, New Delhi 1986.
5. Raghuram, G.And Rangaraj,N., Logistic And Supply Chain Management :Cases And Concept, Macmillan India Limited, New Delhi, 2000.

Course Name: Experimental Stress Analysis **Course Code: ME332**
L T P: 3 0 0 **Credits: 3**

Prerequisite: Students must have already studied course, "*Strength of Materials and Theory of machine*".

Objective:

The course covers the basic aspects of experimental stress analysis that includes exhaustive treatment of the most versatile techniques like photoelasticity and strain gauges and also a brief introduction to the emerging techniques like digital image correlation.

Learning Outcomes:

Course Outcome	Description
CO1	Explain the measurement of strain under static and dynamic loads.
CO2	Describe the Mechanical, optical, pneumatic and electrical strain gauges for strain measurement.
CO3	Create awareness about the fixing of gauges and temperature effects in bonded gauges and measure of stress in stress gauges.
CO4	Analysis of measuring circuits and strains of different strain gauge rosettes.
CO5	Describe the measurements by using transducers and exciters.
CO6	Introduction to digital image correlation.

Course Content:

Unit-1:

Strain measurement, ideal strain gauge, mechanical, optical, acoustical, pneumatic, dielectric and electrical strain gauges, differential transformer and piezoelectric transducers.

Unit-2:

Electrical wire resistance strain gauges: bonded type gauges, bonding agents, foil gauges, gauge materials, weldable gauges.

Unit-3:

Strain gauge- adhesive, fixing of gauges, temperature effects in bonded gauges, gauge factor and gauge sensitivity, measurement of stress, stress gauge.

Unit-4: Measuring circuits and strain gauge rosette: potentiometer circuit, Wheatstone bridge, circuit sensitivity and output, temperature compensation and signal addition, rectangular, delta and tee- delta rosette, applications of strain gauge in practical problems.

Unit-5:

Vibration measurement: Introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis.

Unit-6:

Three dimensional photoelasticity, Stress freezing, Slicing, Application to a complex problem, Integrated photoelasticity, Principle of optical equivalence. Introduction to digital photoelasticity, Use of colour information for quantitative analysis, Three Fringe Photoelasticity (TFP), Refined TFP (RTFP) to solve slow time variant problems. Paradigm shift in data

processing, Processing of intensity data for photoelastic data extraction, Overview of digital photoelasticity, Ten-step method, Understanding phase maps.

Teaching Methodology:

The entire course is broken down into six units. The course introduces the physical principle used by various experimental techniques and also provides a guideline to select an experimental technique for a given application. The role of analytical, numerical and experimental methods in solving a problem in solid mechanics is discussed. Attention is drawn on the richness of whole field information provided by most of the optical techniques. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5& Unit-6 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

1. JW Dally and WF Riley, "Experimental Stress Analysis", McGrawHill Publications, 2003

Reference Books/Material:

1. CC Perry and HR Lissner, "The Strain Gage Primer", McGrawHill, 2000.
2. Abdul Mubeen, "Experimental Stress Analysis", DhanpatRai and Sons, 2001.
3. PS Theocaris, "Moire Fringes in Strain Analysis", Pergammon Press, 2002.

Web References:

https://nptel.ac.in/courses/112106068

Journals References:

https://www.sciencedirect.com/topics/engineering/experimental-stress-analysis

Title: Energy Management and Audit **Code: ME333**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: The students must have understanding of basics of Physics, chemistry and mathematics

Scope and Objectives:

1. To make students familiar with the systems consuming energy in the industry and business organizations and buildings.
2. To make them acquainted with the basic techniques of energy conservation and auditing procedure with case studies.
3. To introduce him to emerging energy efficient processes.

Learning Outcomes:

Course Outcome	Description
CO1	Outline scope of energy management and audit in industry and business organizations.
CO2	Describe various terminologies used in analysis of energy management and energy audit.
CO3	Develop skills of measurements and choose right measuring equipment for measurement of entities related with energy management and audit.
CO4	Identify energy efficient technologies, energy opportunities and alternative energy sources in equipments, processes, practices and offices.
CO5	Apply the principles of energy management in boilers, heat exchangers, lighting systems, motors, HVAC etc.
CO6	Demonstrate the top management about energy saving methods through financial analysis, payback periods and environmental benefits.

Course Content

Unit 1:Introduction of energy basics

Energy Scenario, Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Security, Energy Conservation and its Importance, Electricity tariff, Load management and Maximum demand control, Power factor.

Unit 2:Introduction to energy management and audit

Energy Management & Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments. Managerial function, Roles and responsibilities of energy manager, Accountability.

Unit 3: Financial management

Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques-Simple pay back period, Return on investment, Net present value, Internal rate of return.

Unit 4: HVAC and refrigeration system

Vapor compression refrigeration cycle, Refrigerants,Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioningsystem performance and savings opportunities.Vapor absorption refrigeration system: Working principle, Types and comparison withvapor compression system, Saving potential.

Unit 5:Energy efficiency in boilers

Boilers:Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities. FBC boilers**:** Introduction, Mechanism of fluidised bed combustion, Advantages, Types of FBC boilers, Operational features, Retrofitting FBC system to conventional boilers, Saving potential. Cogeneration: Definition, Need, Application, Advantages, Classification, Saving potentials.

Unit 6:Waste heat recovery

Waste Heat Recovery**:** Classification, Advantages and applications, Waste heat survey, Commercially viable waste heat recovery devices, Saving potential, Emerging technologies in waste heat recovery.

Unit 7:Energy efficient technologies in electrical systems

Energy Efficient Technologies in Electrical Systems:Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology.

Unit 8:Energy management in lighting systems

Lighting System**:** Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues, Good practices in lighting systems.

Unit 9:Energy management in buildings

Principles of envelope analysis, Roofs, Floors, Fenestration, Infiltration, Thermal “Weight”, Envelope analysis for existing and new buildings, Sustainability and high performance Green Building.

Unit 10:Use of alternative energy

Introduction, Solar Energy, Wind Energy, Biomass Energy, Emerging Technologies.

Teaching Methodology:

The subject will help the students to understand the importance of energy management, energy conservation, and energy efficiency in various industrial applications. The student will learn the energy management concepts. He can also choose to become energy manager or energy auditor after having some experience in core industry.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& 2
Test-2	25 Marks	Based on Unit-3,4, 5 & 6 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-7,8,9 &10 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text Books:

1. General aspects of energy management and audit, Bureau of Energy Efficiency.
2. Energy efficiency in thermal utilities, Bureau of Energy Efficiency.
3. Energy efficiency in electrical Utilities

Reference Books:

1. Hand book of energy conservation Vol.1
2. Hand book of energy conservation Vol.2

Title: Processing of Non-metals **Code: ME334**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Material Science*" and "*Manufacturing Technology*".

Objective:

1. To study about the different types of non-metals
2. To study the application, characteristics and constituents of non-metals
3. To study the various fabrication techniques of non-metals
4. To study about the different types of composites and ceramics

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of processing methods for non-metals.
CO2	Describe the applications, characteristics and constituents of non-metals.
CO3	Develop an idea to modify the conventional methods to process the non-metals such as polymers and composites.
CO4	Identify the most influencing process parameters to process the non-metals.
CO5	Apply most appropriate processing technique to fabricate a non-metallic product economically.
CO6	Demonstrate and deployment the processing of non-metals for solving real-world problems.

Course Content:

Unit-1: Introduction to non-metals, structure and properties of non-metals, Classification of non-metal materials and processing techniques.

Unit-2: Glass structure and properties, Types of glasses, glass melting and forming, glass fiber, glass fiber and glass wool forming, glass annealing.

Unit-3: Classification of ceramics, crystal structures and properties of ceramics, ceramic powder preparation, fabrication of ceramic products from powders, casting, vapour phase techniques, sintering, finishing, machining processes.

Unit-4: Introduction to plastics, Structure and mechanical properties of plastics, thermoplastics and thermosets.

Unit-5: Processing of Plastics: Extrusion of Plastics, injection/rotational/blow moulding of Plastics, Thermoforming, Compression moulding, Transfer moulding, General behavior of polymer melts, Machining of plastics.

Unit-6: Introduction to polymer matrix composites, properties of polymer matrix composites, Applications of polymer matrix composites, processing techniques of Polymer matrix composites such as hand lay-up, autoclaving, filament winding, pultrusion, compression moulding.

Unit-7: Introduction to Ceramic Matrix Composites, mechanical properties of ceramic matrix composites, Applications of Ceramic matrix composites, different processing techniques for ceramic matrix composites such as Powder processing, Chemical vapour infiltration, slurry infiltration and liquid infiltration

Teaching Methodology:

This course is introduced to help students to understand the various processing techniques for non-metals with their applications. The entire course is broken down into seven separate units: Introduction to non-metals, Glasses, Ceramics, Plastics, processing of plastics, polymer matrix composites, and ceramics matrix composites. Students are motivated to do research work in the area of non-metals.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 & Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures on Processing of non-metals are available on JUET server.

Text Book:

[4] Manufacturing Processes for Engineering Materials : S. Kalpakjian, 3rd edition Addison - Wesley, 1997

[5] Hull, D. and Clyne, T.W., Introduction to composite materials, Cambridge University press, 1996.

Reference Books/Material:

[1] Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press.

[2] Plastic Materials and Processing : A. Brent Strong, Prentice Hall, ISBN 0-13-021626-7

Web References:

- www.nptel.com
- https://nptel.ac.in/courses/112/104/112104229/
- https://nptel.ac.in/courses/112/107/112107221/

Journals References:

- Journal of Manufacturing Processes: Elsevier
- Materials and Manufacturing Processes: Taylor & Francis
- Journal of Materials Processing Technology: Elsevier
- Composite Part A: Elsevier
- Composite Part B: Elsevier

Title: Plant Layout & Material Handling **Code: ME335**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "Mathematics".
Objective:

1. This course is an introductory course in plant layout and material handling.
2. To understand the underlying mechanisms for how to design, measure, analyze, and compare facility layouts and how to make facility location decisions.
3. Students also learn the basics of material handling techniques and how they can be effectively and efficiently used to support facility objectives.

Learning Outcomes:

Plant Layout and Material Handling	
Course Outcome	**Description**
CO1	Outline the purpose and factors affecting plant layout. Also to understand the role of layout engineer.
CO2	Describe the types of plant layout and evaluate the relative merits and demerits of plant layout.
CO3	Develop skill of Quantitative evaluation of the plant layout.
CO4	Identify issues in selections of material handling equipments for different industries.
CO5	Demonstrate the design techniques for designing of material handling systems for various types of materials used in manufacturing/process industries.
CO6	Apply rules and regulations for designing, operations for plant layout and materials handling systems.

Course Content:

UNIT-1 Introduction:

Plant layout and management, Management factors effecting plant planning, Plant layout organization in different plants, Types of plant layout characteristics and qualifications required in plant layout engineer.

UNIT-2 Layout of a New Plant:

Expanding the plant, revising the plant to accommodate technologies advances in product design and equipment, improving the layout through analysis and work simplification.

UNIT-3 Plant Layout Factor:

Steps in designing a plant layout, Preliminary survey, Developments necessitating plant layout, Product design, Functional design and production design, Factors influencing plant layout, Material.

UNIT-4 Quantitative analysis of plant layout :

Machinery, Man movement within service, Building and charge, Consideration of management policies and layout objectives, Plant sector and its influence on plant layout, Plant layout tools and techniques, Product layout, Process layout, Group layout and JIT layout.

UNIT- 5 Material Handling:
Materials handling principles, Work simplification, Cost factors, Equipment procedures for establishing and improving the layout through materials handling systems.
UNIT -6 Materials Handling Equipments:
Lifting and lowering devices (vertical motion), Transporting devices (horizontal motion), Combination devices (Lifting and lowering plus transportation)-Conveyors, Cranes, Hoists, Lifts, Chutes etc.

Teaching Methodology:
This course is introduced to help students to transition skills needed for being a layout engineering and material handling system engineer. This course also introduces the understudying relationship among the different department functions in production plant. The entire course is broken down into four major sections: Introduction, types of payout and factors affecting , quantitative analysis of layout and material handling.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit -3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Digital copy of important material will be available on the JUET server.

TEXT BOOKS:
1. G.K. Agarwal, Plant Layout and material handling,
2. Immer R. John, Materials Handling Equipments, McGraw Hill.

3. Spivakowsky & Dyachke V.,Conveyors and related equipments, Pease publishers, Moscow.
4. Meyers, E. Fred, and Stephens, P. Matthew, Manufacturing facilities design and material handling, practice hall.
5. Tompkins, White, Bozer, Frazelle, Tanchoco, Trevino, Facilities planning, John Wiley and Sons.
6. Apple James M., Plant layout and material handling, John Wiley and sons.

REFERENCE BOOKS

1. Rudenko N., Material Handling Equipments Pease publishers, Moscow.
2. Hand Book, Material Handling.
3. Kulweic, Raymond, Material Handling Hand Book, American Society of Mechanical
4. Engineers & the international Material Management Society, John Wiley & Sons, New York.
5. Material Handling and storing, U.S. Dept. of labor (occupational safety and health administration).
6. Moore James M., Plant layout and design, Macmillan publishing, New York.
7. Alexander, Material Handling Equipment, MIR Publications.

Resource Weblinks:

1. https://www.youtube.com/watch?v=-aGk5-yx340
2. https://www.youtube.com/watch?v=swk6Fo-BoSA
3. https://www.youtube.com/watch?v=RTUkczG1Rcg
4. https://www.youtube.com/watch?v=KT1x9lH4gA0
5. https://www.youtube.com/watch?v=N0U9PnzHmdo

Title: Unconventional energy sources **Code: ME336**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: The student must have knowledge of fundamentals of physics and electronics

Scope and Objectives:

1. To introduce them to conventional and unconventional sources of energy.
2. To make them understand the importance of unconventional energy and reducing fossile fuel reserves.
3. To make them understand energy conservation and sustainable development.
4. He will be able to appreciate different grades of energy and necessity of their conversion and costs involved.

Course Outcome	Description
CO1	Outline scope of renewable energy.
CO2	Describe the types of unconventional energy sources.
CO3	Develop the graphs from historical data of wind and solar power generation.
CO4	Identify suitability of unconventional energy for a given site.
CO5	Apply analytical skills to estimate the potential of unconventional energy source.
CO6	Demonstrate the use of measuring instruments used in unconventional energy sources.

COURSE CONTENT

Unit 1:INTRODUCTION

The energy crisis – causes and options, Renewable and Non-renewable forms of energy and their characteristics, Availability of renewable energy and Land area requirements.

Unit 2: SOLAR ENERGY

Solar radiations, Solar thermal power and it's conversion, Solar collectors, Flat plat, Concentric collectors, Cylindrical collectors, Thermal analysis of solar collectors. Solar energy storage, Different systems, Solar pond. Applications, Water heating, Space heating & cooling, Solar distillation, Solar pumping, Solar cooking, Greenhouses, Solar power plants.

Unit 3:BIOGAS

Photosynthesis, Bio gas production, Aerobic and anaerobic bio-conversion process, Raw materials, Properties of bio gas, Transportation of bio gas, Bio gas plant technology & status, Community biogas plants, Problems involved in bio gas production, Bio gas applications, Biomass conversion techniques, Energy plantation, Fuel properties.

Unit 4:WIND ENERGY

Properties of wind, Availability of wind energy in India, Wind Velocity, Wind machine Fundamentals, Types of wind machines and their characteristics, Horizontal and Vertical axis wind mills, Elementary design principles, Coefficient of performance of a wind mill rotor, Aerodynamic considerations in wind mill design, Selection of a wind mill, Economic issues, Recent development.

Unit 5:ELECTROCHEMICAL EFFECTS AND FUEL CELLS

Revisable cells, Ideal fuel cells, Other types of fuel cells, Efficiency of cells, Thermions systems.

Unit 6:TIDAL POWER

Tides and waves as sources of energy, Fundamentals of tidal power, Use of tidal energy, Limitations of tidal energy conversion systems.

Unit 7: HYDROGEN ENERGY

Properties of hydrogen in respect of it's use as source of renewable energy, Sources of hydrogen, Production of hydrogen, Storage and transportation, Problems with hydrogen as fuel.

Unit 8:THERMOELECTRIC SYSTEMS

Kelvin relations, Power generation, Properties of thermoelectric materials, Fusion, Plasma generators.

Unit 9:GEOTHERMAL ENERGY

Hot springs, Steam ejection, Principal of working, Types of geothermal station with schematic representation, Site selection for geothermal power plants. Advanced concepts, Problems associated with geothermal conversion.

Unit 10: OCEAN ENERGY

Principal of ocean thermal energy conversion, Power plants based on ocean energy, Problems associated with ocean thermal energy conversion systems.

Teaching Methodology:

The subject will help the students to know alternative energy sources in use and in experimental stage, potential of unconventional energy sources in our country.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1,
Test-2	25 Marks	Based on Unit-2 & 3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-3 &4 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

TEXT/ BOOKS:

1. Khan B.H., Non-conventional Energy Resources, TMH Education Pvt.Ltd.NewDelhi.
2. Rai G. D., Non-Conventional Energy Sources, Khanna Publishers.
3. Bansal N. K., Kleemann M. and Meliss M., Renewable Energy Sources and Conversion Technology, Tata McGraw Hill.

REFERENCE BOOKS:

1. Sukhatme S. P., Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill.
2. Craig B. Smith, Energy management Principles, Pergamon Press.
3. Parikh Jyoti, Energy Systems and Developments, Oxford University.

Title: Machine Tool Design **Code: ME337**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied course, "*Manufacturing Technology*".

Objective:

[1] To provide fundamental knowledge and principles in material removal processes.
[2] To provide the knowledge of different drives and mechanisms used in machine tools, The design of gear boxes & feed boxes, structures, guideways, spindles and various control systems used in machine tools.
[3] To demonstrate the fundamentals of machining processes. Vibrations induced in machine tools.
[4] To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the machine tools, cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
CO2	Describe the concepts of design of machine tools and machine tools drives, design and analysis of machine tool structures, columns, beds, spindles, slide ways and bearings.
CO3	Develop newer concepts of designing CNC Machine tool.
CO4	Identify machine tool vibrations, different theories of vibration in machine tools.
CO5	Apply Modal analysis, vibrations induced in machine tools and calculate the values of various forces involved in the machining operations.
CO6	Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish.

Course Content:

Unit-1: Metal cutting : Mechanics of metal cutting, Geometry of tool and nomenclature, Tool materials, Orthogonal vs oblique cutting. Mechanics of chip formations, types of chips, tools angles, shear angle, Merchant's force circle diagram, Cutting forces, power required, Cutting fluids/lubricants, Tools wear and tool life.

Unit-2: Design and Analysis of Machine Tool Structures, Columns, Beds, Spindles, Slide ways and Bearings.

Unit-3: Design of Kinematic Schemes of Machine Tools, Design of kinematic schemes used in modern machine tools drives**,** Concepts of design of machine tools, Design of Machine tool drives.

Unit-4:Computer controlled manufacturing process: NC, CNC, DNC, part programming, Introduction to computer aided manufacturing and robotics.
Unit-5: Machine Tool Vibrations, different theories of vibration in machine tools, Modal analysis, Vibration isolation, Static and dynamic testing of machine tools.

Teaching Methodology:
This course is introduced to help students to understand Machine tools,the various parts of machine tools, the forces which act on them. Students will gain advanced knowledge of machining process modeling as well as vibration analysis of machine tools.
Course will equip students to diagnose machining process related issues, and will motivate practical solutions for some industrial problems in the machine tool.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:
[1] Manufacturing Automation by Y. Altintas.
[2] Machining Dynamics by T. Schmitz & K. Smith;

Reference Books/Material:
[1] Machine Tool Structures by Koenigsberger & Tlusty

Web References:
[1] https://www.youtube.com/watch?v=orKAv91M0Uo

Journals References:
[1] International Journal of Machine Tools and Manufacture: Elsevier

Title: Reliability Engineering **Code: ME338**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied course, "Mathematics".
Objective:

1. To apply methods of estimating the reliability of equipment and engineering system
2. To make scientific understanding of methods for identify the causes of failure that do occur in engineering system

Learning Outcomes:

Course Outcome	Description
CO1	Outline the scope and concept of reliability engineering
CO2	Describe reliability, maintainability, conditional probability
CO3	Develop the skill of failure data analysis.
CO4	Identify the key issues in system engineering, components reliability and system reliability.
CO5	Apply the reliability concepts for maintenance planning and measurement, and trade – off between reliability and maintainability
CO6	Demonstrate skills for reliability evaluation and evaluation of repairable systems in industries.

Course Content:

Unit-I: RELIABILITY: DEFINITION

Probability concept, Addition of probabilities, Complimentary events,Kolmogorov axioms

Unit-II: FAILURE DATA ANALYSIS

Introduction, Mean failure rate, Mean time to failure (MTTF), Mean time between failures (MTBF), Graphical plots, MTTF in terms of failure density, MTTF in integral form

Unit-III: HAZARD MODELS

Introduction, Constant hazard, linearly increasing hazard, Weibull model, Density function and distribution function, Reliability analysis, important distributions and their choice, Standard deviation and variance

Unit-IV: CONDITIONAL PROBABILITY

Introduction, Multiplication rule, Independent events, Vernn diagram, Hazard rate as conditional probability, Bayes theorem

Unit-V: SYSTEM RELIABILITY

Series, Parallel and mixed configurations, Complex systems, Logic diagrams, Markov models, Maintenance planning, Reliability and maintainability trade – off

Unit-VI: RELIABILITY IMPROVEMENT & REPAIRABLE SYSTEMS

Redundancy, Element, Unit and standby redundancy, Optimization, Reliability – cost trade- off, Introduction to repairable systems, Instantaneous repair rate, MTTR, Reliability and availability functions, Important applications, Fault-tree construction, Calculation of reliability, Tie- set and minimal tie-set

Teaching Methodology:

This course is introduced to help students to transition from basic engineering skills to system engineering skills. Starting from use of basic engineering skill to understand the engineering system. This course also introduces the understudying relationship among the different engineering steams for proper functioning of system. The entire course is broken down into four major sections: Scope and definitions, Fundamental, failure data analysis and reliability – maintainability trade off. Each section includes numerical problems and methodology to analyze the problem.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit -3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Digital copy of important material will be available on the JUET server.

Text Books

1. Ebeling, Charles E., (1997), An Introduction to Reliability and Maintainability Engineering, McGraw-Hill Companies, Inc., Boston.
2. Blanchard, Benjamin S. (1992), Logistics Engineering and Management (Fourth Ed.), Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
3. Neubeck, Ken (2004) "Practical Reliability Analysis", Prentice Hall, New Jersey

References

4. Kapur, K.C., and Lamberson, L.R., (1977), Reliability in Engineering Design, John Wiley & Sons, New York
5. Gano, Dean L. (2007), "Apollo Root Cause Analysis" (Third Edition), Apollonian Publications, LLC., Richland, Washington
6. Kececioglu, Dimitri, (1991) "Reliability Engineering Handbook", Prentice-Hall, Englewood Cliffs, New Jersey

Title: Microrobotics **Code: ME339**
L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, *Engineering Mechanics, Introduction to Robotics or Robotics.*

Objective:

3. To learn and know about the anatomy of robots and how to perform robots.
4. To develop the abilities to write a program for a typical application of robot.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the terminology, components and subsystems of microrobots.
CO2	Describe the laws of Scaling laws for designing macro, micro and nano systems.
CO3	Develop an idea to fabricate microrobots.
CO4	Identify the most influencing parameters for micro-manipulation of robots.
CO5	Apply appropriate technique to analyze and fabricate the microrobots.
CO6	Demonstrate the real world applications of Microrobotics.

COURSE CONTENT:

Unit-1: Scaling laws for designing macro, micro and nano systems: scaling laws in fluids, electo-magnetism, thermodynamics, optics and quantum effect. Micro-mechanics, design and selection of materials for micro- robotics systems, control for surface walkers.

Unit-2: Introduction to different micro-fabrication techniques. Micro actuators and micro sensors: micro force sensors and tactile sensors, Magnetic actuation, electrostatic actuation, piezo electric actuation, shape memory alloy and conducting polymer based actuation, stick slip, comb drive actuator, micro-pumps, micro engines, magnetic helical micro machines.

Unit-3: Micro-manipulation: Mechanics of micro-manipulation, Atomic force microscope as micro/Nano robot, micro manipulation in particle assembly.

Unit-4: 3D micro/Nano fiber pulling, integrated nano tool carrier, micro-assembly, micro air vehicles (MAVS) and multirobot systems.

Unit-5: Bio- inspired micro-mechanics: Microscale propulsion, locomotion in liquids, modeling of propulsion systems, micro mechanical flying insect, Gecko inspired climbing robots, bioinspired fibrillar adhesive, lizard inspired water runner robot, water strider inspired water walker robot, Magnetic swimming micro-robot for bio-medical application, medical micro-robots.

Teaching Methodology:

This course is introduced for helping students to understand the microrobots and how they are fabricated and their applications in different industries. The entire course is broken down into five separate units: Scaling laws, fabrication, micro-manipulations, 3D micro/nano fiber pulling, and Bio- inspired micro-mechanics.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2

Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 40% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Robotics Engineering (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[8] John J. Craig, Introduction to Robotics, Pearson, 2009.

[9] N. Chaillet, S. Regnier, Microrobotics for Micromanipulation, Wiley, IST, 2010, ISBN: 978-1-84821-186-5

[10] Y. Bellouard, Microrobotics, methods and applications, CRC Press, 2009, ISBN: 9781420061956

Reference Books/Material:

[1] Fatikow, Sergej, Rembold, Ulrich, Microsystem technology and microrobotics, Spirnger publication, 2000, ISBN 978-3-662-03450-7

[2] Ananthasuresh, Micro and Smart Systems: Technology and Modelling, Wiley, 2012, India, ISBN:9780470919392

Web References:

- https://nptel.ac.in/courses/112/105/112105249/

Title: Energy Management Principles **Code: ME345**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: The students must have understanding of basics of Physics and Chemistry
Objectives:

1. To make students familiar with the concepts of energy conservation and energy management.
2. To make them acquainted with the basic techniques of energy audit procedure with case studies.

Learning Outcomes:

Course Outcome	Description
CO1	Outline scope of energy conversion and utilization in industry and business organizations Understand the energy storage and conversation techniques.
CO2	Describe various terminologies used in analysis of energy conversion and energy audit.
CO3	Develop skills of measurements and choose right measuring equipment for measurement of entities related with energy management and audit.
CO4	Develop skills of measurements and choose right measuring equipment for measurement of entities related with energy management and audit.
CO5	Identify energy efficient technologies, energy opportunities and alternative energy sources in equipments, processes, practices and offices.
CO6	Apply the principles of energy management in boilers, heat exchangers, lighting systems, motors, HVAC etc.

Course content

Unit 1:INTRODUCTION
Role of energy in industrial activity, Conventional and Non conventional energy sources, Energy demand and availability, Energy audit, Energy conservation techniques in domestic, transport and in industrial sector, Energy Conservation in production of Heat and in Power generation.

Unit 2:ENERGY CONSERVATION IN USE OF HEAT

Economical design of furnace, Water treatment, Drying conditioning and industrial space heating, Boiler accessories etc., Heat recovery in Waste heat boilers, Co-generation Selection of Cycles: Combined cycle, Power generation for better energy efficiency management, Different

systems for combined cycle power generation, Energy conservation for better management techniques.

Unit 3:NEW AND RENEWABLE ENERGY TECHNOLOGIES

Clean Coal Technologies – coal beneficiation, Supercritical cycles, Integrated gasification combined cycles (IGCC), and Fluidized bed combustion, Electro gas dynamic, Thermionic, Thermoelectric generators, Fuel cells, Hydrogen economy, Renewable energy sources, Solar, Wind, Hydro, Biomass, Tidal, Geothermal, Animal and Human energy.

Unit 4:ENERGY AUDIT

Introduction, Types of audit, Field audit, Billing audit, Micro audit, Energy accounting & analysis, Survey Instrumentation, Energy economic decision making, the heating, Ventilation and air conditioning audit, Energy efficiency in unit operation, Demand side management, Energy economics, Energy related standards & Norms, Energy intensive industries, The utility energy audit, maintenance and energy audits, Self-evaluation checklists, Case studies & success stories.

Teaching Methodology:

The subject will help the students to understand the importance of energy, energy conservation, and energy efficiency in various industrial applications. The student will learn the energy management concepts. He can also choose to become energy manager or energy auditor after having some experience in core industry.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1,
Test-2	25 Marks	Based on Unit-2 & 3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-3 &4 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text Books:

4. General aspects of energy management and audit, Bureau of Energy Efficiency.
5. Energy efficiency in thermal utilities, Bureau of Energy Efficiency.
6. Energy efficiency in electrical Utilities

Reference Books:

3. Hand book of energy conservation Vol.1
4. Hand book of energy conservation Vol.2

Web References:

1. https://www.youtube.com/playlist?list=PL4ptNk2TMqR7bdL0-UmFtxU1ewoY6e3Ff
2. https://www.youtube.com/watch?v=MfNmtHCYNKk&list=PL4ptNk2TMqR7bdL0-UmFtxU1ewoY6e3Ff&index=2
3. https://www.youtube.com/watch?v=SW5u23wMXjE&list=PL4ptNk2TMqR7bdL0-UmFtxU1ewoY6e3Ff&index=3

Title: Six Sigma **Code: ME346**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses like "Engineering Mathematics-1, 2 and 3."

Objectives:

- Six sigma is a methodology of implementing a highly successful project, or producing a high quality product or service, using techniques and principles that ensure excellence.
- Its goal is to produce a nearly error-free product or service. It is aimed at reducing problem levels below than 3.4 problems per million transactions.

Learning outcome:

Course Outcome	Description
CO1	Outline definition, History, objectives and benefits of Six Sigma in industries. Relationship of six sigma and quality.
CO2	Describe basic statistical measures such as variance, standard deviation, process capability, voice of customer, normal distribution, various quality tools and concepts such as brainstorming, benchmarking and design of experiment.
CO3	Develop ability to prepare various types of control charts, house of quality, six sigma matrices.
CO4	Identify the areas of poor quality where six-sigma concept is required to be implemented to obtain the necessary improvement.
CO5	Apply acquired knowledge to conduct a six sigma study by following six sigma methodologies.
CO6	Demonstrate ability to develop and maintain six sigma standard in an organization.

Course Content

Introduction to Six Sigma, History of Six Sigma, Goals and Objectives, Benefits of Six Sigma, What is Quality, Gaps in Service, Achieving Six Sigma quality, Voice of Customer.

Basic statistics: Mean, Median, Mode, Variance, SD, Process Capability, Voice of customer, Six Sigma Data Type's, Normal Distribution, Organizational Structure and Roles, COPQ (Cost Of Poor Quality)

Six Sigma Methodologies: DMAIC, DMADV, Six Sigma metrics, DPU & DPMO, Yield Computations, Hidden Factory, How to calculate Sigma level

DEFINE Stage: Introduction to DEFINE Phase, Objectives, Project Charter, Introduction SIPOC, Create SIPOC, Sample SIPOC, Flow Chart, Process map, Top level Process definition, KANO's model, Quality Function Deployment, Affinity Diagram

MEASURE Stage: Introduction to MEASURE Phase, Objectives, Why MEASURE phase needed, Key Performance Indicators (KPI), Metric definition, CTS,CTQ,CTP Explained, Measurement System Analysis, Precision versus Accuracy, Sampling methods, Process Capability, Value-added Non-Value-added activities

ANALYZE Stage: Introduction to ANALYZE Phase, Objectives, Failure Modes and Effects Analysis, Value Stream Analysis, Analyzing Sources of Variation, Exploratory Data Analysis (EDA), Data Mining, Check sheet, Run Chart, Pareto Analysis, Scatter diagram, Cause and effect diagram, Control charts, Box-Plot-Components, Hypothesis Testing, Risk

IMPROVE Stage:Introduction to IMPROVE Phase, Objectives, Defining the New Processes, Lateral Thinking, Brainstorming, Benchmarking, Five-S, Mistake Proofing, Design of Experiments (DOE), Implementation and Verification

Control Charts: X bar R charts, X bar S charts, Np Chart, P Chart, C Chart, U Chart

Teaching Methodology:
This course is introduced to help students learn and understand the Six Sigma quality tool. Students will be introduced with concept of Six sigma. Then Six sigma methodology is taught step by step with practical examples. This course also covers various types of control charts.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1, Unit-2 and Unit-3
Test-2	25 Marks	Based on Unit-3, Unit-4, Unit-5 and around 30% from covera of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7, Unit-8 and around 30% from covera of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

TEXT/REFERENCE BOOKS:

1. Pande Pete, Holpp Larry, What is six sigma, McGraw- Hill.
2. Gygi Craig, Williams Bruce, Six sigma workbook for Dummies, Wiley Publishing House.
3. Georage Michael L, Maxey John, Rowlands David, Price Mark, The lean six sigma pocket toolbook: A quick reference guide to 100 tools for improving quality and speed 1st addition, McGraw – Hill.

Title: Fault Diagnosis Using Signal Processing **Code: ME347**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Mathematics", "Theory of Machine", "Design of Machine Elements" and "Vibration"

Objective:

1. To present recent developments in the field of machine fault signature analysis with particular regard to vibration analysis.
2. To identify the different types of faults in machine components by analyzing vibration signatures

Learning Outcomes:

Course Outcome	*Description*
CO1	Outline the various vibration principles and techniques
CO2	Describe the signal processing and data acquisition techniques
CO3	Develop the data acquisition and noise monitoring techniques for noise vibrations
CO4	Identify enhanced skills on fault diagnostics and analysis
CO5	Setup and manage noise and vibration monitoring programs
CO6	Demonstrate and deployment of basic knowledge of fault diagnostics and analysis for solving real-world problems

Course Content:

Unit-1: Introduction: Introduction, maintenance principle, failure modes effects & criticality analysis, basics of machinery vibration.

Unit-2: Signal Acquisition: Basics of instrumentation, sensors and transducers, data recording and signal transmission, vibration transducers, vibration monitoring.

Unit-3:Techniques of Signal Analysis: Engineering applications of vibration, rotor dynamics, time domain signal analysis, frequency domain signal analysis, Computer aided data acquisition, FFT analysis, modulation and sidebands envelope analysis, Cepstrum analysis, order analysis.

Unit-4: Noise Monitoring: Basics of noise and noise monitoring, numerical in noise vibration and data acquisition.

Unit-5: Balancing: Field balancing, misalignment detection, cracked shaft detection, looseness and rub detection.

Unit-6: Faults in Rotating Machines: Ball and journal bearings, gear fault detection - fans, blowers and compressors - pumps and turbines contaminant analysis, oil analysis, fault detection in motors and transformers, motor current signature analysis.

Unit-7: Non-Destructive Testing: Thermograph, ultrasonic, acoustic emission and eddy current testing, radiography, dye penetration test and visual inspection.

Teaching Methodology: This course is introduced to help students in applying theirknowledge of Mathematics, Theory of Machine, Design of Machine Elements and Vibration in order to explore the vast area of maintenance of machineries and to enhance students' ability to identify and diagnose the faults in machine components by analyzing vibration signatures. The entire course is divided into seven separate units: Introduction, Signal Acquisition, Techniques of Signal Analysis, Noise Monitoring, Balancing and Non-Destructive Testing. These sections have been framed to impart a systematic understanding of the basic mechanism of fault diagnosis, maintenance and finally implement these methodologies to laws to solve the real-world problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5, Unit-6, Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Fault Diagnosis using Signal Processing (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention by Jack A. Collins John Wiley & Sons; 2nd Edition, 1993.

[2] Signal-processing techniques utilized in fault diagnosis procedures by Jawad Faiz, Vahid Ghorbanian and Gojko Joksimovic, IET Digital Library.

Reference Books/Material:

[3] Fault-Diagnosis Systems by Rolf Isermann, Springer, 2006

[4] Maintenance and Spare Parts Management by Gopalakrishnan, PHI Learning, 2nd Edition, 2013.

Web References:

[1] https://nptel.ac.in/courses/112/105/112105232/

[2] https://nptel.ac.in/courses/112/105/112105048/

[3] https://edukite.org/course/machinery-fault-diagnosis-and-signal-processing-nptel/

[4] https://www.intechopen.com/books/time-series-analysis-data-methods-and-applications/process-fault- diagnosis-for-continuous-dynamic-systems-over-multivariate-time-series

Journals References:

[1] Mechanical Systems and Signal Processing, Elsevier

[2] Journal of Tribology, ASME

[3] Signal Processing, Elsevier

[4] Journal of Signal Processing, J-STAGE

Title: Applications of Composite Materials **Code: ME348**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Material Science*" and "*Manufacturing Technology*".

Objective:

1. To explain the fundamental concepts of mechanical behavior of composite materials.
2.
3. To explore the applications of composite materials in modern manufacturing industries.

Learning Outcome:

Course Outcome	Description
CO1	Outline various types of composite materials.
CO2	Describe the fabrication and applications of composite materials.
CO3	Develop an idea to fabricate the advanced composite material using the concept of sustainable manufacturing.
CO4	Identify the most influencing process parameters to fabricate the composites.
CO5	Apply most appropriate processing technique to fabricate the polymer matrix composites.
CO6	Demonstrate the applications of composite materials in real-world.

Course Content:

Unit-1: General introduction of composites, Historical development, Material properties that can be improved by forming a composite material, classification of composites and advantages of composites materials.

Unit-2: Future Aircraft Structures: From Metal to Composite Structures, Opportunities for Polymeric-Based Composite Applications for Transport Aircraft

Unit-3: Processing of fibers, Fabrication of polymer matrix composites, metal matrix composites, and ceramic matrix composites.

Unit-4: Mechanical properties and other characteristics of different composite materials, Failure modes.

Unit-5: Multifunctional Polymer Based Structures for Human Tissues Reconstruction, Current and Future Applications of Polymer Composites in the Field of Tribology.

Unit-6: Developments in Characterizing the Structural Behavior of Composites in Fire.

Teaching Methodology:

This course is introduced to help students to understand the various types of composite materials and their applications. The entire course is broken down into six separate units:

Introduction to composites, Future aircraft structure and polymer based composite applications, processing of fibers and fabrication of composites, Mechanical properties of composites, Multifunctional polymer based structures, and developments in Characterizing the Structural Behavior of Composites in Fire.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 & Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Referred video lectures on Processing of non-metals are available on JUET server.

TEXT BOOKS-

1. Srinivasan. K, Composite materials: production properties testing and applications, Narosa Publishing House, 2009.
2. Hull, D. and Clyne, T.W., Introduction to composite materials, Cambridge University press, 1996.

REFERENCE BOOKS-

1. Bunsell, A, R. and Renard, J., Fundamentals of fiber reinforced composite materials,Institute of Physics Pub, 2005.
2. Gibson, Ronald F**.,** Principles of composite material mechanics**,** CRC Press (Taylor & Francis Group), 2012.
3. Luigi Nicolais., Eva Milella, Michele Meo, Composite materials – A vision for future, Springer, 2011.

Web References:

[1] www.nptel.com
[2] https://nptel.ac.in/courses/112/104/112104229/

Journals References:

[1] Journal of Manufacturing Processes: Elsevier
[2] Materials and Manufacturing Processes: Taylor & Francis
[3] Journal of Materials Processing Technology: Elsevier
[4] Composite Part A: Elsevier
[5] Composite Part B: Elsevier

Title: Engineering System Modeling and Simulation **Code: ME349**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied calculus, linear algebra, differential equations, basic probability and statistics, familiarity with matlab and simulink.

Objective:

[1] The course will introduce the basic concepts of computation through modeling and simulation that are increasingly being used by architects, planners, and engineers to shorten design cycles, innovate new products, and evaluate designs and simulate the impacts of alternative approaches.

[2] Engineering problem modelling and solving through the relationship between theoretical, mathematical, and computational modelling for predicting and optimizing performance and objective.

[3] Develop different models to suit special characteristics of the system being modelled.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the basic concepts to model deterministic systems and differentiate between nonlinear and linear models.
CO2	Describe numerically simulation of linear and non-linear ordinary differential equations and deterministic systems.
CO3	Develop the impact of alternative approaches on simulation of models.
CO4	Identify a project that analyzes one of a variety of scientific problems.
CO5	Apply MATLAB and other soft wares to explore a range of programming and modeling concepts.
CO6	Demonstrate the designing a representative model, implementing the model, completing a verification and validation process of the model, reporting on the model in oral and written form, and changing the model to reflect corrections, improvements and enhancements.

Course Content:

Unit-1: Demonstrate basic programming skills – functions, arrays, loops, conditional statements, procedures.

Unit-2: Demonstrate technical communication skills: Create a comprehensive report and an oral presentation with accurate visual representations of a model and its results.

Unit-3: Explain the Role of Modeling: Discuss the importance of modeling to science and engineering, the history and need for modeling, the cost effectiveness of modeling, the time-effect of modeling, define the terms associated with modeling to science and engineering, list questions that would check/validate model results, describe future trends and issues in science

and engineering, and identify specific industry related examples of modeling in science and engineering.

Unit-4: Utilize the Modeling Process to identify the key parameters of a model, estimate model outcomes, utilize a computational tool, e.g., Matlab to implement the mathematical representation of the model, convey the results of the simulation accurately, validate the model with data, and discuss the quality and sources of errors in the model.

Unit-5: Explain and conduct the transforming of continuous functions and dynamics equations into discrete computer representations. Write pseudo-code for finite difference modeling equations and create a simulation in a computational tool, e.g., Matlab.

Unit-6: Examine mathematical representations of functions - Describe and utilize linear and nonlinear functions to model empirical data. Visualize empirical data and the fitting function using a computational tool. Utilize Matlab as a computational tool - Describe the system syntax, define elementary representations, functions, etc. Explain programming and the scripting process, e.g., relational operations, logical representations, condition statements, loops, etc. Create tabular and graphical results.

Unit-7: Analyze modeling and simulation - Identify different types of models and simulations, describe the iterative development process of a model, and explain the use of models and simulations for hypothesis testing and explain how models link the physical world, the virtual world and the science of prediction.

Unit-8: Assess computational models - Discuss methods for reviewing models, their verification and validation. Discuss the differences between the predictions of the model, the actual results and the relevance of these differences to the problem. Discuss the suitability and limits of the model to address the problem for which the model was designed.

Teaching Methodology:

The course activities include lectures, computer laboratory, modelling tutorials, presentations, group discussions, assignments and reports on case studies.The knowledge of this subject is very essential for modelling and simulationof various parts of a machine.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 to Unit-6 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-7 & Unit-8 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided onJUET server. This can include eBook, lecture material, supplementary course notes, problem sheets and solutions.

Text Book:

[1] Fundamentals of Modeling and Analyzing Engineering Systems by Cha P. D., Rosenberg J. J. and Dym C. L.

Reference Books/Material:

[1] Modeling and Simulation of Dynamic Systems by Woods Robert L. and Kent L.

[2] Modeling and Analysis of Dynamic Systems - Wiley

Web References:

[1] https://nptel.ac.in/courses/112107214/

[2] https://in.mathworks.com/solutions/system-design-simulation.html

Journals References:

[3] International Journal of Engineering Systems Modelling and Simulation : SJR

Title: 3D Printing **Code: ME350** **(OE-2)**
L-T-P Scheme: 3-0-0 **Credit: 3**

Objectives:

1. To make the students aware about the 3D printing and reverse engineering technologies used for conceptual modeling, prototyping and rapid manufacturing.
2. Students will know about various file formats, wide range of materials and applications of 3D printing in industry and society.

Course Outcome:

At the end of the course students will be able to:

Course Outcome	Description
CO1	**Define** and understand basic fundamentals of subtractive manufacturing, 3D printing and reverse engineering.
CO2	**Describe** process chain of 3D printing, classification, working and materials for various 3D printing processes.
CO3	**Apply** concepts of 3D printing to choose correct file format, material and processes for fabrication of model, prototype and functional components.
CO4	**Analyze** and compare various 3D printing processes and applications in different industries.

Introduction: Introduction, evolution, process chain, advantages and disadvantages over conventional processes, materials for 3D printing

(7)

Classification: Liquid based processes: stereo lithography apparatus (SLA), solid ground curing (SGC); Powder based processes: selective laser sintering (SLS), powder bed binder jetting 3D printing, electron beam melting (EBM); Solid based processes: laminated object manufacturing (LOM), fused deposition modelling (FDM); Directed energy deposition processes: laser engineered net shaping (LENS), direct metal deposition (DMD), electron beam based metal deposition. Classifications according to ASTM International

(16)

File formats: Introduction to STL and other facetted file formats, strength and weakness of STL format, Data conversion and associated difficulties, Data repair procedure, slicing algorithms, Introduction to IGES, DXF and STEP file formats

(7)

Applications: 3D printing applications in prototyping, concept models, visualization aids, replacement parts and end-use parts. Industrial applications in aerospace, automobile, medical, electronics, architecture and construction, sports, food and fashion industries using forward and reverse engineering.

(12)

Learning Resources:

Text Books:

1. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition
2. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Ian Gibson, David W Rosen, Brent Stucker, 2nd Edition, Springer, 2015

Reference Books:

1. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer, 2001.
2. Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, John Wiley & Sons, 2006.
3. Additive Manufacturing, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
4. C.P Paul, A.N Junoop, "Additive Manufacturing: Principles, Technologies and Applications,Second Edition, McGrawHill, 2021.