Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
MA0U20A	PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX ANALYSIS	BSC	3	1	0	4	2020

i) PRE-REQUISITE: A basic course in partial differentiation and complex numbers.

ii) COURSE OVERVIEW:

This course introduces basic ideas of partial differential equations which are widely used in the modelling and analysis of a wide range of physical phenomena and has got application across all branches of engineering. The basic theory of functions of a complex variable, residue integration and conformal transformation are discussed.

iii) COURSE OUTCOMES

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

CO 1	Solve partial differential equations.	Apply
CO 2	Use appropriate methods to solve one dimensional wave equation and heat equation.	Apply
CO 3	Solve problems using analyticity of complex functions	Apply
CO 4	Find the image of regions under conformal mapping	Apply
CO 5	Find complex integrals using Cauchy's formulas to compute several kinds of integrals.	Apply
CO 6	Find the series expansion of complex functions	Apply

iv) SYLLABUS

Partial differential equations: Formation of partial differential equations, Solutions of a partial differential equations, Linear equations of the first order, Method of separation of variables.

One dimensional wave equation-derivation and solution -One dimensional heat equation, derivation and solution

Complex Differentiation: Analytic functions, Cauchy-Riemann equations, harmonic functions, Conformal mappings- standard mappings, Linear fractional transformation .

Complex integration: Line integrals in the complex plane, Contour integrals, Cauchy integral theorem, Cauchy Integral formula

Taylor's series and Laurent's series, zeros of analytic functions, singularities, Residues, Cauchy Residue theorem, Evaluation of definite integral using residue theorem.

v) (a) TEXT BOOKS

1) B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2018.
2) Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2016.

(b) REFERENCES

1) J. Stewart, Essential Calculus, Cengage, 2nd Edition, 2017.
2) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
3) Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants-elimination of arbitrary functions, Solutions of a partial differential equations, Equations solvable by direct integration, Linear equations of the first order- Lagrange's linear equation, Non-linear equations of the first order - Charpit's method. Boundary value problems, Method of separation of variables.	**12**
II	One dimensional wave equation- vibrations of a stretched string, Derivation. Solution of wave equation using method of separation of variables, Fourier series solution of boundary value problems involving wave equation, D'Alembert's solution of the wave equation. One dimensional heat equation, derivation. Solution of the heat equation, using method of separation of variables, Fourier series solutions of boundary value problems involving heat equation-solution of Laplace's equations by method of separation of variables.	**13**
III	Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations-harmonic functions, finding harmonic conjugate-Conformal mappings- mappings of $w = z^2, w = e^z, w = \frac{1}{z}, w = sinz$	**12**
IV	Complex integration, Line integrals in the complex plane, Basic properties, first evaluation method, second evaluation method, use of representation of a path-Contour integrals, Cauchy integral theorem (without proof) on simply connected domain, on multiply connected domain (without proof). Cauchy Integral formula (without proof), Cauchy Integral formula for derivatives of an analytic function Taylor's series and Maclaurin series.	**11**

V	Laurent's series (without proof)-zeros of analytic functions, singularities, poles, removable-singularities, essential singularities, Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem-Residue integration of real integrals –integrals of rational functions of $cos\theta$ and $sin\theta$, integrals of improper integrals of the form $\int_{-\infty}^{\infty} f(x)dx$with no poles on the real axis. ($\int_{A}^{B} f(x)dx$ whose integrand become infinite at a point in the interval of integration is excluded from the syllabus).	**12**
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U20A	MECHANICS OF SOLIDS	PCC	3	1	0	4	2020

i) **PREREQUISITE:** ES0U10A Engineering Mechanics

ii) **COURSE OVERVIEW:**

The goal of this course is to help the students to understand the concept of stress and strain in different types of structures/machines under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular section, strain energy, different theories of failure, stresses in thin cylinder thick cylinder and spheres due to external and internal pressure.

iii) **COURSE OUTCOMES**

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

CO 1	Explain the concepts of stresses and strains in various structural members.	Understand
CO 2	Apply tensorial and graphical (Mohr's circle) approaches to determine the stresses, strains and displacements of structures.	Apply
CO 3	Analyse the strength of materials using stress-strain relationships for structural and thermal loading.	Apply
CO 4	Analyse the shafts subjected to torsional loading and/or beams subjected to bending moments.	Apply
CO 5	Determine the deformation of structures subjected to various loading conditions using different methods.	Apply
CO 6	Determine the strength of thin cylinders, spherical vessels and columns.	Apply

iv) **SYLLABUS**

Deformation behavior of elastic solids in equilibrium under the action of a system of forces, Displacement, gradient of displacement, Cartesian strain matrix, strain-displacement relations. Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress.Mohr's circle for 2D case.
Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Material Properties. Constitutive equations-generalized Hooke's law, Hooke's law for Plane stress and plane strain conditions. Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading.
Torsional deformation of circular shafts. Shear force and bending moment diagrams.

Differential equations between load, shear force and bending moment. Flexural formula. Shear stress formula for beams.

Deflection of beams using Macaulay's method Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads. Castigliano's theorem.
Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Introduction to Theories of Failure.

v) a) TEXTBOOKS

1) R. C. Hibbeler, Mechanics of Materials,PearsonEducation,2008.
2) E. P. Popov, T. A. Balan, Engineering Mechanics of Solids, PearsonEducation,2012.
3) L. S. Srinath, Advanced Mechanics of Solids, McGraw HillEducation,2017.
4) V. B Bhandari, Design of Machine Elements, McGraw HillIndia,2016.

b) REFERENCES

1) S. H. Crandal, N. C. Dhal, T. J. Lardner, An introduction to the Mechanics of Solids, McGrawHill,1999.
2) I.H. Shames, J. H. Pitarresi, Introduction to Solid Mechanics, Prentice Hall of India,2006.
3) James M.Gere, Stephen Timoshenko, Mechanics of Materials, CBS Publishers & Distributors, NewDelhi,2012.
4) Rattan, Strength of Materials, 2e McGraw Hill EducationIndia,2011.

vi) COURSEPLAN

Module	Contents	No. of hours
I	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe method of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix. Equality of cross shear (Derivation not required). Write Cauchy's equation(Derivation not required),Find resultant stress, Normal and shear stress on a plane given stress tensor and direction cosines (no questions for finding direction cosines).Displacement, gradient of displacement, Cartesian strain matrix, Write strain displacement relations (small-strain only), Simple problems to find strain matrix given displacement field (2D and 3D), write stress tensor and strain tensor for Plane stress and plane strain conditions. Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress. Mohr's circle for 2D case: find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohr's circle.	12

II	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio. Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in in terms of Young's Modulus and Poisson's ratio (3D).Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required),Numerical problems. Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports. Numerical problems for axially loaded members	**12**
III	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula. Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts. Numerical problems for basic design of circular shafts subjected to externally applied torques. Shear force and bending moment diagrams for cantilever and simply supported beams subjected to point load, moment, UDL and linearly varying load. Differential equations between load, shear force and bending moment. Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections Shear stress formula for beams: (Derivation not required),numerical problem to find shear stress distribution for rectangular section.	**12**
IV	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macaulay's method (procedure and problems with multiple loads). Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads (short derivations in terms of loads and deflections). Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Simple problems to solve elastic deformations. Castigliano's second theorem to find displacements, reciprocal relation, (Proof not required for Castigliano's second theorem and reciprocal relation).	**12**

V	Fundamentals of bucking and stability, critical load, Euler's formula for long columns, assumptions and limitations, effect of end conditions(derivation only for pinned ends), equivalent length. Critical stress, slenderness ratio, Rankine's formula for short columns, Problems. Introduction to Theories of Failure. Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain. Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy	**12**
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U20B	Mechanics of Fluids	PCC	3	1	0	4	2020

(i) PREREQUISITE: Nil

(ii) COURSE OVERVIEW:
This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering, pipe networks. It introduces the concepts of boundary layer, dimensional analysis and model testing.

(iii) COURSE OUTCOMES:

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

CO1	Explain the concepts of fluid mechanics	Understand
CO2	Solve the static equilibrium cases of fluids	Apply
CO3	Solve the dynamic equilibrium cases of fluids	Apply
CO4	Examine the different types of fluid flow using the principles of fluid kinematics	Apply
CO5	Explain the concept of boundary layer and dimensional analysis	Understand
CO6	Utilize dimensional analysis for model study	Apply

(iv) SYLLABUS

Introduction: –Fluids and continuum, Physical properties of fluids, Newton's law of viscosity, fluid Statics, measurement of pressure , hydrostatic pressure on plane and curved surfaces, Stability of immersed and floating bodies

Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, flow patterns, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations

Control volume analysis of mass, momentum and energy, Equations of fluid dynamics, Energies in flowing fluid, heads, and flow measuring devices

Pipe Flow: Viscous flow, Reynolds experiment ,significance of Reynolds number, shear stress and velocity distribution in a pipe, Hagen Poiseuille equation , Major and minor loss, Turbulent flow ,pipe connections , siphon, transmission of power through pipes and efficiency, Water hammer, Cavitation.

Boundary Layer : Growth of boundary layer over a flat plate and definitions, Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of Control

Dimensional Analysis: Buckingham's theorem, important non dimensional numbers and their significance

Applications and limitations of model testing, simple problems only

iv) a) TEXTBOOKS

1) John. M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE),2019
2) Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, Fluid Mechanics, Wiley India,2018

b) REFERENCES

1) White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition,2017
2) Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations	12
II	Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow,1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses	12
III	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates. Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.	12

IV	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.	**12**
V	Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only	**12**
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U20C	METALLURGY AND MATERIAL SCIENCE	PCC	3	1	0	4	2020

i) PREREQUISITE: PH0U10B Engineering Physics B and CY0U10A Engineering Chemistry

ii) COURSE OVERVIEW:

Goal of this course is to build awareness regarding the behaviour of materials in engineering applications and select the materials for various engineering applications. This course also aims to develop an awareness to apply knowledge of material behaviour in material selection

iii) COURSE OUTCOMES

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

CO 1	Explain the various engineering materials presently in use and the correlation of the properties with crystallographic structure.	Understanding
CO 2	Explain the different modes of failure of engineering materials and develop an awareness to apply this knowledge in material design.	Understanding
CO 3	Explain equilibrium diagram of common types of binary systems.	Understanding
CO 4	Apply heat treatment techniques as per the engineering requirement.	Apply
CO 5	Choose the correct alloying element required for a particular application.	Apply
CO 6	Explain the various material deformation and fracture mechanisms in metals, alloys and composites	Understanding

iv) SYLLABUS

Earlier and present development of atomic structure. Crystallography: - SC, BCC, FCC, HCP structures, APF, Miller Indices. Modes of plastic deformation. Crystallization.

Classification of crystal imperfections. Polishing and etching. X – ray diffraction, SEM and TEM, Diffusion in solids, Fick's laws.

Phase diagrams: equilibrium diagram of common types of binary systems, Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties. Heat treatment: TTT, CCT diagram, applications. Tempering. Hardenability, Surface hardening methods.

Strengthening mechanisms: cold and hot working. Alloy steels: how alloying elements affecting properties of steel, nickel steels, chromium steels, high speed steels, cast iron, principal non-ferrous alloys.

Fatigue, creep, DBTT, super plasticity - need, properties and applications of composites, super alloy, intermetallics, maraging steel, Titanium, Ceramics: structures, applications.

v) a) TEXT BOOKS

1) Callister William. D., Material Science and Engineering, JohnWiley,2014
2) Raghavan V, Material Science and Engineering, PrenticeHall,2015
3) Higgins R.A. - Engineering Metallurgy part - I –ELBS,1998

b) REFERENCES

1) Anderson J.C. *et.al.*, *Material Science for Engineers*, Chapman andHall,1990
2) Clark and Varney, *Physical metallurgy for Engineers*, Van Nostrand,1964
3) Reed Hill E. Robert, *Physical metallurgy principles*, 4thEdn. CengageLearning,2009
4) Avner H Sidney, *Introduction to Physical Metallurgy*, Tata McGrawHill,2009

vi) COURSE PLAN

Module	Contents	No. of hours
I	Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive force, density, directional and non-directional - properties based on atomic bonding:- attributes of deeper energy well and shallow energy well to melting temperature, coefficient of thermal expansion - attributes of modulus of elasticity in metal cutting process -Secondary bonds:- classification- hydrogen bond and anomalous behavior of ice float on water, application- specific heat, applications. (Brief review only). Crystallography:- Crystal, space lattice, unit cell- SC, BCC, FCC, atomic packing factor and HCP structures - short and long range order - effects of crystalline and amorphous structure on mechanical properties. Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy. Miller Indices: - crystal plane and direction - Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning. Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications. Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity - Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems.	12

II	Classification of crystal imperfections: - types of point and dislocations. Effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation - Burgersvector, Dislocation source, significance of Frank-Read source in metals deformation - Correlation of dislocation density with strength and nano concept, applications. Significance high and low angle grain boundaries on dislocation – driving force for grain growth and applications during heat treatment. Polishing and etching to determine the microstructure and grain size-Fundamentals and crystal structure determination by X – ray diffraction, simple problems –SEM and TEM. Diffusion in solids, fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems	**12**
III	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types. Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid. Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensite transformation, bainite, spheroidite etc. Heat treatment: - Definition and necessity – TTT for a eutectoid iron–carbon alloy, CCT diagram, applications - annealing, normalizing, hardening, spheroidizing. Tempering:-austempering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming. Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.	**12**

IV	Cold working: Detailed discussion on strain hardening; recovery; recrystallization, effect of stored energy; re- crystallization temperature - hot working, Bauschinger effect and attributes in metal forming. Alloy steels:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties Nickel steels, Chromium steels etc. – change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead - High speed steels - Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications - Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications. Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve. Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life – effect of temperature on fatigue, thermal fatigue and its applications in metal cutting.	**12**
V	Fracture: – Brittle and ductile fracture – Griffith theory of brittle fracture – Stress concentration, stress raiser – Effect of plastic deformation on crack propagation - transgranular, intergranular fracture - Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure Structural features of fatigue: - crack initiation, growth, propagation - Fracture toughness (definition only), applications - Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBTT, applications. Creep: - Creep curves – creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding - Mechanism of creep deformation - threshold for creep, prevention against creep - Super plasticity: need and applications Composites: - Need of development of composites; fiber phase; matrix phase; only need and characteristics of PMC, MMC, and CMC. Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys, Titanium Ceramics:-coordination number and radius ratios- AX, AmXp, AmBmXp type structures –applications.	**12**
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ES0U20A	DESIGN AND ENGINEERING	ESC	2	0	0	2	2020

i) **PRE-REQUISITE:** Nil. Its generic to all engineering disciplines.

ii) **COURSE OVERVIEW:**

Goal of this course is to expose the students to the fundamental principles of design engineering. Students are expected to apply design thinking in learning, which is very important and relevant for today. The course also focuses on familiarizing the students with the aesthetics, ergonomics and sustainability factors in designs and practice professional ethics while designing.

iii) **COURSE OUTCOMES**

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

CO 1	Demonstrate the different stages involved in design engineering process	Understanding
CO 2	Compose a problem statement with design objectives taking into account the customer requirements, design constraints and functionality.	Create
CO 3	Develop innovative solutions to the Design problem through brainstorming and ideation.	Apply
CO 4	Identify the concepts of Biomimicry, Aesthetics and Ergonomic factors in designs to add more value to it.	Apply
CO 5	Apply the Design communication tools to model an idea.	Apply
CO6	Incorporate different segments of knowledge in engineering in order to develop innovative, reliable, sustainable and economically viable designs.	Apply

iv) **SYLLABUS**

Introduction to engineering design. Generate a design through the Design Process stages.

Design Thinking Approach, Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning.

Ideation in Design Thinking - Brainstorming sessions. Design Engineering Concepts. Application of Biomimicry, Aesthetics and Ergonomics in Design. Design for X – Quality, Reliability and Sustainability

Design Communication, Data Representation, Communicating Designs Orally, Graphically and in Writing. Modelling, Prototyping and Proof of Concept.

Value Engineering, Concurrent and Reverse Engineering. Expediency, Economics and Environment in Design Engineering. Design Rights. Ethics in Design.

v) (a) TEXT BOOKS

1) YousefHaik,SangarappillaiSivaloganathan,TamerM.Shahin,*EngineeringDesignProcess*, Third Edition, Cengage Learning, (1 January2017)
2) Linda C. Schmidt , George Dieter, *Engineering Design*, McGraw Hill Education; Fourth edition(1July2017)
3) PavanSoni, *Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-Solving*,PenguinRandomHouseIndiaPrivateLimited,2020
4) Voland,G.,*EngineeringbyDesign*,PearsonIndia2014, SecondEdition,ISBN9332535051

(b) OTHERREFERENCES

1) CliveLDym, *EngineeringDesign:A ProjectBased Introduction*,FourthEdition,JohnWiley & Sons, New York2009.
2) Tim Brown, *Change by Design: How Design Thinking Transforms Organizations and InspiresInnovation*,HarperBusiness;Revised,Updateded.edition(5March2019)
3) Don Norman,*TheDesignof EverydayThings*,BasicBooks;2 edition(5November2013)
4) Dominique Forest , *Art of Things: Product Design Since 1945*, Abbeville Press Inc.,U.S.; Special edition (16 October2014)
5) Javier Abarca, Al Bedard, et al, *Introductory Engineering Design – A Projects-Based Approach*,3rded,RegentsoftheUniversityofColorado,2000.
6) Nigel Cross, Design Thinking: *Understanding How Designers Think and Work*, Berg Publishers 2011, First Edition, ISBN:978-1847886361
5) Pahl,G.,Beitz,W.,Feldhusen,J.,Grote,K.-H.,*EngineeringDesign:ASystematicApproach*, Springer 2007, Third Edition, ISBN978-1-84628-319-2.
6) George Dieter, *Engineering Design: A Materials and Processing Approach* , McGraw-Hill Education / Asia; 3 edition (16 February2000)

vi) COURSE PLAN

Module	Contents	No. of hours
I	Design Process: - Defining a Design Process-: Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.	**3**
	Practical Exercise: Need Identification. How to define a Problem Statement. Present an idea using the stages of Design Process.	**3**

II	Design Thinking Approach: -Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Empathize – User Persona, Day in the Life Technique, identify customer requirements using Morphological Chart and set design objectives. Define - Identifying and formulating a Problem Statement - Fish Bone Diagram	**4**
	Practical Exercise: User Persona Chart. Morphological Chart	**2**
III	Ideate - Brainstorming sessions, and ideation using Random word technique, SCAMPER. Design Engineering Concepts: Modular Design and Life Cycle Design Approaches. Application of Biomimicry, Aesthetics and Ergonomics in Design. Design for X – Quality, Reliability and Sustainability.	**4**
	Practical Exercise: Brainstorming, 6-3-5 technique, Random Word Technique	**2**
IV	Design Communication: - Data Representation, Communicating Designs Orally, Graphically and in Writing. Modelling, Prototyping and Proof of Concept. Awareness of Basic tools of Design like – Autodesk, CATIA, MATLAB	**3**
	Practical Exercise: Communicating Designs Graphically.	**4**
V	Value Engineering, Concurrent Engineering, and Reverse Engineering in Design. Expediency, Economics and Environment in Design Engineering:- Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights. Ethics in Design	**3**
	Practical Exercise: Case Studies	**2**
	Total hours	**30**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
NC0U20A	SUSTAINABLE ENGINEERING	MNC	2	0	0	NIL	2020

i) **PREREQUESITE:** Nil

ii) **COURSEOVERVIEW**

The objective of this course is to expose the students to the concept of sustainability, the global initiatives towards attaining sustainable development goals and the various sustainable practices. The students should realize the potential of technology in addressing environmental issues and bringing in sustainable solutions.

iii) **COURSE OUTCOMES**

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

CO 1	Explain the relevance and the concept of sustainability and the global initiatives towards attaining sustainable development.	Understand
CO 2	Identify sustainable solutions for different types of environmental pollution problems	Apply
CO 3	Discuss the environmental regulations and standards, various tools for environmental management and clean development mechanism.	Apply
CO 4	Explain the concept of circular economy, bio-mimicking and the sustainable framework developed in industrial ecology and industrial symbiosis.	Apply
CO 5	Choose the best practice of nonconventional and sustainable energy depending on the available resources and its utilization.	Apply
CO6	Demonstrate the broad perspective of sustainable practices applicable for energy efficient buildings, green engineering, sustainable cities, sustainable urbanization, and sustainable transport.	Apply

iv) **SYLLABUS**

Sustainability-need and concept, Technology and Sustainable Development, Sustainable Development Goals.

Environmental Pollution: Natural resources and their pollution, Carbon credits, Zero waste concept and 3 R concepts, Clean Development Mechanism: Carbon Trading and Carbon foot print, legal provisions for environmental protection.

Environmental management standards: ISO 14001:2015 frame work, Life Cycle Analysis, Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.

Resources and its utilisation: Basic concepts of Conventional and non-conventional energy.

Sustainability practices: Sustainable habitat, Green buildings, green materials, Sustainable urbanization.

v) (a) TEXTBOOKS

1) Bradley, A.S., Adebayo,A.O., Maria, P.,*Engineering applications in sustainable design and development*, Cengagelearning, 1st Edition,2015.
2) Allen, D. T. and Shonnard, D. R., *Sustainability Engineering: Concepts, Design and Case Studies*, Prentice Hall, 1st Edition,2011
3) Purohit, S.S., *Green Technology: An Approach For Sustainable Environment*, Agrobios(India), 1st Edition,2021.
4) Janine, M.B., *Biomimicry: Innovation Inspired by Nature*, William Morrow Paperbacks,2002

(b) REFERENCES

1) Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
2) ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA RatingSystem.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs).	**6**
II	Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Clean Development Mechanism (CDM):Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.	**6**

III	Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.	**6**
IV	Resources and its utilisation: Basic concepts of Conventional and non- conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.	**6**
V	Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport.	**6**
	Total hours	**30**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U28A	COMPUTER AIDED MACHINE DRAWING	PCC	0	0	3	2	2020

i) COURSEOVERVIEW

The objective of the course is to introduce students to the basics and standards of engineering drawing related to machines and components, make students familiarize with different types of riveted and welded joints, surface roughness symbols; limits, fits and tolerances, to convey the principles and requirements of machine and production drawings, introduce the preparation of drawings of assembled and disassembled view of important valves and machine components used in mechanical engineering applications and to introduce standard CAD packages for drafting and modelling of engineering components.

ii) COURSE OUTCOMES

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

CO 1	Apply the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components.	Apply
CO 2	Formulate standard assembly drawings of machine components and valves using part drawings and bill of materials.	Understand
CO 3	Apply limits and tolerances to components and choose appropriate fits for given assemblies.	Apply
CO 4	Interpret the symbols of welded, machining and surface roughness on the component	Understand
CO 5	Formulate part and assembly drawings and Bill of Materials of machine components and valves using CAD software.	Apply

iii) SYLLABUS

1) Introduction to machine drawing, drawing standards, fits, tolerances, surface roughness
2) Introduction to assembly and part drawings of simple assemblies and subassemblies of machine parts viz., couplings, clutches, bearings, I.C. engine components, valves, machine tools, etc.;
3) Introduction to CAD

iv) REFERENCES

1. N. D. Bhatt and V.M. Panchal, Machine Drawing,Charotar Publishing House, 2011
2. P I Varghese and K C John, Machine Drawing, VIP Publishers,2009
3. Ajeet Singh, Machine Drawing Includes AutoCAD, Tata McGraw-hill,2008
4. P S Gill, Machine Drawing, Kataria& Sons,2013

v) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
	PART –A (Manual drawing) ***(Minimum 6 drawings compulsory)***	
I	Temporary Joint: Principles of drawing, free hand sketching, Importance of machine Drawing. BIS code of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, Riveted joints.	**3**
II	Fasteners: Sketching of conventional representation of welded joints, Bolts and Nuts or Keys and Foundation Bolts.	**3**
III	Fits and Tolerances: Limits, Fits – Tolerances of individual dimensions – Specification of Fits – basic principles of geometric & dimensional tolerances. Surface Roughness: Preparation of production drawings and reading of part and assembly drawings, surface roughness, indication of surface roughness, etc.	**3**
IV	Detailed drawing of Cotter joints, Knuckle joint and Pipe joints	**6**
V	Assembly drawings(2D): Stuffing box and Screw jack	**3**
	PART –B (CAD drawing) ***(Minimum 6 drawings compulsory)***	
VI	Introduction to drafting software like Auto CAD, basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning, Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.	**3**
VII	Drawing of Shaft couplings and Oldham's coupling	**6**
VIII	Assembly drawings(2D)with Bill of materials: Lathe Tailstock and Universal joint	**6**

IX	Assembly drawings(2D)with Bill of materials: Connecting rod and Plummer block	**6**
X	Assembly drawings(2D) with Bill of materials: Rams Bottom Safety Valve OR steam stop	**6**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CE0U20A	MATERIAL TESTING LAB - I	PCC	0	0	3	2	2020

i) COURSE OVERVIEW:

The students will be able to undertake the testing of materials when subjected to different types of loading.

ii) COURSE OUTCOMES

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

CO 1	Apply the fundamental modes of loading of structures.	Apply
CO 2	Examine how to measure loads, displacements and strains.	Apply
CO 3	Compare the strength of the material and stiffness properties of different structural elements.	Apply
CO 4	Discover professional and ethical responsibility in the areas of material testing.	Apply
CO 5	Apply techniques, skills and modern engineering tools necessary for engineering.	Apply

iii) SYLLABUS

Study on stress-strain characteristics of mild steel rod, Estimation of modulus of rigidity of Steel wire, Estimation of modulus of rigidity of mild steel circular bars and Tor steel, Study on flexural behaviour of wooden beam, Estimation of compressive strength of wooden specimen, Estimation of toughness of steel, Estimation of modulus of rigidity of open coiled and closed coiled springs, Estimation of hardness properties of engineering materials,

Determinationofshearcapacityofmildsteelspecimen,Determinationofmomentofinertia of fly wheel, Bend and rebend test on mild steel specimen, Verification of Clerk Maxwell's Reciprocal Theorem, Study on flexural behaviour of steel I section, Estimation of modulus of elasticity of Torr steel using strain gauge, Demonstration on strain gauges and load cells.

iv) REFERENCES

1) Davis,Troxell and Hawk, *Testing of Engineering Materials*", International Student Edition, McGraw Hill Book Co. New Delhi, 4thEdition,2005
2) Gambhi ,M,L.,and Neha Jamwal, *Building and construction materials Testing and quality control*, McGraw Hill education(India)Pvt. Ltd.,2014

3) Holes,K, A,. *Experimental Strength of Materials*, English Universities Press Ltd. London, 2019
4) Suryanarayana ,A,K., *Testing of Metallic Materials*, Prentice Hall of India Pvt. Ltd. New Delhi,2007
5) Kukreja, C, B., Kishore. K., and Chawla, R., Material *Testing Laboratory Manual*, Standard Publishers & Distributors,2006.
6) Dally, J, W., Railey, W, P., *Experimental Stress analysis*, McGarwHill,2012
7) Baldev, R., Jayakumar, T., and Thavasimuthu M., *Practical Non-destructive testin*g, Narosa Book Distributors, 2015
8) Relevant ISCodes

v) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
I	Tension test on Mild Steel Rod	3
II	Torsion test on Steel wire	3
III	Torsion test on Mild Steel Rod	3
IV	Bending Test on wooden beams	3
V	Study on estimation of compression strength of timber specimen	
VI	Impact test a. Izod Apparatus b. Charpy Apparatus	3
VII	Spring test a. Open Coiled Spring b. Closed Coiled Spring	3
VIII	Hardness Test a. Brinell hardness b. Rockwell Hardness	3
IX	Double shear test	
X	Moment of Inertia of Fly wheel	3
XI	Bend and rebend test on mild steel specimen	3

XII	Verification of Clerk Maxwell's Theorem	3
XIII	Bending test on steel I Section	3
XIV	Modulus of Elasticity of Tor Steel Using Strain Gauge	3
XV	Study/Demonstration of strain gauges and load cells.	3
XVI	At the end of the course, students are required to do a term project in group (maximum 6 members) where in they will be supplied a material in crude form/ unworked form and they are supposed to shape the material in the required form (they can make use of facilities at mechanical workshop) and carry out tests to assess its material properties.	3
	Total hours	**42**