SRI VENKATESWARA COLLEGE OF ENGINEERING
(An Autonomous Institution, Affiliated to Anna University, Chennai)
SRIPERUMBUDUR TK - 602 117

REGULATION – 2018
M.E. Computer Aided Design
Choice Based Credit System
I-IV Semesters CURRICULUM

SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C	Prerequisites	Fixed/Movable
THEORY										
1.	MA18182	Advanced Numerical Methods	FC	4	3	1	0	4	-	F
2.	CD18101	Computer Applications in Design	PC	3	3	0	0	3	-	F
3.	CD18102	Advanced Mechanics of Materials	PC	3	3	0	0	3	-	F
4.	CD18103	Analysis and synthesis of mechanisms	PC	3	3	0	0	3	-	F
5.	CD18104	Quality Concepts in Design	PC	3	3	0	0	3	-	F
6.		Professional Elective I	PE	3	3	0	0	3	-	M
PRACTICAL										
7.	CD18111	CAD Laboratory	PC	4	0	0	4	2	-	F
8.	CD18112	Advanced Analysis and Simulation Laboratory	PC	4	0	0	4	2	-	F
TOTAL				**27**	**18**	**1**	**8**	**23**	-	

SEMESTER II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C	Prerequisites	Fixed/Movable
THEORY										
1.	CD18201	Advanced Finite Element Analysis	PC	3	3	0	0	3	CD18102	F
2.	CD18202	Vibration Analysis and Control	PC	3	3	0	0	3	-	F
3.	CD18203	Computer Aided Tools for Manufacturing	PC	3	3	0	0	3	-	F
4.	CD18204	Integrated Mechanical Design	PC	4	3	1	0	4	CD18102	F
5.		Professional Elective II	PE	3	3	0	0	3	-	M

6.		Professional Elective III	PE	3	3	0	0	3	-	M
7.	MC18081	Introduction to Research Methodology and IPR	MC	2	2	0	0	2	-	F
PRACTICAL										
8.	CD18211	Vibration Laboratory	PC	4	0	0	4	2	-	F
9.	CD18212	Design Project	EEC	4	0	0	4	2	-	F
TOTAL				**29**	**20**	**1**	**8**	**25**	-	-

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C	Prerequisites	Fixed/Movable
THEORY										
1.		Professional Elective IV	PE	3	3	0	0	3	-	F
2.		Professional Elective V	PE	3	3	0	0	3	-	F
3.		Professional Elective VI	PE	3	3	0	0	3	-	F
PRACTICAL										
7.	CD18311	Project Work Phase I	EEC	12	0	0	12	6	All Professional core courses	F
TOTAL				**21**	**9**	**0**	**12**	**15**	-	-

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C	Prerequisites	Fixed/Movable
PRACTICAL										
7.	CD18411	Project Work Phase II	EEC	24	0	0	24	12	All Professional core courses	F
TOTAL				**24**	**0**	**0**	**24**	**12**	**-**	**-**

PROFESSIONAL ELECTIVES (PE)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C	Prerequisites	Fixed/Movable
1.	CD18001	Design of Pressure Vessel and Piping	PE	3	3	0	0	3	-	M
2.	CD18002	Additive Manufacturing and Tooling	PE	3	3	0	0	3	-	M
3.	CD18003	Information Analytics	PE	3	3	0	0	3	-	M
4.	CD18004	Optimization Techniques in Design	PE	3	3	0	0	3	-	M
5.	CD18005	Experimental Methods in Stress Analysis	PE	3	3	0	0	3	-	M
6.	CD18006	Design for Manufacturing Assembly and Environment	PE	3	3	0	0	3	-	M
7.	CD18007	Advanced Tool Design	PE	3	3	0	0	3	-	M
8.	CD18008	Industrial Robotics and Expert System	PE	3	3	0	0	3	-	M
9.	CD18009	Computational Fluid Dynamics for Design Engineers	PE	3	3	0	0	3	-	M
10.	CD18010	Mechanics of Composite Materials	PE	3	3	0	0	3	-	M
11	CD18011	Engineering Fracture Mechanics	PE	3	3	0	0	3	-	M
12	CD18012	Tribology in Design	PE	3	3	0	0	3	-	F
13	CD18013	Mechanical Behavior of Materials	PE	3	3	0	0	3	-	F
14	CD18014	Product Life Cycle Management	PE	3	3	0	0	3	-	F
15	CD18015	Design for Internet of Things	PE	3	3	0	0	3	-	F
16	CD18016	Systems Engineering	PE	3	3	0	0	3	-	F
17	CD18017	Biomechanics	PE	3	3	0	0	3	-	F
18	CD18018	Plasticity and metal forming	PE	3	3	0	0	3	-	F

MANDATORY COURSE

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT HOURS	L	T	P	C
1.	MC18081	Research Methodology and IPR	OE	2	2	0	0	0

Summary

Subject Area	Credits per Semester				Total
	I	II	III	IV	
Humanities and Social Sciences (HS), including Management	-	-	-	-	-
Basic Sciences (BS) including Mathematics, Physics, Chemistry, Biology	04	-	-	-	**04**
Professional Subjects-Core (PC), relevant to the chosen specialization/branch; (May be split into Hard (no choice) and Soft (with choice), if required)	16	15	-	-	**31**
Engineering Sciences (ES), including Materials, Workshop, Drawing, Basics of, Electrical/Electronics/Mechanical/Computer Engineering, Instrumentation	-	-	-	-	-
Professional Subjects – Electives (PE), relevant to the chosen specialization/ branch	03	06	09	-	**18**
Open Subjects - Electives (OE), from other technical and/or emerging subject areas	-	02	-	-	**02**
Project Work, Seminar and/or Internship in Industry or Elsewhere (EEC)	-	02	06	12	**20**
Total Credits	**23**	**25**	**15**	**12**	**75**

MA18182	ADVANCED NUMERICAL METHODS (Common to Mechatronics, CAD and Internal Combustion Engineering)	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS 9+3

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system –Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Raphson Method, Graffe's Root squaring method, Eigen value problems-Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 9+3

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 9+3

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 9+3

Laplace and Poisson's equations in a rectangular region: Five-point finite difference schemes, Leibmann's iterative methods, and Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 9+3

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method-one parameter.

TOTAL: (L:45 + T:15): 60 PERIODS

OUTCOMES:

- It helps the students to get familiarized with the numerical methods which are necessary to

solve numerically the problems that arise in engineering.

REFERENCES:

1. Saumyen Guha and Rajesh Srivastava, Numerical methods for Engineering and Science, Oxford Higher Education, New Delhi, 2010
2. Gupta S.K., Numerical Methods for Engineers, 3rd Edition Reprint, New Age Publishers, 2018
3. Burden, R.L., and Faires, J.D., Numerical Analysis – Theory and Applications, 9th Edition – Revised, Cengage Learning, India Edition, New Delhi, 2010
4. Jain M. K, Iyengar S. R, Kanchi M. B., Jain R. K, Computational Methods for Partial Differential Equations,2nd Edition, New Age Publishers, 2012
5. Morton K.W. and Mayers D.F., Numerical solution of partial differential equations, Cambridge University press, Cambridge, 2014

CD18101	COMPUTER APPLICATIONS IN DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on computer graphics which are used routinely in diverse areas as science, engineering, medicine, etc.

UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 8

Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotators) windowing - view ports - clipping transformation

UNIT II CURVES AND SURFACES MODELLING 10

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.

Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

UNIT III NURBS AND SOLID MODELING 9

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations - constructive solid Geometry - comparison of representations - user interface for solid modeling.

UNIT IV VISUAL REALISM 9

Hidden–Line–Surface–solid removal algorithms shading–coloring. Introduction to parametric and variational geometry-based software's and their principles creation of prismatic and lofted parts using these packages.

UNIT V ASSEMBLY OF PARTS AND PRODUCT DATA EXCHANGE 9

Assembly Modeling - Interferences of Positions and Orientation - Tolerances Analysis - Mass Property Calculations - Mechanism Simulation. Graphics and Computing Standards– Open GL Data Exchange Standards – IGES, STEP etc– Communication Standards.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

At the end of the course, students:

- Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
- Understand 2D, 3D transformations and projection transformations
- Get knowledge of various approaches of geometric modeling
- Understand mathematical representation of 2D and 3D entities

- Understand the concept of shading and coloring.

REFERENCES:

1. Ibrahim Zeid and Sivasubramanian R, CAD/CAM Theory and Practice, Tata McGraw Hill Publication, 2009
2. Donald Hearn and M. Pauline Baker, Computer Graphics with open GL, 4th Edition, Prentice Hall Inc., 2014.
3. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education, 2003.
4. David F. Rogers, James Alan Adams, Mathematical elements for computer graphics, 2nd Edition, Tata McGraw-Hill edition, 2002
5. Chennakesava R. Alavala, CAD/CAM: Concepts and Applications, PHI Learning Pvt. Ltd., 2009
6. Jayanta Sarkar, Computer Aided Design: A Conceptual Approach, CRC Press, 2017
7. Dr. Sadhu Singh, Computer Aided Design, S.K. Kataria and Sons, 2014

CD18102	ADVANCED MECHANICS OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the fundamentals of mechanics of materials under various loading conditions

UNIT I	**ELASTICITY**	**9**

Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium-compatibility-boundary conditions-representation of three-dimensional stress of a tension generalized hook's law - St. Venant's principle - plane stress - Airy's stress function. Energy methods.

UNIT II	**SHEAR CENTER AND UNSYMMETRICAL BENDING**	**10**

Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.

UNIT III	**STRESSES IN FLAT PLATES AND CURVED MEMBERS**	**10**

Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions

UNIT IV	**TORSION OF NON-CIRCULAR SECTIONS**	**7**

Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes.

UNIT V	**STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES**	**9**

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-deflection of bodies in point and line contact applications.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

At the end of this course, students will be able to

- Understand the fundamental concepts of stress and strain and the relationship between both through the strain stress equations in order to solve problems for simple tridimensional elastic solids
- Solve problems relating to pure and non-uniform bending of beams and other simple structures
- Solve problems relating to torsional deformation of bars and other simple tridimensional

structures • Demonstrate the different stresses under different loading conditions.	
REFERENCES:	
1.	Arthur P Boresi, Richard J. Schmidt, Advanced mechanics of materials, 6th edition, John Wiley,2009.
2.	Timoshenko and Goodier, Theory of Elasticity,3rd Edition, McGraw Hill, 2010
3.	Robert D. Cook, Warren C. Young, Advanced Mechanics of Materials, Pearson publications, 1999
4.	Srinath. L.S., Advanced Mechanics of solids, 3rd Edition, Tata McGraw Hill, 2008
5.	G H Ryder, Strength of Materials, Macmillan, India Ltd, 2007.
6.	Allan F. Bower, Applied Mechanics of Solids, CRC press – Special Indian Edition, 2009
7.	K. Baskar and T.K. Varadan, Theory of Isotropic/Orthotropic Elasticity, Ane Books Pvt. Ltd., New Delhi, 2015.

CD18103	ANALYSIS AND SYNTHESIS OF MECHANISMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To develop a thorough understanding of the various mechanisms and its design and simulation with ability to effectively uses the various mechanisms in real life problems.

UNIT I	**INTRODUCTION**	**9**

Review of fundamentals of kinematics-classifications of mechanisms-components of mechanisms – mobility analysis – formation of one D.O.F. multi loop kinematic chains, Network formula – Gross motion concepts-Basic kinematic structures of serial and parallel robot manipulators-compliant mechanisms - Equivalent mechanisms.

UNIT II	**KINEMATIC ANALYSIS**	**9**

Position Analysis – Vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar linkages. Analytical methods for velocity and acceleration Analysis– four bar linkage jerk analysis. Plane complex mechanisms-auxiliary point method. Spatial RSSR mechanism - Denavit - Harten berg Parameters – Forward and inverse kinematics of robot manipulators.

UNIT III	**PATH CURVATURE THEORY, COUPLER CURVE**	**9**

Fixed and moving centrodes, inflection points and inflection circle. Euler Savary equation, graphical constructions – cubic of stationary curvature. Four bar coupler curve-cusp, Crunode coupler driven six-bar mechanisms-straight line mechanisms

UNIT IV	**SYNTHESIS OF FOUR BAR MECHANISMS**	**9**

Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique, inversion technique-point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein's Equation-Bloch's Synthesis.

UNIT V	**SYNTHESIS OF COUPLER CURVE BASED MECHANISMS AND CAM MECHANISMS**	**9**

Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell-double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects.

TOTAL: (L: 45): 45 PERIODS

**** A Term Project must be given for Assessment-3 using dynamic simulation software (Compulsory)**

OUTCOMES:

Students will be able to:

- Develop analytical equations describing the relative position, velocity and acceleration

of all moving links.

- Select, configure, and synthesize mechanical components into complete systems.
- Use kinematic geometry to formulate and solve constraint equations to design linkages for specified tasks.
- Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by graphical and analytical methods.

REFERENCE BOOKS:

1.	Arthur G. Erdman, George N. Sandor, Sridhar Kota, Mechanism Design: Analysis and Synthesis: Volume: 1, Prentice Hall; 4thEdition, 2001
2.	Arthur G. Erdman, George N. Sandor, Mechanism Design: Analysis and Synthesis: 2, Prentice Hall; 1984
3.	Robert L.Norton., Design of Machinery, McGraw Hill, 5th edition,2011
4.	Uicker, J.J., Pennock, G. R. and Shigley, J.E., Theory of Machines and Mechanisms, Oxford University Press, 2017
5.	Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanism and Machines, T&F India, 2016.
6.	Kenneth J, Waldron, Gary L. Kinzel, Kinematics, Dynamics and Design of Machinery,3rd Edition, John Wiley-sons, 2016.
7.	Ramamurti V., Mechanics of Machines,3rd Edition, Narosa, 2009.
8.	J. S. Rao, R. V. Dukkipati, Mechanism and Machine Theory, New Age Publishers, 2014

CD18104	QUALITY CONCEPTS IN DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on various concepts in engineering design and principles of implementing quality in a product or service through tools such as quality houses, control charts, statistical process control method, failure mode effect analysis and various strategies of designing experiments, methods to uphold the status of six sigma and improve the liability of a product.

UNIT I	**DESIGN FUNDAMENTALS, METHODS AND MATERIAL SELECTION**	**9**

Morphology of Design – The Design Process – Computer Aided Engineering – Concurrent Engineering – Competition Bench Marking – Creativity – Theory of Problem solving (TRIZ) – Value Analysis - Design for Manufacture, Design for Assembly – Design for casting, Forging, Metal Forming, Machining and Welding.

UNIT II	**DESIGN FOR QUALITY**	**9**

Quality Function Deployment -House of Quality-Objectives and functions-Targets-Stakeholders Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan- experimental design – testing noise factors- Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.

UNIT III	**FAILURE MODE EFFECTS ANALYSIS AND DESIGN FOR SIX SIGMA**	**9**

Basic methods: Refining geometry and layout, general process of product embodiment checklist-Advanced methods: systems modeling, mechanical embodiment principles-MEA method- linking fault states to systems modeling - Basis of SIX SIGMA –Project selection for SIX SIGMA- SIX SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services.

UNIT IV	**DESIGN OF EXPERIMENTS**	**9**

Importance of Experiments, Experimental Strategies, Basic principles of Design, Terminology, ANOVA, Steps in Experimentation, Sample size, Single Factor experiments -Completely Randomized design, Randomized Block design, Statistical Analysis, Multifactor experiments - Two and three factor full Factorial experiments, 2K factorial Experiments, Confounding and Blocking designs, Fractional factorial design, Taguchi's approach - Steps in experimentation, Design using Orthogonal Arrays, Data Analysis, Robust Design- Control and Noise factors, S/N ratios

UNIT V	**STATISTICAL CONSIDERATION AND RELIABILITY**	**9**

Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause

and Effect Diagrams-Box plots- Probability Distribution-Statistical Process control–Scatter diagrams–Multivariable charts –Matrix plots and 3-D Plots-Reliability-Survival and Failure-Series and parallel systems-Mean time between failure-Weibull distribution.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

Students will be able to...

- Understand concepts in quality and reliability principles in the design of an engineering product or a service.
- Apply statistical techniques such as quality houses, control charts, statistical process control method, failure mode effect analysis in new product development process
- Strategies of designing experiments, methods to uphold the status of six sigma and improve the reliability of a product.

REFERENCES:

1.	George Dieter and Linda C. Schmidt, Engineering Design - A Materials and Processing Approach, 4th Edition, McGraw Hill International Editions, 2013
2.	Kevin Otto & Kristin Wood, Product Design - Techniques in Reverse Engineering and New Product Development, Pearson Education (LPE), 2006
3.	Karl Ulrich and Steven Eppinger, Product Design and Development, 5thEdition, McGraw Hill International Editions, 2016
4.	James Robert Evans, William M. Lindsay, The Management and control of Quality, 8thEdition, South-Western Cengage Learning, 2010
5.	Amitava Mitra, Fundamentals of Quality control and Improvement, 4thEdition, John Wiley & Sons, 2016
6.	Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley and Sons,2017
7.	Phillip J.Ross, Taguchi techniques for quality engineering , 2nd Edition, McGraw Hill, 2005
8.	R.Pannerselvam, Design and Analysis of Algorithms, PHI Learning Pvt. Ltd., 2007
9.	K. Krishnaiah & P. Shahabudeen, Applied Design of Experiments and Taguchi Methods, PHI Learning Pvt. Ltd., 2012

CD18111	CAD LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To gain practical experience in handling 3D modelling software systems
- To understand and practice the drawings of machine components and simple assemblies using standard CAD packages.
- To understand simulation of linkages in CAD software.

	LIST OF EXPERIMENTS	
I	**3D GEOMETRIC MODELLING AND ASSEMBLY**	

Develop a detailed drawing of given model such as (any 5 exercises)

(i) Screw Jack
(ii) Universal Joint
(iii) Plumber block
(iv) Milling Fixture
(v) Swivel bearing
(vi) Steam stop valve
(vii) Tail stock
(viii) Machine vice
(ix) Piston Head
(x) Flange coupling
(xi) Knuckle Joint

II	**Kinematics mechanism in Assembly- 2 exercises**	
III	**3D modeling by importing cloud data points (Reverse Engineering) – 2 exercises**	
	TOTAL: 60 PERIODS	

OUTCOMES:

Students will be:

- Able to develop 2D models and 3D models using modeling software.
- Familiarize with the computer applications in design and preparing drawings for various mechanical components.
- Able to demonstrate kinematic mechanisms using simulation software.

REFERENCES:

1. Randy Shih, Parametric Modeling with Creo Parametric 5.0, SDC Publications, 2018
2. Michael Rider, Designing with Creo Parametric 5.0, SDC Publications, 2018

3.	Sadhu Singh, P. L. Sah, Fundamentals of Machine Drawing, PHI learning Pvt. Ltd., 2012
4.	http://www.sdcpublications.com/pdfsample/978-1-58503-815-2-2.pdf
5.	https://support.ptc.com/apps/help_center/brand=Creo

CD18112	ADVANCED ANALYSIS AND SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To understand the concept of analysis, its suitability for various applications.

LIST OF EXPERIMENTS

1. Static analysis using 1D/2D elements using FEA software.
2. Static analysis of typical industrial components using 3D elements.
3. Dynamic analysis of mechanical systems
4. Steady state thermal analysis of engine/compressor parts
5. Transient thermal analysis of elements such as fins, engine parts, electronic parts, etc.
6. Thermo mechanical analysis of component such as spindle, brake, etc.
7. Estimation of fatigue life of mechanical/automotive components
8. Static structural analysis of composite parts
9. Analysis of internal and external fluid flow (Pipes, Ducts, Aerofoil, etc) using CFD software
10. Estimation of fatigue life in Mechanical systems.

TOTAL: 60 PERIODS

OUTCOMES:

Students will be able to

- Model complex Engineering problem and solving through the relationship between theoretical, mathematical, and computational modelling for predicting and optimizing performance and objective.
- Develop solutions and extract results from the information generated in the context of the engineering domain to assist engineering decision making.
- Interpret the model and apply the results to resolve critical issues in a real-world environment.

REFERENCES:

1.	Saeed Moaveni, Finite Element Analysis: Theory and Applications with ANSYS, 3rd Edition, Pearson Publications, 2014
2.	Harold Klee, Randal Allen, Simulation of Dynamic Systems with Matlab and Simulink,3rd Edition, CRC Press, 2018
3.	Michael R. Hatch, Vibration Simulation Using MATLAB and ANSYS, CRC Press, 2000
4.	http://www.mece.ualberta.ca/tutorials/ansys

CD18201	**ADVANCED FINITE ELEMENT ANALYSIS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To develop a thorough understanding of the advanced finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design

UNIT I	**BENDING OF PLATES AND SHELLS**	**9**

Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements –Degenerated shell elements- Application and Examples.

UNIT II	**NON-LINEAR PROBLEMS**	**10**

Introduction – Iterative Techniques – Material non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Non-linearity – large displacement Formulation –Solution procedure-Application in Metal Forming Process and Contact Problems.

UNIT III	**DYNAMIC PROBLEM**	**8**

Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Eigen solution-Subspace Iterative Technique – Response analysis-Houbolt, Wilson, Newmark – Methods – Explicit & Implict Methods- Lanchzos, Reduced method for large size system equations.

UNIT IV	**FLUID MECHANICS AND HEAT TRANSFER**	**9**

Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution.

UNIT V	**ERROR ESTIMATES AND ADAPTIVE REFINEMENT**	**9**

Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

- The students will understand the Finite Element Formulation of Plate and Shell Elements and its application.
- The students will be able to gain knowledge in material & geometric non-and plasticity.
- The students will be able to solve problems under dynamic conditions by applying various techniques.
- The students can arrive at the solutions for fluid mechanics and heat transfer problems.
- The students will acquire knowledge in error norms, convergence rates and refinement.
- The students will solve the real world engineering problems using FEA.

REFERENCES:		
1.	Bathe K.J., Finite Element Procedures in Engineering Analysis, Prentice Hall, 2006	
2.	Cook R.D., Concepts and Applications of Finite Element Analysis, John Wiley and Sons, 2007	
3.	Olek C Zienkiewicz, Robert L Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, 6^{th} Edition, Elsevier, 2005	

CD18202	VIBRATION ANALYSIS AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the Fundamentals of Vibration and its practical applications
- To understand the working principle and operations of various vibration measuring instruments
- To understand the various Vibration control strategies

UNIT I	**FUNDAMENTALS OF VIBRATION**	**10**

Introduction -Sources of Vibration-Mathematical Models- Displacement, velocity and Acceleration-Review of Single Degree Freedom Systems -Vibration isolation Vibrometers and accelerometers Response to Arbitrary and non- harmonic Excitations – Transient Vibration – Impulse Loads-Critical Speed of Shaft-Rotor systems.

UNIT II	**TWO DEGREE FREEDOM SYSTEM**	**7**

Introduction-Free Vibration of Undamped and Damped - Forced Vibration with Harmonic Excitation System –Coordinate Couplings and Principal Coordinates

UNIT III	**MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM**	**9**

Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method – Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values & Eigenvectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams.

UNIT IV	**VIBRATION CONTROL**	**9**

Specification of Vibration Limits –Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods- -Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber- Damped Vibration Absorbers-Static and Dynamic Balancing-Balancing Machines-Field balancing – Vibration Control by Design Modification - Active Vibration Control.

UNIT V	**EXPERIMENTAL METHODS IN VIBRATION ANALYSIS**	**10**

Vibration Analysis Overview - Experimental Methods in Vibration Analysis. -Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics –Frequency Measuring Instruments System Identification from Frequency Response -Testing for resonance and mode shapes.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

The students will be able to:

- Demonstrate the basics of vibration and ability to apply the concept of vibration control
- Solve dynamic problems in field the vibration and its control.
- Demonstrate the working operations of various vibration measuring instruments, vibration control and analysis techniques.

REFERENCES:

1.	Singiresu S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2018
2.	Thomson, Theory of Vibration with Applications,5th Edition, Pearson Education, 2008
3.	J. P. Den Hartog, Mechanical Vibrations, Dover Publications, 2013
4.	Singh, V.P., Mechanical Vibrations, Danpatrai Publication, 2016
5.	Ramamurti. V, Mechanical Vibration Practice with Basic Theory, CRC Press, 2000
6.	S. Graham Kelly, Mechanical Vibrations: Theory and Applications, Cengage Learning, 2012
7.	G.K.Groover, Mechanical Vibrations, 8th Edition, Nem Chand & Bros, 2009
8.	J.S.Rao., Introductory Course on Theory and Practice of Mechanical Vibrations, 1999
9.	Leonard Meirovitch, Elements of Vibrations Analysis, McGraw-Hill Education (ISE Editions); International 2nd Edition,1986
10.	Sujatha.C, Vibration and Acoustics: Measurement and Signal Analysis, McGraw Hill Education,2010

CD18203	COMPUTER AIDED TOOLS FOR MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- The purpose of this course is to make the students to get familiarized with various computer aided tools that can be implemented in various industrial applications

UNIT I	**COMPUTER AIDED MANUFACTURING**	**9**

Manufacturing Processes – Removing, Forming, Deforming and joining – Integration equipments. Integrating CAD, NC and CAM – Machine tools – Point to point and continuous path machining, NC, CNC and DNC – NC Programming – Basics, Languages, G Code, M Code, Tool path generation and verification – CAD/CAM NC Programming – Production Control – Cellular Manufacturing.

UNIT II	**COMPUTER AIDED PROCESS PLANNING**	**9**

Role of process planning in CAD/CAM Integration – Computer Aided Process Planning – Development, Benefits, Model and Architecture – CAPP Approaches – Variant, Generative and Hybrid – Process and Planning systems – CAM-I, D-CLASS and CMPP – Criteria in selecting a CAPP System.

UNIT III	**COMPUTER AIDED INSPECTION**	**9**

Engineering Tolerances – Need for Tolerances – Conventional Tolerances – FITS and LIMITS – Tolerance Accumulation and Surface quality – Geometric Tolerances – Tolerances Practices in design, Drafting and manufacturing – Tolerance Analysis – Tolerance synthesis – Computer Aided Quality control – Contact Inspection Methods – Non Contact Inspection Methods - Non optical.

UNIT IV	**REVERSE ENGINEERING**	**9**

Scope and tasks of Reverse Engineering – Domain Analysis – Process Duplicating – Tools for RE – Developing Technical data – Digitizing techniques – Construction of surface model – Solid part model – Characteristic evaluation – Software's and its application – CMM and its feature capturing – surface and solid modeling.

UNIT V	**DATA MANAGEMENT**	**9**

Strategies for Reverse Engineering Data management – Software application – Finding renewable software components – Recycling real time embedded software – Design experiments to evaluate a RE tools – Rule based detection for RE user interface – RE of assembly programs.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

The students will be able to:

- Demonstrate the computer aided tools for various industrial applications
- Perform design and analysis of automatic storage and retrieval system.

- Optimize the number of machines required for machine cell in a given production system.
- Develop strategies for real time engineering problems using reverse engineering concepts

REFERENCES:

1.	Ibrahim Zeid, Mastering CAD/CAM, special Indian Edition, Tata McGraw Hill Publication, 2005
2.	Catherine A. Ingle, Reverse Engineering, Tata McGraw Hill Publication, 1994
3.	David D. Bedworth, Mark R. Henderson, Philp M. Wolfe, Computer Integrated Design and manufacturing, McGraw Hill International series, 1991
4.	Donald R. Honra, Coordinate measurement and reverse Engineering, American Gear Manufacturers Association.
5.	Ibrahim Zeid and R. Sivasubramanian, CAD/CAM Theory and Practice, 2nd Edition, Tata McGraw Hill Publication, 2009
6.	Linda Wills, Reverse Engineering, Springer Soft cover reprint, 2013

CD18204	INTEGRATED MECHANICAL DESIGN	L	T	P	C
	(Use of Approved Data Book is Permitted)	**3**	**1**	**0**	**4**

OBJECTIVES:

- To know the integrated design procedure of different machine elements for mechanical applications.

UNIT I	**FUNDAMENTALS AND DESIGN OF SHAFTS**	**12**

Phases of design – Standardization and interchangeability of machine elements - Process and Function Tolerances – Individual and group tolerances – Selection of fits for different design situations – Design for assembly and modular constructions – Concepts of integration –BIS, ISO, DIN, BS, ASTM Standards. Oblique stresses – Transformation Matrix – Principal stresses – Maximum shear stress - Theories of Failure – Ductile vs. brittle component design - Analysis and Design of shafts for different applications – integrated design of shaft, bearing and casing – Design for rigidity

UNIT II	**DESIGN OF GEARS AND GEAR BOXES**	**12**

Principles of gear tooth action – Gear correction – Gear tooth failure modes – Stresses and loads– Component design of spur, helical, bevel and worm gears – Design for sub assembly –Integrated design of speed reducers and multi-speed gear boxes – application of software packages.

UNIT III	**BRAKES & CLUTCHES**	**12**

Dynamics and thermal aspects of brakes and clutches – Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipments.

UNIT IV	**INTEGRATED DESIGN**	**24**

Integrated Design of systems consisting of shaft, bearings, springs, motor, gears, belt, rope, chain, pulleys, Cam & Follower, flywheel etc. Example - Design of Elevators, Escalators, Gear Box, Valve gear Mechanisms, Machine Tools.

TOTAL: (L:45 + T:15): 60 PERIODS

The Pattern of Question Paper will consist of one Question from Unit – 4 for 50% of total marks.

**** A Term Project must be given for Assessment – 3 (Compulsory)**

OUTCOMES:

The students will be able to:

- Analyze constructions and kinematics of different types of machine elements.
- Construct ray diagrams and speed spectrum diagrams for speed and feed box.
- Develop the conceptual design, systematic analysis of machine design problems.
- Apply the design procedures on different types of integrated mechanical systems.

REFERENCES:		
1.	Norton L. R., Machine Design – An Integrated Approach 5th Edition Pearson Education, 2013	
2.	Maitra G.M., Hand Book of Gear Design, Tata McGraw Hill publication, 2001	
3.	Shigley, J.E., Mechanical Engineering Design, McGraw Hill publication, 2015	
4.	Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981	
5.	Raymond A. Kulweic, Materials Handling Handbook, Wiley India Pvt. Ltd., 2009.	
APPROVED DATA BOOKS:		
6.	P.S.G. Tech., Design Data Book, Kalaikathir Achchagam, Coimbatore, 2015	
7.	Lingaiah. K., Machine Design Data Hand Book, Vol. 1 & 2, 2nd Edition, Mcgraw Hill, 2010.	

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CD18211	VIBRATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- Introduce basic aspects of vibrational analysis, considering both single and multi-degree-of freedom systems.
- Discuss the use of exact and approximate methods in the analysis of complex systems.

LIST OF EXPERIMENTS

1. To determine the radius of gyration ‘k’ of a given compound pendulum
2. To determine the radius of gyration ‘k’ of a given Flywheel and axle system
3. To determine the radius of gyration of given disc using Trifilar suspension.
4. To determine the radius of gyration of given bar using Bi-filler suspension
5. To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
6. To determine the frequency of undamped free vibration of an equivalent spring mass system.
7. To determine the critical speed of shaft of different sizes
8. To determine the frequency of force vibration of a spring mass system.
9. To determine the modal shapes of cantilever beam using Impulse hammer technique
10. To study the jumping phenomenon of cam follower mechanism

TOTAL: 60 PERIODS

OUTCOMES:

Student will be able to

- Compute the natural frequency (or frequencies) of vibratory systems and determine the system's modal response.
- Determine the overall response based upon the initial conditions and/or steady forcing input.
- Design a passive vibration absorber to reduce vibrations in a forced system.

REFERENCES:

1. Singiresu S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2018
2. Sujatha.C, Vibration and Acoustics: Measurement and Signal Analysis, McGraw Hill Education, 2010
3. Ramamurti. V, Mechanical Vibration Practice with Basic Theory, Narosa, NewDelhi, 2012.

CD18212	DESIGN PROJECT	L	T	P	C
		0	0	4	2

OBJECTIVES:

- It is proposed to carryout detailed design calculations and analysis of any mechanical component or mechanical system. This helps the students to get familiar with respect to the design methodologies applied to any component or mechanical system subjected to static, dynamic and thermo-mechanical loads.

SYLLABUS:

Each student is required to select any new component or an integrated mechanical system that involves various sub components which are to be designed as per design standards and further required to be analyzed for optimum dimensions with respect to the strength and stiffness.

TOTAL: 60 PERIODS

OUTCOMES:

- It helps the students to get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.

CD18311	PROJECT WORK PHASE I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

SYLLABUS:

The student individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of engineering design. The topic may be theoretical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

OUTCOMES:

- It helps the students to get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- At the end of the course the students will have a clear idea of their area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

CD18411	PROJECT WORK PHASE II	L	T	P	C
		0	0	24	12

OBJECTIVES:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

SYLLABUS:

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

OUTCOMES:

- It helps the students to get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- On completion of the project work students will be in a position to take up any challenging practical problem in the field of engineering design and find better solutions to it.

MC18081	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	2

OBJECTIVES:

- To impart knowledge on formulation of research problem, research methodology, ethics involved in doing research and importance of IPR protection.

UNIT I	**RESEARCH METHODOLOGY**	**6**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, Plagiarism, Research ethics.

UNIT II	**RESULTS AND ANALYSIS**	**6**

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective), outcome as new idea, hypothesis, concept, theory, model etc.

UNIT III	**TECHNICAL WRITING**	**6**

Effective technical writing, how to write a manuscript/ responses to reviewers comments, preparation of research article/ research report, Writing a Research Proposal - presentation and assessment by a review committee

UNIT IV	**INTELLECTUAL PROPERTY RIGHTS**	**6**

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright. Process of Patenting and Development: technological research, innovation, patenting & development. Procedure for grants of patents, Patenting under PCT.

UNIT V	**PATENT RIGTS AND NEW DEVELOPMENTS IN IPR**	**6**

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System.

TOTAL: (L: 30): 30 PERIODS

OUTCOMES:

At the end of this course, students will be able to

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understand research problem formulation & Analyze research related information and Follow research ethics
- Correlate the results of any research article with other published results. Write a review article in the field of engineering.

- Appreciate the importance of IPR and protect their intellectual property. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

REFERENCES:

1.	Ranjit Kumar, Research Methodology- A step by step guide for beginners, Pearson Education, Australia, 2005.
2.	Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
3.	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
4.	Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, 2004.
5.	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
6.	Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
7.	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd , 2007.
8.	Mayall , "Industrial Design", McGraw Hill, 1992.
9.	Niebel , "Product Design", McGraw Hill, 1974.
10.	Asimov , "Introduction to Design", Prentice Hall, 1962.

CD18001	DESIGN OF PRESSURE VESSEL AND PIPING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- The main objective is to present the industrial related problems, procedures and design principles for pressure vessels and enhance the understanding of design procedure of pressure vessel and Design of piping layout.

UNIT I	**INTRODUCTION**	**3**

Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

UNIT II	**STRESSES IN PRESSURE VESSELS**	**15**

Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

UNIT III	**DESIGN OF VESSELS**	**15**

Design of Tall cylindrical self-supporting process columns – Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. . Introduction to ASME pressure vessel codes.

UNIT IV	**BUCKLING OF VESSELS**	**8**

Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

UNIT V	**PIPING**	**4**

Introduction – Flow diagram, Piping layout and piping stress analysis.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

On completion of this course students will be able to:

- Analyze thin plates and shells for various types of stresses.
- Design shells, end closures and nozzles of pressure vessels using ASME codes.
- Analyze piping systems and design piping layouts for various complex industrial problems.
- familiarized with the various theories and practice on pressure vessel and piping design and procedures which are necessary to solve the industrial practical problems that arise and also for the research in the field of pressure vessel design.

REFERENCES:		
1.	John F.Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors, Reprinted, 2001.	
2.	Henry H.Bedner, Pressure Vessels, Design Hand Book, CBS Publishers and Distributors, 1991.	
3.	Stanley, M.Wales, Chemical process equipment, selection and Design. Buterworths series in Chemical Engineering,1988.	
4.	Eugene Megyesy, Pressure Vessel Handbook, 14th Edition, P V Publishing Inc, 2008	
5.	J. Phillip Ellenberger Pressure Vessels: ASME Code Simplified 8th Edition, McGraw-Hill Education,2004.	
6.	Dennis R.Moss, Pressure Vessel Design Manual, 4th Edition, Butterworth-Heinemann, 2013.	

CD 18002	ADDITIVE MANUFACTURING AND TOOLING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive Manufacturing Technology and the associated Aerospace, Architecture, Art, Medical, industrial applications and Tools used.

UNIT I	**INTRODUCTION**	**9**

Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM - Classification of AM processes- Benefits-Applications.

UNIT II	**REVERSE ENGINEERING AND CAD MODELING**	**9**

Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies.

UNIT III	**LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS**	**9**

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

UNIT IV	**POWDER BASED ADDITIVE MANUFACTURING SYSTEMS**	**9**

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

UNIT V	**TOOLING**	**9**

Classification, Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication processes, Applications Case studies automotive, aerospace and electronics industries

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

- Understand history, concepts and terminology of additive manufacturing

- Apply the reverse engineering concepts for design development
- Understand the variety of additive manufacturing techniques
- Design and develop newer tooling models
- Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools

REFERENCES:

1.	Chua, C.K., Leong K.F. and Lim C.S., Rapid prototyping: Principles and applications, second edition, World Scientific Publishers, 2010.
2.	Gebhardt, A., Rapid prototyping, Hanser Gardener Publications, 2003.
3.	Gibson, I., Rosen, D.W. and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
4.	Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.
5.	Kamrani, A.K. and Nasr, E.A., Rapid Prototyping: Theory and practice, Springer, 2006.
6.	Liou, L.W. and Liou, F.W., Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press, 2011.
7.	D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

CD18003	INFORMATION ANALYTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students with fundamental concepts and the tools needed to understand emerging role of information analytics in the organization.

UNIT I	**DATA ANALYTICS LIFE CYCLE**	**9**

Introduction to Big data Business Analytics - State of the practice in analytics role of data scientists - Key roles for successful analytic project - Main phases of life cycle - Developing core deliverables for stakeholders.

UNIT II	**STATISTICS**	**9**

Sampling Techniques - Data classification, Tabulation, Frequency and Graphic representation - Measures of central value - Arithmetic mean, Geometric mean, Harmonic mean, Mode, Median, Quartiles, Deciles, Percentile - Measures of variation – Range, IQR, Quartile deviation, Mean deviation, standard deviation, coefficient variance, skewness, Moments & Kurtosis.

UNIT III	**PROBABILITY AND HYPOTHESIS TESTING**	**9**

Random variable, distributions, two dimensional R.V, joint probability function, marginal density function. Random vectors - Some special probability distribution - Binomial, Poison, Geometric, uniform, exponential, normal, gamma and Erlang. Multivariate normal distribution - Sampling distribution – Estimation - point, confidence - Test of significance, 1& 2 tailed test, uses of t distribution, F-distribution, χ 2 distribution.

UNIT IV	**PREDICTIVE ANALYTICS**	**9**

Predictive modeling and Analysis - Regression Analysis, Multicollinearity, Correlation analysis, Rank correlation coefficient, Multiple correlation, Least square, Curve fitting and goodness of fit.

UNIT V	**TIME SERIES FORECASTING AND DESIGN OF EXPERIMENTS**	**9**

Forecasting Models for Time series: MA, SES, TS with trend, season - Design of Experiments, one way classification, two way classification, ANOVA, Latin square, Factorial Design.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

Upon completion of the course, the students will be able to

- Understand the importance of data analysis in the design of new products.
- Carry out statistical analysis.
- Do probability analysis and hypothesis testing.
- Perform predictive analysis.
- Learn the effect of forecasting methods and to apply for business process.
- Build a reliable, scalable, distributed information system.

REFERENCES:		
1.	Alberto Cordoba, Understanding the Predictive Analytics Lifecycle, Wiley, 2014.	
2.	Chris Eaton, Dirk Deroos, Tom Deutsch et al., Understanding Big Data, McGraw Hill, 2012.	
3.	James R Evans, Business Analytics – Methods, Models and Decisions, Pearson 2013.	
4.	R. N. Prasad, SeemaAcharya, Fundamentals of Business Analytics, Wiley, 2015.	
5.	S M Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Foundation, 2011.	

CD18004	OPTIMIZATION TECHNIQUES IN DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.

UNIT I	**UNCONSTRAINED OPTIMIZATION TECHNIQUES**	**10**

Introduction to optimum design - General principles of optimization – Problem formulation & their classifications - Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.

UNIT II	**CONSTRAINED OPTIMIZATION TECHNIQUES**	**10**

Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming.

UNIT III	**ADVANCED OPTIMIZATION TECHNIQUES**	**10**

Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

UNIT IV	**STATIC APPLICATIONS**	**8**

Structural applications – Design of simple truss members - Design applications – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members – Design of springs.

UNIT V	**DYNAMIC APPLICATIONS**	**7**

Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

At the end of the course:

- Students will know the principles of optimization.
- Students will have knowledge of algorithms for design optimization
- Students will be able to formulate an optimization problem.
- Students should able to find the optimum solution of their problems using optimization techniques.

REFERENCES:	
1.	Rao, Singaresu, S., Engineering Optimization – Theory & Practice, New Age International (P)Limited, New Delhi, 2000
2.	Goldberg, D.E., Genetic Algorithms in Search, Optimization and Machine Learning, Pearson,2016.
3.	Kalyanmoy Deb, Optimization for Engineering design algorithms and Examples, Prentice Hall of India Pvt. 2004.
4.	Taha H.A, Operations Research: An Introduction, Pearson Prentice Hall, Pearson Education Ltd, Eighth edition, 2007.

CD18005	EXPERIMENTAL METHODS IN STRESS ANALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the principles of measurement, its need, within the field of production, vibration, acoustics, fluid mechanics, fracture mechanics and NDT.

UNIT I	**FORCES AND STRAIN MEASUREMENT**	**9**

Strain gauge, principle, types, performance and uses. Photo elasticity – Principle and applications - Moire Fringe - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of Testing Machines.

UNIT II	**VIBRATION MEASUREMENTS**	**9**

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems.

UNIT III	**ACOUSTICS AND WIND FLOW MEASURES**	**9**

Principles of Pressure and flow measurements – pressure transducers – sound level meter – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis.

UNIT IV	**DISTRESS MEASUREMENTS**	**9**

Diagnosis of distress in structures – crack observation and measurements – corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.

UNIT V	**NON DESTRUCTIVE TESTING METHODS**	**9**

Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing – Brittle coating.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

After completing the course, students will be able to:

- Understand and design strain gage-based transducers for measuring specific loads
- Analyze photo elastic technique to stress analysis
- Analysis of measuring circuits and strains of different strain gauge rosettes
- Describe the measurements by using transducers and exciters.
- Analyze experimental data and develop appropriate, logical conclusions based on comparisons to theoretical results and other experimental evidence

REFERENCES:		
1.	Sadhu Singh– Experimental Stress Analysis, Khanna Publishers, New Delhi, 2009	
2.	L.S.Srinath et al, Experimental Stress Analysis, Tata McGraw Hill Company, New Delhi, 2004.	
3.	JW Dalley and WF Riley, Experimental Stress Analysis, McGraw Hill Book Company, N.Y.1991.	
4.	JW Dalley and WF Riley, Experimental Stress Analysis, McGraw Hill Book Company, N.Y.1991.	
5.	R.S.Sirohi, HC Radhakrishna, Mechanical Measurements, New Age International (P) Ltd.1997 .	
6.	F.K Garas, J.L. Clarke and GST Armer, Structural assessment, Butterworths, London, 1987.	
	D.E. Bray & R. K.Stanley, Non-destructive Evaluation, McGraw Hill Publishing Company, N.Y.1989.	

CD18006	DESIGN FOR MANUFACTURING ASSEMBLY AND ENVIRONMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- This course will impart the knowledge on product concept, design principles implementation for various aspects of manufacturing, assembly and environment.

UNIT I	**INTRODUCTION**	**5**

General design principles for manufacturability, strength and mechanical factors, mechanisms selection., Process capability - Feature tolerances Geometric tolerances - Assembly limits -Datum features - Tolerance stacks. Overview of Industry 4.0

UNIT II	**FACTORS INFLUENCING FORM DESIGN**	**13**

Working principle, Material, Manufacture, Design- Possible solutions - Materials choice – Influence of materials on form design - form design of welded members, forgings and castings. Design for sheet metal forming and Design for bulk forming.

UNIT III	**COMPONENT DESIGN - MACHINING CONSIDERATION**	**8**

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for Machinability - Design for economy - Design for Clampability– Design for accessibility - Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly.

UNIT IV	**COMPONENT DESIGN – CASTING CONSIDERATION**	**10**

Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design- Modifying the design - group technology - Computer Applications for DFMA.

UNIT V	**DESIGN FOR THE ENVIRONMENT**	**9**

Introduction – Environmental objectives – Global issues – Regional and local issues – Basic DFE methods – Design guide lines – Example application – Lifecycle assessment – Basic method – AT&T's environmentally responsible product assessment - Weighted sum assessment method – Lifecycle assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for disassembly – Design for recyclability – Design for manufacture – Design for energy efficiency – Design to regulations and standards.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

- Identifying the factors affecting the manufacturing and materials
- Enhancing the ability to apply the design principle for casting and welding.

- Enhancing the ability to apply the design principles for forging and machining.
- Enhancing the ability to apply the design principles for assembly of components
- Improving the knowledge on design principles for environment

REFERENCES:

1.	G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 2005
2.	A K Chitale and R C Gupta, Product Design and Manufacturing, PHI, New Delhi, 2003.
3.	K.G. Swift Knowledge based design for Manufacture, Kogan page Limited, 1987.
4.	Kevien Otto and Kristin Wood, Product Design. Pearson Publication, 2004.
5.	G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
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8.	S S Rao, Engineering Optimization: theory and practice, John Wiley, NY, 1996.
9.	Fixel, J. Design for the Environment McGraw hill., 1996.
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11.	Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995
12.	K.G. Swift Knowledge based design for Manufacture, Kogan page Limited, 1987**.**
13.	James G. Bralla, Hand book of product design for manufacturing McGraw Hill Co., 1986.
14.	Boothroyd, G, Design for Assembly Automation and Product Design. New York, MarcelDekker 1980.

CD 18007	ADVANCED TOOL DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- The purpose of this course is to make the students to get familiarized with the design of various tools that can be implemented for different mechanical operations

UNIT I	**INTRODUCTION TO TOOL DESIGN**	**8**

Introduction –Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in Manufacturing- Challenges and Requirements- Standards in Tool Design-Tool Drawings -Surface Finish – Fits and Tolerances - Tooling Materials- Ferrous and Nonferrous Tooling Materials-Carbides, Ceramics and Diamond -Nonmetallic Tool Materials-Designing with relation to Heat Treatment.

UNIT II	**DESIGN OF CUTTING TOOLS**	**9**

Mechanics of Metal Cutting – Oblique and Orthogonal Cutting- Chip Formation and Shear Angle - Single-Point Cutting Tools – Milling Cutters – Hole Making Cutting Tools- Broaching Tools - Design of Form Relieved and Profile Relieved Cutters-Design of Gear and Thread Milling Cutters.

UNIT III	**DESIGN OF JIGS AND FIXTURES**	**10**

Introduction – Fixed Gages – Gage Tolerances –Selection of Material for Gages – Indicating Gages – Automatic Gages – Principles of Location – Locating Methods and Devices – Principles of Clamping – Drill Jigs – Chip Formation in Drilling – General Considerations in the Design of Drill Jigs – Drill Bushings – Methods of Construction –Thrust and Turning Moments in Drilling - Drill Jigs and Modern Manufacturing- Types of Fixtures – Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures – Modular Fixtures – Cutting Force Calculations.

UNIT IV	**DESIGN OF PRESS TOOL DIES**	**10**

Types of Dies –Method of Die Operation–Clearance and Cutting Force Calculations- Blanking and Piercing Die Design – Pilots – Strippers and Pressure Pads- Presswork Materials – Strip Layout – Short-Run Tooling for Piercing – Bending Dies – Forming Dies – Drawing Dies-Design and Drafting.

UNIT V	**TOOL DESIGN FOR CNC MACHINE TOOLS**	**8**

Introduction –Tooling Requirements for Numerical Control Systems – Fixture Design for CNC Machine Tools- Sub Plate and Tombstone Fixtures-Universal Fixtures– Cutting Tools– Tool Holding Methods– Automatic Tool Changers and Tool Positioners – Tool Presetting– General Explanation of The Brown and Sharp Machine.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

After completing the course, students will be able to:

- Identify the properties of tool material, tool nomenclature and to classify the cutting tools.
- Interpret the parameters of the cutting tools for machining process
- Distinguish the various locating and clamping methods
- Describe the principles of clamping, drill jigs and press tool design
- Design fixtures for milling, boring, lathe, and grinding and tool design for NC machine tools.

REFERENCES:

1.	Cyrll Donaldson, George H.LeCain, V.C. Goold, Tool Design, Tata McGraw Hill Publishing Company Ltd., 4th edition, 2012.
2.	E.G.Hoffman, Jig and Fixture Design, Thomson Asia Pvt Ltd, Singapore, 2008
3.	Prakash Hiralal Joshi, Jigs and fixture, McGraw Hill Education, 2010.
4.	Venkataraman K., Design of Jigs, Fixtures and Press tools, Wiley-Blackwell; 2nd Edition, 2015
5.	Eric Henriksen, Jig & Fixture Design Manual, Industrial Press Inc., U.S,2012
6.	John Nee, Fundamentals of Tool Design, Society of Manufacturing Engineers; 6th Revised edition, 2010.
7.	Wilson F.W., Fundamentals of Tool Design, ASTME, Prentice Hall, India, 2010.
8.	G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, Kolkata, 2009
9.	Haslehurst M., Manufacturing Technology, The ELBS, 1978.
10.	Mehta, N.K., Machine Tool Design, Tata McGraw Hill, 2012.

CD18008	INDUSTRIAL ROBOTICS & EXPERT SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To teach students the basics of robotics, construction features, sensor applications, robot cell design, robot programming and application of artificial intelligence and expert systems in robotics.

UNIT I	**INTRODUCTION AND ROBOT KINEMATICS**	**10**

Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

UNIT II	**ROBOT DRIVES AND CONTROL**	**9**

Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers.

UNIT III	**ROBOT SENSORS**	**9**

Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system.

UNIT IV	**ROBOT CELL DESIGN AND APPLICATION**	**9**

Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots. Recent trends in robotics- Robotics in industry 4.0

UNIT V	**ROBOT PROGRAMMING, ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS**	**8**

Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots- swarm intelligence - ant colony optimization.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

At the end of the course students will be able to

- Understand basic terminologies and concepts associated with Robotics and Automation
- Demonstrate comprehension of various Robotic sub-systems
- Understand kinematics and dynamics to explain exact working pattern of robots

- Aware of the associated recent updates in Robotics.

REFERENCES:

1.	Deb, S.R. Robotics Technology and Flexible Automation, Tata Mc Graw-Hill, Second Edition, 2017.
2.	K.S.Fu, R.C. Gonzalez and C.S.G. Lee, Robotics Control, Sensing, Vision and Intelligence, McGraw Hill, 1987.
3.	Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, Industrial Robotics Technology, Programming and Applications, Mc Graw-Hill, Int. 1986.
4.	Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, Robotics Engineering – An Integrated Approach, Prentice-Hall of India Pvt. Ltd., 1994.
5.	Timothy Jordanides, Expert Systems and Robotics, Springer –Verlag, New York, May 1991.
6.	Springer Handbook of Robotics, Springer-Verlag Berlin Heidelberg, 2008.

CD18009	COMPUTATIONAL FLUID DYNAMICS FOR DESIGN ENGINEERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.

UNIT I	**GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**	**8**

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer– Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods –Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II	**DIFFUSION PROCESSES: FINITE VOLUME METHOD**	**10**

Steady one-dimensional diffusion, Two and three-dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT III	**CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD**	**9**

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme– Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV	**FLOW PROCESSES: FINITE VOLUME METHOD**	**8**

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms.

UNIT V	**MODELLING OF COMBUSTION AND TURBULENCE**	**10**

Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model & $k - \varepsilon$, $k - \omega$ models - Standard and High and Low Reynolds Number models.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

On successful completion of this course the student will be able to:

- Apply the concepts of CFD to analyze the fluid flow and heat transfer problems along with range of governing parameters.
- Develop models and simulate the Fluid Dynamics problems with finite volume methods
- Develop models and simulate the Mechanisms of combustion and Chemical Kinetics
- Demonstrate the explicit & implicit algorithms for real world engineering problems using CFD methods.

REFERENCES:

1.	Ghoshdastidar, P.S., Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
2.	JiyuanTu, Guan Heng Yeoh, Chaogun Liu, Computational Fluid Dynamics A Practical Approach Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
3.	John D. Anderson. JR. Computational Fluid Dynamics the Basics with Applications McGraw-Hill International Editions, 1995
4.	Muralidhar, K., and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003
5.	Subas and V.Patankar Numerical heat transfer fluid flow, Hemisphere Publishing Corporation, 1980.
6.	Versteeg and Malalasekera, N, An Introduction to computational Fluid Dynamics the Finite Volume Method, Pearson Education, Ltd., Second Edition, 2014.

CD18010	MECHANICS OF COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of composite material strength and its mechanical behavior
- Understanding the analysis of fiber reinforced Laminate design for different combinations of plies with different orientations of the fiber.
- Thermo-mechanical behavior and study of residual stresses in Laminates during processing.
- Implementation of Classical Laminate Theory (CLT)to study and analysis for residual stresses in an isotropic layered structure

UNIT I	**INTRODUCTION TO COMPOSITE MATERIALS**	**10**

Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers- fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites

UNIT II	**MANUFACTURING OF COMPOSITES**	**10**

Manufacturing of Polymer Matrix Composites (PMCs)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-, bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) –hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces

UNIT III	**INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS**	**12**

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT IV	**LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES**	**7**

Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies

UNIT V	**THERMAL ANALYSIS**	**6**
Assumption of Constant Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's. C.T.E's for special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates.		
	TOTAL: (L: 45): 45 PERIODS	

OUTCOMES:

The students will be able to

- Identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
- Predict the elastic properties of both long and short fiber composites based on the constituent properties.
- Relate stress, strain and stiffness tensors using ideas from matrix algebra
- Analyze a laminated plate in bending, including finding laminate properties from lamina properties
- Predict the failure strength of a laminated composite plate.

REFERENCES:

1.	Gibson, R.F., Principles of Composite Material Mechanics, Thired Edition - CRC press, 2011,
2.	Hyer, M.W., Stress Analysis of Fiber – Reinforced Composite Materials, McGraw-Hill,2008
3.	Issac M. Daniel and Ori Ishai, Engineering Mechanics of Composite Materials, Oxford University Press-2013
4.	Mallick, P.K., Fiber –Reinforced Composites: Materials, Manufacturing and Design, Maneel Dekker Inc, 1993.
5.	Halpin, J.C., Primer on Composite Materials, Analysis, Techomic Publishing Co., 1992
6.	Agarwal, B.D., and Broutman L.J., Analysis and Performance of Fiber Composites, John Wiley and Sons, New York, 1990.
7.	Mallick, P.K. and Newman, S., (edition), Composite Materials Technology: Processes and Properties, Hansen Publisher, Munish, 1990.
8.	Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
9.	Chung, Deborah D.L., Composite Materials: Science and Applications, Ane Books Pvt.Ltd./Springer, New Delhi, 1st Indian Reprint, 2009
10	Robert M. Jones, Mechanics of Composite Materials (Materials Science & Engineering Series) Second edition, Taylor & Francis,2015

CD18011	ENGINEERING FRACTURE MECHANICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on mechanics of cracked components of different modes by which these components fail under static load conditions.
- To impart knowledge on mechanics of cracked components of different modes by which these components fail under fatigue load conditions.

UNIT I	**ELEMENTS OF SOLID MECHANICS**	**9**

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis – Airy's function – field equation for stress intensity factor.

UNIT II	**STATIONARY CRACK UNDER STATIC LOADING**	**9**

Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdaale model – determination of J integral and its relation to crack opening displacement.

UNIT III	**ENERGY BALANCE AND CRACK GROWTH**	**9**

Griffith analysis – stable and unstable crack growth –Dynamic energy balance – crack arrest mechanism –K1c test methods - R curves - determination of collapse load.

UNIT IV	**FATIGUE CRACK GROWTH CURVE**	**9**

Empirical relation describing crack growth law – life calculations for a given load amplitude – effects of changing the load spectrum -- rain flow method– external factors affecting the K1c values - leak before break analysis.

UNIT V	**APPLICATIONS OF FRACTURE MECHANICS**	**9**

Crack Initiation under large scale yielding – thickness as a design parameter – mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

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

- Use any one of the four parameters for finding out damage tolerance: stress intensity factor, energy release rate, J integral, Crack tip opening displacement.
- Manage singularity at crack tip using complex variable.
- Understand important role played by plastic zone at the crack tip.
- Learn modern fatigue and will able to calculate the fatigue life of a component with or without crack in it.
- Learn modern sophisticated experimental techniques to determine fracture toughness and stress intensity factor.

REFERENCES:	
1.	David Broek, Elementary Engineering Fracture Mechanics , Fifthoff and Noerdhoff International Publisher, 1978.
2.	Kare Hellan, Introduction of Fracture Mechanics, McGraw-Hill Book Company, 1985.
3.	Preshant Kumar, Elements of Fracture Mechanics, Wheeler Publishing, 1999.
4.	John M.Barson and StanelyT.Rolfe Fatigue and fracture control in Structures, Prentice hall Inc. Englewood cliffs. 1977
5.	Deformation and Fracture Mechanics of Engineering Materials, Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg ,Wiley-2012
6.	Fracture Mechanics Fundamentals and Applications, Ted L..Anderson, CRC Press, 2005.
7.	Tribikram Kundu, Fundamentals of Fracture Mechanics, Ane Books Pvt. Ltd. New Delhi/ CRC Press, 1st Indian Reprint, 2012

CD18012	TRIBOLOGY IN DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge in the friction, wear and lubrication aspects of machine components
- To understand the material properties which influence the tribological characteristics of surfaces
- To understand the analytical behavior of different types bearings and design of bearings based on analytical /theoretical approach

UNIT I	**SURFACE INTERACTION AND FRICTION**	**7**

Topography of Surfaces – Surface Features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction Rolling Friction-Friction properties of metallic and non-metallic materials friction in extreme conditions Thermal considerations in sliding contact

UNIT II	**WEAR AND SURFACE TREATMENT**	**8**

Types of wear – Mechanism of various types of wear – Laws of wear Theoretical wear models, Wear of Metals and Nonmetals– Wear Maps - Surface treatments – Surface modifications – surface coatings methods- Surface Topography measurements Laser methods –instrumentation - International standards in friction and wear measurements

UNIT III	**LUBRICANTS AND LUBRICATION REGIMES**	**8**

Lubricants and their physical properties- Viscosity and other properties of oils Additives-and selection of Lubricants- Lubricants standards ISO, SAE, AGMA, BIS standards –Lubrication Regimes Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication-hydrodynamic lubrication -Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

UNIT IV	**THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION**	**10**

Reynolds Equation, -Assumptions and limitations-One and two-dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic Bearings-Long and short bearings-Pad bearings and Journal Bearings-Squeeze film effects-Thermal Considerations-Hydrostatic lubrication of Pad bearing-Pressure, flow, load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings

UNIT V	**HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION**	**12**

Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory - Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings-

Stresses and deflections-Traction drives- Bearing performance measurement - Bearing Vibration Measurement.	
	TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

- Ability to select material / surface properties based on the tribological requirements
- Methodology for deciding lubricants and lubrication regimes for different operating conditions.
- Analysis ability of different types of bearings for given load/ speed conditions.
- Understand the Bearing performance measurement and Bearing Vibration Measurement

REFERENCES:

1.	Rabinowicz.E, Friction and Wear of materials, John Willey & Sons, UK, 2008
2.	Cameron, A. Basic Lubrication Theory, Ellis Herward Ltd., UK, 1981
3.	Halling, J. (Editor), Principles of Tribology, Macmillian, 1991
4.	Williams J.A. Engineering Tribology, Oxford Univ. Press, 2005.
5.	S.K.Basu, S.N.Sengupta & B.B.Ahuja ,Fundamentals of Tribology, Prentice –Hall of India Pvt Ltd , New Delhi, 2005
6.	G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth- Heinemann, UK, 2005.
7	A.Stolarsk, Tribology in Machine Design, Butterworth- Heinemann, UK,2013.
8	Giovanni Straffelini, Friction and Wear: Methodologies for Design and Control, Springer 2015
9	Michael M.Khonsari, Applied Tribology: Bearing Design and Lubrication, Wiley-Blackwell; 2nd Revised edition, 2008.
10	Avraham Harnoy, Bearing Deign in Machinery: Engineering Tribology and Lubrication, Dekker 2007.

CD18013	MECHANICAL BEHAVIOR OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the mechanical behavior of both metallic and non-metallic materials under different loading and temperature conditions.

UNIT I	**BASIC CONCEPTS OF MATERIAL BEHAVIOR**	**10**

Elasticity in metals and polymers– Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity – . Griffith's theory, – Ductile, brittle transition in steel – High temperature fracture, creep – Larson Miller parameter – Deformation and fracture mechanism maps.

UNIT II	**BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES**	**10**

Stress intensity factor and fracture toughness – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law- Safe life, Stress life, strain-life and fail - safe design approaches -Effect of surface and metallurgical parameters on fatigue – Fracture of nonmetallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III	**SELECTION OF MATERIALS**	**10**

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

UNIT IV	**MODERN METALLIC MATERIALS**	**8**

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials. .

UNIT V	**NON-METALLIC MATERIALS**	**7**

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TIC, TaC, Al_2O_3, SiC, Si_3N_4 CBN and diamond – properties, processing and applications

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

After completing the course, students will be able to:

- Understand the mechanical properties and behavior of materials and how these properties are measured.

- Evaluate the conditions for failure
- Select modern metallic and non-metallic materials for specific design application and environment
- Demonstrate recognition of failure mechanisms and identify key mechanical properties and analyses and cause of failure and evaluate solutions to prevent failure

REFERENCES:

1.	Ashby M.F., Materials selection in Mechanical Design,4th Edition, Butter worth, 2011.
2.	Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (3rd edition), Butterworth-Heiremann, 2001.
3.	Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4^{th}Edition) Jaico, 1999.
4.	George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988
5.	Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.
6.	Thomas H. Courtney, Mechanical Behavior of Materials, (2nd edition), McGraw Hill, 2005.

CD18014	PRODUCT LIFE CYCLE MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- This course provides the knowledge and practice regarding Product Life Cycle Management. This course gives practice through Product Life Management Strategies and Product Data Management. Product forecasting gives new Product Design for Manufacturing. Also, to understand the integration of PLM/PDM with other applications.

UNIT I	**INTRODUCTION TO PRODUCT LIFE CYCLE**	**9**

Product life cycle – Introduction, growth, maturity & decline, Product Lifecycle Management- Definition & Overview, Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (CPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM).PLM/PDM Infrastructure– Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II	**PLM/PDM FUNCTIONS AND FEATURES**	**9**

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

UNIT III	**PLM/PDM FUNCTIONS AND FEATURES**	**9**

Case Studies based on top few commercial PLM/PDM tools. Architecture of PLM & PDM tool- PLM vs ERP integration- Agile PLM integration- PLM SCM integration.

UNIT IV	**ROLE OF PLM IN INDUSTRIES**	**9**

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance.

UNIT V	**BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE**	**9**

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

Students will be able to:

- Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
- Illustrate various approaches and techniques for designing and developing products.

• Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc. • Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant	
REFERENCES:	
1.	Grieves Michael, Product Lifecycle Management- Driving the Next Generation of Lean Thinking, McGraw-Hill, 2006.
2.	Stark, John. Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer-Verlag, 2016.
3.	Antti Saaksvuori, AnselmiImmonen, Product Life Cycle Management - Springer, 3rd Edition,2010.
4.	Clement, Jerry; Coldrick, Andy; & Sari, John. Manufacturing Data Structures, John Wiley & Sons, 1992
5.	Kari Ulrich and Steven D. Eppinger, Product Design & Development, McGraw Hill International, 6th edition, 2015.
6.	Effective Product Design and Development – by Stephen Rosenthol, Business One Orwin, Homewood, 1992

CD18015	DESIGN FOR INTERNET OF THINGS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To apply the concept of Internet of Things in the real world scenario

UNIT I	**INTRODUCTION TO INTERNET OF THINGS**	**9**

Machine to Machine (M2M) to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT the global context, A use case example. Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels

UNIT II	**IoT STRUCTURE**	**10**

M2M to IoT – A Market Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

UNIT III	**IoT NETWORKING**	**9**

M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management.

UNIT IV	**IoT ARCHITECTURE**	**7**

IoT Architecture-State of the Art – Introduction, State of the art, Architecture Reference Model- Introduction, Reference Model and architecture, IoT reference Model.

UNIT V	**ARCHITECTURE MODELING**	**10**

IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control. Industrial Automation- Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, Commercial Building Automation-Introduction, Case study: phase one-commercial building automation today, Case study: phase two- commercial building automation in the future.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

Students will be able to:

- Understand the vision of IoT from a global context.

- Determine the Market perspective of IoT.
- Use of Devices, Gateways and Data Management in IoT.
- Understand the design constraints in the real world.
- Apply of IoT in Industrial and Commercial Building Automation and Real-World Design Constraints

REFERENCES:

1.	Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, 1st Edition, Academic Press, 2014
2.	Bernd Scholz-Reiter, Florian Michahelles, Architecting the Internet of Things, Springer-Verlag,2011.
3.	Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, Willy Publications, 2013.
4.	Vijay Madisetti and Arshdeep Bahga, Internet of Things (A Hands-on-Approach), 1st Edition, VPT, 2014.
5.	Francis da Costa, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, 1st Edition, A press Publications, 2013.
6.	Peter Waher, Learning Internet of Things, PACKT publishing, Birmingham – Mumbai, 2015.
7.	http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html

CD18016	SYSTEMS ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Introduce the concepts related to system engineering, with design, analysis, game theory, decision making analysis, etc.

UNIT I	**INTRODUCTION TO SYSTEM ENGINEERING**	**9**

Overview, Systems definition and concepts, Conceptual system design, Systems thinking, Systems Engineering (SE) and Systems Engineering.

UNIT II	**DESIGN AND DEVELOPMENT**	**9**

Detail Design Requirements, The Evolution of Detail Design, Design Data, Information, and Integration, Various phases in product life cycle, Systems verification & Integration

UNIT III	**DESIGN FOR OPERATIONAL FEASIBILITY**	**9**

Design for Reliability, Maintainability, Usability, Sustainability and Affordability- Definition and Explanation, Measures, System Life Cycle cost, Analysis Methods, Practical considerations

UNIT IV	**SYSTEMS ENGINEERING MANAGEMENT**	**9**

Systems Engineering Planning and Organization, Systems Engineering Management Plan (SEMP) – Scope & Examples, Program Leadership and Direction, Risk Management, Evaluation and Feedback.

		9
UNIT V	**CASE STUDIES**	

Systems Integration -Aircraft Systems, Missile Systems, Satellite Systems-Launch Vehicle Systems and Radar, Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

- Understand to impart the advanced concepts of systems engineering to the engineers.
- To provide the necessary mathematical knowledge those are needed in understanding their significance and operation Ability to design hydraulic and pneumatic circuits.
- Have an exposure on various topics such as conceptual system design, system design and development, design for operational feasibility, systems engineering management.
- Will be able to deploy skills effectively in the understanding of systems engineering.

REFERENCES:

1. Ian Moir and Allan Seabridge, Design and Development of an Aircraft Systems Wiley & Sons Ltd, 2nd edition,2013.
2. Andrew P.Sage and James .Armstrong, Introduction to Systems Engineering, Wiley& Sons

	Ltd, 2000.
3.	Benjamin S. Blanchard / Wolter J.Fabrycky, Systems Engineering and Analysis Prentice Hall, 5th Edition, 2017.
4.	Erik Aslaksen & Rod Belcher, Systems Engineering, Prentice Hall, 1992.

CD18017	BIO MECHANICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The student should be made to:

- Be exposed to principles of mechanics.
- Learn the mechanics of physiological systems.
- Be familiar with the mathematical models used in the analysis of biomechanical systems

UNIT I	**INTRODUCTION TO MECHANICS**	**9**

Principles of Mechanics, Vector mechanics, Mechanics of motion - Newton's laws of motion, Kinetics, Kinematics of motion, Fluid mechanics – Euler equations and Navier Stoke's equations, Viscoelasticity, Constitutive equations, Stress transformations, Strain energy function

UNIT II	**BIOFLUID MECHANICS**	**9**

Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow. Cardiovascular system - biological and mechanical valves development, artificial heart valves testing of valves, Structure, functions, material properties and modeling of Blood vessels

UNIT III	**BIOSOLID MECHANICS**	**9**

Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models – anisotropy. Soft Tissues: Structure, functions, material properties and modeling of Soft Tissues: Cartilage, Tendon, Ligament, Muscle.

UNIT IV	**BIOMECHANICS OF JOINTS AND IMPLANTS**	**9**

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle. Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

UNIT V	**MODELING AND ERGONOMICS**	**9**

Introduction to Finite Element Analysis, Analysis of bio mechanical systems using Finite element methods, Graphical design. Ergonomics- Gait analysis, Design of work station, Sports biomechanics, Injury mechanics.

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

At the end of the course, the student should able to:

- Explain the mechanics of physiological systems.

- Analyze the biomechanical systems.
- Design Orthopaedic applications.
- Modeling and analysis of bio mechanical system using FEM

REFERENCES:

1.	Duane Knudson, Fundamentals of Biomechanics, Second Edition Springer Science Business Media, 2007
2.	Jay D. Humphrey, Sherry De Lange, An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, Springer Science Business Media, 2004
3.	Marcelo Epstein, The Elements of Continuum Biomechanics, First Edition, Willey & Sons Limited, ISBN: 978-1-119-99923-2, 2012.
4.	Shrawan Kumar, Biomechanics in Ergonomics, Second Edition, CRC Press 2007.
5.	Y.C. Fung, Bio-Mechanics- Mechanical Properties of Tissues, Springer-Verlag, 1998.

CD18018	PLASTICITY AND METAL FORMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on theory of plasticity, analysis of various metal forming processes that arise in engineering applications.

UNIT I	**THEORY OF PLASTICITY**	**9**

Theory of plastic deformation - Engineering stress and strain relationship – Stress tensor - Strain tensor - Yield criteria's - Plastic stress strain relationship – Plastic work - Equilibrium conditions - Incremental plastic strain

UNIT II	**CONSTITUTIVE RELATIONSHIPS AND INSTABILITY**	**7**

Uniaxial tension test - Mechanical properties - Work hardening, Compression test, bulge test, plane strain compression stress, plastic instability in uniaxial tension stress, plastic instability in biaxial tension stress.

UNIT III	**ANALYSIS OF METAL FORMING PROBLEMS**	**12**

Slab analysis - Slip line method, upper bound solutions, statistically admissible stress field, numerical methods, contact problems, effect of friction, thermo elastic Elasto plasticity, elastovisco plasticity - Thermo mechanical coupling – Analysis of forging, rolling, extrusion and wire drawing processes - Experimental techniques of the evaluation of metal forming.

UNIT IV	**ANALYSIS OF SHEET METAL FORMING**	**8**

Bending theory - Cold rolling theory - Hill's anisotropic theory, Hill's general yield theory - Sheet metal forming - Elements used - Mesh generation and formulation Equilibrium equations - Consistent full set algorithm - Numerical solutions procedures - examples of simulation of simple parts - Bench mark tests – Forming limit diagrams

UNIT V	**ADVANCES IN METAL FORMING**	**9**

Orbital forging, Isothermal forging, Warm forging, Hot and Cold isotropic pressing, high speed extrusion, rubber pad forming, micro blanking –Superplastic forming - Overview of Powder Metal techniques - Powder rolling - Tooling and process parameters-Overview of Severe plastic deformation techniques

TOTAL: (L: 45): 45 PERIODS

OUTCOMES:

After completing the course, students will be able to:

- Analyze the plastic behavior of materials during forming processes.
- Model the elastic and plastic behaviour of structural engineering materials.
- Understand and compare the capabilities various advanced forming processes
- Integrate knowledge gained in this course to select and design a complete metal forming system

REFERENCES:		
1.	Hosford. W. F and Caddell. RM., Metal Forming Mechanics and Metallurgy, Fourth Edition, Prentice Hall Eaglewood Cliffs, 2011.	
2.	Narayanaswamy. R, Theory of Metal Forming Plasticity, Narosa Publishers, 1999.	
3.	Shiro Kobayashi, Altan. T, Metal Forming and Finite Element Method, Oxford University Press, 1989.	
4.	Slater. R A. C., Engineering Plasticity - Theory & Applications to Metal Forming, John Wiely and Sons, 1987.	
5.	Surender Kumar, Technology of Metal Forming Processes, Prentice Hall of India, New Delhi, 2008	
6.	Wagoner. R H., and Chenot. J.L., Metal Forming analysis, Cambridge University Press, 2001.	