Curriculum
for
Master of Technology
in
Computer Aided Analysis and Design (CAAD)

Department of Mechanical, Production, Industrial and Automobile Engineering
Delhi Technological University
Shahbad, Daulatpur, Delhi-110042

M. Tech (Computer Aided Analysis and Design)

M.Tech (Computer aided analysis and design) course is meant for those candidates, who are desirous of seeking higher education in the field of application of computational techniques in analysis of design. The basic purpose of this M.Tech. Course is to serve Delhi Technological University, government, and industry through research and development of advanced computational Mechanics, modeling, simulation, and design of physical systems to solve real world problems. Our aim is to build a centre of excellence for multidisciplinary engineering simulation and design which combines a range of analytical, computational and experimental techniques. Our strength lies in this sophisticated mix of engineering methods, coupled with industrial applications: a particular focus for our activities over the next few years will be the development of grid-based, problem-solving services to be used use by academia and industry. The primary research interests fall into three broad themed areas:

- Design optimisation and analysis
- Applied computational modelling
- Computational methods
- Latest tools like AI and data analytics

The overall purpose of the proposed M.Tech. Programme is to establish a cohesive and expanding base of research in applied computational science and analysis and Design engineering. It will produce sustained growth in research funding, excellence in integrated research and education, and increase in national and international stature and economic competitiveness for Indian Industries. Now a days, Computational Mechanics and Design methods are critically important for the analysis and design of sophisticated technological products and systems in a competitive global marketplace and fulfilling the needs of the society. The future security and economic well being of our country will depend in part on an adequate supply of scientists and engineers, who are highly skilled in the use of computers to solve important design problems using modeling, simulation and computer assisted design.

This evolution is expected to transform the use of advanced technology by introducing computational simulation and design software that supplements experiments and testing to produce competitive advantages in critical areas such as price, time-to-market, life-cycle costs, and overhead. Although these benefits to industry are driving the changes in engineering practice and technical education in India, yet, it has not responded

adequately to the challenge of providing graduates, post graduate and researchers, who are adequately prepared in Machine design field. In view of the extensive use of computational analysis methodologies in design by industry, there is a significant role for creating innovative curricula meant for educating the young minds. In this way, they may be able to solve programs of integrated research and graduate education (i.e., graduate research in an applications environment) that is distinct from traditional university research activity. The use of computers to solve complex, large-scale, practical problems is a trend that will accelerate in years to come.

In view of the large scale skill development in this emerging area of design, Delhi Technological University has recognized the needs of starting a post graduate program in the computer aided analysis and design area. This new program will offer opportunities to provide the leadership in computational applications driven research. This education is certainly needed for future competitiveness in the advanced technology sector of the global economy through starting of this master program in design area. The students graduating from this program will be able to carry out research in the area of computational mechanics and design, along with the capability of working on design and analysis of engineering systems for industry.

University Vision

"To be a world class university through education, innovation and research for the service of humanity "

University Mission

1. To establish centres of excellence in emerging areas of science, engineering, technology, management and allied areas.
2. To foster an ecosystem for incubation, product development, transfer of technology and entrepreneurship.
3. To create environment of collaboration, experimentation, imagination and creativity.
4. To develop human potential with analytical abilities, ethics and integrity.
5. To provide environment friendly, reasonable and sustainable solutions for local & global needs.

Program Educational Objectives PEOs

The objectives of the M.Tech. Programme in Computer Aided Analysis and Design are:

PEO 1: To develop the scientific and engineering manpower of high quality to cater to the needs of the industry and institutes.

PEO 2: To provide a broad grasp of the fundamental principles of the mechanics and design through its advanced curriculum.

PEO 3: To provide a deep understanding of the area of specialization to serve and understand better the industrial problems.

PEO 4: To provide an innovative ability to solve real case studies problems.

PEO 5: To provide a capacity to learn continually and interact with multidisciplinary groups.

PEO 6: To develop the students with a capability to cater the requirements and aspirations of society.

Program Outcomes (PO)

PO 1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO 2: An ability to write and present a substantial technical report/document.

PO 3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO 4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO 5: To be able to apply the research knowledge for solution to industry specific problems.

PO 6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

Programme Specific Outcomes (PSOs)

PSO 1: Build capability for research in the area of computational mechanics and design along with problem solving skills for industry.

PSO 2: Recognize the need for lifelong learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

PSO 3: The student will be equipped in the use of various CAD/CAE softwares, thereby having high employability potential for industry along with possibility of entrepreneurship and pursuit of higher studies.

With these objectives in mind, the M.Tech. Programme has been designed to include courses of study, practicals/seminars and project/thesis through which a student may develop his/her concepts and intellectual skills. The procedures and requirements stated in this proposal embody the philosophy and regulations of the M.Tech. education and ensure a high standard of performance at the University and industries.

This will certainly expand the demonstrated capability of the University in the area of Industrial Engineering & Management applications and to explore research activities that broaden and expand research expertise in this field. It will definitely find appropriate opportunities for educational outreach activities and training courses for other institutes and universities near Delhi to create awareness and to stimulate interest in Industrial Engineering & Management.

Eligibility Criteria: Students with Bachelor degree (4-years degree Programs; B.Tech./B.E/B.Sc.Engg., and equivalent degree) in the branch of Mechanical Engineering or Production Engineering or Design or Civil Engineering or Engineering Physics will be eligible to take admission in this program. For scholarship a valid GATE Score is mandatory.

Intake: 25

DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)

SCHEME OF FULL TIME M. TECH as per NEP-2020

MASTER OF TECHNOLOGY IN COMPUTER AIDED ANALYSIS & DESIGN (CAAD)

Semester-I

Code	Type	Cr	L-T-P	Total Credits	Level
CAD 501	Numerical Methods for Engineering Applications	**4**	3-0-2	24	500-599
CAD 503	Plasticity & Metal Forming	**4**	3-0-2		
CAD 505	Advanced Vibration and Control	**4**	3-0-2		
CAD 507	Finite Element Method	**4**	3-0-2		
	Department Elective -1	**4**			
CAD 511	Fracture Mechanics		3-0-2		
CAD 513	Composite Material Technology		3-0-2		
CAD 515	Rapid Prototyping and Tooling		3-0-2		
CAD 517	Product Life Cycle Management		3-1-0		
CAD 519	Machine Tool Design		3-0-2		
	Self Study				
CAD 551	Seminar	**2**	-		
CAD 553	MOOC				
	Skill Enhancement Course 1	**2**			
CAD 541	Modelling, Simulation and Analysis		0-0-4		
CAD 543	Professional Software		0-0-4		
	Audit Course	**0**			
UEC 501	English for Research Paper writing		2-0-0		
UEC 503	Disaster Management		2-0-0		
UEC 505	Sanskrit for Technical Knowledge		2-0-0		
UEC 507	Value Education		2-0-0		
UEC 509	Constitution of Inda		2-0-0		
UEC 511	Pedagogy Studies		2-0-0		
UEC 513	Stress Management by Yoga		2-0-0		

DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
SCHEME OF FULL TIME M. TECH as per NEP-2020
MASTER OF TECHNOLOGY IN COMPUTER AIDED ANALYSIS & DESIGN

Semester-II

Code	Type	Cr	L-T-P	Total Credits	Level
CAD502	Industrial Tribology	**4**	3-0-2	24	500-599
CAD504	Product Design and Development	**4**	3-0-2		
	Department Elective -2	**4**			
CAD 520	Optimization Techniques		3-1-0		
CAD 522	Lubricating Oil and Grease Design		3-0-2		
CAD 524	Reliability Engineering		3-1-/0		
CAD 526	Computer Aided Design		3-0-2		
CAD 528	Rotor Dynamics		3-0-2		
	Department Elective -3	**4**			
CAD 530	Smart Materials		3-1-0		
CAD 532	Human Factors in Engineering and Biomechanical Design		3-1-0		
CAD 534	Design for Manufacture and CIM		3-1-0		
CAD 536	Instrumentation and Control Systems		3-0-2		
CAD 538	Mechatronic System Design		3-0-2		
UEC 502	Research Methodology & IPR	**4**	3-1-0		
	Skill Enhancement Course 2	**4**			
CAD 540	Industrial Training		0-0-8		
CAD 542	Professional Software		0-0-8		
	NHEQF Level				**6.5**

Semester-III

Code	Type	Cr	L-T-P	Total Credits	Level
CAD601	Computational Mechanics of Materials	**4**	3-0-2	16	**600-699***
	Open Elective				
OME601	Computational Methods for Fluid Dynamics	4	3-0-2		
CAD603	Minor Project/Research Thesis/Patent	8	-		

Semester-IV

Code	Type	Cr	L-T-P	Total Credits	Level
CAD604	Major Project/Research Thesis/Patent	16	-	16	**-**
	NHEQF Level				**7.0**

Course code: Course Title	Course Structure			Pre-Requisite
CAD501-Numerical Methods for Engineering applications	L	T	P	NIL
	3	0	2	

Course Objective: To familiarize the students with basics of errors, solution of linear equations, Interpolation, differentiation and integration, Fourier integral and transform, partial differential equations and statistical methods. To impart in-depth knowledge of numerical methods or real life application.

S. No.	Course Outcomes (CO)
CO1	To understand, explain and evaluate the errors in numerical computations.
CO2	To understand the fundamental of algebraic equations and find solutions of interpolation problems.
CO3	To understand and comprehend the principles of differentiation and integration.
CO4	To understand and explain the concepts of transformation techniques and be able to design and compare different numerical algorithms with respect to accuracy and efficiency of solution.
CO5	To analyze and apply the concepts of statistical tools and hypothesis testing.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	2	2	2	2	2	2
CO3	2	2	2	2	2	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 501-Numerical Methods for Engineering applications	Contact Hours
Unit 1	Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation. Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss-Seidal), convergence of iteration methods, Newton Raphson method — Solution of linear system of equations.	9
Unit 2	Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomial Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration.	8
Unit 3	Transform techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT)	8
Unit 4	Differential equations: Initial and boundary value problems, eigenvalues problems, solutions to elliptical and parabolic equations, partial differential equations. Kutta method for solving first order equations — Multi step methods — Milne?s and Adams — Bash forth predictor corrector methods for solving first order equations	8
Unit 5	Statistical methods: Statistical representation of data, modeling and analysis of data, test of hypotheses. Solution to practical engineering problems using software tools Regression methods: Linear and non-linear regression, multiple linear regression, general linear least squares	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	Schilling R.J and Harris S L, "Applied Numerical Methods for Engineering using MatLab and C", Brooks/Cole Publishing Co.,	2000
2	ChapraS C and CanaleR P, "Numerical Methods for Engineers", McGraw Hill,	1989.
	Hines, W.W and Montrogmery, "Probability and Statistics in Engineering and Management Studies", John Willey,	1990.
3	SanthoshK.Gupta, "Numerical Methods for Engineers", New Age international publishers,	2005.

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 503-Plasticity & Metal Forming	L	T	P	NIL
	3	0	2	

Course Objective: To familiarize the students with basics of state of stress and strain, in three dimensions, Yield criteria, forming processes, forging, rolling, wire drawing. To impart in-depth knowledge of real-life application Sheet metal forming operations, Sheet metal cutting operations like blanking, shearing and laser cutting and its force analysis, bending and spring back, die design for deep drawing and bending

S. No.	Course Outcomes (CO)
CO1	To explain, interpret and use the concepts of stress at a point, stress and strain tensors, Mohr's circle, invariants of stress, Principle of super position and reciprocal theorem and be able to apply in theoretical and practical formulation of elastic problems.
CO2	To understand the fundamental of Airy's stress function, Analysis of stress and strain in 3-d, ellipsoid, variational methods, Castigliano's theorems. Anisotropic elasticity, finite deformation elasticity and be able to analyze the bending of beams and curved beams.
CO3	To understand the assumptions underlying several continuum plasticity theories, deviatoric stress tensor, deformation theory, yield surface, normality rule, flow rule theory, Hill's anisotropic yield, Prandtl Reuss, Levy mises equations etc. and to apply the concepts of various yielding principles in formulation of plasticity problems and solutions.
CO4	To analyze the plasticity based problems using upper and lower bound theorems
CO5	To analyze and apply the slab methods. slip line field theory and extremum principles in solving various plasticity problems.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	1	1
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 503-Plasticity & Metal Forming	Contact Hours
Unit 1	Elasticity, Review of two-dimensional stress and strain, state of stress in three dimensions, Stress tensor, Invariants, Mohr's circle for 3-dimensional state of Stress, strain at a point, Mohr's circle for strain, Hydrostatic & Deviatory components of stress, Elastic stress strain relations. Plane stress and plane strain Conditions.	9
Unit 2	Nature of plastic deformation, Flow curves, true stress & true strain, Yield criteria for ductile metals, von Misses & Tresca yield criteria, combined stress state tests. The yield locus, Anisotropy in yielding, Yield surface, Levy-Misses, Prandtl-Reuss equations, Octahedral shear stress and strain components, stress-strain relations in elastic and plastic problems, work hardening, formulation of elastic plastic problems.	8
Unit 3	Classification of forming processes, process and design variables in metal forming and their optimization, Hot working, Cold working, Strain rate effect, Friction and lubrication, Deformation zone geometry, Workability, Residual stress. Analytical method based on homogeneous compression slip line field theory, Upper bounds and lower bounds, Slab method of analysis. Flow stress determination,	8
Unit 4	Analysis of metal forming processes: Forging: die design and lubrication, Classification and selection of forging machines, Die failure and economics of forging, Analysis of forging operation, Load calculation in plane strain forging, Rolling: Forces & geometrical relationship in rolling, Rolling load and torque in rolling operation, Extrusion: Analysis of direct and indirect extrusion process, Extrusion pressure, Wire and tube Drawing.	8
Unit 5	Sheet metal forming operations, Sheet metal cutting operations like blanking, shearing and laser cutting etc., Analysis of deep drawing, load, strip drawing and its force analysis, bending and spring back, Die design for deep drawing and bending. Drawability, Anisotropy and texture evaluation of sheet metal, Erischen cupping tests, Determination of Forming Limit Diagrams and their applications, Limiting dome height and Limiting draw ratio. Advances in metal forming operations	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	Fundamentals of Metal forming process by Juneja B.L., New age international Publishers	2010
2	Principal of Industrial Metal working Processes by Rowe G.W, CBS publishers & Distributers	2005
3	Manufacturing Science by Ghosh Amitabha & Mallik Kumar Asok, East-West Prem Pvt Ltd	2002

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 505- Advanced Vibration and Control	L	T	P	NIL
	3	0	2	

Course Objective:

The students understand to model the physical system, derivation of equation of motion for single, two and multi-degree of freedom systems and analyze the system responses. They are also able to determine the natural frequency by numerical method and its importance for vibratory system. They understand the basic theory and use of instruments to measure vibration response. They know the concept of vibration stability control, non-linear vibration and continuous system. Familiarize them with MATLAB programming to solve vibration problems.

S. No.	Course Outcomes (CO)
CO1	Understand the vibrations phenomenon, Fourier series analysis and mathematical modelling of vibratory systems
CO2	Analyze and solve problems of free and forced vibration systems with single and two degrees of freedom.
CO3	Understand the methodology of estimating natural frequencies and mode shapes of multi degree of freedom systems using exact and numerical methods.
CO4	Learn the process of vibration measurements, control and dynamic instability
CO5	To apply the concept of vibration of continuous systems and the concept of non-linear vibration

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	2	1
CO2	2	2	2	2	2	2
CO3	2	3	2	2	3	2
CO4	3	3	3	3	3	3
CO5	2	3	2	2	3	2

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 505- Advanced Vibration and Control	Contact Hours
Unit 1	**Two-degree of Freedom System** Principal modes of vibration, Vibration analysis of Spring-mass,Double pendulum and Torsional systems, Forced vibration of damped and undamped systems, Coordinate coupling, Vibration absorbers, Vibration isolation	8
Unit 2	**Multi-degree Freedom systems** Eigen-value problem, Close coupled and far coupled systems, Orthogonality of mode shapes, Modal analysis for free, damped and forced vibration systems, Approximate methods for fundamental frequency-Rayleigh's, Dunkerely's, Stodola and Holzer methods, Method of matrix iteration, Finite element method for close coupled and far coupled systems	9
Unit 3	**Vibration Control** &**Dynamic Instability** Vibration control strategies and case studies, experimental and theoretical routes to vibration engineering, vibration testing. Lumped parameter and distributed parameter modeling of mechanical vibratory systems, Vibration control solutions, balancing of rotating and reciprocating machines, Design of vibration isolators, Auxiliary mass systems including tuned dampers for vibration control, Application of damping treatment for vibration control in machines and structures. Active control of vibrations, Introduction to NVH and its control, Random vibrations, Measurement and processing of random data	9
Unit 4	**Continuous systems:** Forced vibration of systems governed by wave equation, Free and forced vibrations of beams/ bars	8
Unit 5	**Non-linear Vibrations:** Non-linear systems, Undamped and forced vibration with non-linear spring forces, Self-excited vibrations	8
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	Theory and practice of Mechanical Vibrations -J.S. Rao and K. Gupta- New Age International	1999
2	Mechanical Vibrations: Modeling and Measurement - K.Scott Smith and Tony L. Schmitz – Springer	2014
3	Introduction to Linear, Parametric and Non-Linear Vibrations- M.C. Cartmell- Chapman and Hall	1990
4	Mechanical Vibrations -G.K. Groover -Nem Chand & Brothers	2009
5	Mechanical Vibration Practice and Noise Control -V. Ramamurti -Narosa Publications	2012
6	Mechanical Vibrations- V.P. Singh- Dhanpat Rai & sons	2016

Course code: Course Title	Course Structure			Pre-Requisite
CAD 507: Finite Element Method	L	T	P	NIL
	3	0	2	

Course Objective:
To familiarize the students with basics of FEM, formulation of stiffness, load matrix and solution of bar, truss, beam, frames two dimensional plane problems axisymmetric solids, numerical integration, three dimensional solids, dynamic problem, heat transfer and fluid problems. . To impart in-depth knowledge of software MATLAB, ABAQUS & ANSIS to solve real life application.

S. No.	Course Outcomes (CO)
CO1	Students are able to understand fundamental concepts of Finite Elements Methods, displacement models, derivation of stiffness matrix and load vectors for element and entire domain. One dimensional problem (Bars of uniform and variable cross sections), Galerkin approach, Potential energy approach, Shape function, evaluation of displacement, stresses and reaction forces. Use of FEM for differential equations& Relay Ritz method.
CO2	Students will able to understand plane trusses, Local and global coordinate system, element stiffness matrix and stress calculations for truss, beam elements and frames.
CO3	Students will able to understand finite element formulations of stiffness and load vectors for two dimensional planes, constant strain triangles (CST) and axisymmetric solids and numerical integration.
CO4	Students will able to use of FEM for three dimensional solids and understand element mass matrices, evaluation of Eigenvalues and eigenvectors.
CO5	They are able to apply finite element methods to fluid mechanics and heat transfer and Electromagnetic simulation. Also they can work on software such as ABAQUS, MATLAB and ANSYS.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	1
CO2	1	2	2	2	2	2
CO3	3	3	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

S. No.	CAD 507: Finite Element Method	Contact Hours
Unit 1	Introduction to Finite Element Method Engineering Analysis, History, Advantages, Classification, Basic steps, Differential equations formulations, Variational formulations, weighted residual method, Virtual work principle, Classification, boundary conditions and characteristics of second order partial differential equations, boundary value problems, eigenvalues problems, orthogonal matrices, similarity transformation. Rayleigh Ritz method	9
Unit 2	One-Dimensional Elements-Analysis of Bars and Trusses Basic Equations and Potential Energy Functional, 1-D Bar Element, Shape functions, Stiffness matrix, Assembly Procedure, Boundary Conditions, 2-D truss element. Beam Elements-Analysis of Beams and Frames: Beam elements, Reduced integration, Elements based on Bernoulli and Timoshenko theory of beams	9
Unit 3	Two-Dimensional Elements-Analysis of Plane Elasticity Problems: Constant strain triangle (CST), Linear Triangular and Quadrilateral Elements, Shape functions for Higher Order Elements, Isoparametric elements, Numerical integration, convergence criteria, discretization error, convergence rate, patch test. Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading: Axisymmetric Triangular and Quadrilateral Ring Elements.	8
Unit 4	Three-Dimensional Elements-Applications to Solid Mechanics Problems Tetrahedral Elements, Hexahedral Elements. Dynamic Considerations: Formulation for point mass and distributed masses, Consistent mass matrix, Lumped mass matrix, Evaluation of eigenvalues and eigenvectors.	8
Unit 5	Heat Transfer *and* Fluid Flow: Steady state heat transfer, heat conduction governing equation, boundary conditions, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, Basic differential equation for fluid flow in pipes and around solid bodies. Electromagnetic simulation using FEM. Use of softwares like Abaqus and Ansys.	8
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	ChandrupatlaT.R., "FiniteElementsinengineering"-2ndEdition, PHI	2007
2	LakshminarayanaH.V., "FiniteElementsAnalysis"–ProceduresinEngineering, Universities Press	2004
3	P.Seshu,"TextbookofFiniteElement Analysis"-PHI	2004
4	RaoS.S."FiniteElementsMethodinEngineering"-4thEdition, Elsevier,	2006
5	Cook R.D., et al."Concepts and Application of Finite ElementsAnalysis"-4thEdition, Wiley &Sons,2003.	2006

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD502-Industrial Tribology	L	T	P	NIL
	3	0	2	

Course Objective: To familiarize the students with basics of lubrication, wear &cost of friction . To impart in-depth knowledge of mechanisms of erosive and cavitations wear, hydrostatic lubrication, design of bearing, smart bearing and bearing with IOT.

S. No.	Course Outcomes (CO)
CO1	To understand fundamental concepts of Lubrication, cost of friction and wear.
CO2	To analyze law of sliding friction, laws of wear, mechanism of corrosive & cavitations wear.
CO3	To identify Mechanism of adhesion, corrosive and oxidative wear.
CO4	To apply fretting wear, melting wear, wear due to electrical discharges, diffusive wear, impact wear.
CO5	To discuss the concepts of design of bearing and apply for various case studies.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	2	2	2	2	2	2
CO3	2	2	2	2	3	3
CO4	2	2	2	2	2	2
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD502-Industrial Tribology	Contact Hours
Unit 1	**Introduction** History of evolution and definition, Lubrication, wear, cost of friction and wear. Lubricants and their physical properties, viscosity index, Reynolds equation, Derivation and physical significance, standard reduction forms of Reynolds equation.	7
Unit 2	**Friction and Wear** Law of sliding friction, concept of adhesion. Taylor's model of friction, Measurement of friction. Laws of wear, Abrasive, Erosive and Cavitation wear: Introduction, abrasive wear, mechanisms of abrasive wear, mechanisms of erosive wear, effect of impingement angle and impact speed on erosive wear rate. Effect of particle shape, hardness, size and flux rates on erosive wear rate. Erosive wear by liquid, Cavitation wear, mechanism of cavitation wear.	9
Unit 3	**Adhesion and adhesive wear** Mechanism of adhesion. Corrosive and oxidative wear: Introduction, corrosive wear, transition between corrosive and adhesive wear, synergism between corrosive and abrasive wear, oxidative wear, kinetics of oxide film growth on metals at high and low temperatures.	8
Unit 4	**Fatigue wear& Lubrication** : Introduction, fretting wear, melting wear, wear due to electrical discharges, diffusive wear, impact wear. Sitiback number, curve and law. Solid lubrication and surface treatments: Introduction, Lubrication by solids, lubrication by lamellar solids. Hydrostatic Lubrication, formation of fluid film, pressure distribution and flow, normal load component, frictional torque and power loss. Introduction to gas lubrication.Thermo hydrodynamic lubrication: governing equation and boundary conditions.	10
Unit 5	**Bearing Design** Design of bearing, Clearance in journal bearing, minimum film thickness, sommar-field number, oil grooves and flow of oil in axial and circumferential grooves cavitations and turbulence in oil bearings. Heat generation and cooling or bearing hydrostatic and dynamic and their applications in machine tools. Design of air bearing and other gas bearing. Smart bearing and bearing with IOT.	8
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Engineering Tribology**- Gwidon W. Stachowiak and Andrew W. Batchelor	1993
2	**Fundamentals of fluid film lubrication**- Bernard J. Hamrock	1991
3	**Industrial Tribology**, Dr.B.S.Prabhu, McGraw Hill	2010

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
	L	T	P	
CAD 504: Product Design and Development	3	**0**	**2**	**NIL**

Course Objective: To provide students with a systematic approach to modern design methodologies across the product development lifecycle covering key areas such as value engineering, material and process selection, concurrent and reverse engineering, and advanced strategies like DFMA and Design for "X". Students will also learn to apply tools like QFD and Pugh's method through case studies, while gaining awareness of patents, liability, and ethics in engineering design.

S. No.	Course Outcomes (CO)
CO1	Understand and apply various stages of the design process including problem formulation, generation of alternatives, evaluation, and redesign, supported by real-world case studies.
CO2	Analyze and implement value engineering and concurrent/reverse engineering principles to enhance product development and lifecycle management.
CO3	Evaluate and select suitable materials and manufacturing processes for product design using computer-aided tools and systematic approaches.
CO4	Apply Design for Manufacture and Assembly (DFMA) principles to improve product manufacturability and assembly efficiency for different manufacturing processes.
CO5	Integrate advanced design considerations such as safety, sustainability, aesthetics, and ethics into product development, while understanding design protection and liability aspects.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**2**	**3**	**1**
CO2	**1**	**2**	**2**	**3**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**1**	**3**
CO4	**2**	**1**	**2**	**1**	**2**	**2**
CO5	**3**	**3**	**2**	**2**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 504- Product Design and Development	Contact Hours
Unit 1	**Stages in design process** Introduction to various stages of the design process: Formulation of problem, Generation of alternatives, Evaluation, Guided Redesign. Case study. **Product life cycle** New product introduction: early introduction, increased product life. Life cycle management tools: System integration, QFD, House of quality, Pugh's method, Pahl and Beitz method. Case studies.	9
Unit 2	**Value engineering** Introduction, nature and measurement of value. Value analysis job plan. Creativity and techniques of creativity. Value analysis test. Case studies. **Concurrent/ reverse engineering** Introduction, basic principles, components, benefits of concurrent engineering. Concept of reverse engineering	8
Unit 3	**Material selection** Materials in design. The evolution of engineering materials. Design tools and material data. Function, material, shape and process. Material selection strategy, attribute limits, selection process, computer aided material selection. Case studies. **Process selection** Introduction. Process classification: shaping, joining and finishing. Systematic process selection. Ranking, process cost. Computer – aided process selection	9
Unit 4	**Design for manufacture and assembly** Design for Manufacture and Assembly (DFMA). Reasons for not implementing DFMA. Advantages of DFMA with case studies. Design features and requirements with regard to assembly, production. Design for Manufacture in relation to any two manufacturing processes: machining and injection molding. Need, objectives.	8
Unit 5	**Design for "X"** Introduction. Design for: Safety, packaging and storage, quality, reliability, energy conservation, environment, aesthetics, ergonomics, maintenance, recyclability and disposal. Case studies. **Patents, liability and ethics** Introduction. Protecting your design: patents, copyright, basic tools of design protection. Liability issues in product design. Ethical considerations. Examples/ case studies.	8
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Product Design and Development**, "Karl T. Ulrich, Steven D. Eppinger" McGrawHill	1992
2	**Integrated Product and Process Development**, "John M. Usher, Utpal Roy and H. R. Parasaei	2019
3	**Product Design for Manufacture and Assembly**, "G. Boothroyd, P. Dewhurst and W. Knight" Marcel Daker	2010
4	**Engineering Design and Design for Manufacturing**: A structured approach, "John R. Dixon and CorrodoPoli" Field Stone Publishers, USA.	1999
5	**Material Selection in Mechanical Design**, "M. F. Ashby" Elsevier.	1992

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
UEC 502-Research Methodology & IPR	L	T	P	NIL
	3	0	2	

Course Objective: To familiarize the students with the basic techniques and tools for conducting systematic researchand and develop an understanding of the relevant tools and techniques applicable in proposed area of research. To familiarize them with basic skills in design, implementation and evaluation of research methods to conduct the research.

S. No.	Course Outcomes (CO)
CO1	To introduce research methods and processes.
CO2	To formulate research problem statement and prepare the plan for investigations
CO3	To apply various quantitative techniques for data analysis.
CO4	To communicate and present research findings.
CO5	To understand IPR and related aspects.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	2
CO2	3	3	2	3	2	2
CO3	2	2	2	2	2	3
CO4	2	2	1	1	2	2
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	UEC 502-Research Methodology & IPR (Online)	Contact Hours
Unit 1	Introduction, Concepts of research, Meaning and objectives of research, Research process, Types of research, Research problem identification, Research proposal-contents, Funding agencies, Ethical aspects and Plagiarism detection tools.	8
Unit 2	Research design process, Need and types of research design, Literature survey, Use of internet and advanced search techniques, Various reputed publishers and their databases, identification of research gaps, Measurement and scaling techniques, Data collection-types and methods, Processing and analysis of data, Design and analysis of experiment.	9
Unit 3	Quantitative techniques, sampling fundamentals, Type of hypothesis, Introduction and applications of Binomial, normal and Poisson distributions, Statistical tests: Chi-squared test, t-test, f-test etc., Multivariate analysis, Introduction to various statistical analysis software.	9
Unit 4	Computer applications in research, Pre-writing considerations, Principles of thesis and report writing, Formats for thesis, report and research papers, Documentation and presentation tools- introduction to LATEX and MS Office.	8
Unit 5	Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development, new developments in IPR: National and international scenarios.	8
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	Dr. C.R. Kothari, "Research Methodology: Methods and Techniques", New Age International Publisher.	2019
2	Stuart Melville and Wayne Goddard, "Research Methodology: An Introduction for Science &| Engineering Students", Juta and Company Ltd.	2004
3	Wadehra B.L., "Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indicators", Universal Law Publishing	2004

**: Latest edition of the title of author may please be listed.*

.

Course code: Course Title	Course Structure			Pre-Requisite
CAD 601-Computational Mechanics of Materials	L	T	P	NIL
	3	0	2	

Course Objective: To familiarize the students with basics deformation gradient nonlinear analysis, dynamic problems solutions SFEM, XFEM Mesh free Finite Element methods. To impart in-depth knowledge of contact problems &large deformation problems.

S. No.	Course Outcomes (CO)
CO1	To understand, explain and evaluate nonlinear analysis using Newton Raphson method. apply the use of tensors in strains and vorticity.
CO2	To understand, explain and evaluate nonlinear analysis using Newton Raphson method.
CO3	To understand formulation of dynamic problems and time integration techniques for solving transient analysis.
CO4	To understand and analyze the concepts of large deformation and contact problems using finite elements.
CO5	To understand and explain the concepts of smoothethed finite element methods, extended finite element methods and mesh-free finite element method

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	2
CO2	3	3	2	3	2	2
CO3	2	2	2	2	2	3
CO4	2	2	1	1	2	2
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 601-Computational Mechanics of Materials	Contact Hours
Unit 1	**Analysis of deformation and motion** Motion of a continuum, deformation gradient, polar decomposition, objectivity of tensor fields, measures of strain, rate of deformation and vorticity.	9
Unit 2	**Nonlinear Analysis**: Newton -Raphson method, displacement control, and arc-length control methods for solving non linear problems like those in beam, plate, and shell structure.	8
Unit 3	**Dynamic problems**: Formulation of dynamic problems and time integration techniques for solving transient analysis.	8
Unit 4	**Analysis of large deformation and strain in 3-D elastic continuum** Formulation of boundary value problems: examples. **Contact Problems**: Formulation and analysis of contact problems using finite elements.	8
Unit 5	**Advanced Elements Formulations:** Smoothethed Finite Element Methods(SFEM), Extended Finite Element Methods(XFEM) and Mesh-free Finite Element Method.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Continuum Mechanics**, Gurtin and Anand	2009
2	**An Introduction to Continuum Mechanics**, J. N. Reddy	2013
3	K.J. Bathe, "Finite Element Procedures", Prentice- Hall of India.	1997
4	J.N. Reddy, "An Introduction to Nonlinear Finite Element Analysis", Oxford University Press.	2004
5	**Nonlinear elastic deformations**, R. W. Ogden	1984
6	G. R. Liu and N. R. Trung, Smoothed Finite Element Methods, CRC Press.	2010
7	S. Mohammadi, Extended Finite Element Method: For Fracture Analysis of Structures, Wiley.	2008
8	G. R. Liu, Meshfree Methods: Moving beyond the finite Element Method, CRC Press	2010

**: Latest edition of the title of author may please be listed*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 511: -Fracture Mechanics **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To familiarize the students with basics of Griffith's energy balance approach, the shape of the plastic zone for plane stress and plane strain cases, Stress intensity factors and plane strain fracture toughness. To impart in-depth knowledge of elastic plastic fracture mechanics and fatigue crack propagation and applications of fracture mechanics.

S. No.	Course Outcomes (CO)
CO1	To explain the sources of crack, interpret and use the concepts of fracture mechanics with stress concentration and be able to apply Griffith energy balance approach in theoretical and practical formulation of design problems.
CO2	To understand the fundamental of Airy's stress function, analysis of complex stress and strain, and be able to apply the concepts of shape of the plastic zone for plane stress and plane strain cases in formulating and solving design problems.
CO3	To understand the assumptions underlying several numerical and experimental methods of determination of fracture toughness and be able to the concepts of crack resistance, J-integral tearing modulus and stability.
CO4	To analyze the Crack-tip opening displacement its application and experimental determination with understanding of Parameters affecting the critical CTOD and use of J integral.
CO5	To interpret, analyses the concepts of fracture mechanics in fatigue crack propagation and explain the fatigue life using Paris equations and be able to apply the concepts in composite materials using FEM approach.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**	**2**	**3**	**3**
CO2	**3**	**3**	**2**	**2**	**3**	**3**
CO3	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**2**	**2**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD** 511: Fracture Mechanics	**Contact Hours**
Unit 1	**Fracture mechanics principles**: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems.	9
Unit 2	**The Airy stress function**: Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems. Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic corrections factor. The Thickness effect, numerical problems.	8
Unit 3	**Determination of Stress intensity factors and plane strain fracture toughness**: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test. Size requirements. Non-linearity. Applicability. The energy release rate, Criteria for crack growth. The crack resistance (R curve). compliance, J integral. Tearing modulus. Stability.	8
Unit 4	**Elastic plastic fracture mechanics**: Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral.	8
Unit 5	**Fatigue crack propagation and applications of fracture mechanics**: Crack nucleation and growth and the stress intensity factor. Factors affecting crack propagation, fatigue life prediction, Paris law, statistical analysis, variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, mixed mode (combined) loading and design criteria. Fracture of composite materials. Use of FEM software like ABAQUS for analysis of bodies containing cracks.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	.**Elementary Engineering Fracture Mechanics** - David Broek, Noordhoff.	1982
2	**Fracture Mechanics-Fundamental and Application** - Anderson, T.L CRC press.	1998
3	**Introduction to Fracture Mechanics**, Prashant Kumar	2009
4	**Fracture and Fatigue Control in Structures** - Rolfe and Barsom, , Prentice Hall.	1977

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD513: Composite Material Technology **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To familiarize the students with basics of matrices material and reinforcements, elastic constants, compliance and stiffness matrix, rule of mixture and failure theories. To impart in-depth knowledge of Lay up process, Bag moulding and filament winding process& Injection moulding.

S. No.	Course Outcomes (CO)
CO1	To understand classification and types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. To understand application of composite materials for Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational
CO2	To understand Hooke's law for different types of materials, number of elastic constants, derivation of nine independent constants for orthotropic material, two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.
CO3	To understand evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems
CO4	To understand Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.
CO5	To understand Layup and curing - open and closed mould processing, Hand lay, Up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling, Quality assurance, Introduction, material qualification, Types of defects, NDT methods.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**	**2**	**3**	**3**
CO2	**3**	**3**	**2**	**2**	**3**	**3**
CO3	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**2**	**2**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design. The mastery should be at a level higher than the requirements in the appropriate bachelor program
Note: Program may add up to three additional POs approved by BOS of the department.
Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

S. No.	**CAD**513: Composite Material Technology	Contact Hours
Unit 1	**Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. **Metal Matrix Composites:** Manufacturing of MMC, Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.	9
Unit 2	**Macro Mechanics of a Lamina:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.	8
Unit 3	**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. **Biaxial Strength Theories:** Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problems.	8
Unit 4	**Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.	8
Unit 5	**Manufacturing:** Lay up and curing - open and closed mould processing, Hand lay, Up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling, Quality assurance, Introduction, material qualification, Types of defects, NDT methods. **Application Developments:** Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Mechanics of composite materials,** Autar K. Kaw CRC Press New York.	2006
2	**Mechanics of Composite Materials,** Rober M. JonessMc-Graw Hill Kogakusha Ltd.	1998
3	**Composite Material Science and Engineering,** Krishan K. Chawla Springer.	2015
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD515: Rapid Prototyping and Tooling **(Elective)**	**L**	**T**	**P**	**NIL**
	4	**0**	**0**	

Course Objective: To Familiarize Students to Understand RPT Origin, Concept Modelers, Ballistic Particle Manufacturing, Multijet Modelling with Advantages and Limitations
-3D Printing, Build Technique, Applications
-FDA, LOM, Stereolithography, SLS

S. No.	Course Outcomes (CO)
CO1	To understand basics of Rapid Prototyping and Testing.
CO2	To understand RPM, Multijet Modelling with Applications.
CO3	To understand thoroughly 3D Printing with the applications in industries.
CO4	To understand the difference between additive Manufacturing and subtractive manufacturing.
CO5	To understand the concepts of Reverse Engineering, Stereolithography layered optimum manufacturing etc

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**1**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An ability to write and present a substantial technical report/document
PO3: An ability to demonstrate expertize over the area as per the specialization of the program.
PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.
PO-5: To be able to apply the research knowledge for solution to industry specific problems.
PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.
The mastery should be at a level higher than the requirements in the appropriate bachelor program
Note: Program may add up to three additional POs approved by BOS of the department.
Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.
Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD**515: Rapid Prototyping and Tooling	**Contact Hours**
Unit 1	**Introduction:** Historical developments, Fundamentals of RP Systems and its Classification, Rapid prototyping process chains, 3D modeling and mesh generation, Data conversion and transmission	9
Unit 2	**RP Systems:** Liquid polymer based rapid prototyping systems, Teijin Seikis' solid form and other similar commercial RP systems, Solid input materials based rapid prototyping systems, laminated object manufacturing (LOM) and fused deposition modelling systems etc.	8
Unit 3	Power based rapid prototyping systems, selective Laser sintering, SoligenDiren's shell production casting (DSPC), Fraunhofer's multiphase jet solidification (MJS) and MIT's 3D printing (3DP) etc.	8
Unit 4	**RP Database:** Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data.	8
Unit 5	**RP Applications:** Development of dies for moulding, RP applications in developing prototypes of products, application in medical fields, Development of bone replacements and tissues, etc., RP materials and their biological acceptability	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Rapid Prototyping of Digital Systems: A Tutorial Approach**- Hamblen James O k.	**1999**
2	**Rapid Prototyping: Principles And Applications**- Kai Chua Chee World Scie	**2003**
3	**Rapid System Prototyping WithFpgas: Accelerating The Design Process**- R C pringer.	**2005**
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD 517: Product Life Cycle Management **(Elective)**	**L**	**T**	**P**	**NIL**
	4	**0**	**0**	

Course Objective: To familiarize the students with the CE techniques like DFM,, DFA,QFD,TD. To familiarize with IT and artificial intelligence with in-depth knowledge of PLM

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**1**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD**517: Product Life Cycle Management	Contact Hours
Unit 1	**Introduction:** Extensive definition of Concurrent Engineering (CE), CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA (Design for assembly), QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, Organizing for CE, CE tool box, Collaborative product development.	9
Unit 2	**Use of Information Technology:** IT support, Solid modeling, Product data management, Collaborative product Commerce, Artificial Intelligence, expert systems, Software hardware component design.	8
Unit 3	**Design Stage:** Lifecycle design of products, Opportunities for manufacturing enterprises, Modality of concurrent engineering design, automated analysis Idealization control, CE in optimal structural design, Real time constraints.	8
Unit 4	**Need for PLM:** Importance of PLM, Implementing PLM, Responsibility for PLM, Benefits to different managers, Components of PLM, Emergence of PLM, Lifecycle problems to resolve, Opportunities to seize. Role of sustainability, Sustainable product life management.	8
Unit 5	**Components of PLM:** Components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, Practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards. **Block chain concept in product**	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Integrated Product Development** M.M. Anderson and L Hein IFS Publications	**1987**
2	**Design for Concurrent Engineering** J. Cleetus CE Research Centre, Morgantown	**2005**
3	**Concurrent Engineering Fundamentals: Integrated Product Development** -Prasad a	**1995**
4	**Concurrent Engineering in Product Design and Development** -I Moustapha New	**2001**
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD 519: Machine Tool Design **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To familiarize the students with basic knowledge of design of machine tools, Kinematics of machine tool drives and Rapid prototyping data formats. To impart knowledge on CNC machine tools, controllers, feed drives and servomotors.

S. No.	Course Outcomes (CO)
CO1	To understand the basics of single point and multipoint cutting tools.
CO2	To understand the concepts & theories in metal cutting. Study of recent advancement in cutting tool materials.
CO3	To identify the problem and applying the fundamental concepts in solving the problem arising in metal cutting.
CO4	To select the tool and work-piece temperature and their effect on quality. To develop the skills of effective utilization of the cutting fluids.
CO5	To apply the concepts in practical aspects of tool wear mechanisms, tool life, Machinability, their economic aspects and technological aspects.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**1**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 519: Machine Tool Design	Contact Hours
Unit 1	**Design approach** Design requirements of machine tools. A design approach for machine tools. Identification and quantification of objectives and constraints in machine tool design. Kinematics of machine tool drives, stepped and stepless speed regulation,	9
Unit 2	**Power requirements** Estimation of power requirements and selection of motor for metal cutting machine tool spindles. 1. Gearbox design 2. Design of gearbox, spindle and guide-ways.	8
Unit 3	**RP Database:** Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data.	8
Unit 4	**CNC machine design** Introduction to computer integrated manufacturing systems and CNC machine tools.	8
Unit 5	**Design of CNC systems** Design/selection of linear motion systems, ball, screws, CNC feedback devices, controllers, feed drives and servomotors for CNC machine tools. Recent developments in CNC and other machine tools.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Design of Devices and Systems**, "William H. Middendorf and Richard H. RC Press.	**1997**
2	**Computer numerical control of machine tools**, "G. E. Thyer" Heinemann blishing.	**1991**
3	**Machine Design Fundamentals: A Mechanical Designers' Workbook** , Shigley and Charles R. Mischke, Mcgraw Hill.	**2004**
4	**Numerical Control and Computer aided manufacture**, "Kundra, Rao, Tiwari" Tata McGraw Hill.	**1985**
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD 541: Modelling, Simulation and Analysis **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: The course aims to provide a foundational understanding of system modeling, simulation, and analysis. It introduces the principles of probability and statistics as tools for modeling uncertainty in systems, along with the use of bond graphs for unified physical system modeling. Students will learn various simulation techniques and explore system dynamics of mechanical and hydraulic systems through mathematical modeling and simulation using appropriate software tools, preparing students for real-world engineering applications.

S. No.	Course Outcomes (CO)
CO1	Demonstrate understanding of basic probability, statistics, and their role in system simulation.
CO2	Apply bond graph methodology to model physical systems in a unified framework.
CO3	Use simulation techniques including Monte Carlo methods and numerical approaches to evaluate system behaviour.
CO4	Develop and analyze system dynamics models using growth, decay, and logistic functions.
CO5	Construct simulation models of mechanical and hydraulic systems and evaluate their performance using simulation software.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**	**1**	**1**	**2**
CO2	**3**	**2**	**3**	**3**	**2**	**3**
CO3	**3**	**2**	**3**	**3**	**3**	**3**
CO4	**2**	**1**	**2**	**2**	**2**	**2**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD** 541: Modelling, Simulation and Analysis	Contact Hours
Unit 1	**Introduction:** A review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation. **Physical Modelling**: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation	9
Unit 2	**Modeling of Physical System Dynamics: A Unified Approach** Physical systems, Introduction to Bond graphs, Ports, Bonds and Power; Elements of Bond graphs:1-port elements – resistor R, Stiffness C, and Inertia I, Source of Effort Se and Flow SF; 2-port elements – Transformer TF and Gyrator GY, with modulation, Junction elements 1 and 0; Causality, Causality for basic 1-port and multi-ports. Derivation of System equations from Bond graphs in first order state space form.	8
Unit 3	**Bond Graph Modeling of Multi-energy Systems** Mechanical Systems, Translation and rotation (about a fixed axis) **System Simulation**: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages	8
Unit 4	**System Dynamics**: Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random Numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs.	8
Unit 5	**Simulation of Mechanical Systems**: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**System Simulation**- Geoffrey Gordon -Prentice Hall	**1978**
2	**System Simulation: The Art and Science** -Robert E. Shannon -Prentice Hall	**2007**
3	**System Modelling and Control** -J. Schwarzenbach and K.F. Gill Edward Arnold	**1978**
4	**Modelling and Analysis of Dynamic Systems** -Charles M Close and Dean K. Frederick Houghton Mifflin	**2001**
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD 520: Optimization Techniques	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To allow students to develop the technical, analytic, and managerial skills necessary to perform the tasks successfully

S. No.	Course Outcomes (CO)
CO1	Apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems.
CO2	Apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems.
CO3	Formulate and solve non-linear programming problems and constrained optimization
CO4	Demonstrate the applications of multi-objective optimization methods
CO5	Formulate and solve the stochastic programming and Solve the problems using heuristic modelling techniques.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**1**	**1**	**1**	**2**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**2**	**2**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Industrial Engineering and Management. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 520: Optimization Techniques	Contact Hours
1	Introduction to Optimization; Introduction, Engineering Applications, Statement of an Optimization Problem, Classification; Linear Programming: Simplex Algorithm; Two Phase Method, Big 'M' Method, Revised Simplex Method, Duality in Linear Programming; Prime-Dual Relations, Duality Theorem, Dual simplex method, Sensitivity and Post Optimality Analysis	9
2	Transportation and Assignment Problem; Integer Programming – Branch and bound Method, Cutting Plane Method	8
3	Dynamic Programming: Elementary Concepts of Dynamics Programming, Multi stage Decision Process, Calculus Method and Tabular Method; Classical Optimization techniques – Unconstrained Optimization: Optimizing Single-Variable Functions, Optimizing Multi-Variable Functions.	8
4	Constrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Lagrange Multipliers Method. Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary conditions, Kuhn –Tucker Sufficient Conditions; Non-Linear Programming-Unconstrained Optimization Techniques: Direct search methods, Descent Methods.	9
5	Constrained Optimizations: Direct and Indirect methods;Introduction to Advanced Optimization Techniques –Genetic Algorithms (GA), Simulated Annealing, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) etc.	8
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	Optimization of Engineering Design by Deb, K., PHI	2021
2	Operations Research by Hamdi A. Taha, Pearson	2006
3	Operations Research by D.S. Hira, P. K. Gupta, S. Chand	1995

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 522- Lubricating Oil and Grease Design	L	T	P	NIL
	3	0	2	

Course Objective:
After completion of this course, the students understand the principles of lubrication, tribology, and the role of lubricants in mechanical systems. They explore the formulation, production, and testing of lubricating oils for various applications. This course provides in-depth knowledge of grease formulation, production, and performance characteristics. They understand the advanced applications of lubricants in specialised environments and performance optimisation and sustainable practices in lubricant technology.

S. No.	Course Outcomes (CO)
CO1	Understand the basic principles of tribology and lubrication. Identify the role of base oils and additives in lubricant performance and analyse the physical and chemical properties critical to lubricant selection.
CO2	Understand the design lubricating oil formulations for specific applications, manufacturing processes and quality assurance for lubricating oils.
CO3	Understand grease manufacturing processes and quality control measures. Learn the formulation greases for specific industrial applications and evaluate grease performance using standardized testing methods.
CO4	Understand the selection of appropriate lubricants for extreme and specialized applications. Learn the application of oil analysis techniques for predictive maintenance and performance optimization.
CO5	Understand the environmental impact and regulatory requirements for lubricants and development of sustainable lubricant formulations using bio-based materials and nano-additives.

CO-PO Articulation Matrix						
COs	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	2	2	2	2	2	2
CO3	2	2	2	2	2	3
CO4	2	3	3	3	3	3
CO5	3	3	3	3	3	3

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertise over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of

problem statement to focus on alternate approaches for their solution.
PO-5: To be able to apply the research knowledge for solution to industry specific problems.
PO6: To demonstrate a master degree over the area as per Industrial Engineering and Management. The mastery should be at a level higher than the requirements in the appropriate bachelor program
Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD 522- Lubricating Oil and Grease Design	Contact Hours
Unit 1	**Fundamentals of Lubrication and Tribology** Introduction to tribology, Functions of lubricants, Types of lubrication regimes, Base oils- Mineral, synthetic (PAO, esters, polyglycols), and bio-based oils; API base stock classifications (Group I–V), Physical and chemical properties of lubricants- Viscosity, flash point, pour point, and thermal stability, Lubricant additives- Antioxidants, anti-wear agents, extreme pressure (EP) additives, and corrosion inhibitors.	8
Unit 2	**Lubricating Oil Formulation and Manufacturing** Base oil refining, Additive chemistry- Detergents, dispersants, viscosity modifiers, and friction modifiers, Formulation of lubricating oils- Engine oils, hydraulic oils, gear oils, and turbine oils, Manufacturing processes- Blending, quality control, and packaging, Standards and specifications- API, SAE, ISO viscosity grades, and ACEA classifications, Testing methods- Viscosity index, TAN/TBN, oxidation stability, and shear stability.	8
Unit 3	**Grease Composition and Production** Grease composition- Base oils, thickeners, and additives , Thickener types- Metallic soaps (lithium, calcium, sodium), complex soaps, and non-soap thickeners (bentonite, silica), Grease manufacturing- Saponification, cooking, milling, and additive blending, Grease properties- Consistency (NLGI grades), dropping point, water resistance, and shear stability, Thixotropy and bleeding in greases- Mechanisms and control, Testing of greases- Penetration, oxidation stability, and corrosion resistance.	8
Unit 4	**Advanced Lubricant Applications and Performance** Lubricants for extreme conditions- High/low temperatures, high loads, and shock loads, Specialty lubricants: Marine greases, dielectric greases, and food-grade lubricants, Automatic lubrication systems- Single-point lubricators, dual-line systems, and progressive systems, Lubricant selection criteria:-Viscosity, speed factor (nDm), load factor (P/C), and environmental considerations, Contamination control- Filtration, water separation, and storage practices, Oil analysis and condition monitoring- Wear debris analysis, FTIR spectroscopy, and viscosity trending.	9
Unit 5	**Emerging Trends and Sustainability in Lubricant Design** Bio-based lubricants- Synthesis, performance, and biodegradability, Nanotechnology in lubricants- Nano-additives for enhanced wear protection and friction reduction, Lubricant degradation and re-refining- Oxidation, thermal breakdown, and recycling processes, Environmental regulations- REACH, EPA standards, and eco-labeling (e.g., EU Ecolabel), Energy-efficient lubricants- Low-viscosity oils and greases for fuel economy, Case studies- Lubricant design for electric vehicles, wind turbines, and aerospace applications.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	Lubricants and Lubrication by Mang, T., & Dresel, W. (Eds.) - Wiley-VCH.	2007
2	Automotive Lubricants Reference Book by Haycock, R. F., & Hillier, J. E.- SAE International.	2004
3	Grease Lubrication in Rolling Bearings by Lugt, P. M. - Wiley.	2013
4	Machinery Lubrication and Reliability by Roman, A. J. -Industrial Press.	2020
5	Biolubricants: Science and Technology by Bart, J. C. J., Gucciardi, E., & Cavallaro, S. -Woodhead Publishing.	2013

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 5063: Reliability Engineering	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To develop the ability in formulating suitable maintenance strategies to achieve reliable a manufacturing system. To equip with essential system diagnosis techniques so that students can identify and take appropriate actions on error symptoms and causes of failures.

S. No.	Course Outcomes (CO)
CO1	To understand major concepts of reliability prediction
CO2	To analyze statistical experiments leading to reliability modeling (DFM) implications of design choices for specific manufacturing processes
CO3	To identify reliability testing components
CO4	To apply reliability theory to assessment of reliability in engineering design
CO5	To estimate reliability functions and parameters of product/component systems using reliability block diagram, fault tree and event tree and evaluate maintainability and availability of product/component systems, and different maintenance strategies.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**1**	**1**	**1**	**2**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**2**	**2**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems.

PO6: To demonstrate a master degree over the area as per Industrial Engineering and Management. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

.

S. No.	CAD 524: Reliability Engineering	Contact Hours
Unit 1	Introduction: System concepts in reliability, availability and maintainability (RAM) Engineering, Practical applications of RAM Engineering to systems, products and processes; Concepts, terms and definitions	8
Unit 2	Failure rate function, Probability density function, Cumulative distribution function, reliability function, Mean time to failure (MTTF), MTBF, MTTR; Fundamentals of reliability: Failure distributions; Exponential, Weibull, Normal and Lognormal; Constant failure rate model and time dependent failure models	8
Unit 3	System reliability assessment: Series, Parallel, Combined series-parallel configurations; Cut sets and path sets approach, fault tree analysis (FTA); State dependent systems; Markov analysis, load sharing system, standby system, degraded system, Monte Carlo simulation; Design for Reliability and reliability improvement: Reliability specifications and system measurements	9
Unit 4	reliability allocation; exponential case, optimal allocations, arnica method, AGREE method, Various types of redundancies; active and passive redundancy, k-out-of-n-redundancy, standby redundancy, optimization, reliability-cost trade off; Availability and maintainability: Point, mission and steady state availability;	8
Unit 5	Availability assessment, Maintainability and its assessment; Maintenance policies: individual policy, Planned, preventive and condition based maintenance; Opportunistic maintenance policy; Design for maintainability: Maintenance requirements, measurements and specifications, fault diagnosis, failure mode and effect analysis (FMEA), Parts standardization and interchangeability, modularization, accessibility, repair versus replacement, proactive maintenance, maintainability prediction and demonstration.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	Reliability Engineering by Srinath, L. S., East –West Press Ltd., New Delhi	2005
2	Engineering Maintainbility by Dhillon, B. S., Prentice Hall of India, New Delhi	1999

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 526: Computer Aided Design **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To provide an overview of how computers are being used in design, development of manufacturing plan. Understand the transformation of 2D and 3D part. Understand the mathematical representation of curves and surfaces used in geometrical construction.

S. No.	Course Outcomes (CO)
CO1	Understanding of use of computer for machine design and working of hardware of computer.
CO2	Apply principle of transformations for different geometries.
CO3	Understanding of different types of curves used for geometrical modelling.
CO4	Understanding of solid modeling i.e.CSG, B-rep,half space etc.
CO5	Understanding visual realism robust design, reliability, ergonomics consideration in design. Feature based design.

CO-PO Articulation Matrix						
COs	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**	**1**	**1**	**2**
CO2	**3**	**2**	**3**	**3**	**2**	**3**
CO3	**3**	**2**	**3**	**3**	**3**	**3**
CO4	**2**	**1**	**2**	**2**	**2**	**2**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD** 526: Computer Aided Design	**Contact Hours**
Unit 1	**Introduction and Review of CAD** Introduction and Overview, Need and Scope of computer aided Machine design, Role of Geometric modelling, Principles of interactive Computer graphics, Overview of hardware available for use in CAD..	9
Unit 2	**Three Dimensional Transformations** Geometric transformations & Axonometric, Diametric, Trimetric and oblique Projections, Windowing & View porting.	8
Unit 3	**Geometric Modelling and Applications**: Introduction, wire frame models and entities, curve representations, parametric representation of analytical curves, synthetic curves, Bezier curves, B-spline curves, Rational curves, curve manipulations, design and engineering applications.	8
Unit 4	**Solid modelling** Half spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytical solid making, and solid manipulation.	8
Unit 5	**Visual Realism and advances in Computer Aided Engineering Design** Hidden-Line surface-solid removal algorithm-Shading-coloring-computer animation., Robust design, Reliability, Ergonomic considerations in Design, Feature based design, Design for manufacturing, Design for Automation, CAD of complex Engineering Systems.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Computer Graphics** -D Hearn & M P Baker- Prentice Hall	2002
2	**CAD/CAM Theory and Practice**- Ibrahim Zeid& R Sivasubramanian - Tata McGraw- Hill	2009
3	**CAD/CAM- Principles and Applications** -P N Rao Tata McGraw-Hill	2010
4	**Computer Aided Engineering Design** -A Saxena and B Sahay- Anamya Publications	2005
5	**Mathematical Elements for Comp. Graphics**- D F Rogers and J A Adams- McGraw-Hill International	1989
6	**CAD/CAM** -H P Groover and E W Zimmers -Prentice Hall	2023
7	Radhakrishnan and Kothandaraman, " **Computer Graphics and Design**" Dhanpat Rai.	1997
8	Rogers David F " **Procedures Elements for Computer Graphics**" second Ed. Tata McGraw Hill	2001

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD 528: Rotor Dynamics (Elective)	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To provide an overview of basic theory of fluid film lubrication, stability of flexible Shafts, turbo-rotor and system stability.

S. No.	Course Outcomes (CO)
CO1	To understand the basic of fluid film stiffness and damping coefficients.
CO2	To explain principle of radial elastic friction forces.
CO3	Implement of different types iinstability of rotors due to the effect of hydrodynamic oil layer in the bearings.
CO4	Describe development of element transfer matrices, the matrix differential equation.
CO5	Apply general turbo-rotor system, generalized forces and co-ordinates system assembly element matrices.

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**	**1**	**1**	**2**
CO2	**3**	**2**	**3**	**3**	**2**	**3**
CO3	**3**	**2**	**3**	**3**	**3**	**3**
CO4	**2**	**1**	**2**	**2**	**2**	**2**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	Content: **CAD** 528: Rotor Dynamics	Contact Hours
Unit 1	**Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.	9
Unit 2	**Stability of Flexible Shafts:** Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.	8
Unit 3	**Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. **Rotor Bearing System:** Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.	8
Unit 4	**Turbo-rotor System Stability by Transfer Matrix Formulation:** General turbo-rotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches.	8
Unit 5	**Turbo-rotor System Stability by Finite Element Formulation: G**eneral turbo-rotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, Linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis.	9
Total		42

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint*
1	**Rotor Dynamics**- J.S. Rao	2018
2	**Rotor Dynamics**-Tondel	2008
3	**Vibration Problems in Engineering** - Timosenko, Young, Von Nostrand 5. Zienkiewicz, "The Finite Element Method", McGraw Hill.	2008
4	**Matrix methods of Elastomechanics**- Peztel, Lockie, McGraw Hill.	1963
5	**Non-conservative problems of the Theory of elastic stability** - Bolotin, Pergamon.	1963
6	**Principles of Lubrication** - Cameron Longmans.	1981

**: Latest edition of the title of author may please be listed.*

Course code: Course Title	Course Structure			Pre-Requisite
CAD: 530: Smart Materials **(Elective)**	**L**	**T**	**P**	**NIL**
	4	**0**	**0**	

Course Objective: To familiarize the students with basics of Smart Materials, Smart Sensor, Actuator and Transducer Technologies, Measurement, Signal Processing, Drive and Control Techniques. To impart in-depth knowledge of Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products.

S. No.	Course Outcomes (CO)
CO1	To Familiarize with the various types of Smart Sensor used in engineering application.
CO2	To study the Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products
CO3	To study basics of sensors & transducers and its engineering application
CO4	To study basics of actuators and its engineering application
CO5	To study Measurement, Signal Processing, Drive and Control Techniques

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD**530: Smart Materials	Contact Hours
Unit 1	**Overview** of Smart Materials, Structures and Products Technologies.	5
Unit 2	**Smart Materials (Physical Properties)** piezoelectric materials, materials, magnetostrictive electrostrictive materials, magneto electric materials. magnetorheological fluids, electrorheological fluids, applications of electroreological fluids, shape memory materials, fiber-optic sensors.	9
Unit 3	**Smart Sensor, Actuator and Transducer Technologies** smart sensors: accelerometers; force sensors; load cells; torque sensors; pressure sensors; microphones; impact hammers; MEMS sensors; NEMS sensors, sensor arrays smart actuators: displacement actuators; force actuators; power actuators; vibration dampers; shakers; fluidic pumps; motors smart transducers: ultrasonic transducers; sonic transducers; air transducers.	10
Unit 4	**Measurement, Signal Processing, Drive and Control Techniques** quasi-static and dynamic measurement methods; signal-conditioning devices; constant voltage, constant current and pulse drive methods; calibration methods; structural dynamics and identification techniques; passive, semi-active and active control; feedback and feed forward control strategies.	8
Unit 5	**Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products:** Case studies incorporating design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products. Emphasis on structures, automation and precision manufacturing equipment, automotives, consumer products, sporting products, computer and telecommunications products, medical and dental tools and equipment.	10
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Smart Materials and Structures** - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).	1992
2	**Smart Structures and Materials** - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).	1996
3	**Smart Structures: Analysis and Design** - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).	2001
4	. **Electroceramics:** Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429	2003
5	**Piezoelectric Sensories:** Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).	2002
6	**Piezoelectric Actuators and Wtrasonic Motors** - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).	1997
7	**Handbook of Giant Magnetostrictive Materials** - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).	2000
8	**Shape Memory Materials** - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).	1990
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD 532: Human Factors in Engineering and Biomechanical Design (Elective)	**L**	**T**	**P**	**NIL**
	4	**0**	**0**	

Course Objective: To familiarize the students with basics of human factors and systems, symbols and code, visual display of dynamic Information. To impart in-depth knowledge of Work-space design and Seating, and Biomechanical systems.

S. No.	Course Outcomes (CO)
CO1	To define and study human factors and systems
CO2	To analyze Information Input and Processing, Symbols and Codes
CO3	To describe physical work and human control of systems,
CO4	To apply human factors system in Biomechanical Design
CO5	To apply basic concepts in various case studies and analysis and human factors applications

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	CAD532: Human Factors in Engineering and Biomechanical Design	Contact Hours
Unit 1	**Introduction** Human factors and systems. Human factors research methodologies **Information Input** Information Input and Processing, Text, Graphics, Symbols and Code, Visual Display of Dynamic Information, Auditory, Tactual and Olfactory Displays, Speech Communications	9
Unit 2	**Human Output and Control** Physical Work and Manual Materials Handling Motor Skills, Human Control of systems, Controls and Data Entry devices, Hand tools and devices,	8
Unit 3	**Workplace Design** Applied Anthropometry, Work-space design and Seating, Arrangement of Components within a Physical Space, Interpersonal Aspects of Workplace Design **Environmental Conditions** Illumination, Climate, Noise, Motion	8
Unit 4	**Human Factors Applications** Human Error, Accidents and Safety, Human Factors and the Automobile. Human Factors in Systems design	8
Unit 5	**Biomechanical Design** Biomechanical systems, Biomechanical analysis, Natural design vs Mechanical Design, Designing and developing equivalent mechanical systems, Case studies and analysis, Biomechanical modeling and simulation.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	Mark Sanders, Ernest McCormick, **Human Factors In Engineering and Design**, 7th edition, McGraw-Hill International Editions.	2005
2	Y.C. Fung, "**Biomechanics Vol. 1, 2, 3**."	1981
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD534: Design for Manufacture and CIM (Elective)	**L**	**T**	**P**	**NIL**
	4	**0**	**0**	

Course Objective: To understand the operations and programming of NC, CNC and DNC machines. To understand the concepts of reverse engineering, computer-aided process planning and unmanned manufacturing. To provide an overview of how computers are being used in design, development of manufacturing plan. Understand the transformation of 2D and 3D part. Understand the mathematical representation of curves and surfaces used in geometrical construction.

S. No.	Course Outcomes (CO)
CO1	Explain the role of computer and CNC in manufacturing.
CO2	Describe the applications of various CNC machine tools and techniques in manufacturing planning and operational processes.
CO3	Demonstrate the knowledge of component design and design consideration.
CO4	Describe the application of CIM in manufacturing.
CO5	Apply the knowledge of Solid Modelling and CAD/CAM processes.

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD534**: Design for Manufacture and CIM	Contact Hours
Unit 1	**Effect of Materials and Manufacturing Process On Design:** Major phases of design. Effect of material properties on design, Effect of manufacturing processes on design. Material selection process. **Tolerance Analysis:** Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law.	9
Unit 2	**Selective Assembly:** Interchangeable part manufacture and selective assembly, Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples. **Datum Features:** Functional datum, Datum for manufacturing, Changing the datum.	8
Unit 3	**Design Considerations:** Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviate sand cores. **Component Design:** Component design with machining considerations like design for turning, milling, Drilling and other related processes including finishing operations.	8
Unit 4	**True positional theory:** Comparison between co-ordinate and conventional method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. **Design of Gauges:** Design of gauges for checking assemble with emphasis on various types of limit gauges for both hole and shaft.	8
Unit 5	**Computer Integrated Manufacturing (CIM):** Basic concepts of CIM, Evolution of CIM, Unmanned manufacturing , Elements of CIM, CIM implementation , CIM hardware and CIM software. Product development through CIM, Sequential engineering, Concurrent engineering, Comparison of sequential and concurrent engineering, implementation of concurrent engineering, concurrent engineering and information technology, Characteristics of concurrent engineering. Soft computing in CIM: Artificial neural networks/Artificial intelligence, Fuzzy, Fuzzy AHPBenefits of CIM , Lean manufacturing , comparison of lean manufacturing with conventional manufacturing , applications of lean manufacturing , etc.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Designing for Manufacturing -** Harry Peck, Pitman Publications	1983.
2	**Machine Engineering Design** Shigley's McGraw hill	2014
3	**Metrology -** R.K. Jain Khanna Publication for topic 6.	2021
4	**Product design for manufacture and assembly -** Geoffrey Boothroyd, peter dewhurst, Winston Knight, Merceldekker. Inc. New york.	2010

Course code: Course Title	Course Structure			Pre-Requisite
CAD536: Instrumentation and Control Systems **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To familiarize the students with basics of Instrumentation and Control Systems, Mathematical Modelling of Dynamic Systems and Various Measurement Techniques. To impart in-depth knowledge control system applications.

S. No.	Course Outcomes (CO)
CO1	**State** the concepts of measurement, and various types of errors in measuring systems
CO2	**Explain** the mathematical modeling of dynamic system with their static and dynamic characteristics
CO3	**Demonstrate** the Various Measurement techniques with standard of measurement
CO4	Understand the modern control theory and data acquisition systems.
CO5	Analysis and design of Control Systems using MATLAB

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD**536: Instrumentation and Control Systems	Contact Hours
Unit 1	**Introduction** Generalized measurement system: Functional elements of Instrument. Description and usages of transducers, intermediate stage and terminal devices including various indicating and recording devices. Measurement standards, Calibration need and procedure, Errors in measurement systems and statistical interpretation of experimental data.	9
Unit 2	**Mathematical Modelling of Dynamic systems** Transfer function and impulse response function, block diagrams, signal flow graph, state-space representation, Transient response analysis of first order and second order systems Static and Dynamic characteristics of measurement systems. Harmonic and special waveforms and their analysis.	8
Unit 3	**Measurement techniques** Various Measurement techniques with standard of measurement, principle, construction and working for displacement, strain, velocity, acceleration, force, Static and Dynamic pressure, temperature and fluid flow Modern control theory. Sequence control and programmable logic controllers. .	8
Unit 4	**Modern Control Theory** Control components. Comparators, hydraulic, pneumatic and electrical type of controllers, servomotors. Electromechanical and electro-optical transducers and control elements. Signal conditioning, indicating and recording elements Computer based data acquisition systems, ADC, DAC. Microprocessor applications in measurement and control. Static and dynamic analysis. FFT analyzers.	8
Unit 5	**Analysis and design of Control Systems** Controllability and observability, pole placement method, examples of control system design using MATLAB, Current developments in measurement and control of motion, force, torque, pressure, temperature, flow, noise etc. Virtual instrumentation.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Mechanical measurements, T.G. Thomas Beckwith**	2006
2	**Mechanical measurements and Control, D.S.Kumar**	2015
3	**Instrumentation Mechanical measurements and Control , A.K.Tayal**	2015
4	**Modern Control Engineering**, "K. Ogata" PHI.	2015
5	**Automatic Control Systems**, B.C. Kuo, PHI.	2014
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
CAD538: Mechatronic System Design **(Elective)**	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To understand the concept and skills to design, develop and analyze integrated mechatronic systems. Understanding the principle of sensor and controllers. Understanding the principle of MEMS and fabrication process of Micro System.

S. No.	Course Outcomes (CO)
CO1	Explain the role of control system and data prestation system.
CO2	Understanding the principles and working of sensors and transducers.
CO3	Understanding the working of electrical actuation systems
CO4	To apply the concepts of system models and signal conditioning in practical problems.
CO5	To apply the concepts of. MEMS and Microsystems in advanced Applications in Mechatronics

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	**CAD**538: Mechatronic System Design	Contact Hours
Unit 1	**Introduction**: Definition and Introduction to Mechatronic Systems. Modeling & Simulation of Physical systems. Overview of Mechatronic Products and their functioning measurement systems. Control Systems, simple Controllers. **Data Presentation Systems:** Basic System Models, System Models, Dynamic Responses of System.	9
Unit 2	**Study of Sensors and Transducers:** Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. Interfacing, ADC, DAC, software and hardware principles and tools to build mechatronic systems	8
Unit 3	**Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. Design and selection of mechatronic elements namely sensors like encoders and resolvers. Stepper and servomotors. Ball screws, solenoid like actuators, and controllers	8
Unit 4	**System Models:** Mathematical models: mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. **Signal Conditioning**: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.	8
Unit 5	**MEMS and Microsystems:** Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. **Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design. Analysis and synthesis of mechatronic systems with applications to CNC systems, robotics, consumer electronic products etc.	9
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	**Mechatronics"** - W. Bolton, 2 Ed. Addison Wesley Longman, Pub,	2018
2	HSU "**MEMS and Microsystems design and manufacture**"- TMH	2002
3	Kamm, "**Understanding Electro-Mechanical Engineering an Introduction to Mechatronics"**- PHI.	1995
4	**"Fine Mechanics and Precision Instruments"**- Pergamon Press, . 1971	1971
5	Shetty and Kolk "**Mechatronics System Design**"-Thomson.	1996
**: Latest edition of the title of author may please be listed.*		

Course code: Course Title	Course Structure			Pre-Requisite
OME 601: Computational Methods for Fluid Dynamics (Elective)	**L**	**T**	**P**	**NIL**
	3	**0**	**2**	

Course Objective: To familiarize the students with the conservation equations, grid generations, finite difference methods, boundary layer treatment.

S. No.	Course Outcomes (CO)
CO1	Students will gain an understanding of the conservation of mass, conservation of momentum and conservation of energy equations.
CO2	Students will develop knowledge of various types of equations: parabolic and elliptic, hyperbolic.
CO3	Students will learn the importance of grid generation techniques, appropriate transformations, adaptive grids, structured and unstructured grids.
CO4	Students will understand the fundamental aspects of the Finite Difference methods: Taylor series expansion, Integration over element, Finite volume methods, treatment of boundary conditions.
CO5	Students will apply the solution of finite difference equations, iterative methods, matrix inversion methods, ADI method, Operator splitting, fast Fourier transform methods for industrial applications.

CO-PO Articulation Matrix						
Cos	**POs**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**2**	**1**	**1**	**1**
CO2	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**2**	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**3**

Three values 1/2/3 (1 indicates low, 2 indicates medium, and 3 indicates high) can be filled for CO-PO articulation matrix. As per NBA, there are three standard POs that are given below.

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate expertize over the area as per the specialization of the program.

PO-4: To integrate basic and advance research knowledge for identification and formulation of problem statement to focus on alternate approaches for their solution.

PO-5: To be able to apply the research knowledge for solution to industry specific problems. PO6: To demonstrate a master degree over the area as per Computer Aided Analysis and Design.

The mastery should be at a level higher than the requirements in the appropriate bachelor program

Note: Program may add up to three additional POs approved by BOS of the department.

S. No.	OME601: Computational Methods for Fluid Dynamics	Contact Hours
Unit 1	**Introduction:** Conservation equation, Mass Momentum and Energy equations, Convective form of the equation and general description.	9
Unit 2	Classification into various types of equations: Parabolic, Elliptic, Boundary and initial Conditions, Overview of numerical methods.	8
Unit 3	Grid generation techniques, appropriate transformations, adaptive grids, structured and unstructured grids.	8
Unit 4	**Finite difference methods:** Different means for formulating finite difference equations, Taylor series expansion, Integration over element, Local function method; Finite volume methods, Central upwind and hybrid formulations and comparison for convection-diffusion problem, Treatment of boundary conditions; Boundary layer treatment; Variable property, Interface and free surface treatment, Accuracy of F.D. method.	10
Unit 5	Solution of finite difference equations; Iterative methods; Matrix inversion methods, ADI method, Operator splitting, Fast Fourier Transform applications.	7
Total		42

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint***
1	Computational Fluid Dynamics", John Anderson," McGraw- Hill Ltd	2017
2	Computational Methods for Fluid Dynamics, Ferziger Joel H, Springer-Verlog.	2019
3	Computational Fluid Dynamics, T.J. Chung, Cambridge Publication	2010

**: Latest edition of the title of author may please be listed*