DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN COMPUTATIONAL DESIGN (CDN)

Semester-I

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	CDN 501	System Modelling, Simulation and Analysis	Core	4	3	0	2	15	25	20	40	-	17
	2	CDN 503	Computational Mechanics of Materials	Core	4	3	0	2	15	25	20	40	-	
Group B	3	CDN 5401/5403/……	Elective 1	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	CDN 5301/5303/……	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	CDN 5201/5203/……/ UEC5201/5203/……	Elective 3/University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	CDN 502	Finite Element Method	Core	4	3	0	2	15	25	20	40	-	17
	2	CDN 504	Robotics and Control	Core	4	3	0	2	15	25	20	40	-	
Group D	3	CDN 5402/5404/……	Elective 4	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	CDN 5302/5304/……	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	CDN 5202/5204/……/ UEC5202/5204/……	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group E	**Track 1**													12
	1	CDN 651	Research Project	Core	12	0	0	12	0	-	0	100	-	

	Track 2													
	1	CDN 601	Major Project I	Core	3						40	60		
	2	CDN 6401/6403/……	Elective 7	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	3	CDN 6301/6303/……	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	CDN 6201/6203/……	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credits**
Group F	**Track 1**													12
	1	CDN 652	Research Project	Core	12	0		12	0	-	0	100	-	
	Track 2													
	1	CDN 602	Major Project II	Core	12	0		12	0	-	0	100	-	

LIST OF ELECTIVES :													
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 1	1	CDN5401	Advanced theory of Vibration and Control	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	CDN5403	Fracture Mechanics		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	CDN5405	Theory of Elasticity and Plasticity		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 2	1	CDN5301	Optimization Techniques in Design	Elective	3	3	0	0	20	-	30	50	-
	2	CDN5303	Numerical Methods in Engineering		3	3	0	0	20	-	30	50	-
	3	CDN5305	Design of Experiments		3	3	0	0	20	-	30	50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 3	1	CDN5201	Seminar	Elective	2	2	0	0	2	-	-	100	-
	2	CDN5203	Smart Structures and Materials		2	2	0	0	20	-	30	50	-
	3	CDN5205	Human Factors in Engineering and Biomechanical Design		2	2	0	0	20	-	30	50	-
	4	CDN5207	Design for Manufacture		2	2	0	0	20	-	30	50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 4	1	CDN5402	Engineering Tribology and Bearing Design	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	CDN5404	Rapid Prototyping and Tooling		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	CDN5406	Innovative Engineering Design		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 5	1	CDN5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	CDN5304	Rotor Dynamics		3	3	0	0	20	-	30	50	-
	3	CDN5306	Product Design and Development		3	3	0	0	20	-	30	50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 6	1	CDN5202	Reliability Engineering	Elective	2	2	0	0	20	-	30	50	-
	2	CDN5204	Product Life Cycle Management		2	2	0	0	20	-	30	50	-
	3	CDN5206	Noise and Acoustics Design		2	2	0	0	20	-	30	50	-
	S.	**Course**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**

	No.	Code											
Elective 7	1	CDN6401	Computational Methods for Fluid Dynamics	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	CDN6403	Machine Tool Design		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	CDN6405	Pressure Vessels and Piping Design		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 8	1	CDN6301	Composite Material Technology	Elective	3	3	0	0	20	-	30	50	-
	2	CDN6303	Mechatronic System Design		3	3	0	0	20	-	30	50	-
	3	CDN6305	Instrumentation and Control Systems		3	3	0	0	20	-	30	50	-
	S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 9	1	CDN6201	Computer Aided Design	Elective	2	2	0	0	20	-	30	50	-
	2	CDN6203	Surface Engineering		2	2	0	0	20	-	30	50	-
	3	CDN6205	Automotive System Design		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

CDN501 System Modelling Simulation and Analysis

A review of basic probability and statistics; 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; Modeling of Physical System Dynamics: A Unified Approach: Physical systems, Introduction to Bond graphs, Ports, Bonds and Power; Elements of Bond graphs; Derivation of System equations from Bond graphs in first order state space form; 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, Simulation software packages; System Dynamics: Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation; Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems.

Suggested Books:

1. System Simulation by Geoffrey Gordon, Prentice Hall
2. System Simulation: The Art and Science by Robert E. Shannon, Prentice Hall
3. System Modelling and Control by J. Schwarzenbach and K.F. Gill Edward Arnold
4. Modelling and Analysis of Dynamic Systems by Charles M Close and Dean K. Frederick Houghton Mifflin
5. Simulation of Manufacturing by Allan Carrie, John Wiley & Sons
6. Bond Graph in Modeling, Simulation and Fault Identification by Amalendu Mukherjee, Ranjit Karmakar, Arun Samantary , I.K. Int. Pub. house

CDN503 Computational Mechanics of Materials

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; **Transport theorem, balance laws:** Mass conservation, momentum balance equations, Cauchy stress tensor, Conjugate stress tensors, stress rates; **General constitutive theory:** Material symmetry, invariance requirements, Cauchy elastic material, Green elastic material; **Analysis of large deformation and strain in 3-D elastic continuum:** Formulation of boundary value problems: examples; **Variational principles and conservation laws:** Virtual work principle for large deformation problems. Principle of stationary potential energy, complementary and mixed variational principles, variational principles with constraints.

Reference Books

1. **Continuum Mechanics** by Gurtin and Anand
2. **Continuum Mechanics** by J. N. Reddy
3. **Nonlinear elastic deformations** by R. W. Ogden

CDN5401 Advanced Theory of Vibration and Control

Single degree of Freedom System; Two-degree of Freedom System: Principal modes of vibration, Vibration isolation; **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; **Vibration Control**: Vibration control strategies and case studies, experimental and theoretical routes to vibration engineering, vibration testing. Application of damping treatment for vibration control in machines and structures; **Dynamic Instability Control:**

Dynamic instability control, Introduction to modal tesing, modal updating and structural dynamic modifications to improve dynamic design of machine structures, Active control of vibrations, Introduction to NVH and its control. Random vibrations, Measurement and processing of random data; **Continuous systems; Non-linear Vibrations.**

Reference Books:

1. Theory and practice of Mechanical Vibrations by J.S. Rao and K. Gupta, New Age International
2. Mechanical Vibrations by G.K. Groover, Nem Chand & Brothers
3. Mechanical Vibration Practice by V. Ramamurti, Narosa Publications
4. Mechanical Vibrations by V.P. Singh, Dhanpat Rai & sons
5. Textbook of Mechanical Vibrations by R.V. Dukkipati & J. Srinivas, Prentice Hall of India
6. Dynamics of structures by Chopra, Pearson press
7. Vibration and Control by A.K. Mallik

CDN5403 Fracture Mechanics

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. The Airy stress function; **Determination of Stress intensity factors and plane strain fracture toughness**: Plane strain fracture toughness test, Criteria for crack growth. The crack resistance(R curve). Compliance, J integral. Tearing modulus. Stability. Plasicity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor; **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; **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;
Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness, Testing for fracture; **Fatigue crack propagation and applications of fracture mechanics**: Use of FEM softwares like ABAQUS for analysis of bodies containing cracks.

Reference Books:

1. **Elementary Engineering Fracture Mechanics** by David Brock, Noordhoff.
2. **Fracture Mechanics-Fundamental and Application** by Anderson, T.L CRC press1998.
3. **Engineering fracture mechanics** by S.A. Meguid, Elsevier.
4. **Fracture of Engineering Brittle Materials,** Applied Science - Jayatilake, London.

CDN5405 Theory of Elasticity and Plasticity

Introduction: Analysis of stress and strain; Equilibrium; Specification of stress at a point; **Elastcity Problems:** Airy's stress function, investigation for simple beam problems; **Yield Criteria for Materials:** Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material. Hills' criterion, Plastic stress-strain relations, Prandtl Reuss Saint Venant, Levy - Von Mises, Experimental verification of the Prandtl-Rouss equation, Yield locus, Symmetry convexity, Normality rule; **Upper and lower bound solutions:** Upper and lower bound theorems and and corollaries. Application to problems: Uniaxial tension and compression, bending of beams, Torsion of rods and tubes, Simple forms of indentation problems using upper bounds. Slip line theory, Basic equations for incompressible two dimensional flow, continuity

equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.

Reference Books:

1. **Engineering Plasticity - Theory and Application to Metal Forming Process** by R. A. C. Slater, McMillan Press Ltd.
2. **Theory of Plasticity and Metal forming Process** by Sadhu Singh, Khanna Publishers, Delhi.
3. **Plasticity for Mechanical Engineers -** Johnson and Mellor.

CDN5301 Optimization Techniques in Design

Introduction to Optimization - Problem Statement, Classification of optimization problems and applications; **Classical Optimization techniques:** Unconstrained Optimization: Optimizing Single- Variable Functions, conditions for Local Minimum and Maximum, Optimizing Multi- Variable Functions. 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; **Goal Programming:** Formulation and solution of goal problems; **Non-Linear Programming:** One-Dimensional Methods: Elimination Methods, Interpolation Methods, Direct Root Methods; Quasi-Newton Method, Secant Method. Dichotomous search method, Fibonacci method, Golden section method, Unconstrained Optimization Techniques: Direct search methods, Descent Methods. Constrained Optimizations: Direct and Indirect methods; **Dynamic Programming:** Concept of Dynamic Programming, Multi stage Decision Process, Calculus Method and Tabular Method; **Integer Programming –** Branch and bound Method, Cutting Plane Method; **Introduction to Advanced Optimization Techniques:** Genetic Algorithms (GA), Simulated Annealing, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Neural Network, Separable Programming, Stochastic Programming, Monte Carlo Simulation.

Reference Books:

1. **Operations Research** by Taha, H . A., PHI
2. **Optimization of Engineering Design by** Deb, K., PHI
3. **Operations Research buy** D. S. Hira and P. K. Gupta, S. Chand
4. **Optimization techniques by** Rao, New Age international
5. **Introduction to Optimal Design by** Jasbir Singh Arora, McGraw Hill International

CDN5303 Numerical Methods in Engineering

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, eigen values and eigen vectors Interpolation methods: Newton's divided difference, interpolation polynomials , Lagrange interpolation polynomials;
Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration; **Transform techniques**: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform (DFT),Fast Fourier Transform(FFT); **Differential equations**: Initial and boundary value problems, eigenvalues problems, solutions to elliptical and parabolic equations, partial differential equations. **Regression methods**: Linear and non-linear regression, multiple linear regression, general linear least squares; **Statistical methods**: Statistical representation of data, modeling and analysis of data, test of hypotheses; Solution to practical engineering problems using software tools

Reference Books*:*

1. **Applied Numerical Methods for Engineering using MatLab and C** by Schilling R. J and Harris S L, Brooks/Cole Publishing Co.
2. **Numerical Methods for Engineers** by Chapra S C and Canale R P, McGraw Hill
3. **Probability and Statistics in Engineering and Management Studies** by Hines, W.W and Montrogmery, John Willey
4. **Numerical Methods for Engineers** by Santhosh K.Gupta, New Age international publishers

CDN5305 Design of Experiments

Introduction: Basic principles, Guidelines for designing experiments, history of statistical design, statistical design in experimentation; **Simple Comparative Experiments:** Basic statistical concepts, Sampling and sampling Distribution, Inferences in means, randomized designs, Paired comparison Designs, Inferences in Normal Distributions; **Introduction to Factorial Design:** Definition and principles, Advantages of factorials, The two factor factorial design, General factorial design, Fitting response curves and Surfaces, Blocking in a factorial design; **Fitting Regression Models:** Linear regression models, Estimate of parameters, Hypothesis testing and Confidence intervals in multiple regression, Prediction of new response observations, Regression model diagnostics, Testing for lack of fit; **Taguchi Method:** Concept design, Parameter design, Tolerance design, Quality loss function, S/N ratio, Orthogonal array experiments, Analysis of Mean (ANOM), Selection and testing of noise factors, control factors, Parameter optimization experiment, Parameter design case study; **Analysis of Variance:** Degrees of freedom, Error variance and pooling, Error variance and application, Error variance and utilizing empty columns, the F-test.

Reference Books:

1. Probability and Statistics for Engineers and Scientists by Walpole, Myers, Myers and Ye, Pearson Education.
2. **Statistics in Research** by Bernand Ostle & Richard N.Mensing, Oxford & IBH Pub Co.
3. **Probability and Statistics in Engineering** by Hines, Montgomery, Goldsman and Borror, John Wiley & Sons.
4. **Experimental Design, Theory & application** by Federer, Oxford & IBH pub Co

CDN5203 Smart Structure and Materials

Overview of Smart Materials, Structures and Products Technologies; **Smart Materials (Physical Properties)** piezoelectric materials, materials, magnetostrictive electrostrictive materials, magnetoelectric materials. magnetorheological fluids, electrorheological fluids, applications of electroreological fluids, shape memory materials, fiber-optic sensors; **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; **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; **Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products.**

Reference Books:

1. **Smart Materials and Structures** by M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York
2. **Smart Structures and Materials** by B. Culshaw, Artech House, Boston
3. **Smart Structures: Analysis and Design** by A. V. Srinivasan, Cambridge University Press, Cambridge; New York
4. **Electroceramics:** Materials, Properties and Applications by A. J. Moulson and J. M. Herbert. John Wiley & Sons
5. **Piezoelectric Sensories:** Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York
6. **Piezoelectric Actuators and Wtrasonic Motors** by K. Uchino, Kluwer Academic Publishers, Boston

7. **Handbook of Giant Magnetostrictive Materials** by G. Engdahl, Academic Press, San Diego, Calif.; London
8. **Shape Memory Materials** by K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York

CDN5205 Human Factors Engineering and Biomechanical Design

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; **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; **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; **Human Factors Applications;** Human Error, Accidents and Safety, Human Factors and the Automobile. Human Factors in Systems design; **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.

Reference Books:

1. **Human Factors In Engineering and Design** by Mark Sanders, Ernest McCormick, McGraw-Hill International Editions.
2. **Biomechanics Vol. 1, 2, 3** by Y.C. Fung,

CDN5207 Design for Manufacture

Effect of Materials And Manufacturing Process On Design: Major phases of design. Effect of material properties, Effect of manufacturing processes, Material selection process; **Tolerance Analysis:** Process capability, mean, varience, skewness ,kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish; **Selective Assembly:** Interchangeable and selective assembly, Deciding the number of groups -Model-1: Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations; **Datum Features:** Functional datum, Datum for manufacturing, changing the datum; **Design Considerations for Casting; Component Design for Manufacturing; True positional theory:** Comparison between co-ordinate and convention 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; **Design of Gauges.**

Reference Books:

1. **Designing for Manufacturing** by Harry Peck, Pitman Publications
2. **Machine Design by** Dieter McGraw hill Publications for topic 1.
3. **Metrology by** R.K. Jain Khanna Publication for topic 6.
4. **Product design for manufacture and assembly by** Geoffrey Boothroyd, peter dewhurst, Winston Knight, Mercel dekker. Inc. New york.
5. **Material selection and Design, Vol. 20** by ASM Hand book.

SEMESTER II

CDN502 Finite Element Method

Introduction to Finite Element Method; One-Dimensional Elements-Analysis of Bars and Trusses; Two-Dimsional Elements-Analysis of Plane Elasticity Problems, Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading; Three-Dimensional Elements-Applications to Solid Mechanics Problems; Beam Elements-Analysis of Beams and Frames; Heat Transfer *and* Fluid Flow; Dynamic problems

Reference Books:

1. **Finite Elements in engineering** by Chandrupatla T. R., PHI
2. **Finite Elements Analysis** – Procedures in Engineering by Lakshminarayana H. V., Universities Press
3. **Finite Elements Method in Engineering** by Rao S. S., Elsevier
4. **Textbook of Finite Element Analysis** by P. Seshu, PHI
5. **Finite Element Method** by J.N.Reddy, McGraw -Hill International Edition.
6. **Concepts and Application of Finite Elements Analysis** by Cook, Malkus, Plesha and Witt, Wiley & Sons
7. Finite Element Method by K. J. Bathe, Prentice Hall of India
8. FEM by Zienkiewicz and Taylor

CDN504 Robotics and Control

Introduction; Evolution of robot and robotics, laws of robotics, robot anatomy: Links, joints, Degrees of freedom (DOF), Arm configuration, wrist configuration, end-effectors; **Coordinate Frame, Mapping and Transforms;** Coordinate frames, description of objects in space, transformation of vectors, inverting a homogeneous transform, fundamental rotation matrices; **Kinematics;** Denavit- Hartenberg Notation, kinematic relationship between adjacent links, Manipulator transformation matrix, Inverse kinematics Linear and angular velocity of a rigid body, velocity propagation along links, manipulator jacobian; **Dynamics:**
Lagrange-Euler Formulation, Newton-Euler Formulation; **Control of manipulators:** Position control, Force control: Applications of standard control strategies; **Actuators:**Types, Characteristics, Comparision of hydraulic, Electric, pneumatic, actuators, Hydraulic actuators, Proportional feedback control, Electric Motors; **Sensors:** Sensor characteristics, Position sensors, Displacement sensor, Velocity sensor-, Acceleration sensors, Force and Pressure sensors, Torque sensors, Touch and tactile sensor, Proximity

Reference Books:

1. **Fundamental Concepts and Analysis** by Ghosal A., Robotics, Oxford
2. **Introduction to Robotics Analysis** by Niku, S. B., Systems, Applications, Pearson Education
3. **Introduction to Robotics: Mechanica and Control** by Craig, J. J., Addison-Welsey
4. **Fundamentals of Robotics, Analysis and Control** by Schilling R. J., PHI
5. **Robotics Control, Sensing, Vision and Intelligence** by Fu, K, S., Gonzalez R. C., Lee C.S. G., McGraw Hill

CDN5402 Engineering Tribology and Bearing Design

Introduction: definition, Lubrication, wear, cost of friction and wear.

Friction and Wear: Law, concept, Taylor's model of friction, Measurement of friction.
Laws of wear, Abrasive, Erosive and Cavitation wear, Effect of particle shape, hardness, size and flux rates on erosive wear rate. Erosive wear. **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. **Fatigue wear:** Introduction, fretting wear, melting wear, wear due to electrical discharges, diffusive wear, impact wear. Sitiback number, curve and law. **Lubrication:** Solid lubrication and surface treatments, Hydrostatic Lubrication, formation of fluid film, pressure distribution and flow, normal load component, frictional torque and power loss, gas lubrication. Thermo hydrodynamic lubrication.

Bearing Design: Design of bearing, Heat generation and cooling or bearing hydrostatic and dynamic and their applications in machine tools. Design of air bearing ad other gas bearing

Reference Books:

1. **Engineering Tribology** by Gwidon W. Stachowiak and Andrew W. Batchelor
2. **Fundamentals of fluid film lubrication** by Bernard J. Hamrock
3. **Industrial Tribology** by Dr. B. S. Prabhu, McGraw Hill

CDN5404 Rapid Prototyping and Tooling

Introduction: Historical developments, Fundamentals of RP Systems and its Classification, Rapid prototyping process chains, 3D modeling and mesh generation, Data conversion and transmission; **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., Power based rapid prototyping systems, selective Laser sintering, Soligen Diren's shell production casting (DSPC), Fraunhofer's multiphase jet solidification (MJS) and MIT's 3D printing (3DP) etc.; **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; **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.

Reference Books:

1. **Rapid Prototyping of Digital Systems: A Tutorial Approach** by Hamblen James O Kluwer Aca
2. **Rapid Prototyping: Principles And Applications** by Chua, Leong and Lim, World Scientific
3. **Rapid System Prototyping With Fpgas: Accelerating The Design Process** by Cofer and Harding, Newnes
4. **Rapid Prototyping of Digital Systems** by James O Hamblen, Springer

CDN5406 Innovative Engineering Design

Creative Product & System Design: Creative design, Innovation versus invention, Globalisation, Team work, Project Scheduling and management; **Creative Mind:** Whole Brain thinking, Creativity, What makes an individual creative?; **Reclaiming Creativity:** Mental Barriers, Types of mental Barriers, False assumptions and nonexistent limitations, Associating thinking, misunderstandings, inability to communicate properly, emotions, culture and environment related barriers, improper method of solution; **Creative Problems solving Techniques:** Brain storming, 6-3-5 method, Morphological attitude list, list of alternative actions, analogy (Case based reasoning) method, random attributes Scamper method; **Imagination, visualisation, graphical representation and communication:** Imagination, drawings, engineering drawings, realistic drawings, Perspectives and location of objects, determining depth in perspective: scale factors, drawing perspective, sketching, put in- the-box scheme: **Design Consideration and Decisions; Economics of Design:** Value of a Product or System, Global Economics Models, Costs, Revenues and Profits, Cost Breakdown of Products and Systems, Product Life Span, Engineering Economy; **Design and Product Liability:** Standards and Codes.

Reference Book:

Creative Design of Products and Systems by Saeed Benjamin Niku,

CDN5304 Rotor Dynamics

Fluid Film Lubrication: Basic theory, Generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, hydrodynamic journal bearing, Two lobe journal bearings; **Stability of Flexible Shafts:** Introduction, 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, instability in magnetic field; **Critical Speed; 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 centre; **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; **Turbo-rotor System Stability by Finite Element Formulation; Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches.

Reference Books:

1. **Principles of Lubrication** by Cameron Longmans.
2. **Nonconservative problems of the Theory of elastic stability** by Bolotin, Pergamon.
3. **Matrix methods of Elastomechanics** by Peztel, Lockie, McGraw Hill.
4. **Vibration Problems in Engineering** by Timosenko, Young, Von Nostrand 5. Zienkiewicz, "The Finite Element Method", McGraw Hill.
5. **Rotor Dynamics** by J. S. Rao
6. **Rotor Dynamics** by Tondel

CDN5306 Product Design and Development

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; **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; **Material selection; Process selection:** Introduction. Process classification: shaping, joining and finishing. Systematic process selection. Ranking, process cost. Computer – aided process selection; **Design for manufacture and assembly; 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.**

Reference Books:

1. **Product Design and Development by** Karl T. Ulrich and Steven D. Eppinger, Mc GrawHill
2. **Integrated Product and Process Development** by John M. Usher, Utpal Roy and H. R. Parasaei
3. **Product Design for Manufacture and Assembly** by G. Boothroyd, P. Dewhurst and W. Knight, Marcel Daker
4. **Engineering Design and Design for Manufacturing**: A structured approach by John R. Dixon and Corrodo Poli, Field Stone Publishers, USA.
5. **Material Selection in Mechanical Design** by M. F. Ashby, Elsevier.

CDN5202 Reliability Engineering

Introduction: System concepts in reliability, availability and maintainability (RAM) Engineering, Practical applications of RAM Engineering to systems,

products and processes; Concepts, terms and definitions; Failure rate function, Probability density function, Cumulative distribution function, reliability function, Mean time to failure (MTTF), MTBF, MTTR etc.; **Fundamentals of reliability:**
Failure distributions; Exponential, Weibull, Normal and Lognormal; Constant failure rate model and time dependent failure models; **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, 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; Design for maintainability.**

Reference Books:

1. **An introduction to Reliability and Maintainability Engineering** by Ebeling Charies E., Tata McGraw-Hill
2. **Reliability Engineering** by Srinath, L. S., East –West Press Ltd.
3. **Engineering Maintainbility** by Dhillon, B. S., Prentice Hall of India
4. **Logistics Engineering and Management** by Blanchard, Benjamin, S., Prentice Hall of India

CDN5204 Product Life Cycle Management

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; **Use of Information Technology:** IT support, Solid modeling, Product data management, Collaborative product Commerce, Artificial Intelligence, expert systems, Software hardware component design; **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; **Need for PLM; 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.

Reference Books:

1. **Integrated Product Development by** M. M. Anderson and L Hein, IFS Publications
2. **Design for Concurrent Engineering by** J. Cleetus, CE Research Centre, Morgantown
3. **Concurrent Engineering Fundamentals: Integrated Product Development by** Prasad, Prentice hall India
4. **Concurrent Engineering in Product Design and Development by** I Moustapha, New Age International
5. **Product Lifecycle Management** by John Stark, Springer-Verlag, UK
6. **Product Lifecycle Management by** Michael Grieves, McGraw Hill
7. **Concurrent Engineering**: **Automation tools and Technology** by Andrew Kusiak, Wiley Eastern

CDN5206 Noise and Acoustic Design

Mathematical Basis of Acoustics; Radiation and Reception of Acoustics Waves; Pipes Resonators and Filters: Noise, Signal detection, Hearing and speech; **Architectural Acoustics:**
Environmental Acoustics; **Measurement of Sound and Vibration; Noise Pollution**

Reference Books:

1. **Fundamentals of Acoustics** by Lawerence E.Kinsler, Austin, R.Frey, Alan B.Coppens, James V.Sanders, Wiley
2. **Acoustics** by L. Berarek, McGraw-Hill

SEMESTER III

CDN6401 Computational Methods for Fluid Dynamics

Introduction: Conservation equation, Mass Momentum and Energy equations, Convective form of the equation and general description; **Clarification into various types of equation:** Parabolic, Elliptic, Boundary and initial conditions, Overview of numerical methods; **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; **Solution of finite difference equations;** Iterative methods; Matrix inversion methods, ADI method, Operator splitting, Fast Fourier Transform applications; **Phase change problems**, Rayleigh-Ritz, Galerkin and Least square methods; Interpolation functions, One and two dimensional elements, Applications. Phase change problems; Different approaches for moving boundary; Variable time step method, Enthalpy method.

Reference Books:

1. **Computational Methods for Fluid Dynamics by** Ferziger Joel H, Springer-Verlog
2. **Principles of Heat Transfer by** Kaviany M, Wiley-International
3. **Radiative Heat Transfer by** Modest Michael, Academic Press

CDN6403 Machine Tool Design

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; **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;
Structural design: Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and over arms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements; **CNC machine design:** Introduction to computer integrated manufacturing systems and CNC machine tools; **Design of CNC systems.**

Reference Books:
1. **Design of Devices and Systems** by William H. Middendorf and Richard H. Engelmann, CRC Press.
2. **Computer numerical control of machine tools** by G. E. Thyer, Heinemann Professional Publishing.
3. **Machine Design Fundamentals: A Mechanical Designers' Workbook** by Joseph Edward Shigley and Charles R. Mischke, Mcgraw Hill.
    1. 4. **Numerical Control and Computer aided manufacture by** Kundra, Rao, Tiwari, Tata McGraw Hill.

CDN6405 Pressure Vessels and Piping Design

Stresses in pressure vessels: Membrane stresses, dilation of pressure vessels, thick cylinder and thick sphere, bending of plate, discontinuity stresses in pressure vessels, thermal stresses;
Factors influencing the design of pressure vessels: Design criterion of elliptical, hemispherical, conical, toriconical and torispherical heads, Autofrettage;

Design of pressure vessel components such as shells, heads, nozzles, flanges as per ASME and IS codes: Localised stresses, stress concentration about a circular and an elliptical opening, theory of reinforced openings, nozzle reinforcement, welded joints; **Fracture Control:** Fatigue of various components of pressure vessels, Fatigue life prediction, thermal stress fatigue, criteria for design with defects; **Piping elements, Dynamic analysis of piping; Use of FEM softwares for stress calculations.**

Reference Book:

Pressure vessel design by Harvey

CDN6301 Composite Material Technology

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction; **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 twodimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems; **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, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems; **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; **Manufacturing; Application Developments; Metal Matrix Composites.**

Reference Books:

1. **Composite Materials handbook** by Mein Schwartz, McGraw Hill Book Company
2. **Mechanics of composite materials** by Autar K. Kaw, CRC Press New York.
1. **Mechanics of Composite Materials** by Rober M. Joness, Mc-Graw Hill Kogakusha Ltd.
2. **Stress analysis of fiber Reinforced Composite Materials** by Michael W, Hyer, Mc-Graw Hill International.
3. **Composite Material Science and Engineering** by Krishan K. Chawla, Springer.
4. **Fibre Reinforced Composites** by P. C. Mallik, Marcel Decker.

CDN6303 Mechatronic System Design

Introduction: Definition and Introduction to Mechatronic Systems; **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; **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; **System Models:** Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydromechanical 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; **MEMS and Microsystems; Data Presentation Systems; Advanced Applications in Mechatronics.**

Reference Books:

1. **Mechatronics** by W. Bolton, Addison Wesley Longman, Pub

2. **MEMS and Microsystems design and manufacture** by HSU, TMH
3. **Understanding Electro-Mechanical Engineering** by Kamm
4. **Mechatronics System Design** by Shetty and Kolk, Thomson.
5. **Mechatronics** by Mahalik, TMH.
6. **Mechatronics** by HMT, TMH.

CDN6305 Instrumentation and Control Systems

Introduction: Classification and representation of control systems Examples of control systems, closed loop and open loop control systems, The Laplace transform; **Mathematical Modelling of Dynamic systems:** Transfer function and impulse response function, block diagrams, signal flow graph, statespace representation, Transient response analysis of first order and second order systems; **Time domain analysis and design:** Root locus method, Routh stability criteria, effect of poles and zeros on system performance; **Frequency domain analysis and design:**Bode plot , Nyquist stability criteria, Lag , lead compensation; **Modern Control Theory:** Modern control theory. Sequence control and programmable logic controllers. 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 systems:**
Computer based data acquisition systems, ADC, DAC. Microprocessor applications in measurement and control. Static and dynamic analysis. FFT analysers; **Analysis and design:**
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.

Reference Books:

1. **Modern Control E ngineering** by K. Ogata, PHI.
2. **Automatic Control Systems** by B.C. Kuo, PHI.
3. **Control System Engineering** by Nise, Wiley.
4. **Modern Control Systems by** Dorf and Bishop, Pearson Education.
5. **Modern Control System Theory** by M. Gopal, New Age International

CDN6201 Computer Aided Design

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; **Three Dimensional Transformations:** Geometric transformations & Axonometric, Diametric, Trimetric and oblique Projections, Windowing & View porting; **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; **Solid modelling:** Half spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytical solid making, and solid manipulation; **Advances in Computer Aided Engineering Design:** Failure considerations in designing, Robust design, Reliability, Ergonomic considerations in Design, Feature based design, Design for manufacturing, Design for Automation, CAD of complex Engg. Systems.

Reference Books:

1. **Computer Graphics** by D Hearn & M P Baker, Prentice Hall
2. **CAD/CAM Theory and Practice** by Ibrahim Zeid & R Sivasubramanian, Tata McGraw- Hill

3. **CAD/CAM- Principles and Applications** by P N Rao, Tata McGraw-Hill
4. **Computer Aided Engineering Design** by A Saxena and B Sahay, Anamya Publications
5. **Mathematical Elements for Comp. Graphics** by D F Rogers and J A Adams, McGraw-Hill International
6. **CAD/CAM** by H P Groover and E W Zimmers, Prentice Hall
7. **Computer Graphics and Design** by Radhakrishnan and Kothandaraman, Dhanpat Rai
8. **Procedures Elements for Computer Graphics** by Rogers David F, Tata McGraw Hill

CDN6203 Surface Engineering

Introduction- thermal spray coating. Definition, History, Coating Build-up, Market segmentation, Material used for spraying, Method of powders production, Methods of powder characterization, Spray drying, Cladding, Mechanical alloying, Self propagating high temperature synthesis; **Pre-spray treatment**: Introduction, Surface cleaning, Substrate shaping, Surface activation, Masking, Thermal spraying techniques; **Thermal spray process**: Introduction, Flame spraying, Atmospheric plasma spraying, Arc spraying, Detonation gun spraying, High velocity oxy fuel spraying, Vacuum plasma spraying; **Post spray treatment**: Heat treatment, Impregnation, Finishing, Method of coating characterization, Method of microstructure characterization, Mechanical properties of coating, Physical properties of coating, Chemical properties of coating; **Properties of coatings**: Mechanical properties, Thermo-physical properties, Electric properties, Magnetic properties, Optical properties, Corrosion resistance, Application of coatings: Corrosion protection, Iron and steel industries, Energy generation and transport, Non ferrous metal industries, Paper industries.

Reference Books:

1. Introduction to surface engineering and functionally engineered materials by Peter Martin, John Wiley and Sons
2. Tribology and Surface Engineering by J. Paulo Davum, Nova Science Publishing.
3. Advances in Surface Engineering, SA
4. Material and Surface Engineering in Tribology by Jamal Takadoum, Wiley

CDN6205 Automotive System Design

Introduction: Design Requirement of Automobile (power-speed curves), Engine as a system and its subsystems, Fuel injection systems, Cooling system; **Design of Various subsystems:** Design requirements of the automobile transmission, Automatic transmissions, Dynamic considerations in designing of suspension system, modern systems of suspensions, Kinematic requirements of a steering mechanism, Need for power steering, Braking requirements of an automobile, brake materials; **Modeling and simulation:** Modeling and simulation of different subsystems, e.g., suspension system, Wheels, Braking system etc.; **Instrumentation and control:** gauges(speedometer, oil, temperature indicators etc.), microprocessor controlled units, safety and comfort aspects in the automotive component designs; **Computer application in automotive Design:** Use of softwares like Adams, Abaqus etc to analyse subsystems like transmission system, suspension mechanism and steering mechanism etc.;
Crash modeling of vehicles.

Reference Books:

1. **Light and Heavy Vehicle Technology** by M J Nunney, Elsevier Butterworth Heinemann
2. **An Introduction to Modern Vehicle Design** by Jullian Happian Smith, SAE
3. **Crashworthiness of Vehicles** by Johnson W. and Mamalis AG, MEP London