Curriculum Structure and Curriculum Content for the Academic Batch 2021-23
School /Department: School of Mechanical Engineering
Program: Master of Technology: Design Engineering

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Vision and Mission of KLE Technological University

Vision

KLE Technological University will be a national leader in Higher Education–recognised globally for innovative culture, outstanding student experience, research excellence and social impact.

Mission

KLE Technological University is dedicated to teaching that meets highest standards of excellence, generation and application of new knowledge through research and creative endeavors.

The three-fold mission of the University is:

- To offer undergraduate and post-graduate programs with engaged and experiential learning environment enriched by high quality instruction that prepares students to succeed in their lives and professional careers.

- To enable and grow disciplinary and inter-disciplinary areas of research that build on present strengths and future opportunities aligning with areas of national strategic importance and priority.

- To actively engage in the Socio-economic development of the region by contributing our expertise, experience and leadership, to enhance competitiveness and quality of life.

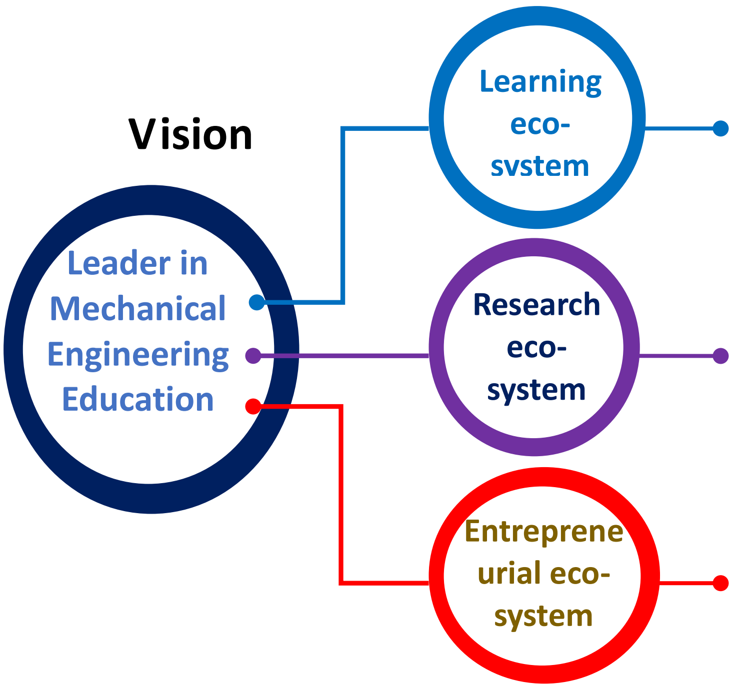
As a unified community of faculty, staff and students, we work together with the spirit of collaboration and partnership to accomplish our mission.

Vision and Mission Statements of the School

Vision

KLE Tech - School of Mechanical Engineering will be a national leader in mechanical engineering education - recognized for innovative culture, outstanding research and societal outreach.

Mission



Offer programs in an **engaging and experiential learning environment**, preparing students for success in their lives and professional careers.

Engage in Mechanical-discipline and inter-disciplinary research aligned to areas of national importance and priority.

Contribute to **socio-economic development** of the region for enhanced quality of life.

Program Educational Objectives/Program Outcomes and Program-Specific Outcomes **Program Educational Objectives -PEOs**
1. Graduates will demonstrate technical competence in design of products, processes and systems as a solution to complex problems applying research and sustainability principles incorporating modern computing tools.
2. Graduates will be competent in their managerial roles striving towards attainment of professional and organizational goals with due adherence to professional ethics, team expectations and sensitivities of cultural diversity
3. Graduates will practice engineering profession in corporate and governmental settings to meet stakeholder needs, thereby contributing to societal development.
4. Graduates will continuously upgrade to become proficient practitioners, engage in adapting new knowledge and skills to meet the expectations of ever changing industry and pursue new careers.
Program Outcomes-POs
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: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4: Ability to use modern computational tools in modeling, simulation and analysis of Design Engineering related problems with an understanding of their limitations.
PO5: An ability to select and integrate products and processes that account for long-term consumer satisfaction and environmental conservation.

Curriculum Structure-Overall

Semester- 1 to 4 (2021-23)				Total Program Credits: 88
	I	II	III	IV
Course with course code	Computational Methods in Engineering Analysis (20EDGC701)	Theory of Vibrations with Applications (20EDGC704)	Industrial Training/ Minor Project (20EDGI801)	Project Phase II (20EDGW802)
	Finite Element Practice in Machine Design (20EDGC702)	Dynamics and Mechanism design (20EDGC705)	Project Phase I (20EDGW801)	
	Failure of Materials in Mechanical Design (20EDGC703)	Research Methodology (20EDGC706)		
	Program Elective-1 (20EDGE7XX)	Program Elective-3 (20EDGE7XX)		
	Program Elective-2 (20EDGE7XX)	Program Elective-4 (20EDGE7XX)		
	CAD Modelling Lab (20EDGP701)	Analysis Lab (20EDGP702)		
		Mini Project (20EDGW701)		
Credits	**25**	**25**	**18**	**20**

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Curriculum Structure-Semester wise

Semester – I

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No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
01	20EDGC701	Computational Methods in Engineering Analysis	PC	3-1-0	04	05	50	50	100	3 hours
02	20EDGC702	Finite Element Practice in Machine Design	PC	3-1-0	04	05	50	50	100	3 hours
03	20EDGC703	Failure of Materials in Mechanical Design	PC	3-1-0	04	05	50	50	100	3 hours
04	20EDGE7XX	Program Elective-1	PE	4-0-0	04	04	50	50	100	3 hours
05	20EDGE7XX	Program Elective-2	PE	4-0-0	04	04	50	50	100	3 hours
06	20EDGP701	CAD Modelling Lab	PC	0-0-5	05	10	80	20	100	2 hours
TOTAL				**17-3-5**	**25**	**33**				

Semester – II

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No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
01	20EDGC704	Theory of Vibrations with Applications	PC	3-1-0	04	05	50	50	100	3 hours
02	20EDGC705	Dynamics and Mechanism design	PC	3-1-0	04	05	50	50	100	3 hours
03	20EDGC706	Research Methodology	PC	2-1-0	03	04	100	--	100	NA
04	20EDGE7XX	Program Elective-3	PE	4-0-0	04	04	50	50	100	3 hours
05	20EDGE7XX	Program Elective-4	PE	4-0-0	04	05	50	50	100	3 hours
06	20EDGP702	Analysis Lab	PC	0-0-3	03	06	80	20	100	2 hours
07	20EDGW701	Mini Project	PC	0-0-3	03	06	50	50	100	2 hours
			Total	**16-3-6**	**25**	**35**				

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Semester- III

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No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
01	20EDGI801	Industrial Training/ Minor Project	PI	0-0-10	10	30	50	50	100	2 hours
02	20EDGW801	Project Phase I	PW	0-0-8	8	24	50	50	100	2 hours
			Total	**0-0-18**	**18**	**54**				

Semester- IV

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No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
01	20EDGW802	Project Phase II	PW	0-0-20	20	40	50	50	100	2 hours
			Total	**0-0-20**	**20**	**40**				

Semester	I	II	III	IV	**Total**
Credits	25	25	18	20	88

List of Program Electives

Sr. No	Name of the Course	Course Code
1	Design of Pressure vessels	20EDGE701
2	Mechanics of Solids	20EDGE702
3	Integrated Product Design	20EDGE703
4	Automobile System Design	20EDGE704
5	Design and Analysis of Experiments	20EDGE705
6	Optimization Techniques in Design	20EDGE706
7	Multi Body Dynamics	20EDGE707
8	Engineering Tribology	20EDGE708
9	Mechanical Behaviour of Materials	20EDGE709
10	Applied Stress Analysis	20EDGE710
11	Fracture Mechanics	20EDGE711
12	Rotor Dynamics	20EDGE712

Program: PG_Design Engineering		Semester: I
Course Title: Computational Methods in Engineering Analysis		Course Code: 20EDGC701
L-T-P: 3-1-0	Credits: 04	Contact Hours: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 05	Examination Duration: 3hrs	

1. Approximations and round off errors: 06 Hrs

Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modelling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering.

2. Roots of Equations: 06 Hrs

Bracketing methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed point iteration.

3. Roots of polynomial: 06 Hrs

Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.

4. Numerical Differentiation and Numerical Integration: 06 Hrs

Newton –Cotes and Guass Quadrature Integration formulae, integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.

5. System of Linear Algebraic Equations and Eigen Value Problems: 06 Hrs

Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, iteration Methods.

6. Eigen values and Eigen Vectors: 05Hrs

Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.

7. Linear Transformation: 05 Hrs

introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engg.

Reference Books:

1. Erwin Kreyszig , Advanced Engineering Mathematics, 10th Edition , Willely India, 2016.
2. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
3. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, 4th Ed, 2002.
4. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.
5. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.
6. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.

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←back-1Semester

Program: PG_Design Engineering		**Semester: I**
Course Title: Finite Element Practice in Machine Design		**Course Code: 20EDGC702**
L-T-P: 3-1-0	**Credits: 04**	**Contact Hours: 40**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 05	**Examination Duration: 3hrs**	

1. Introduction:08 Hrs

Introduction to FEA, General FEM procedure, • Approximate solutions of differential equations: FDM method, W-R technique, collocation least square sub-domain and Galerkin method Numerical integration, Gauss quadrature in 2-D and 3-D, Structure of FEA program, Pre and Post processor, commercially available, standard packages, and desirable features of FEA packages, • Principal of minimum total potential, elements of variational calculus, minimization of functional, Rayleigh-Ritz method, Formulation of elemental matrix equation, and assembly concepts.

2. One Dimensional FEM:08 Hrs

Coordinate system: Global, local, natural coordinate system, Shape functions: Polynomial shape functions, Derivation of shape functions, Natural co-ordinate and coordinates transformation, Linear quadratic and cubic elements, Shape functions using Lagrange polynomials. Convergence and compatibility requirement of shape functions, One dimensional field problems: structural analysis (step-bar, taper-bar), Structural analysis with temperature effect, Thermal analysis, heat transfer from composite bar, fins.

3. Two Dimensional FEM Trusses: 08 Hrs

Thermal effects in truss members, Beams, Two dimensional finite elements formulations, Three noded triangular element, Four-noded rectangular element, Four-noded quadrilateral element, derivation of shape functions: natural coordinates, triangular elements, and quadrilateral elements, Six-noded triangular elements, Eight-noded quadrilateral elements, Nine noded quadrilateral element, Strain displacement matrix for CST element

4. Three dimensional elements:08 Hrs

Tetrahedron, Rectangular prism (brick), Arbitrary hexahedron, Three Dimensional polynomial shape functions, Natural co-ordinates in 3D, Three dimensional Truss (space trusses), Introduction to material models: Introduction to plasticity (Von-Mises Plasticity), Hyper –elasticity. Generating and using experimental data to model material behaviour, Errors in FEA, sources of errors, method of elimination, Patch test.

5. Iso-parametric formulation and Dynamic Analysis: 08 Hrs

Penalty Method, Lagrange methods, Multipoint Constraints, Concept of Master/Slave entities, Examples of Contact problems, Iso-parametric concepts, basic theorem, Iso-parametric, super-parametric, sub-parametric elements, Concept of Jacobian.

Finite element formulation of Dynamics, application to free-vibration problems, Lump and consistent mass matrices, Eigen value problems, Transient dynamic problems in heat transfer and solid mechanics, Convergence, Impact of Mesh quality on convergence.

Reference Books:

1. Reddy J. N, An introduction to the Finite Element Method, 3rd Edition, McGraw-Hill, 2006.
2. S.S.Rao, the Finite Element Method in Engineering, 5th Edition, Academic Press, Elsevier, 2011.
3. Tirupati R. Chandrupatla, Ashok D.Belegundu, Introduction to Finite Elements in Engineering,

4th edition, Pearson, 2011.

4. David Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2005.
5. 5. Kenneth Huebner, Donald Dewhirst, Douglas Smith and Ted Byrom, The Finite Method for Engineers, Wiley- India Edition, 2009.
6. Liu G. R., Quek S. S.,The Finite Element Method A practical Course, 2nd Edition, Elsevier, 2014.
7. George R Buchanan, Adapted by Rudramurthy, Finite Element Analysis, McGraw Hill, 2006.
8. Daryl L. Logan, A First course in the Finite Element Method, 4th Edition, Thomson, 2007.
9. S. M. Murigendrappa, Fundamentals of Finite Element Methods, Interline Publication, 2nd Edition 2009.

←back-1Semester

Program: PG_Design Engineering		Semester: I
Course Title: Failure of Materials in Mechanical Design		**Course Code: 20EDGC703**
L-T-P: 3-1-0	**Credits: 04**	**Contact Hours: 40**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 05	**Examination Duration: 3hrs**	

1. Introduction: 04 Hrs

Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.

2. Fatigue of Materials: 05 Hrs

Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

3. Surface Failure: 06 Hrs

Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.

4. Stress-Life (S-N) Approach: 05 Hrs

S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

5. Strain-Life approach: 05 Hrs

Monotonic stress-strain behavior ,Strain controlled test methods ,Cyclic stress-strain behavior ,Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

6.Notches and their effects: 05 Hrs

Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches.

7.Fatigue from Variable Amplitude Loading: 05 Hrs

Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.

8.Load Determination: 05 Hrs

Loading classes, Load analysis, Vibration loading, Impact loading, Beam loading.

Reference Books:

1. Ralph I. Stephens, Ali Fatemi, Robert.R. Stephens, Henry o. Fuchs, Metal Fatigue in Engineering, 2nd edition, John wileyNewyork, 2011.
2. Jack. A. Collins, Failure of Materials in Mechanical Design, 2nd edition, John Wiley & Sons, 1993.
3. Robert L. Norton, Machine Design, An Integrated Approach, 2nd edition, Pearson, 2000.
4. S. Suresh, Fatigue of Materials, 2nd edition, Cambridge University Press, 1998.

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Program: PG_Design Engineering		**Semester: I**
Course Title: Design of Pressure Vessels		**Course Code: 20EDGE701**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 50**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: 3hrs**	

1. Introduction:10 Hrs

Materials- shapes of Vessels –stresses in cylindrical spherical and arbitrary, shaped shells. Cylindrical Vessels subjected to internal pressure, wind load bending and torque-ilation of pressure vessels –conical and tetrahedral vessels.

Theory of thick cylinders; Shrink fit stresses in built up cylinders – auto frettage of thick cylinders Thermal stresses in Pressure Vessels.

2. Theory of Rectangular Plates: **10 Hrs**

Pure bending – different edge conditions.

Theory circular plates: Simple support and clamped ends subjected to concentrated and uniformly distributed loads-stresses

3. Discontinuity Stresses in Pressure Vessels: 10 Hrs

Introduction beam on an elastic foundation, infinitely long beam semi-infinite beam, cylindrical vessel under axially symmetrical loading, extent and significance of load deformations on pressure vessels, discontinuity stresses in vessels, stresses in a bimetallic joint, deformation and stresses in flanges. Pressure vessel materials and their environment: Introduction ductile material tensile tests, structure and strength of steel Leuder's lines determination of stress patterns from plastic flow observations, behavior of steel beyond the yield point, effect of cold work or strain hardening on the physical properties of pressure vessel steels fracture types in tension. Toughness of materials, effect of neutron irradiation of steels, fatigue of metals, fatigue crack growth fatigue life prediction cumulative fatigue damage stress theory of failure of vessels subject to steady state and fatigue conditions.

4. Stress Concentrations: 10 Hrs

Influence of surface effects on fatigue, effect of the environment and other factors on fatigue life thermal stress fatigue creep and rupture of metals at elevated temperatures, hydrogen embitterment of pressure vessel steels brittle fracture effect of environment on fracture toughness, fracture toughness relationships criteria for design with defects, significance of fracture mechanics evaluations, effect of warm pre-stressing on the ambient temperature toughness of pressure vessel steels.

5. Design Features: **10 Hrs**

Localized stresses and their significance, stress concentration at a variable thickness transition section in a cylindrical vessel, stress concentration about a circular hole in a plate subject to tension, elliptical openings, stress concentration, stress concentration factors for position , dynamic and thermal transient conditions, theory of reinforced openings and Re-inforcement, placement and shape fatigue and stress concentration.

Reference Books:

1. Dennis R Moss, Pressure Vessel Design Manual, Illustrated procedures for solving major pressure vessel design problems, Gulf Professional, 2004.
2. Bickell M., B. Ruizes, Pressure Vessel Design and Analysis,Macmillan Education UK, Year: 1967.
3. Dennis Moss, Michael Basic, Pressure Vessel Design Manual, 4th Edition, Butterworth-Heinemann is an imprint of Elsevier, 2013.
4. Donatello Annaratone ,Pressure Vessel Design, Springer, 2007
5. A S Tooth , J Spence, Pressure Vessel Design: Concepts and Principles, Spon Press, 1994.

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Program: PG_Design Engineering		Semester: I
Course Title: Mechanics of Solids		Course Code: 20EDGE702
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Analysis of stress: 07 Hrs

Introduction, body force, surface force and stress vector, the state of stress at a point, rectangular stress components, stress components on an arbitrary plane, equality of cross shears, differential equations of equilibrium, principal stresses, Mohr's circles for the three-dimensional state of stress, octahedral stresses, decomposition into hydrostatic and pure shear states.

2. Analysis of Strain: 07 Hrs

Introduction, deformation, strain displacement relations, state of strain at a point, strain tensors, cubical dilatation, principal strains, spherical and deviator strain tensors, octahedral strains, compatibility conditions.

3. Stress-Strain Relations for Linearly Elastic Solid: 06 Hrs

Generalized Hooke's law, stress–strain relations for isotropic materials, transformation of compatibility condition from strain components to stress components, relations between the elastic constants, Saint Venant's principle and uniqueness theorem.

4. Two Dimensional Problems in Cartesian Co-ordinates: 07 Hrs

Plane stress and plane strain problems, Airy's stress function, solution of two-dimensional problems by the use of polynomials, pure bending of a beam, bending of a narrow cantilever beam under end load, simply supported beam subjected to point load and uniformly distributed load, use of Fourier series to solve two dimensional problems.

5. Two Dimensional Problems in Polar Co-ordinates: 07 Hrs

General equations, biharmonic equation, stress distribution symmetrical about an axis, strain components in polar co-ordinates, thick-walled cylinders, rotating disks of uniform thickness, effect of circular holes on stress distribution in plates.

6. Torsion of Prismatic Bars: 06 Hrs

Introduction, general solution of the torsion problem, torsion of circular, elliptical and equilateral triangular cross section bar, membrane analogy, torsion of thin tubes.

7. Thermal Stresses: 05 Hrs

Introduction, thermoelastic stress–strain relations, thin circular disk; temperature symmetrical about centre, long circular cylinder, normal stresses in straight beams due to thermal loading.

8. Introduction to Plasticity: 05 Hrs

Mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, theories of plastic flow, Tresca and Von Mises yield criteria, discussion of plasticity conditions, experimental evidence for yield criteria.

Reference Books:

1. L S Srinath, Advanced Mechanics of Solids, 3rd Edition, Tata Mcgraw Hill Company, 2009.
2. T.G. SitharamandL. Govindaraju, Elasticity for Engineers,I K International Publishing House, 2016.
3. Dr. Sadhu Singh, Theory of Plasticity and Metal Forming Process, 3rd Edition, Khanna Publishers, 2011.
4. J. Chakraborty, Theory of Plasticity, 3rd Edition, Butterworth-Heinemann, 2006.

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Program: PG_Design Engineering		Semester: I
Course Title: Integrated Product Design		Course Code: 20EDGE703
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Introduction to Product development: 10 Hrs

Product development versus design, types of design and redesign, reverse engineering and redesign product development process, examples of product development process, product life cycle – S-curve, Bath tub Curve, new product development. Tear down method, post teardown report, benchmarking and establishing engineering specifications, product portfolios.

2. Understanding customer needs & Requirement Engineering: 10 Hrs

Gathering customer needs (VOC/VOE), QFD, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Introduction to Concept generation Techniques, Information gathering, brain ball, C-sketch/6-3-5 method, TIPS (TRIZ), Morphological analysis, Concept screening and Evaluation (Scoring), concept selection, technical feasibility, measurement theory, Fault Tree Model.

3. Six Sigma & 5'S: 06Hrs

Overview – DMAIC approach, Phases- Define (Pareto Chart, Brainstorming, Logic Tree), Measure (Sampling, Gauge R&R), Analyze (Fish Bone Diagram, FMEA), Improve (Design of Experiments) & Control (SPC), DFSS Tools, 5S, Poka-Yoke (Fool-Proofing)

4. Testing & Industrial Design: 06 Hrs

Types of prototypes (Mock-ups, engineering Assessment Prototype, Alpha, Beta, Gama), Introduction to Rapid Prototyping. What is Industrial Design? Assessing the need for industrial design (ID) and its impact, The industrial design process, Management of ID and assessing the quality of ID.

5. Tolerance analysis: 08 Hrs

Cumulative effect of tolerances – Worst case method, root sum square method, dimensions following truncated normal distributions, Monte Carlo simulation. Tolerance synthesis, non linear tolerance, tolerance analysis. Process capability, mean, variance, Cp, Cpk, feature tolerances, geometric tolerances – ISO standards

6. DFMA: 05 Hrs

Design for Assembly, Design for Manufacture, Design for Machining, Design for Injection Molding, Design for Sheet Metal Working, Design for Die Casting and Numerical.

7. IPR Essentials: 05 Hrs

Introduction to vertical specific product development processes, product development trade-offs, Intellectual property rights and confidentially.

Reference Books:

1. Karl T Ulrich and Stephen D Eppinger, Product Design and Development, McGraw Hill, 1994.
2. Kevin Otto and Kristin Wood, Product Design – Techniques in Reverse Engineering and New Product Development, Pearson Education, 2004.
3. Harry Peck, Design for Manufacturing, Pitman Publishing, 1983.
4. Geoffrey Boothroyd, Winston A. Knight, Peter Dewhurst, Product Design for Manufacture and Assembly, 3rd Edition, CRC Press Publication, 2010.

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Program: PG_Design Engineering		**Semester: I**
Course Title: Automobile System Design		**Course Code: 20EDGE704**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 50**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: 3hrs**	

1. Body Load Analysis: **10 Hrs**

Vehicle Loads: Static load, Load due to Acceleration and Braking, Moments and Torque due to driving conditions, resistance to motion and aerodynamic load, Types of materials used in body construction, Analysis and Selection of body member sections, Body sub frame and under floor structure, car front and rear end structure, Vehicle Structure Analysis by Simple Structural Surface (SSS) Method: Saloon and simple van.

Body Shapes: Aerodynamic Shapes, drag forces for small family cars.

2. Engine balancing: **06 Hrs**

firing order, longitudinal forces, transverse forces, pitching moments, yawing moments, Engine layout, major critical speed & minor critical speed, design of engine mounting.

3. Design of I.C. Engine I:06 Hrs

Introduction: Determination of engine power, Engine selection, swept volume, stroke, bore & no. of cylinders, Arrangement of cylinders stroke to bore ratio. Design procedure of theoretical analysis, Design considerations

4. Design of I.C. Engine II: **10 Hrs**

Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars.

5. Transmission System: **10 Hrs**

Design of transmission systems – gearbox, differential.

Suspension System: Vibration fundamentals, vibration analysis -single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

6. Design of cooling system - **08 Hrs**

design principles of exhaust & inlet systems, Primary design calculation of major dimensions of fuel injection system

Reference Books:

1. Julian Happian-Smith, an Introduction to Modern Vehicle Design, Butterworth- Heinemann, 2002.
2. Jason C. Brown, A. John Robertson, Stan T. Serpento, Motor Vehicle Structures: Concepts and Fundamentals, Butterworth Heinemann, 2002.
3. N.K. Giri, Automobile Technology, Khanna Publishers, 2011.
4. W. Steed, Mechanics for Road Vehicles"–, Illiffe Books Ltd., London.
   Crouse, Engine Design, Tata McGraw Publication, Delhi,2000

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Program: PG_Design Engineering		**Semester: I**
Course Title: Design and Analysis of Experiments		**Course Code: 20EDGE705**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 50**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: 3hrs**	

1. Introduction: 04 Hrs

Taguchi's approach to quality and quality loss function, noise factors and average quality loss, exploiting non linearity, classification of parameters.

2. Analysis of variance: 06 Hrs

No-Way ANOVA, One-Way ANOVA, Two-Way ANOVA and Three-Way ANOVA.

3. Two Level Experiments: 10 Hrs

Two factor factorial design, model adequacy checking and estimating model parameters, 2^2 full factorial design, 2^3 full factorial design, 2^k full factorial design and Two level fractional factorial design, General 2^{k-p} fractional factorial design.

4. Steps in Robust Design: 10 Hrs

Identification of process and its main function, Noise factors and testing conditions, Control factors and their levels, Matrix experiment and data analysis plan, Conducting the experiment and data analysis, Verifying experiment and future plan.

5. Signal to Noise Ratios: 10 Hrs

Comparison of the quality of two process conditions, Relationship between Signal to Noise Ratio and quality loss after adjustment, Identification of a scaling factor, Signal to Noise Ratios for static problems, Signal to Noise Ratios for dynamic problems, Analysis of ordered categorical data.

6. Inner and Outer array analysis: 05 Hrs

Taguchi inner and outer arrays, Orthogonal arrays and fractional factorial designs, Parameter design and tolerance design, Analysis of inner/outer array experiment, Alternative inner/outer Orthogonal array experiments.

7. Orthogonal arrays: 05 Hrs

Constructing orthogonal arrays, Dummy level technique, Compound factor method, Linear graphs and Interaction assignment, Modification of linear graphs, Column merging method, Branching design.

Reference Books:

1. Montgomery, D. C., Design and Analysis of Experiments, John Wiley & Sons.
2. Khuri A. I. and Cornell J. A. Response Surfaces: Designs and Analyses, Marcel Dekker, Inc., New York.
3. Myers R. H., Montogomery, D. C. and Anderson-Cook C. M. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, John Wiley & sons, Inc., New York.
4. Mason R. L., Gunst, R. F., Hess J. L., Statistical design and Analysis of Experiments with Applications to Engineering and SISAnce, John Wiley & sons, Inc., New York.

Program: PG_Design Engineering		Semester: I
Course Title: Optimization Techniques in Design		Course Code: 20EDGE706
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1.Basic Concepts: 10 Hrs

Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Overview of optimization technique

2.Unconstrained Optimization Technique: 10 Hrs

Necessary and sufficient condition – search method (unrestricted Fibonacci and Golden) – Interpolation method (Quadratic, Cubic & Direct root method).

3.Response Surface Method: 10 Hrs

Response Surface, The Least-Squares Methods, Two-
Level Factorial Design, Addition of Center Points, Central Composite Design(CCD), Sequential Nature of RSM, Other Experimental Design

4. Newtonian Method: 06 Hrs

Newton's method, Marquardt's method, Quasi Newton method.

5. Discrete Event Simulation: 08 Hrs

Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.

6. Integer L.P. Model: 06 Hrs

Gomory's cutting plane method, Branch & Bound Technique

Reference Books:

1. Pablo Pedregal, Introduction to Optimization, Springer, 2003.
2. S.S. Rao, Engineering Optimization - Theory and Practice, John Wiley and Sons Inc. 1996.

←back-1Semester

Program: PG_Design Engineering		**Semester: I**
Course Title: CAD Modelling Lab		**Course Code: 20EDGP701**
L-T-P: 0-0-5	**Credits: 05**	**Contact Hours: 120**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 10	**Examination Duration: 3hrs**	

- Introduction to CAD / CAM / CAE Software's
- Brief introduction to CATIA Software and Industrial applications
- Introduction to Work benches
- Brief introduction on Sketcher work bench environment
- Structure of users and saving of files.
- Part Design
- Generative Sheet Metal Design (GSMD) Workbench
- Assembly Design Workbench

Drafting Workbench

Reference Books:

1. Material prepared by School of Mechanical Engineering, KLETU-Hubballi.
2. Sham Tickoo, "Catia V5R20 for Engineers and Designers-,A Tutorial Approach", CAD CIM Technologies , 2009.

Program: PG_Design Engineering		Semester: II
Course Title: Theory of Vibrations with Applications		Course Code: 20EDGC704
L-T-P: 3-1-0	Credits: 04	Contact Hours: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 05	Examination Duration: 3hrs	

1. Review of Mechanical Vibrations 06 hrs

Undamped and damped free vibrations of single degree of freedom systems, importance of the study of vibration, free vibration of an undamped translational systems, equation of motion and natural frequency of systems, types of damping, response of single degree freedom viscous damped systems, logarithmic decrement, systems with Coulomb damping.

2. Harmonically Excited Vibration 05 hrs

Introduction, response of a viscous damped system under harmonic force, response of a system under the harmonic motion of the base, relative motion, response of a system under rotating and reciprocating unbalance, vibration isolation, transmissibility and force transmitted.

3. Transient Vibrations of Single Degree of Freedom Systems 05 hrs

Impulse excitation, arbitrary excitation, Laplace transform formulation, step input, pulse excitation, shock response spectrum, shock isolation.

4. Multi Degree-of-Freedom Systems 06 hrs

Introduction, two degree-of-freedom systems, free vibration analysis of an un-damped system, torsional system, coordinate coupling, influence coefficients, natural frequencies using matrix iteration method, fundamental frequency using Dunkerley's method and Rayleigh's Method, torsional Systems, standard Eigenvalue problem-Choleski decomposition.

5. Vibration Measurement and Acoustics 05 hrs

Introduction, transducers, vibration pickups ,signal analysis, spectrum analyzers, dynamic testing of machines and structures, experimental modal analysis, vibration monitoring techniques, introduction to noise, acoustic wave equation ,noise measuring instruments.

6. Vibration Control 04 hrs

Introduction, vibration Nomo graph and vibration criteria, reduction of vibration at the source, control of vibration, control of natural frequencies, introduction of damping, vibration isolation for different types of foundation, shock isolation, active vibration control, vibration absorbers, undamped and damped dynamic vibration absorber.

7. Nonlinear Vibration 05 hrs

Introduction ,examples of nonlinear vibration problems-simple pendulum, mechanical chatter, belt friction system, variable mass system, exact methods, approximate analytical methods-basic philosophy, Lindstedt's perturbation method, iterative method, Ritz-Galerkin method, subharmonic and super harmonic oscillations, systems with time-dependent coefficients (Mathieu equation), stability of equilibrium states-stability analysis, classification of singular points, limit cycles.

8. Continuous Systems 04 hrs

Vibrating string, Longitudinal vibration of rods, torsional vibration of rods, Euler equation for beams.

Reference Books:

1. Singiresu S. Rao, Mechanical Vibrations, Pearson Education, 6th Edition, 2018.
2. W.T. Thomson and Marie Dillon Dahleh, Theory of Vibration with Applications, Pearson New International Edition, 5th Edition, 2014.
3. S. Graham Kelly, Mechanical Vibrations: Theory and Applications, Cengage Learning, SI Edition, 2012.

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Program: PG_Design Engineering		**Semester: II**
Course Title: Dynamics and Mechanism Design		**Course Code: 20EDGC705**
L-T-P: 3-1-0	**Credits: 04**	**Contact Hours: 40**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 05	**Examination Duration: 3hrs**	

1. Geometry of Motion: 06 hrs

Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method.

2. Synthesis of Linkages: 06 hrs

Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle.

3. Graphical Methods of Dimensional Synthesis: 06 hrs

Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages.

4. Analytical Methods of Dimensional Synthesis: 06 hrs

Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.

5. Spatial Mechanisms: 06 hrs

Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles

6. Generalized Principles of Dynamics: 05 hrs

Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum.

7. Lagrange's Equation: 05 hrs

Lagrange's equation from D'Alembert's principles, Examples, Hamilton’s equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, Derivation of Hamiltons equations, Examples.

Reference Books:

1. E. Shigley & J. J. Jicker, Theory of Machines and Mechanism, 2nd edition, McGraw Hill Company, 2007
2. Kenneth J Waldron, Gary Kinzel, Kinematics, Dynamics & Design of Machinery, 2nd edition, John Wiley & Sons, 2011.
3. Greenwood, Principles of Dynamics, Prentice Hall of India, 1988.
4. Robert L Norton, Design of machinery, 2nd edition, McGraw Hill., 2002.

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Program: PG_Design Engineering		Semester: II
Course Title: Research Methodology		**Course Code: 20EDGC706**
L-T-P: 2-1-0	**Credits: 03**	**Contact Hours: 24**
ISA Marks: 50	**ESA Marks: --**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: --**	

Research: Definition, Characteristics and Objectives; Types of Research, Research Methodology, Research Process, Literature Review, Review concepts and theories, Formulation of Hypothesis, Research design, Data collection, Processing and analysis of data collected, Interpretation of data, Computer and internet: Its role in research, Threats and Challenges to research, Writing a research paper, research project, Thesis, Research ethics, Citation methods and rules. Case studies.

Reference Books:

1. Kothari C. R. Research Methodology – Methods & Techniques, Wishwa Prakashan, A Division of New Age International Pvt. Ltd., 2008.
2. Ranjit Kumar, Research Methodology – A step by step guide for Beginners, 3rd Edition, Pearson Edition, Singapore, 2011.
3. Dawson Catherine, Practical Research Methods, UBS Publishers, New Delhi, 2002.

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Program: PG_Design Engineering		**Semester: II**
Course Title: Multi Body Dynamics		**Course Code: 20EDGE707**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 50**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: 3hrs**	

1. Introduction: 05 hrs

Multibody Systems, Reference Frames, Particle Mechanics, Rigid Body Mechanics, Deformable Bodies, Constrained Motion, Computer Formulation and Coordinate Selection.

2. Reference Kinematics: 05 hrs

Rotation Matrix, Properties of the Rotation Matrix, Successive Rotations, Velocity Equations, Accelerations and Important Identities, Rodriguez Parameters, Euler Angles, Direction Cosines, The 4 × 4 Transformation Matrix, Relationship between Different Orientation Coordinates, Problems.

3. Analytical Techniques: 10 hrs

Generalized Coordinates and Kinematic Constraints, Degrees of Freedom and Generalized Coordinate Partitioning, Virtual Work and Generalized Forces, Lagrangian Dynamics, Application to Rigid Body Dynamics, Calculus of Variations, Euler's Equation in the Case of Several Variables, Equations of Motion of Rigid Body Systems, Newton–Euler Equations, Concluding Remarks, Problems.

4. Mechanics of Deformable Bodies: 10 hrs

Kinematics of Deformable Bodies, Strain Components, Physical Interpretation of Strains, Rigid Body Motion, Stress Components, Equations of Equilibrium, Constitutive Equations, Virtual Work of the Elastic Forces, Problems.

5. Floating Frame of Reference Formulation: 10 hrs

Kinematic Description, Inertia of Deformable Bodies, Generalized Forces, Kinematic Constraints, Equations of Motion, Coupling between Reference and Elastic Displacements, Application to a Multibody System, Use of Independent Coordinates, Dynamic Equations with Multipliers, Generalized Coordinate Partitioning, Organization of Multibody Computer Programs, Numerical Algorithms, Problems.

6. The Large Deformation Problem: 10 **hrs**

Background, Absolute Nodal Coordinate Formulation, Formulation of the Stiffness Matrix, Equations of Motion, Relationship to the Floating Frame of Reference Formulation, Coordinate Transformation, Consistent Mass Formulation, The Velocity Transformation Matrix, Lumped Mass Formulation, Extension of the Method, Comparison with Large Rotation Vector Formulation, Problems.

Reference Books:

1. Ahmed A. Shabana, Dynamics Of Multibody Systems, 3rd Edition, Cambridge University Press 2010
2. Michael Blundell and Damian Harty, Multibody Systems Approach to Vehicle Dynamics, Elsevier
3. Jens Wittenburg , Dynamics of Multibody Systems, Second Edition, Springer Berlin Heidelberg New York, 1977
4. Farid M. L. Amirouche, Fundamentals of Multibody Dynamics: Theory and Applications, Birkhäuser Basel, 2006.
5. Michael Blundell and Damian Harty, The Multibody systems approach to vehicle dynamics, Butterworth-Heinemann, , Elsevier Ltd, Year: 2015.

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Program: PG_Design Engineering		Semester: II
Course Title: Engineering Tribology		Course Code: 20EDGE708
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Historical background - 10 hrs

Viscosity - Viscometry - Effect of temperature on viscosity - Effect of pressure in viscosity - Other physical properties of mineral oils - The generalized Reynolds equation - Flow and shear stress - The energy equation - The equation of state - Mechanism of
Pressure development.

2. Circumferential Flow - 10 hrs

Oil flow through a bearing having a circumferential oil groove – Heat generation and lubricant temperature - Heat balance and effective temperature - Bearing design:
Practical considerations - Design of journal bearings - Parallel surface bearing - Step bearing - Some situations under squeeze film lubrication - The mechanism of hydrodynamic instability -
Stiffness and damping coefficients - Stability.

3. Elasto hydrodynamic lubrication: 10 hrs

Theoretical consideration - Grubin type solution - Accurate solution - Point contact - Dimensionless parameters - Film thickness equations - Different regimes in EHL contact - Deep-groove radial bearings - Angular contact bearings - Thrust ball bearings - Geometry - Kinematics - Stress and deformations - Load capacity.

4. Surface Topography – 10 hrs

Surface characterization - Apparent and real area of contact - Derivation of average Reynolds equation for partially lubricated surface - Effect of surface roughness on journal bearings

5. Laws of friction – 10 hrs

Friction theories - Surface contaminants - Frictional heating - Effect of sliding
speed on friction - Classification of wear - Mechanisms of wear - Quantitative laws of wear – Wear resistance materials.

Reference Books:

1. Bharat Bhushan, Introduction to Tribology, Wiley, 2nd Edition, 2013
2. Majumdar, B.C, Introduction to Tribology of Bearings, S Chand, 2008
3. Kenneth C Ludema, Friction. Wear, Lubrication: A Text book in Tribology, CRC Press, 1996.
4. John Williams, Engineering Tribology, Cambridge University Press, 1994.
5. PrasantaSahoo, Engineering Tribology, PHI Learning, 2005
6. Stachowiak& Batchelor, Engineering Tribology", Butterworth – Heinimann, 2005

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Program: PG_Design Engineering		**Semester: II**
Course Title: Mechanical Behaviour of Materials		**Course Code: 20EDGE709**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 50**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 04	**Examination Duration: 3hrs**	

1. Introduction: 10 hrs

Materials in design, The evolution of engineering materials, Fundamental Characteristics of Composites, Interfaces in Composites, Fracture in Composites, 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, Invariant properties, Numerical problems.

2. Plastic Deformation and Dislocation Theory: 10 hrs

Lattice defects, deformation in a perfect lattice, dislocation in crystal and deformation, strain hardening of single crystal, low angle grain boundaries, Stress field of a dislocation, forces between dislocations, dislocation climb and jog, interaction with vacancy and impurity. Multiplication of dislocation and pile-up; Plastic Deformation in Tension, Plastic Deformation in Compression Testing, Plastic Deformation of Polymers.

3. Behavior under Tensile Loading 10 hrs

Engineering and true stress-strain curves, yield point and strain ageing, strength coefficient and strain hardening exponent, necking or instability in tension, Effect of gauge length on strength and elongation, Effect of strain rate and temperature on tensile properties. Yield point phenomenon. Fracture under tension and torsion; Solid-Solution Strengthening, Mechanical Effects Associated with Solid Solutions.

4. Deformation under cyclic loading: 10 hrs

Stress cycle, fatigue curve, fatigue fracture characteristics. Fatigue testing and testing machines, determination of fatigue strength. Factors affecting fatigue- contact under pressure. Under stressing, coaxing and overstressing. Effect of metallurgical impurities;

5. Deformation under high temperature and Super plasticity of Metals: 10 hrs

Creep strain and creep-time curves, low temperature and high temperature creep theories. Fracture at elevated temperature, Stress rupture, Creep-Induced Fracture, Creep in Polymers, Heat-Resistant Materials, Super plasticity, Creep parameters and practical applications. Effect of metallurgical variables and materials for high temperature applications;

Reference Books:

1. Marc Andre Meyers and Krishan Kumar Chawla, Mechanical Behavior of Materials, 2nd Edition, Cambridge University Press, 2009.
2. George Dieter, Mechanical Metallurgy, 3rd Edition, McGraw-Hill, 1988.
3. Norman Dowling, Mechanical behavior of materials engineering methods for deformation, 4th Edition, Prentice Hall, 2012.
4. W F Hosford, Mechanical Behavior of Materials, 1st Edition, Cambridge University Press, 2009.

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Program: PG_Design Engineering		Semester: II
Course Title: Applied Stress Analysis		Course Code: 20EDGE710
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Introduction: 10 hrs

Principal stresses and strains, Three dimensional stress–strain relationships, Plane stress and Plane strain conditions. Strain gauges, Types – Mechanical, Optical and Electrical strain gauges, Electrical resistance strain gauges, Gauge factor, Strain gauge circuitry, Temperature compensation , Bridge balancing and calibration of D.C and A.C bridges.

2. Application of strain gauges: 10 hrs

Transverse sensitivity, Selection and mounting of strain gauges, Strain gauge rosettes, Analysis of strain gauge data and stress calculations, Recording equipments for static and dynamic strains, Strain gauge transducers, Introduction to semiconductor strain gauges, Residual stresses - Beneficial and harmful effects, Principle of residual stress measurement methods.

3. Photo elasticity: 10 hrs

Nature of light, - wave theory of light- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circuclar Polariscopes, Isoclinics Isochromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials.

4. Two Dimensional Photo elasticity Stress Analyses : 10 hrs

Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.

5. Moire Technique: 05 hrs

Geometrical approach, Displacement approach sensitivity of Moire data, data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

6. Non-destructive testing: 05 hrs

Types – Dye penetrate methods, Radiography, X-ray and Gamma ray - X-ray fluoroscopy – Penetrameter - Magnetic particle method, Ultrasonic flaw detection.

Reference Books:

1. Dally and Riley, Experimental Stress Analysis, 2nd Edition, McGraw Hill, 1991
2. L S Srinath, Raghavan, Gargesa and Ramachandra, Experimental Stress Analysis, 2nd Edition, Tata McGraw Hill, 1984.
3. Dr. Sadhu Singh, Experimental Stress Analysis, Fourth edition, Khanna Publishers, 2004.

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Program: PG_Design Engineering		Semester: II
Course Title: Fracture Mechanics		Course Code: 20EDGE711
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Introduction: 05 hrs

History and overview, Fundamental concepts, Fracture mechanics in Metals, Ductile fracture, Cleavage, The Ductile-Brittle transition, Inter-granular fracture, Modes of Fracture Failure;

2. Energy Release Rate: 05 hrs

Introduction, The Griffith energy balance, The energy release rate, Instability and the R-Curve, Thin plate vs Thick plate, Critical Energy release rate;

3. Stress Intensity Factor: 08 hrs

Introduction, Stress analysis of cracks, The stress Intensity Factor, Relationship between K and Global behavior, Effect of Finite size, Principle of superposition, Weight Functions, Relationship between K and G, Crack tip plasticity, Plane stress versus plane strain, K as a failure criterion, Mixed mode fracture

4. Elastic Plastic Fracture Mechanics: 08 hrs

Crack tip opening displacement**,** The J Contour Integral, Relationships between J and CTOD, Crack growth resistance curves, J-controlled fracture, Crack tip constraint under large scale yielding, HRR field;

5. Fracture Toughness testing of metals: 08 hrs

General Considerations, K_{IC} testing, K-R Curve testing, J testing of metals, CTOD testing, Dynamic and crack arrest toughness, Fracture testing of weldments.

6. Fatigue Crack Propagation: 08 hrs

Similitude in fatigue, Empirical fatigue crack growth equations, Crack Closure, Variable amplitude loading and retardation, Growth of short cracks, Micro-mechanisms of fatigue, Experimental measurement of fatigue crack growth, Damage Tolerance.

7. Dynamic and Time-Dependent Fracture 08 hrs

Dynamic Fracture and Crack Arrest, Rapid Loading of a Stationary Crack, Rapid Crack Propagation and Arrest, Crack Speed, Elasto dynamic Crack-Tip Parameters, Dynamic Toughness, Crack Arrest, Dynamic Contour Integrals, Creep Crack Growth, The C* Integral, Short-Time vs. Long-Time Behavior, The Ct Parameter , Primary Creep.

Reference Books:

1. T.L.Anderson, Fracture Mechanics -Fundamentals and Applications, CRC Press, 2nd Edition, 1995.
2. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Education Pvt. Ltd. New Delhi, 2010.
3. David Broek, ArtinusNijhoff , Elementary Engineering Fracture Mechanics, London, 1999.
4. J. F. Knott, Fundamentals of Fracture Mechanics, Bureworth, 2000.
5. C.T.Sun and Z.H.Jin , Fracture Mechanics, Elsevier, 2012.
6. Surjya Kumar Maiti, Fracture Mechanics Fundamentals and Applications, Cambridge University Press, 2015.

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Program: PG_Design Engineering		Semester: II
Course Title: Rotor dynamics		Course Code: 20EDGE712
L-T-P: 4-0-0	Credits: 04	Contact Hours: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 04	Examination Duration: 3hrs	

1. Fluid Film Lubrication: 10 hrs

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.

2. Stability of Flexible Shafts: 10 hrs

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, on-linear problems of large deformation Applied forces, instability of rotors in magnetic field.

3. Critical Speed: 10 hrs

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.

4. Turbo rotor System Stability by Transfer Matrix Formulation: 10 hrs

The 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.

5. Turbo rotor System Stability by Finite Element Formulation: 10 hrs

The general turbo rotor system, generalized forces and co-ordinates system assembly element matrices, consistent mass matrix formulation, lumped mass model, lineared model for journal bearings, system dynamic equations for stability analysis non dimensional stability analysis, unbalance response and transient analysis.

Reference Books:

1. Cameron, The Principles of Lubrication, 3rd edition, John Wiley & Sons Inc, 1978.
2. Bolotin, Nonconservative problems of the theory of elastic stability, Macmillan; Corr, 1963.
3. Peztel, Lockie, Matrix methods of Elastomechanics, McGraw Hill, 1990.
4. Timosenko, Young, Vibration Problems in Engineering D.VanNostrand Company INC.
5. Zienkiewicz, the Finite Element Method, Mcgraw-Hill College, 1987.

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Program: PG_Design Engineering		**Semester: II**
Course Title: Analysis Lab		**Course Code: 20EDGP702**
L-T-P: 0-0-3	**Credits: 03**	**Contact Hours: 80**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 06	**Examination Duration: 2hrs**	

Contents	No. of Sessions
Part-1 Finite Element - Discretization Procedure	
Introduction to Finite Element Method and Altair Hyper works.	01
Hypermesh workbench Getting started with Hypermesh Interacting with panels	01
Geometry Clean up - Theory **Tools used to geometry clean up** **(**Edge edit, Create Surface and Surface edit, Line and Line Edit, Delete …..)	04
2-D mesh Explanation -Theory Auto mesh and Different types of auto mesh Types of 2 D mesh (Ruled, Spline, Rotate……) Quality Parameters checking. Normals and Edge Checking and adjusting.	06
3-D mesh Explanation -Theory Volume mesh Creation Types of 3 D mesh (HexaPenta Type, Tetra mesh……) Quality Parameters checking. Normals and Edge Checking and adjusting.	04
1-D mesh Explanation -Theory Creation of 1 D elements (Bar, Beam Mass….) Creation of Rigid elements (Rbe2 and Rbe3) Creation of Weld elements between two adjacent components.	02
Introduction to **Optistruct solver** Discuss creation of Forces, Boundary conditions, Load steps and output block. Execute **Linear Static Analysis**.	02
Part-2 Finite Element - Analysis Procedures	
Introduction to **Ansys Workbench**	01
Analysis Procedures of **Buckling Analysis** and **Linear Static Analysis**.	01
Modal Analysis (Free Free and Forced Free) and **Thermal Analysis**.	01

Non-Linear Analysis	02
Fatigue Analysis (Stress and Strain Life)	02

Reference Books:

1. Nitin S. Ghokale, Sanjay Deshapande, SanjeevBedekar, “Practical Finite Element Analysis”, Vikas Book house, Pune, 2008
2. Sham Tickoo, “Ansys Workbench 14.0 for Engineers and Designers-,A Tutorial Approach”, Dream Tech Press, 2013
3. Liu G. R. and Quek S. S., “The Finite Element Method” A practical Course, 2nd Edition, Elsevier, 2014.
4. http://148.204.81.206/Ansys/150/ANSYS%20Mechanical%20Users%20Guide.pdf
   http://altairuniversity.com/model-files-for-student-edition-users-accompaniment-to-the-tutorials-in-help/