

GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL (CAD/CAM) (08)/ MECHANICAL (MACHINE DESIGN) (09)

ADVANCED MACHINE DESIGN

SUBJECT CODE: 2710801

M.E. 1ST SEMESTER

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: The course is intended to strengthen fundamentals of applied mechanics of solids and build understanding of design and analysis of machine components under dynamic loading. The course introduces design and analysis of machine components at elevated temperature. The course also includes fundamentals and application of fracture mechanics and surface failures in machine component design.

Teaching and Examination Scheme:

| Teaching Scheme | | | Credits C | Examination Marks | | | | | | Total Marks |
|-----------------|----|---|--------------|-------------------|--------|-----------------|--------|----|----|-------------|
| L | T | P | | Theory Marks | | Practical Marks | | | | |
| | | | ESE (E) | PA (M) | PA (V) | | PA (I) | | | |
| | | | | | ESE | OEP | PA | RP | | |
| 4 | 2# | 0 | 5 | 70 | 30 | 30 | 0 | 10 | 10 | 150 |

Content:

| Sr. No. | Topics | Teaching Hrs. | Module Weightage |
|---------|--|--|------------------|
| 1 | General Design Procedure: Design Philosophies, Design for X: Reliability, Concurrent Engineering, Aesthetics and Ergonomics, Manufacturing and Assembly. | To be covered during Tutorial Session. | 10 |
| 2 | Material Selection: Introduction, General characteristics of machine component applications, Material Selection Factors and Process, Material Selection Charts. | | |
| 3 | Review of Stresses, Strains and Theories of Failures: Introduction, Plane Stress, Rotation of Coordinate Axes, Generalized Plane Stress, Principal Stresses and Maximum Shear Stress, 3D state of stress, Stresses on Octahedral plane, Plane strain, Strain gage rosettes. Introduction to basic Constitutive Relations and Rheological Models: Elastic (Generalized Hooke's Law), Plastic (Rigid-Perfectly Plastic, Elastic-Perfectly, Elastic-Linear Hardening), Creep (Steady state and Relaxation, Transient), Anisotropic and Orthotropic Hooke's Law, Theories of Failures: Distortion Energy, Maximum-Shear Stress, Maximum Normal Stress, Modified Coulomb-Mohr Theory, Comparison of theories of failures. | 12 | 15 |
| 4 | Fracture Mechanics: Introduction, Rise in stresses due to crack, Crack tip opening displacement, LEFM: Effect of crack on strength of ductile and brittle material, Crack opening modes and Griffith theory, Concept of <i>SIF</i> and Crack Tip Plasticity, Use of <i>K</i> in design and analysis, Determination of plastic zone, size and shape, Limitations of LEFM. | 09 | 15 |
| 5 | Fatigue: Introduction, factors affecting fatigue behaviour, Theoretical stress concentration factor and notch sensitivity factor, Fatigue under complex stresses, cumulative fatigue design, Linear damage (Miner's Rule), Manson's | 18 | 25 |

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|---|--|----|----|
| | method, Fatigue crack propagation and life estimation for constant and variable amplitude stress. Strain Based Approach to Fatigue: Strain Vs Life Curve, Mean stress effect, Strain-Life Equation, Life estimate for structural components. | | |
| 6 | Surface Failures: Friction: Rolling, Effect of roughness, velocity and lubrication on friction, Wear: Adhesive, Abrasive and Corrosive, Lubrication: Hydrodynamic, hydrostatic and elastohydrodynamic lubrication, Surface Fatigue, Contact Stresses: Spherical, Cylindrical, General and Dynamic, Surface Fatigue Strength, design to avoid surface fatigue. | 08 | 20 |
| 7 | Creep and Damping: True stress and true strain, Creep phenomenon, Creep Curve, Creep parameters, time-temperature parameters and life estimate: Sherby-Dorn and Larson-Miller, Stress relaxation. Stress-Strain-Time relation, Creep deformation under varying stress, Component stress-strain analysis, Energy dissipation in materials. | 06 | 15 |

Reference Books:

1. Mechanical Behaviour of Materials: Engineering Methods for Deformation Fracture and Fatigue 4^e N E Dowling Pearson.
2. Machine Design: An Integrated Approach 3^e R L Norton Pearson Education.
3. Fundamentals of Machine Design 5^e R C Juvinall & K M Marshek Wiley India.
4. Mechanical Design of Machine Elements and Machines: A failure prevention perspective J A Collins, H Busby and G Stabb Wiley India.
5. Dislocations and Mechanical Behaviour of Materials M. N. Shetty PHI.
6. Mechanical Behaviour of Materials, 2^e T H Courtney McGraw-Hill / Overseas Press India.
7. Metal Fatigue in Engineering R I Stephens, A Fatemi, R R Stephens and H O Fuchs. John-Wiley.
8. Elements of Fracture Mechanics Prashant Kumar McGraw-Hill.
9. Engineering Design Dieter, G McGraw-Hill

Tutorials:

The tutorial component of the course may consist of mixture of performance and study session to include topics.

1. To understand various factors to be considered affecting design process and understand material selection procedure through case studies.
2. Problems related to calculation of stresses and strain along with transformations of basis and Theories of Failures.
3. Study various materials depicting different constitutive relations and understand behaviour of anisotropic and orthotropic materials of composites.
4. Case studies (thin/thick plates and pressure vessels) related to estimation of *SIF* and its use in design.
5. Case Studies related to plastic zone and validation of LEFM.
6. Case studies of Mechanical Components subjected to fluctuating load.
7. Case studies related to complex loading, cumulative damage and strain life approach.
8. Case studies of surface failures in Bearings, Cams and Gears.
9. Study effects of various types of wear mechanisms and effectiveness and suitability of lubrication methods.
10. Study creep mechanism and related parameters
11. Problems related to life estimation theories and design considerations for creep.

Course Outcome:

After learning the course the students should be able to

1. Students will be able to design mechanical components subjected to static loading.
2. Students will be able to design and analyse mechanical components subjected to dynamic loading.
3. For the design and analysis of components students will be able to incorporate effect of crack and creep.