

# MACHINE DESIGN

ENIE 353

Lecture : 3  
Tutorial : 2  
Practical : 0

Year : III  
Part : II

## Course Objectives:

The objective of this course is to develop students with the ability to apply modern design principles to the development of various machine elements. Throughout the curriculum, learners will leverage advanced CAD and CAE tools to facilitate and refine the engineering design process. Furthermore, the course emphasizes the critical analysis of component failure and reliability to ensure mechanical integrity.

### 1 Modern Design Process (4 hours)

- 1.1 Definition, philosophy, general design procedure
- 1.2 General considerations in design of machine elements, synthesis process
- 1.3 Design methodology
- 1.4 Loads acting on machine elements (Static)
- 1.5 Stresses: Bearing pressure, crushing stress, principal stresses
- 1.6 Optimization techniques
- 1.7 Use of AI in design

### 2 Engineering Materials (4 hours)

- 2.1 Material properties: Composites, smart materials
- 2.2 Ashby charts, eco-design
- 2.3 Evaluation methods for material selection
- 2.4 Cost and value analysis
- 2.5 Problem solving and decision making
- 2.6 New product design

### 3 Design Against Failure (5 hours)

- 3.1 Failure theories, fatigue, reliability
- 3.2 Factor of safety (FOS), conditions for selection of FOS
- 3.3 Stress concentration: Concept, causes and remedies to reduce stress concentration
- 3.4 Concept of fatigue, S-N curve and endurance limit
- 3.5 Theories of elastic failures: Maximum principal stress theory and maximum shear stress theory

- 4 Design of Power Transmission through Shaft (8 hours)**
- 4.1 Torsion: Concept, assumptions in theory of pure torsion, torsional equation, angle of twist
  - 4.2 Design of shafts: Types of shafts, shaft materials, standard sizes
  - 4.3 Design of solid and hollow shafts based on strength and rigidity criteria
  - 4.4 Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue, effect of keyway on strength of shaft
  - 4.5 Shaft under fluctuating load and combined loads
  - 4.6 Soderberg approach, Modified Goodman approach, Gerber approach
- 5 Bearings and Lubrication (5 hours)**
- 5.1 Rolling and sliding bearings, selection, tribology
  - 5.2 Bearing life, equivalent bearing load, selection of bearing
  - 5.3 Ball and roller bearings
  - 5.4 Mechanism of lubrication-viscosity, bearing modulus, coefficient of friction
  - 5.5 Minimum oil thickness-heat generated, heat dissipated
  - 5.6 Bearing materials, lubricants and properties
- 6 Design of Belts (4 hours)**
- 6.1 Introduction: Belts, chains, ropes, efficiency analysis
  - 6.2 Open and cross belt
  - 6.3 Flat belt design-belt design
- 7 Gear Design (5 hours)**
- 7.1 Spur, bevel and helical gears
  - 7.2 Design of spur gear, stress in gear tooth, Lewis's equation
  - 7.3 Form factor-dynamic and wear load, failure
- 8 Mechanical Joints and lever (4 hours)**
- 8.1 Welded, riveted, bolted joints, adhesive bonding
  - 8.2 Design parallel and transverse fillet weld subjected to static and dynamic loading
  - 8.3 Rivet joints-types, rivet materials, failure of riveted joints and efficiency
  - 8.4 Eccentric loading of riveted and welded (General design principle)
  - 8.5 Types of levers: First type, second type and third type of levers and its application
- 9 Springs (6 hours)**
- 9.1 Terminology, classification, materials specifications, and applications
  - 9.2 Stresses in helical springs, Wahl's stress factor, deflection of springs

- 9.3 Energy stored in springs
- 9.4 Springs in series and parallel
- 9.5 Design of helical springs
- 9.6 Fatigue life

### Tutorial

**(30 hours)**

1. Simple case study on design and synthesis
2. Select suitable material for a shaft given strength and cost constraints, compare two materials using performance index
3. Explain: Maximum principal stress theory and maximum shear stress theory
4. Calculate fatigue life of a shaft under cyclic loading, determine stress concentration factor for a stepped shaft.
5. Types of shafts and materials and difference between strength and rigidity design.
6. Design shaft under combined bending and torsion and calculate diameter considering fatigue loading.
7. Types of bearings and applications and explain lubrication mechanisms.
8. Design flat belt for given power transmission and calculate belt tensions and length.
9. Design spur gear for given power and speed, calculate dynamic and wear loads
10. Design a riveted joint for given load, analyse eccentric loading in weld
11. Design a helical spring for given load and deflection, calculate energy stored in spring.

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	5
2	4	5
3	5	8
4	8	10
5	5	8
6	4	5
7	5	8
8	4	5
9	6	6
<b>Total</b>	<b>45</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

## References

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2. Dieter, G. E. (1986). Engineering design: A materials and processing approach. McGraw-Hill Education.
3. Hall, A. S., Holowinko, A. R., Laughlin, H. G. (2002). Schaum's outline of theory and problems of machine design. McGraw-Hill Education.
4. Jain, R. K. (2016). Machine design. Khanna Publishers.
5. Juvinall, R. C., Marshek, K. M. (2012). Fundamentals of machine design. John Wiley & Sons.
6. Khurmi, R. S., Gupta, J. K. (2005). A textbook of machine design. S. Chand Publishing.
7. Mahadevan, K., Reddy, B. (2014). Design data handbook. CBS Publishers & Distributors.
8. Norton, R. L. (2013). Machine design. Pearson.
9. Sharma, P. C., Aggarwal, D. K. (2010). Machine design. S. K. Kataria & Sons.
10. Shigley, J. E. (1986). Mechanical engineering design. McGraw-Hill Education.