MACHINE DESIGN I

ENME 353

Lecture	**: 3**	**Year : III**
Tutorial	**: 1**	**Part : II**
Practical	**: 3/2**	

Course Objectives:

The objective of this course is to provide students with fundamental knowledge and essential skills required for the design of commonly used machine elements and to develop their ability to analyze, design and select a wide range of mechanical components and systems effectively for safe, reliable, efficient and economical engineering applications, while strengthening their engineering judgment and problem-solving capabilities.

1 Introduction (2 hours)

- 1.1 Fundamental concept of machine design
- 1.2 Basic steps in the design and synthesis process
  - 1.2.1 Identification of need
  - 1.2.2 Problem definition
  - 1.2.3 Collection of relevant information and functional requirements
  - 1.2.4 Concept development
  - 1.2.5 Evaluation of design alternatives
  - 1.2.6 Design communication
  - 1.2.7 Feedback from manufacturers and users
- 1.3 Communicating the design
  - 1.3.1 Engineering drawings and CAD
  - 1.3.2 Graphs and charts

2 Material Selection for Design (2 hours)

- 2.1 Materials properties
- 2.2 Economics of materials
- 2.3 Evaluation criteria for materials selection
- 2.4 Cost versus performance relations
- 2.5 Cost and value analysis

3 New Product Design (2 hours)

- 3.1 Feasibility studies and assessment
- 3.2 Preliminary design development
- 3.3 Detailed design and engineering analysis

3.4 Planning for manufacturing, distribution and product usage
3.5 Planning for product retirement and end-of-life handling

4 Problem Solving and Decision Making (2 hours)

4.1 Problem-solving process and techniques
4.2 Invention and ideation methods
4.3 Brainstorming
4.4 Problem definition: Needs, goals, constraints, compromises, conditions and evaluation criteria
4.5 Problem-solving stages: Preparation, incubation, inspiration and verification
4.6 Decision matrix method and decision tree analysis

5 Design of Shafts (12 hours)

5.1 Shafts and fatigue failure
5.2 Stress-life method and the S-N diagram
5.3 Design for static loads
5.4 Endurance limit and modifying factors
5.5 Stress concentration and notch sensitivity
5.6 Characterizing fluctuating stresses
  5.6.1 Completely reversed stress
  5.6.2 Fluctuating stress between unequal values
  5.6.3 Fluctuating stress in the same sign (Entirely tension or compression)
5.7 Combination of loading modes (Axial, bending and torsion)
5.8 Failure criterion (Gerber, Soderberg and Goodman)

6 Rolling Contact Bearings (6 hours)

6.1 Bearing types and their classification
6.2 Bearing life, load-life relationship and reliability-life relationship using the Weibull distribution
6.3 Combined radial and thrust loading in bearings
6.4 Bearings under variable loading conditions
6.5 Selection of ball and cylindrical roller bearings
6.6 Selection of tapered roller bearings

7 Lubrication and Journal Bearings (4 hours)

7.1 Types of lubrication, viscosity and viscosity charts
7.2 Petroff's law and stable lubrication (Thick film lubrication)
7.3 Hydrodynamic lubrication theory
7.4 Design considerations for journal bearings
7.5 Minimum film thickness, coefficient of friction, lubricant flow, film pressure and temperature rise

8 Design of Flexible Mechanical Elements (10 hours)

8.1 Flat belts
8.2 V-belts
8.3 Timing belts
8.4 Chain and sprocket drive
8.5 Wire rope

9 Force Analysis of Gears (5 hours)

9.1 Basic concepts of gears: types, nomenclature, involute properties, conjugate action, contact ratio, interference, gear tooth formation, tooth systems and gear trains
9.2 Force analysis
9.3 Spur gearing
9.4 Helical gearing
9.5 Bevel gearing
9.6 Worm gearing

Tutorial (15 hours)

1. Case study on any mechanical engineering design problem (Design methodology, decision-making process and product development stages)
2. Numerical problems on design of shafts (Variable loading problems as well as Shaft layout design) covering all the topics in the syllabus
3. Numerical problems on rolling contact bearings covering all the topics in the syllabus
4. Numerical problems on journal bearings covering all the topics in the syllabus
5. Numerical problems on design of flexible mechanical elements covering all the topics in the syllabus
6. Numerical problems on force analysis of gears covering all the topics mentioned in the syllabus

Practical (22.5 hours)

1. Problems related to the design of shafts (Iterative design problems), covering shaft layout using any computational tools
2. Problems related to the design of rolling contact bearings (Iterative design problems) using any computational tools
3. Problems related to the design of journal bearings (Iterative problems concerned with temperature rise) using any computational tools
4. Problems related to the design of flexible mechanical elements (Multi-options design problem) using any computational tools
5. Problem on a simple power transmission system design comprising shafts, bearings and flexible mechanical elements

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	Mark distribution*
1 and 2	4	6
3 and 4	4	6
5	12	16
6	6	8
7	4	5
8	10	12
9	5	7
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Ullman, D. G. (1997). The mechanical design process (Latest Edition). McGraw-Hill Education.
2. Davidson, J. (1988). The reliability of mechanical systems (Latest Edition). Institution of Mechanical Engineers.
3. Budynas, R. G., Nisbett, J. K. (2011). Shigley's mechanical engineering design. McGraw-Hill Education.
4. Mott, R. L., Vavrek, E. M., Wang, J. (2017). Machine elements in mechanical design. Pearson.
5. Dieter, G. E., Schmidt, L. C. (2013). Engineering design. McGraw-Hill Education.
6. Spotts, M. F. (2003). Design of machine elements. Pearson.