Machine Design 1

1. **Course number and name:** 020CM1ES3 Machine Design 1

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours per week

3. **Name(s) of instructor(s) or course coordinator(s):** Ali AL Shaer

4. **Instructional Materials:** PowerPoint slides

   Textbooks/References:
   - Machine Design: An Integrated Approach, Robert L. Norton, 4th edition, Pearson international, ISBN 978-0-13-138438-5.
   - Shigley's Mechanical Engineering Design, Richard G. Budynas and J. Keith Nisbett, eleventh edition, Mc Graw Hill, ISBN-13 978-0073398211.
   - Mechanics of Materials. R. C. Hibbeler, tenth Edition, Prentice Hall, ISBN-13 978-0134319650.
   - Design of Machinery – An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L. Norton, fourth edition, Mc Graw Hill, ISBN 978-0-07-312158-1

5. **Specific course information**
   a. **Catalog description:**
   This course covers fundamental mechanical design topics, such as static and fatigue failure theories, analysis of shafts, bearings and gears. In addition to fatigue failure criteria and S-N diagrams, it also covers surface failure, contact stresses, and static and fatigue stress concentrations. The students learn to design the common elements of the machines which are studied by emphasizing their behavior under static and dynamic loads. The elements concerned in this course are represented by the transmission shaft, the keys and the couplings, the bearings and lubrication, and the spur gears.

   b. **Prerequisites:** Mechanical Systems (020SMEES1) and Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

   c. **Required** for ME students.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   A student who successfully fulfills the course requirements will have demonstrated an ability to:
   - Discuss the solution of problems where several internal loads (axial load, torsion, bending and shear) occur simultaneously on a member's cross section.
   - Compute maximum normal and maximum shear stresses using stress transformation equations and Mohr's circle.
   - Study the static failure theories of materials and fracture mechanics.

- Develop an understanding of the general design process and the fundamentals of a good design.
- Develop an understanding of static and dynamic modes of failure of machine parts exposed to uni-axial and multi-axial stresses.
- Develop an understanding of the fundamental principles of surface fatigue.
- Study the different fatigue failure criteria for single and combined loadings.
- Design of basic machine elements such as shafts, gears, and bearings to meet desired needs.

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.3	3.2
Covered	x	x	x	x	
Assessed	x	x	x	x	x

7. Brief list of topics to be covered

- **General Introduction:** Introducing machine design and what are the required steps to do a complete design of machine's components. (1 Lecture).
- **Chapter 1: Combined Loading**: Combined loadings – State of stress caused by combined loading. (2 Lectures).
- **Chapter 2: Stress Transformation:** Plane stress transformation – General equations of plane stress transformation – Principal stresses and maximum in-plane shear stress – Mohr's circle (plane stress) – Absolute maximum shear stress – General case: Three-dimensional state of stress. (3 Lectures).
- **Chapter 3: Static Failure Theories and Stress Concentration:** Failure of ductile materials under static loading – Failure of brittle materials under static loading – Stress concentration factors and fracture. (4 Lectures).
- **Chapter 4: Fatigue Failure Theories:** Mechanism of fatigue failure – Fatigue failure models – Fatigue loads – Measuring – Fatigue failure criteria – Estimating fatigue failure criteria – Notches and stress concentration – Residual stresses – Designing for high cycle fatigue – Designing for fully reversed uniaxial stresses – Designing for fluctuating uniaxial stresses – Designing for multiaxial stresses in fatigue – A general approach to high cycle fatigue. (4 Lectures).
- **Chapter 5: Surface Failure:** Surface geometry – Mating surfaces – Friction – Adhesive wear – Abrasive wear – Corrosion wear – Surface fatigue – Surface fatigue failure models. (2 Lectures).
- **Chapter 6: Shafts, keys, and Couplings:** Shaft design – Shaft deflection – Keys and keyways – Splines – Interference fits – Couplings. (3 Lectures).
- **Chapter 7: Bearings and Lubrication:** Lubricants – Viscosity – Types of lubrications – Material combination in sliding bearings – Hydrodynamic lubrication theory – Design of hydrodynamic lubrications – Rolling element bearings – Failure of rolling element bearings – Selection of rolling element bearings. (3 Lectures).
- **Chapter 8: Spur Gears:** Gear tooth theory – Gear tooth nomenclature – Interference and undercutting – Contact ratio – Gear trains – Gear manufacturing – Loading on spur gears – Stresses in spur gears – Gear materials – Lubrication of gearing – Design of spur gears. (2 Lectures).