Selection and Properties of Materials

1. **Course number and name:** 020SPMES4 Selection and Properties of Materials

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 Harkous

4. **Instructional Materials:** PowerPoint slides; Videos.

   Textbooks/References:
   - Materials Selection in Mechanical Design, 5th edition, M.F. Ashby, Butterworth-Heinemann, Elsevier, 2016.
   - Materials and Process Selection for Engineering Design, 4th edition, M. Farag, CRC Press, 2020.
   - Materials Selection and Design, M.A. Maleque, Springer, 2013.
   - Materials Science and Engineering: An Introduction, 9th edition, W.D. Callister, Wiley, 2014.

5. **Specific course information**
   a. **Catalog description:**
   This course deals with the relation between the properties of the materials and the selection procedure during engineering applications. It starts by reviewing the relation between the structure and the properties of a material, the mechanical behavior showing the different types of deformation behavior, and the failure types including fracture, fatigue, creep, and corrosion. Then, it lists the different properties of engineering materials and details their graphical presentation. Then, it introduces the strategy of selection following manual and computer-aided methods. It studies the selection procedure for applications having multiple constraints and conflicting objectives and treats several examples of simple and multiple selection problems. It also discusses the importance of the material-shape relation during selection operation.

   b. **Prerequisite:** Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

   c. **Selected Elective** for ME students.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   - Select appropriate materials for various engineering applications.
   - Analyze the mechanical behavior of materials and identify the different types of deformation.
   - Distinguish the different types of failure and describe their principles and related tests.
   - Recognize the families of materials and the global properties for common ones.
   - Read and analyze the material property charts.

- Explain the importance of the selection in the design.
- Apply the selection procedure.
- Use “Ansys Granta Edupack” software.
- Treat selection with multiple constraints and conflicting objectives.
- Consider the Material-Shape combinations when selecting a material.

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.1	2.2	2.3	7.1	7.2
Covered	x	x	x	x	x	x	x	x
Assessed	x	x	x	x	x	x	x	x

7. Brief list of topics to be covered

- **Chapter 1: Introduction and Review of Basic Concepts:** Historical Perspective – Materials Science and Engineering: The relation between process-structure-properties and performance – Why to study Materials Science and Engineering? – Classification of Materials – Advanced Materials. (2 Lectures).
- **Chapter 2: Review of the Mechanical Properties of Metals:** Mechanical Behavior: Concepts of stress and strain – Properties related to elastic deformation – Properties related to plastic deformation – Property variability and design/safety factors. (2 Lectures).
- **Chapter 3: Mechanical Failure of Materials:** Fracture (Fundamentals of Fracture; Ductile fracture; Brittle fracture; Principles of fracture mechanics; Fracture toughness testing) – Fatigue (Cyclic stresses; The S-N curve; Crack initiation and propagation; Factors that affect fatigue life; Environmental effects) – Creep (Generalized creep behavior; Stress and temperature effects; Data extrapolation methods; Alloys for high-temperature use). (4 Lectures).
- **Chapter 4: Material Property Charts:** Materials Information for Design – Material properties and their units (General properties; Mechanical properties; Thermal properties; Electrical properties; Optical properties; Eco-properties) – Exploring Material Property Charts – The Material Property Charts. (4 Lectures).
- **Chapter 5: Materials Selection - The Basics:** The Importance of Materials Selection – Relation to Design – Product Analysis – The Selection Strategy – Material Indices – The Selection Procedure – Computer-aided Selection – The Structural Index. (3 Lectures).
- **Chapter 6: Case Studies: Materials Selection:** Materials for Oars – Mirrors for Large Telescopes - Materials for Table Legs - Cost: Structural Materials for Buildings – Materials for Flywheels – Materials for Springs – Elastic Hinges and Couplings - Materials for Seals – Deflection-limited Design with Brittle Polymers – Safe Pressure Vessels – Stiff, High-damping Materials for Shaker Tables – Insulation for Short-term Isothermal Containers – Energy-efficient Kiln Walls – Materials for Passive Solar Heating – Materials to Minimize Thermal Distortion in Precision Devices – Materials for Heat Exchangers – Heat Sinks for Hot Microchips – Materials for Radomes. (3 Lectures).

- **Chapter 7: Multiple Constraints and Conflicting Objectives:** Selection with Multiple Constraints – Conflicting Objectives. (1 Lecture).
- **Chapter 8: Case Studies: Multiple Constraints and Conflicting Objectives**: Multiple Constraints: Light Pressure Vessels – Multiple Constraints: Con-rods for High-performance Engines – Multiple Constraints: Windings for High-field Magnets – Conflicting Objectives: Table Legs – Conflicting Objectives: Wafer-thin Casings for Must-have Electronics – Conflicting Objectives: Materials for a Disk-brake Caliper. (3 Lectures).
- **Chapter 9: Selection of Material and Shape**: Shape Factors – Limits to Shape Efficiency – Exploring Material-shape Combinations – Material Indices that include Shape – Graphical Co-selecting Using Indices – Architectured Materials: Microscopic Shape. (2 Lectures).