Advanced Strength of Materials

1. **Course number and name:** 020RMAES4 Advanced Strength 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 AL Shaer

4. **Instructional Materials:** PowerPoint slides

   Textbooks/References:
   - Mechanics of Materials. R. C. Hibbeler, tenth Edition, Prentice Hall, ISBN-13 978-0134319650.
   - Mechanics of Materials. Roy R. Craig, JR., 4th Edition,Wiley, ISBN-13 978-1119612384.
   - Advanced Strength and Applied Elasticity. Ansel .C.Ugural and Saul .K Fenster. 4th edition - Prentice Hall, ISBN-13 978-0130473929.

5. **Specific course information**
   a. **Catalog description:**
   This course concerns the study of stresses due to combined loadings, deflection of beams, principal stresses, absolute maximum shear stress, experimental determination of deformation, buckling of columns, and static failure theories. It brings students to deal with statically indeterminate problems, which are the most present in reality and impossible to solve using only statics. It develops different resolution methods (by integration, superposition, Clapeyron) to determine the reactions at the supports of statically indeterminate members under tension, torsion, bending, and buckling. It also deals with the virtual work theorem, energy methods, static failure theories, three-dimensional state of stress and Mohr's circle in addition to stresses in thin-walled pressure vessels, composite and curved beams, shear centres, and asymmetric bending. It deals also with the plastic analysis of bars, beams, and shafts with elastic perfectly plastic material and two-dimensional problems in elasticity.

   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:**
   A student who successfully fulfills the course requirements will have demonstrated an ability to:
   - Make analysis of stress developed in thin-walled pressure vessels.

- 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 stress and strain and find the orientation of elements upon which they act.
- Study the static failure theories of materials.
- Determine deflections of beams and frames when they are submitted to loads using stiffness and energy methods.
- Solve the support reactions on beams, shafts, or rods that are statically indeterminate.
- Study the buckling of columns (elastic stability).
- Determine bending stresses in composite sections, curved beams, and in case of asymmetric bending.
- Determine the location of shear center for open sections.
- Determine residual stresses due to axial, torsional, and bending loadings for elastic perfectly plastic material.
- Determine the stress fields in two-dimensional problems in elasticity.

b. PI addressed by the course:

PI	1.3
Covered	x
Assessed	x

7. Brief list of topics to be covered

- **General Introduction:** Why we need to learn notions from advanced strength of materials and how these notions can be served or employed in other courses such as machine design courses. (1 Lecture).
- **Chapter 1: Combined Loading**: Thin-walled pressure vessels – Combined loadings – State of stress caused by combined loading. (4 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 (4 Lectures).
- **Chapter 3: Strain Transformation:** Plane strain transformation – General equations of plane strain transformation – Principal strains and maximum in-plane shear strain – Mohr's circle (plane strain) – Absolute maximum shear strain – Strain rosettes – Material-property relationships – Static failure theories. (4 Lectures).
- **Chapter 4: Deflection of Beams and shafts:** The elastic curve – Slope and displacement by integration – Area-moment Method – Method of superposition – Statically indeterminate beams and shafts – Statically indeterminate beams and shafts (Method of superposition) – Examples. (5 Lectures).
- **Chapter 5: Energy Methods:** Work done in deformation – Reciprocity Theorem – Castigliano's Theorem – Crotti-Engesser Theorem – Statically indeterminate systems – Principle of virtual work – Principle pf minimum potential energy (4 Lectures).

- **Chapter 6: Buckling of Columns:** Critical load – Ideal column with pin supports – Columns having various types of supports. (2 Lectures).
- **Chapter 7: Shear center, bending of composite** and **curved beams,** and **Asymmetrical bending** (4 Lectures).
- **Chapter 8: Residual Stresses for Elastic Perfectly Plastic Material:** Normal residual stresses in axially loaded members – Residual bending stresses in straight beams – Residual shear stresses in torque loaded members. (4 Lectures).