Mechanics of Composite Materials

1. **Course number and name:** 020MMCES4 Mechanics of Composite 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

   Textbook/Reference:
   - Mechanics of Composite Materials, A. K. Kaw, 2nd edition, Taylor and Francis, ISBN-13: 978-0-8493-1343-1.

5. **Specific course information**
   a. **Catalog description:**
   This course focuses on anisotropic elasticity and laminate theory, analysis of various members of composite materials, energy methods, failure theories, and micromechanics. Materials and fabrication processes are introduced.

   a. **Prerequisites:** Introduction to Materials Science (020ISMNI2) and Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

   b. **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:
   - Define a composite, enumerate advantages and drawbacks of composites over monolithic materials, and discuss factors that influence mechanical properties of a composite.
   - Develop stress–strain relationships for a unidirectional/bidirectional lamina and find the engineering constants of a unidirectional/bidirectional lamina in terms of the stiffness and compliance parameters of the lamina.
   - Develop stress–strain relationships, elastic moduli, strengths, and thermal and moisture expansion coefficients of an angle ply based on those of a unidirectional/bidirectional lamina and the angle of ply and find the nine mechanical and four hygro-thermal constants: four elastic moduli, five strength parameters, two coefficients of thermal expansion, and two coefficients of moisture expansion of a unidirectional lamina from the individual properties of the fiber and the matrix, fiber volume fraction, and fiber packing.
   - Find the elastic moduli of laminate based on the elastic moduli of individual laminae and the stacking sequence.

- Develop formulas to find the deflection and stresses in a symmetric and nonsymmetric beams that are narrow and wide, and made of composite materials.

b. PI addressed by the course:

PI	1.1	1.2	1.3	7.1	7.2
Covered	x	x	x	x	x
Assessed					

7. Brief list of topics to be covered

- **Introduction to composite materials:** Introduction – Classification (Polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon-carbon composites) – Recycling fiber-reinforced composites – Mechanics terminology – Exercises. (4 Lectures).
- **Macro-mechanical analysis of a lamina:** Introduction – Stress – Strain – Elastic moduli – Strain energy – Hooke's law for different types of materials (Anisotropic material, monoclinic material, orthotropic material, transversely isotropic material, isotropic material – Hooke's law for a two-dimensional unidirectional lamina (Plane stress assumption, Reduction of Hooke's law in three dimensions to two dimensions, relationship of compliance and stiffness matrix to engineering elastic constants of a lamina) – Hooke's law for a two-dimensional angle lamina (Engineering constants of an angle lamina, relationship of compliance and stiffness matrix to engineering elastic constants of an angle lamina) – Strength failure theories of an angle lamina – Exercises. (5 Lectures).
- **Micro-mechanical analysis of a lamina:** Introduction – Evaluation of the four elastic moduli - Ultimate strengths of a unidirectional lamina – Coefficients of thermal expansion – Coefficients of moisture expansion – Exercises. (3 Lectures).
- **Macro-mechanical analysis of laminates:** Introduction – Laminate code – Stress-strain relations for a laminate – In-plane and flexural modulus of a laminate – Hygro-thermal effects in a laminate – Exercises. (4 Lectures).
- **Failure, analysis, and design of laminates:** Introduction – Special cases of laminates – Failure criterion for a laminate – Design of a laminated composite – Other mechanical design issues – Exercises. (4 Lectures).
- **Bending of beams:** Introduction – Symmetric beams – Non-symmetric beams – Exercises. (4 Lectures).
- **Applications using PROMAL software:** This software will allow students to design laminated composite structures (4 Lectures).