Mechanical Systems

1. **Course number and name:** 020SMEES1 Mechanical Systems

2. **Credits and contact hours:** 6 ECTS credits, 3x1:15 contact hours per week

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

4. **Instructional Materials:** PowerPoint slides

   Textbooks/References:
   - 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.
   - Theory of Machines and Mechanisms, Uicker, Pennok, Shigley. Willey, 3rd edition. ISBN13: 9780195155983.
   - Systèmes mécaniques, théorie et dimensionnement, M. Aublin et Al., Dunod, Paris, 1992. SBN-13: 978-2100815876.

5. **Specific course information**
   a. **Catalog description:**
   This course allows students to establish the link between solid kinematics and mechanical construction. It covers the modeling and resolution of problems relating to mechanisms made of non-deformable/rigid bodies: bar-linkages and associated kinematics, kinematic diagram, parameterization, analysis of operation, determination of equations of motion (positions, speeds and accelerations), calculation of the forces applied to the parts and the generated and dissipated mechanical energies. It also introduces students to the fundamentals and principles of multi-bar connections, gears and cams. Modeling of several bar systems on SolidWorks will be carried out in order to study and visualize the movements of the mechanisms.

   b. **Prerequisites:** Computer Assisted Drawing (020DAMCI4 or 020DAMNI4) and Mechanics 2 (020MC2CI3 or 020MC2NI3).

   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:
   - Identify the concept of kinematics and dynamics of machinery in respect to the analysis of mechanisms so that their rigid body behavior is determined.
   - Design a four-bar linkage that provide a required output motion.
   - Understand the concepts of position, velocity, and acceleration that enable to study the motion of linkages.

- Develop the concept of inverse dynamics so that forces and torques are determined in machines.
- Understand the gear tooth, cams and followers' theory, choose gear types and design gears, cams and followers.
- Show how to balance rotating members, reciprocating elements, and also elements having complex motion

b. PI addressed by the course:

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

7. Brief list of topics to be covered

- **Chapter 1: Introduction:** Kinematics and kinetics – Mechanisms and machines – Design process – Human factors – Engineering report. (1 Lecture).
- **Chapter 2: Kinematics Fundamentals:** Degree of mobility/freedom in two dimensions – Types of motion – Links – joints – Kinematics chains – Mechanisms and structures – Synthesis number – Kinematics schema – Inversion – Four bar linkages – Grashof condition – Practical considerations – Electric motors – Applications. (7 Lectures).
- **Chapter 3: Graphical Synthesis of Mechanical Systems:** Toggle positions – Stationary positions – Transmission angles – Two positions graphical syntheses – Three positions graphical syntheses – Different types of motion – Coupler curves of four bar linkages. (6 Lectures).
- **Chapter 4: Position, Velocity, and Acceleration Analyses:** Graphical and analytical position, velocity, and acceleration analyses for different types of motion – Applications. (14 Lectures).
- **Chapter 5: Cams, Followers, Gears and Gears-Trains:** Definition and design of cams and followers - Definition and design of gears and gear-trains – Efficiency - Applications. (4 Lectures).
- **Chapter 6: Dynamics Analysis and Balancing:** Dynamic modeling – Principle of D'Alembert – Energy methods – Principle of virtual work – Calculation of forces and moments – Statics and dynamics equilibrium – Correction of unbalancing – Applications. (4 Lectures).
- **Chapter 7: Spatial Kinematics and Kinetics**: Different types of motion – Velocity and acceleration – Generalized coordinates – Generalized forces of inertia. (4 Lectures).
- **Introduction to SolidWorks**: Applications on four-bar linkage. (2 Lectures).