Turbomachines

1. **Course number and name:** 020TRBES3 Turbomachines

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

3. **Name(s) of instructor(s) or course coordinator(s):** Bassam Riachi

4. **Instructional Materials:** Hydraulic and compressible flow turbomachines, Sayers A. T., 1990.

   Textbooks/References:
   - Gas turbine theory, Cohen H., 2013.
   - Principles of turbomachinery, Seppo A. Korpela 2011.

5. **Specific course information**
   a. **Catalog description:**
   This course provides an overview of the latest technologies and developments in turbomachinery, as well as the diversity of their applications. It aims to make students aware of the potentials and specificities of the application of different turbomachines in the engineering world, from aviation to industrial machinery. In this course the following topics are covered: technology, operation, design and analysis of incompressible turbomachines such as centrifugal and axial flow pumps, impulse (Pelton) turbines and reaction turbines (Francis and Kaplan), as well as compressible flow turbomachines, such as: centrifugal and axial flow compressors, fans and blowers, axial and radial flow gas turbines, and steam turbines. Positive displacement pumps are also covered.

   b. **Prerequisite:** None.

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

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   By the end of the course, the students will be able to:
   - List and describe different types of turbomachines and their components.
   - Apply fundamental theories and equations to solve turbomachinery engineering problems.
   - Analyze the performance of turbomachines and their operating modes.
   - Design and model radial and axial flow hydraulic machines, compressors and gas turbines.
   - List and describe different types of positive displacement hydraulic machines (pumps and motors) and their components.
   - Apply fundamental theories and equations to solve positive displacement pumps problems.

b. PI addressed by the course:

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

7. Brief list of topics to be covered

- **Part A: Incompressible (hydraulic) flow turbomachines:** Course introduction, Basic laws and equations, **Centrifugal (radial) and axial flow pumps:** principle of operation, Euler equation, velocity diagrams, slip factor, power and efficiencies, pump characteristics, cavitation, affinity laws and specific speed, flow regulation, impeller trimming. **Hydraulic turbines:** Pelton, Francis and Kaplan turbines: principle of operation, Euler equation, velocity diagrams, characteristics and cavitation, powers and efficiencies. **Hydraulic clutches and converters:** principle of operation. (8 Lectures).
- **Part B: Positive displacement hydraulic pumps (PDP):** Types of PDP: gear, screw, vane, and piston pumps, principle of operation, pump displacement, flow rate, torque, power and efficiencies, characteristics, pressure relief valves and their characteristics, case study: aircraft hydraulic pumps. (4 Lectures).
- **Part C: Compressible flow turbomachines: Centrifugal compressors and fans:** types, components and principle of operation, Euler and energy equations, velocity diagrams, characteristics and operation limitations (surge and stall). **Axial flow compressors:** principle of operation, Euler and energy equations, velocities limitations, velocity diagrams (superimposed diagrams), reaction ratio, stage loading and flow coefficient, compressor aerodynamics (blade cascades, drag and lift), blade and stage efficiencies, three-dimensional flow, multi-stage performance, compressor characteristics and operation limitations. **Axial flow steam and gas turbines:** turbine stage, Euler and energy equations, velocity diagrams (superimposed diagrams), stator (nozzle) and rotor losses (Soderberg coefficients), reaction ratio and its effect on turbine efficiency, impulse versus reaction turbines, axial thrust, blade types, blade cooling, turbine governing, turbine characteristics. **Radial flow gas turbines:** principle of operation, turbo-compressors, Euler and energy equations, velocity diagrams, spouting velocity, turbine efficiency, dimensionless specific speed. (12 Lectures).