Robotics

1. **Course number and name:** 020ROBES5 Robotics

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

3. **Instructor's or course coordinator's name:** Roy Abi Zeid Daou

4. **Instructional Materials**: Introduction to Robotics, Mechanics & Control, J Craig, 3rd Edition, Pearson-Prentice Hall, 2005.

5. **Specific course information:**
   a. **Catalog description:**
      This course aims to introduce some theoretical and practical fundamentals of robotics engineering related to electrical and mechanical domains. The concept of robotics is introduced starting from the sensors, actuator and closed loop representation, going through dynamics and kinematics equations, and reaching control of robots using linear, non-linear, and adaptive controllers. Concepts of dynamic response related to vibration and motion planning will be presented. The principles of operation of various actuators will be discussed, including pneumatic, magnetic, piezoelectric, linear, stepper, etc. Advanced feedback mechanisms will be implemented using software executing in an embedded system. The concepts for real-time processor programming will be also introduced. Image processing and artificial intelligence will also be presented in this course. Neural networks and advanced controllers will be shown along with their implementation using microcontrollers and/or software based (MATLAB, LabVIEW, etc.) will also be emphasized in this course.

   b. **Prerequisite:** None.

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

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
      At the end of this course, students should be able to:
      - Model a robot using dynamic and kinematic equations.
      - Have knowledge about trajectory planning and following.
      - Make basic image processing techniques (filtering and edge detection) using MATLAB.
      - Determine the essential part of any robotic system (actuators, sensors, and control's processor).
      - Apply fundamentals of robotics on any electro-mechanical machinery.

b. PIs addressed by the course:

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

7. Brief list of topics to be covered

- **Introduction, historical evolution of robotics, importance of robotics in today's life, some real-life examples of robotics in several engineering domains (2 Lectures)**
- **Main components of robotics: sensors and actuators (3-4 Lectures)**
  - Robot mechanical system (links, bearings, shafts, gearboxes, grippers)
  - Robot power system (electrical, pneumatic and hydraulic motors)
  - Internal sensing (position, velocity, acceleration, force)
  - External robot sensing (proximity sensors, range finders, tactile sensors, vision)
- **Robot control systems (1 Lecture)**
  - User specifications
  - Software & Hardware control implementation
- **Robot kinematics (2 Lectures)**
  - Joint and Cartesian space
  - Homogenous transformation
  - Denavit-Hartenberg notation
  - Direct and inverse kinematics solution
- **Robot dynamics (2 Lectures)**
  - Euler-Lagrange formulation
  - Joint and Cartesian forces
- **Robot trajectory planning (1 Lecture)**
- **Controllers design (5-6 Lectures)**
  - Basic linear controllers; Nonlinear controllers; Adaptive controllers
  - Artificial intelligence and control
  - Prediction and estimation
  - MATLAB/LabVIEW implementation
- **Image processing (4 Lectures)**
  - Basic image processing techniques
  - Edge detection techniques
  - Image clustering
  - MATLAB implementation
- **Safety system robots (3-4 Lectures)**
  - Electrical safe system
  - Software safe system
  - ISO / IEC norms
  - xOOy (x Out Of y) architecture
- **Fault analysis (1-2 Lectures)**