Course Title: Introduction to Robotics
Credit Structure (L-T-P-Cr): (3-0-2-4)
Prerequisites (not mandatory): Linear Algebra, Programming, Analog Circuits, etc.

Course Objective: This course will give an opportunity to students to enhance their skills in the field of robotics which includes coding, AI/ML, embedded system computing, etc. Students will gain understanding on robotics architecture, sensors and actuators applications, vehicles automation, and robot-operating-system (ROS) which are required for practical implementation of a robot. Students will acquire skills in robotics using Python and C++ to become a good roboticist.

Industry Relevance: Today, world leading companies such as Google, Amazon, Boston Dynamics, Softbank, DENSO, Disney, HONDRA, Hyundai, etc., are looking for the people who are expertise in the areas of robotics and automation. This program will provide a platform to develop skills for which companies are interested to hire professionals.

Course Content: This course lets students to build a light robot from scratch. Students will acquire the knowledge on coordinate transformations, D-H parameters, kinematics, dynamics, control, robotics graphics, AI/ML and SLAM with special focus on humanoid robotics. The course involves in robot programming with Python and C++, robotics architectural design, and applications. The course consists of two parts which are (i) interactive lecture section, (ii) lab exercises on ROS which will provide a platform to develop a real robot from scratch, and a project for application specific robot development.

Classroom Lecture: Google Meet complemented with Google Classroom

1. Introduction
   - Course Overview, History of Robotics, Robot Arm, Kinematic Structure of Human Arm and Humanoid Robot
2. Coordinate Transformation
   - Coordinate Frames, Rotation Matrix, Translations, Euler Angles, Quaternion
3. Forward Kinematics
   - Homogeneous Transform, Compound Transformations, Jacobians, Denavit-Hartenberg (D-H) Parameters
4. Inverse Kinematics
   - Inverse Kinematics for Position/Orientation/Velocities, Redundancy, Singularities
5. Robot Dynamics
   - Equation of Motion, Euler-Lagrange Formulation, Newton-Euler Formulation
6. Motion Control and Machine Vision
   - Sensors, Actuators, Control Overview, Joint Space Control, PD Control, PID Control, Trajectory Generation, Cartesian Planning, Visual Servoing, Vision-based Robot Control
7. Humanoid Robotics
   - Zero-Moment Point (ZMP), Center of Mass (CoM), Humanoid Robot Stabilization, Kalman Filter, Preview Control
8. AI/ML for Robotics
   - PoseNet, Localization, Filters, Search, SLAM (Simultaneous Localization And Mapping), AI/ML-based Control Architecture, Reinforcement Learning
9. Advanced Topics
   - High-Performance Robotics Computing, Robotics IoT, Robotics Cloud, Robotics Grid Computing, Robotics Apps, etc.
**Lab Exercises:** Robot Operating System (ROS) and Its Applications
- Tutorial 1: Start a ROS Master Node (roscore)
- Tutorial 2: Understanding ROS Topics, Nodes and Messages
- Tutorial 3: ROS Publisher and Subscribers in C++ and Python
- Tutorial 4: ROS PID Controller
- Tutorial 5: ROS Localization (Machine Vision)
- Tutorial 6: Navigation and SLAM (AI/ML)

**Course Project:** Project implementation in ROS will be based on reference of IEEE paper.

**Lab Information:** Practical will be carried out using Robot-Operating-System (ROS). Please download and install the software on your computer/laptop.
[1] ROS Installation [https://www.youtube.com/watch?v=ehtUb55Rmmg&list=PLk51HrKSBQ8-jTqD0qgR1vmQeVSJ5SQc](https://www.youtube.com/watch?v=ehtUb55Rmmg&list=PLk51HrKSBQ8-jTqD0qgR1vmQeVSJ5SQc)
[2] Materials on ROS website:

**Suggested Textbook**

**Related resources**
[1] Essence of Linear Algebra: [https://www.youtube.com/playlist?list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab](https://www.youtube.com/playlist?list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab)

**Course Evaluation Policy**
- Mid-Sem Exam: 25%
- End-Sem Exam: 35%
- Labs: 20%
- Project: 10%
- Assignments and Quizzes: 10%
- **Total:** 100%