(BM-423) - Introduction to Robotics

Course Outline:

Theory:

1. **Fundamentals**
    1. What is a Robot?
    2. Classification of Robots.
    3. What is Robotics?
    4. History of Robotics.
    5. Advantages and Disadvantages of Robots.
    6. Robot Components.
    7. Robot Degrees of Freedom.
    8. Robot Joints.
    9. Robot Coordinates.
    10. Robot Reference Frames.
    11. Programming Modes.
    12. Robot Characteristics.
    13. Robot Workspace.
    14. Robot Languages.
    15. Robot Applications.
    16. Other Robots and Applications.
    17. Social Issues.
2. **Robot Kinematics**
    1. Position Analysis.
    2. Robots as Mechanisms.
    3. Matrix Representation.
    4. Homogeneous Transformation Matrices.
    5. Representation of Transformations.
    6. Inverse of Transformation Matrices.
    7. Forward and Inverse Kinematics of Robots.
    8. Denavit-Hartenberg Representation of Forward Kinematic Equations of Robots.
    9. The Inverse Kinematic Solution of Robots.
    10. Inverse Kinematic Programming of Robots.
    11. Degeneracy and Dexterity.
    12. The Fundamental Problem with the Denavit- Hartenberg Representation.
    13. Differential Motions and Velocities.
3. **Differential Relationships**
    1. Jacobian.
    2. Differential Motions of a Frame.
    3. Interpretation of the Differential Change.
    4. Differential Changes between Frames.
    5. Differential Motions of a Robot and Its Hand Frame.
    6. Calculation of the Jacobian.
    7. How to Relate the Jacobian and the Differential Operator.
    8. Inverse Jacobian.
    9. Design Project.
    10. Dynamic Analysis and Forces.
4. **Lagrangian Mechanics**
    1. A Short Overview.
    2. Effective Moments of Inertia.
    3. Dynamic Equations for Multiple-Degree-of-Freedom Robots.
    4. Static Force Analysis of Robots.
    5. Transformation of Forces and Moments between Coordinate Frames.

6. Design Project.

5. **Trajectory Planning**
    1. Path vs. Trajectory
    2. Joint Space vs. Cartesian-Space.
    3. Basics of Trajectory Planning.
    4. Joint space trajectory planning,
    5. Cartesian space trajectories.
6. **Application of Robotic in BME**
    1. Introduction to medical robotics
    2. Mechanisms for medical robots
    3. Sensing for medical robots
    4. Actuators for medical robots
    5. Controls for medical robots
    6. Interfaces for medical robots

List of Practicals:

1. Introduction to the Rhino
2. The Tower of Hanoi
3. Forward Kinematics
4. Inverse Kinematics
5. Image Processing
6. Camera Calibration
7. Object Centroids
8. Camera Calibration
9. Pick and Place 10 Grading
10. Tactile and force sensing 12 Proximity sensing
11. Medical robotics
12. Open ended lab 1
13. Open ended lab 2
14. Open ended lab 3

Suggested Teaching Methodology:

- Lecturing
- Written Assignments Report Writing

Suggested Assessment:

Theory (100%)

- Sessional (20%)
- Quiz (12%)
- Assignment (8%)
- Midterm (30%)
- Final Term (50%)

Laboratory (100%)

Text and Reference Books:

1. Robotics: Everything You Need to Know About Robotics from Beginner to Expert, Peter Mckinnon(Paperback– January 28, 2016)
2. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, 2011
3. Springer Handbook of Robotics, Siciliano, Bruno, Khatib, Oussama, 2008

4. Robotics Modelling, Planning and Control, Siciliano, B.,Sciavicco, L., Villani, L., Oriolo, 2009.
5. Medical Robotics: Minimally Invasive Surgery, Paula Gomes, ISBN:9780857097392, 2012
6. Medical Robotics, Schweikard, Achim, Ernst, Floris, 2015