



Gyanmanjari
Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester-5

Subject: Robot Dynamics and Control - BETEC15309

Type of course: Professional Elective Courses

Prerequisite: Basics of Robotics, Engineering Mechanics, Control Systems, Mathematics

Rationale:

This course advances students from basic robotics to mathematical modeling, dynamic analysis, and control of robotic systems. It focuses on deriving robot equations of motion, analyzing forces and torques, and designing classical control strategies for precise motion. The course prepares students for industrial robotics, automation, and advanced control applications—without involving AI-based methods.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks					Total Marks
CI	T	P		Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
3	0	2	4	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T-Tutorial; P-Practical; C-Credit; ESE-End Semester Examination; MSE-Mid Semester Examination; V-Viva; CA-Continuous Assessment; ALA-Active Learning Activities.

Course Content:

Unit No	Course Content	Hrs	% Weightage
1.	Introduction to Robot Kinematics: Robot manipulator, DOF, joint types, coordinate frames, transformation matrices, D-H parameters, forward and inverse kinematics, Jacobian and singularities.	7	15%
2.	Robot Dynamics: Kinematics vs dynamics, mass and inertia properties, Newton-Euler and Lagrangian methods, energy formulation, equations derivation concepts.	7	15%



3.	Equations of Motion: General dynamic model, inertia, Coriolis and gravity components, properties of dynamic equations, basic manipulator examples.	8	20%
4.	Trajectory Planning: Joint and Cartesian planning, polynomial trajectories, velocity profiles, interpolation techniques, constraints.	8	15%
5.	Control of Robotic Systems: Open and closed loop control, PID control, joint control methods, computed torque control, and practical issues.	7	20%
6.	Stability and State Space Control: State-space modeling, stability concepts, controllability and observability, state feedback and pole placement.	8	15%

Continuous Assessment:

Sr. No	Active Learning Activities (with Submission)	Marks
1	Modeling and Analysis of Robot Kinematics and Dynamics: Students have to Model a 1-DOF/2-DOF robot, implement kinematics and basic dynamics, plot results and Submit Code, graphs, short report (PDF) on GMIU Web Portal.(Group Member 2)	10
2	Case Study: Students have to analyze trajectory planning and control of a robotic system with basic explanation. Submit, Case study report (PDF) on GMIU Web Portal.	10
3	Mini Project: Student have to Develop simple robot modeling and apply control (simulation/hardware) and Submit: Project report (PDF) + PPT on GMIU Web Portal. (Group Member 3)	10
Total		30

Suggested Specification table with Marks (Theory):60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weight age	10%	20%	20%	10%	10%	30 %



Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from the above table.

Course Outcome:

After learning the course, the students should be able to:	
CO1	Apply kinematic principles to analyze position, velocity, and motion of robotic manipulators.
CO2	Develop dynamic models of robotic systems using Newton-Euler and Lagrangian methods.
CO3	Derive and interpret equations of motion for robotic manipulators.
CO4	Design and analyze trajectory planning techniques for smooth robot motion.
CO5	Apply classical control methods such as PID for robotic system control.
CO6	Analyze stability and implement state-space control techniques for robotic systems.

List of Practical:

Sr. No	Title	Unit No	Hrs
1	Study of robot configuration and DOF to understand different robot types and determine degrees of freedom	1	2
2	Forward kinematics using D-H parameters to determine end-effector position and orientation	1	2
3	Inverse kinematics of simple manipulator to compute joint parameters for given position	1	2
4	Jacobian matrix computation to analyze velocity relationship between joints and end-effector	1	2
5	Dynamic modeling using Newton-Euler method to determine forces and torques on robotic links	2	2
6	Dynamic modeling using Lagrangian method to develop equations of motion using energy approach	2	2
7	Simulation of equations of motion to analyze dynamic behavior of 2-DOF manipulator	3	2



8	Trajectory planning using cubic polynomial to generate smooth motion profile	4	2
9	Trajectory planning using quintic polynomial to include velocity and acceleration constraints	4	2
10	PID control of robotic joint to achieve desired position control	5	2
11	Computed torque control to implement model-based control of robotic system	5	2
12	State-space modeling to represent robotic system in state-space form	6	2
13	Stability analysis to evaluate system stability using simulation tools	6	2
14	Controllability and observability analysis to verify system control properties	6	2
15	Mini project on robotic system modeling and control to integrate concepts and analyze performance	All	2
TOTAL			30

Instructional Method:

The course delivery method will depend on the requirements of the content and the needs of students. The teacher, in addition to conventional teaching methods by blackboard, may also use any tools such as demonstration, role play, quizzes, brainstorming, MOOCs, etc.

From the content, 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e- courses, and Virtual Laboratory

Practical/Viva examination will be conducted at the end of the semester for the evaluation of the performance of students in the laboratory.

Reference Books:

- [1] J. J. Craig, Introduction to Robotics: Mechanics and Control, 3rd ed. Upper Saddle River, NJ, USA: Pearson, 2005.
- [2] M. W. Spong, S. Hutchinson, and M. Vidyasagar, Robot Modeling and Control. New York, NY, USA: John Wiley & Sons, 2005.
- [3] B. Siciliano, L. Sciavicco, L. Villani, and G. Oriolo, Robotics: Modelling, Planning and Control. London, U.K.: Springer, 2009.
- [4] K. Ogata, Modern Control Engineering, 5th ed. Upper Saddle River, NJ, USA: Pearson, 2010.
- [5] R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 13th ed. Upper Saddle River, NJ, USA: Pearson, 2016.

