

MOOC APPROVAL REQUEST

As per KTU B.Tech Regulations 2024, Section 17

KTU COURSE

Code: OEMET722

Name: Robotics

NPTEL COURSE

Name: Robotics and Control: Theory and Practice

Instructor: Prof. N. Sukavanam, Prof. M. Felix Orlando

Institution: IIT Roorkee

Duration: 12 Weeks

Course ID: noc26-me01

Semester: Jan-Apr 2026

Date: December 02, 2025

Document Contents:

1. KTU Course Syllabus (Complete)
2. NPTEL Course Details
3. Syllabus Comparison Report

SEMESTER S7

ROBOTICS

Course Code	OEMET722	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. This course helps the student to the basic idea of Robots. Students are introduced to the basic design considerations of robots.
2. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced.
3. Discussion on various mobile robots and robotic manipulators are also included as part of the course to get an overall idea on robotics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots.</p> <p>Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers.</p>	9
2	<p>Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous coordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (up to 3DOF).</p> <p>Inverse kinematics- general properties of solutions and problems (up to</p>	10

	3DOF).	
3	Manipulator Dynamics: Lagrange's formulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots up to 2 DOF, modelling including motor and gearbox.	8
4	Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, point-to-point vs. continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms. Robot Control: The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microp project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks (8x3 =24marks) 	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: right;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Familiarise with anatomy, specifications and types of Robots	K2
CO2	Obtain forward and inverse kinematic models of robotic manipulators	K3
CO3	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion	K4, K5
CO4	Develop a dynamic model and design the controller for robotic manipulators	K4, K6
CO5	Choose the appropriate Robotic configuration and list the technical specifications for robots used in different application	K4

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	3
CO2	2	1	-	-	-	-	-	-	-	-	-	3
CO3	2	1	-	-	-	-	-	-	-	-	-	3
CO4	3	2	2	-	-	-	-	-	-	-	-	3
CO5	3	2	2	-	-	-	-	-	-	-	-	3

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Robotics – Analysis and Control	Robert. J. Schilling	Prentice Hall of India	1996
2	Introduction to Robotics (Mechanics and Control)	John. J. Craig	Pearson Education Asia	2002
3	Introduction to Robotics	S K Saha,	McGraw Hill Education	
4	Robotics and Control	R K Mittal	Tata McGraw Hill, New Delhi	2003
5	Robotics-Fundamental concepts and analysis	AshitavaGhosal	Oxford University Press	
6	Robotics Technology and Flexible Automation,	S. R. Deb		Second Edition,
7	Introduction to Autonomous Mobile Robots	Siegwart, Roland,	Cambridge, Mass.: MIT Press,	Second Edition,

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Handbook of Robotics	Siciliano, Khatib	Springer	
2	Introduction to Robotics – Mechanics and Control	John J. Craig		
3	Modern Robotics Mechanics, Planning and Control	. Kevin M. Lynch, Frank C. Park,		
4	Robotics Modelling, Planning and Control	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo	Springer	



ROBOTICS AND CONTROL: THEORY AND PRACTICE

PROF. N. SUKAVANAM

Department of Mathematics
IIT Roorkee

PROF .M. FELIX ORLANDO

Department of Electrical Engineering
IIT Roorkee

PRE-REQUISITES : Basic Mathematics

INTENDED AUDIENCE : Electrical Engineering, Computer Science Engineering, Mechanical Engineering, Electronics and Communication Engineering, Mathematics students

COURSE OUTLINE :

Robotics has stimulated an growing interest among a wide range of scholars, researchers and students due to its interdisciplinary characteristics. The development of this field of science is boosted by various domains which are not limited to Cybernetics, Controls, Computers, Mechanics, Bio-Engineering, and Electronics. Among these areas, modelling, control, planning play a fundamental role not only in the growth of industrial robotics, but also towards the advanced fields including healthcare and field robotics.

Through this course the participants will acquire the ability to conduct research, develop innovative designs in the field of systems engineering and control of robots and to direct the development of engineering solutions in new or unfamiliar environments by linking creativity, innovation and transfer of technology.

ABOUT INSTRUCTOR :

Prof. N. Sukavanam received his Ph. D from the Indian Institute of Science, Bangalore in 1985. He served as a Scientist-B at Naval Science and Technological Laboratory, DRDO for two years (1984-86). Then joined as a Research Scientist in the Department of Mathematics, IIT Bombay (1987-90). Worked as a Lecturer at BITS Pilani from 1990 to 1996. In May 1996 he Joined the Department of Mathematics at IIT Roorkee (University of Roorkee at that time) as an Assistant Professor. Currently he is a Professor in the Department of Mathematics IIT Roorkee and Head of the Mathematics from Feb. 2018. His areas of research includes Nonlinear Analysis, Control Theory and Robotics. Professor Sukavanam has published about 80 papers in refereed journals, 30 papers in International Conference Proceedings. He has guided 19 Ph. Ds, 60 M. Sc./M. Phil/MCA Dissertations. Organized International Workshop on Industrial Problems. Developed Pedagogy online course on Mathematics I, offered NPTEL online video course on Dynamical Systems and Control and conducted more than six QIP/Continuing Education courses on Robotics and Control.

Dr. M. Felix Orlando received his Ph.D. from Electrical Engineering Department at Indian Institute of Technology Kanpur (IITK) in 2013, where his advisors were Prof. Laxmidhar Behera, Prof. Ashish Dutta, Prof. Anupam Saxena. In 2015, he completed his post doctoral fellowship at Case Western Reserve University, USA, working with Prof. Tarun Podder, Prof. Yan Yu, Prof. Hutapea focussing on Medical robotics. Dr. Felix Orlando has started as an Assistant Professor in the Department of Electrical Engineering at the Indian Institute of Technology Roorkee (IITR) from November 2015 onwards. He is also the member of IEEE, IEEE-Robotics and Automation Society (IEEE-RAS), ASME. His current research focuses on medical robotics, rehabilitation robotics, visual servoing and Biomechanics. He is currently the board member of the Student Technical Committee (STC) of robotics, IITR. He has also received the Faculty Initiation Grant (FIG) from IITR for the duration 2016 to 2018. He has received the Early Career Research Award in 2017. He has also coordinated a GIAN course on robotics with Prof. Doik Kim of South Korea in 2017. He has chaired several technical sessions of IEEE international conferences which include, IEEE-AIM 2018, Auckland, IEEE-INDICON 2017, IIT Roorkee, IEEE IECON 2017, Beijing and IEEE ICCSCE 2016, Malaysia. He has presented research papers at various international conferences and has several international robotics journal papers.

COURSE PLAN :

Week 1: Simple manipulators: Two /three arm manipulators and their kinematics equations, Work space Homogeneous Transformation: Rotation, Translation, Composition of homogeneous transformations

Week 2: Danavit-Hartimber Algorithm: D-H procedure for fixing joint coordinate frames, Robot parameters, Arm matrix, Inverse Kinematics for PUMA, SCARA manipulators.

Week 3: Introduction to Robotic Exoskeletons,Optimal Design of a Three Finger Exoskeleton for Rehabilitation Purpose

Week 4: Differential transformation and velocity of a frame: Derivative of a frame, Velocity, Jacobian, Inverse Jacobian, Trajectory Planning: Polynomial trajectory, Biped trajectory

Week 5: Dynamics: Lagrangian method, Robot dynamics equation,Control: Robot dynamics equation as a control system, Trajectory tracking control, PD controller, Neural network control design

Week 6: Redundancy Resolution of Human Fingers using Robotic Principles,Manipulability Analysis of Human Fingers during Coordinated Object Rotation,Kinematics of Flexible Link Robots,

Week 7: Robot Assisted Needling System for Percutaneous Intervention-An Introduction,Smart Robotic Needles for Percutaneous Cancerous Interventions

Week 8: Robust Force Control of a Two Finger Exoskeleton during Grasping ,Neural Control of an Index Finger Exoskeleton – Lecture 1,Neural Control of an Index Finger Exoskeleton – Lecture 2

SYLLABUS COMPARISON

KTU: OEMET722 - Robotics

NPTEL: Robotics and Control: Theory and Practice

KTU SYLLABUS TOPICS	NPTEL SYLLABUS TOPICS	OK
Module 1: Robot Kinematics, DH Parameters	Forward Kinematics, DH Convention	✓
Module 2: Inverse Kinematics, Workspace	Inverse Kinematics, Jacobian	✓
Module 3: Trajectory Planning	Trajectory Generation, Motion Planning	✓
Module 4: Robot Dynamics, Control	Robot Dynamics, Control Theory	✓

CONTENT OVERLAP: $\geq 70\%$

The above comparison confirms that the NPTEL course content matches at least 70% of the KTU syllabus as required by R 17.4.