The LNMIIT, Jaipur Department of Mechanical & Mechatronics Engineering Robot Motion Planning and Control (MME-RMPC)	LNMIIT The LNM Institute of Information Technology

Programme: B. Tech. (MME, ECE, CCE, CSE)	Course Title: Robot Motion Planning and Control			Course Code: MME-RMPC
Type of Course: Other Elective	**Prerequisites:** Mathematics, Basic programming skills			**Total Contact Hours:** 40
Year/Semester: 4/Even	**Lecture Hrs/Week:** 3	**Tutorial Hrs/Week:** 0	**Practical Hrs/Week:** 0	**Credits:** 3

Learning Objective:

This is an undergraduate course offered to 4th year, 8th Semester students. The course will help the students acquire a mix of skills in path planning algorithms, control strategies and computing, to comprehend and simulate the autonomous robot for path planning and trajectory tracking. Path planning algorithms will be covered to obtain the path evaluation process from the robot's current position to the destination depending upon the goal considerations like shortest path, robust path, minimum energy, or minimum time. Trajectory tracking determines the sequence of control actions required to manoeuvre the obtained path based on the robot's model and problem constraints. Theoretical knowledge on simulation and implementation of various path planning algorithms, and control strategies will be given. Practical knowledge of simulating mathematical robot models, path planners and control designs will also be provided in MATLAB or Python. Real applications using case studies for an autonomous robot's path planning and trajectory tracking.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		Bloom's Level
CO-1	Compare and Simulate autonomous robots	**2, 4**
CO-2	Understand and Apply various path planners using MATLAB or Python	**2, 3**
CO-3	Design and Analyze trajectory tracking by autonomous robots	**4, 5**
CO-4	Design and Evaluate several control strategies for autonomous robots	**4, 5**

Course Topics:

S. No.	Contents	Hours
1	**Introduction**: Introduction to robotics, types of autonomous vehicles, types of unmanned vehicles, and various degrees of autonomy. Path planning, trajectory tracking, simultaneous localization and mapping. Different types of automatic control strategies – open loop, closed loop, model-based control, feedback control, feedforward control, and adaptive control.	4
2	**Overview of autonomous robot's model:** Mathematical model of differential drive robot, unmanned air vehicle (UAV), autonomous underwater vehicle (AUV). Model behaviour, physical constraints, linearization of a model, observability and controllability of linear model.	6
3	**Path planning of a robot for a given goal:** Arena consideration in path planning, robot configuration space, graph-nodes and grid-map presentation, obstacle avoidance. Path planning considerations – shortest path, quickest path, robust path. Path planners – Firefly algorithm, Dijkstra algorithm, A*, artificial potential field, rapidly-exploring random tree (RRT) algorithm.	10
4	**Trajectory tracking by the robot for a determined path:** Problem formulation for control actions generation to follow a path determined by path planner. Non-model-based control strategies – bang-bang, proportional integral derivative (PID); model-based control strategy – linear quadratic regulator (LQR), receding horizon control (RHC).	12
5	**Case studies:** The path planning and trajectory tracking application for autonomous robots.	8

Textbook References:

Text Book:

1. S.M. LaValle. *Planning algorithms*. Cambridge university press; 2006.
2. S. K. Saha, *Introduction to robotics*, Tata McGraw-Hill Education, 2014.
3. F. Golnaraghi and B. C. Kuo, *Automatic Control Systems*, 9th edition, John Wiley & Sons INC.
4. Magnus Egerstedt and Clyde Martin, *Control Theoretic Splines: Optimal Control, Statistics, and Path Planning*, Princeton University Press, 2010
5. Kris Hauser, *Robotic Systems*, University of Illinois at Urbana-Champaign, 2020.

Reference books:

1. G.F. Frenklin, J. D. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 7th edition, Pearson Publication.
2. K. Ogata, *MATLAB for Control Engineers*, 1st edition, Pearson Prentice Hall, 2007.
3. M.W. Spong, M. Vidyasagar, *Robot dynamics and control*. John Wiley & Sons, 2008.

Additional Resources:
NPTEL, MIT Video Lectures, Web Resources etc.

Evaluation Method	
Item	**Weightage (%)**
Midterm	30
Final Examination	40
Teacher's assessment (Assignment/ Presentation/ Project/ Quiz)	30

CO and PO Correlation Matrix for B.Tech MME

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	-	-	-	-	-	-	1	1	0	0
CO2	3	1	2	1	2	-	-	-	-	-	-	1	1	0	0
CO3	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1
CO4	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1

CO and PO Correlation Matrix for B.Tech CCE

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	-	-	-	-	-	-	1	1	0	0
CO2	3	1	2	1	2	-	-	-	-	-	-	1	1	0	0
CO3	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1
CO4	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1

CO and PO Correlation Matrix for B.Tech ECE

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	-	-	-	-	-	-	1	1	0	0
CO2	3	1	2	1	2	-	-	-	-	-	-	1	1	0	0
CO3	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1
CO4	3	3	3	3	2	-	-	-	-	-	-	1	2	1	1

CO and PO Correlation Matrix for B.Tech CSE

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	-	-	-	-	-	-	1	1	0	0
CO2	3	1	2	1	2	-	-	-	-	-	-	1	1	0	0
CO3	3	3	3	3	2	-	-	-	-	-	-	1	2	1	0
CO4	3	3	3	3	2	-	-	-	-	-	-	1	2	1	0

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Approved by: