SEMESTER S8

CO-OPERATIVE ROBOTICS

Course Code	**PERUT861**	**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. The objective of this course is to give students a basic idea of cooperative robotics and design considerations of various algorithms.
2. Familiarise the various control problems, consensus algorithm and their applications

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to robotics: Components, Odometry, Kinematics, Control, Finite State Machines as Robot Controllers, State Transitions based on Robot–Robot Interactions, Early Micro-Macro Problems, Macroscopic Perspective, Expected Macroscopic Dynamics and Feedback	**8**
2	Discrete Consensus Achievement in Artificial Systems: Consensus Achievement, The Best-of-n Problem, Overview of Current Design Approaches, Bottom–Up Design Approaches, Top–Down Design Approaches. Consensus Algorithms in Cooperative Control: Fundamental Consensus Algorithms, Convergence Analysis of Consensus Algorithms, Synthesis and Extensions of Consensus Algorithms, Design of Coordination Strategies via Consensus Algorithms	**10**

3	Consensus-based Design Methodologies for Distributed Multivehicle Cooperative Control: Coupling in Cooperative Control Problems: Objective Coupling, Local Coupling, Full Coupling, Dynamic Coupling. Approach to Distributed Cooperative Control Problems with an Optimization Objective: Cooperation Constraints and Objectives, Coordination Variables and Coordination Functions, Centralized Cooperation Scheme, Consensus Building Approach to Distributed Cooperative Control Problems Without an Optimization Objective: Coordination Variable Constituted by a Group-level Reference State, Coordination Variable Constituted by Vehicle States	**9**
4	Applications to Multivehicle Cooperative Control:Rendezvous and Axial Alignment with Multiple Wheeled Mobile Robots, Distributed Formation Control of Multiple Wheeled Mobile Robots with a Virtual Leader, Deep Space Spacecraft Formation Flying, Cooperative Fire Monitoring with Multiple UAVs, Cooperative Surveillance with Multiple UAVs	**9**

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

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	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Familiarise with various robotic components and controllers	**K2**
CO2	Describe various design approaches	**K2**
CO3	Understand various consensus algorithms and their applicability	**K2**
CO4	Analyse the use of coupling in cooperative control problems	**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**

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	Swarm robotics: A formal approach	Hamann, Heiko	Springer	2018
2	Distributed consensus in multi vehicle cooperative control	Ren, Wei, and Randal W. Beard	Springer London	2008
3	Achieving consensus in robot swarms	Valentini, Gabriele	Studies in computational Intelligence, Springer	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Path planning of cooperative mobile robots using discrete event models	Mahulea, Cristian, Marius Kloetzer, and Ramón González	John Wiley & Sons	2020
2	Cooperative Robots and Sensor	Koubâa, Anis, and	Springer	2014
3	Distributed autonomous robotic systems 2	Asama, Hajime, Toshio Fukuda, Tamio Arai, and Isao Endo	Springer Science & Business Media	2013

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