M.TECH

SYLLABUS
SCHEME

2022

Discipline:

Electronics and Communication Engineering

Specialization:

Robotics and Artificial Intelligence

SEMESTERI							
SLOT	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	221TIA002	MATHEMATICS FOR INTELLIGENT SYSTEMS	40	60	3-0-0	3	3
B	221TEC104	FUNDAMENTALS OF ROBOTICS	40	60	3-0-0	3	3
C	221EIA015	ARTIFICIAL INTELLIGENCE FOR ROBOTICS	40	60	3-0-0	3	3
D	221EXXXXX	PROGRAMELECTIVE1	40	60	3-0-0	3	3
E	221EXXXXX	PROGRAMELECTIVE2	40	60	3-0-0	3	3
S	221RGE100	RESEARCH METHODOLOGY AND IPR	40	60	2-0-0	2	2
T	221LEC102	ROBOTICSSIMULATION LAB	100	--	0-0-2	2	1
Total			**340**	**360**		**19**	**18**

PROGRAMELECTIVE 1								
SLOT	SL NO.	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
D	1	221EEC109	ROBOTICS SYSTEM CONFIGURATION	40	60	3-0-0	3	3
	2	221EEC110	MICROCONTROLLER ARCHITECTURE AND PROGRAMMING	40	60	3-0-0	3	3
	3	221EEC111	MECHATRONICS SYSTEM DESIGN	40	60	3-0-0	3	3

PROGRAMELECTIVE 2								
SLOT	SL NO.	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
E	1	221EEC201	DIGITAL IMAGE PROCESSING AND COMPUTER VISION	40	60	3-0-0	3	3
	2	221EEC202	DEEP LEARNING TECHNIQUES	40	60	3-0-0	3	3
	3	221EEC203	ALGORITHMS FOR BIG DATA PROCESSING	40	60	3-0-0	3	3

SEMESTERII							
SLOT	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	222TIA003	KINEMATICS, DYNAMICS AND CONTROL OF ROBOTS	40	60	3-0-0	3	3
B	222TEC103	ADVANCED AI AND APPLICATIONS	40	60	3-0-0	3	3
C	222EXXXXX	PROGRAMELECTIVE 3	40	60	3-0-0	3	3
D	222EXXXXX	PROGRAMELECTIVE4	40	60	3-0-0	3	3
E	222EEXXXX / 222EIAXXX	INDUSTRY/INTERDISCIPLINARYE LECTIVE	40	60	3-0-0	3	3
S	222PEC100	MINIPROJECT	100	60	0-0-4	4	2
T	222LEC104	AILAB	100	--	0-0-2	2	1
Total			**340**	**360**		**21**	**18**

PROGRAMELECTIVE 3								
SLOT	SL NO.	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
C	1	222EEC301	NON-LINEAER AND ADAPTIVE CONTROL SYSTEMS	40	60	3-0-0	3	3
	2	222EEC302	ADVANCED ROBOTICS AND APPLICATIONS	40	60	3-0-0	3	3
	3	222EEC303	MOBILEROBOTICS	40	60	3-0-0	3	3

PROGRAMELECTIVE 4								
SLOT	SL NO.	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
D	1	222EEC401	ADVANCED WIRELESS COMMUNICATION	40	60	3-0-0	3	3
	2	222EEC402	REINFORCEMENT LEARNING	40	60	3-0-0	3	3
	3	222EEC403	HARDWARE ARCHITECTURE FOR MACHINE LEARNING	40	60	3-0-0	3	3

INTERDISCIPLINARYELECTIVE								
SLOT	SL NO.	COUR SEC ODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
	1	222EEC501	INTRODUCTION TO ROBOTICS	40	60	3-0-0	3	3
	2	222EEC502	AI FOR ROBOTICS	40	60	3-0-0	3	3

SEMESTERIII							
SLOT	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
TRACKI							
A*	223MECXXX	MOOC	To becompletedsuccessfully		--	--	2
B	223AGEXXX	AUDITCOURSE	40	60	3-0-0	3	--
C	223IEC100	INTERNSHIP	50	50	--	--	3
D	223PEC100	DISSERTATIONPHASE-1	100	--	0-0-17	17	11
TRACKII							
A*	223MECXXX	MOOC	To becompletedsuccessfully		--	2	2
B	223AGEXXX	AUDITCOURSE	40	60	3-0-0	3	--
C	223IEC100	INTERNSHIP	50	50	--	--	3
D	223PEC001	RESERCHPROJECTPHASE-1	100	--	0-0-17	17	11
Total			**190**	**110**		**20**	**16**

TeachingAssistance6hours

*MOOC Course to be successfully completed before the commencement of fourth semester(Startingfrom semesterI)

AUDITCOURSE								
SLOT	SL NO.	COURSE CODE	COURSENAME	MARKS		L-T-P	HOURS	CREDIT
				CIA	ESE			
B	1	223AGE100	ACADEMICWRITING	--	--	3-0-0	3	--
	2	223AGE001	ADVANCEDE NGINEERING MATERIALS	--	--	3-0-0	3	--
	3	223AGE002	FORENSICENGINEERING	--	--	3-0-0	3	--
	4	223AGE003	DATASCIENCEFOR ENGINEERS	--	--	3-0-0	3	--
	5	223AGE004	DESIGNTHINKING	--	--	3-0-0	3	--
	6	223AGE005	FUNCTIONALPRO GRAMMINGINHAS KELL	--	--	3-0-0	3	--
	7	223AGE006	FRENCHLANGUAGE(A1 LEVEL)	--	--	3-0-0	3	--
	8	223AGE007	GERMANLANGUAGE(A1 LEVEL)	--	--	3-0-0	3	--
	9	223AGE008	JAPANESELANGUAGE (N5LEVEL)	--	--	3-0-0	3	--
	10	223AGE009	PRINCIPLES OFAUTOMATI ON	--	--	3-0-0	3	--
	11	223AGE010	REUSE AND RECYCLETECHNO LOGY	--	--	3-0-0	3	--
	12	223AGE011	SYSTEMMODELING	--	--	3-0-0	3	--
	13	223AGE012	EXPERTSYSTEMS	--	--	3-0-0	3	--

SEMESTERIV							
SLOT	**COURSE CODE**	**COURSENAME**	**MARKS**		**L-T-P**	**HOURS**	**CREDIT**
			CIA	**ESE**			
TRACKI							
A	224PEC100	DISSERTATIONPHASE-II	100	--	0-0-17	24	16
TRACKII							
A	224PEC001	RESERCHPROJECTPHASE-II	100	--	0-0-17	24	16
Total			**100**	**100**		**24**	**16**

Teaching Assistance: 5 hours

SEMESTER I

221TIA002	MATHEMATICS FOR INTELLIGENT SYSTEMS	CATEGORY	L	T	P	CREDIT
		CORE	3	0	0	3

Preamble:
Mathematics for intelligent systems are indispensable for computing applications in robotic systems. This course is designed such that it will equip the students with mathematical framework for the numerical computation and optimization and techniques necessary for various computing applications in engineering and robotic systems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply the basic ideas of linear algebra in determining spaces for intelligent systems
CO 2	Apply matrix algebra to represent the dimensions of intelligent systems.
CO 3	Apply probability in engineering
CO 4	Formulate optimization problems and identify a suitable method to solve the same
CO 5	Solve optimization problems in robotics using appropriate optimization techniques

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	3	3	3	2	-
CO 2	3	-	3	3	3	2	-
CO 3	3	-	3	3	3	2	-
CO 4	3	-	3	3	3	2	-
CO 5	3	-	3	3	3	2	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks
Course based Assignments : 10 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 20 marks
Test paper shall include minimum 80% of the syllabus.
End Semester Examination Pattern: 60 marks

Part A: 5 numerical/short answer questions with 1 question from each module, (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.
Each question can carry 5 marks.
Part B: 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five.
Each question can carry 7 marks.

SLOT A

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M.TECH DEGREE EXAMINATION
MONTH &YEAR
Course code: **221TIA002**
Course Name: **Mathematics for Intelligent Systems**

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all Questions. Each question carries 5 Marks

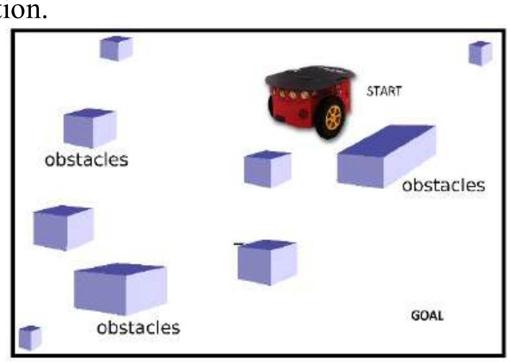
1 a) State whether the following vectors represent a vector space giving explanations

(i) V = a real polynomial of degree 5 or less
(ii) V = {f(x)/ f is continuous on R}
b) Explain an invariant subspace

2 Explain Lasso and Ridge regression models. While building a regression model using a data set, one of the feature is found to have relatively higher negative value. What does it indicate?

3 Prove that: If B ∈ F and P (B) > 0. Then, P (· |B) : F −→ [0, 1] is a probability measure on (Ω, F).

4 Formulate an optimization problem to find a shortest path for a differential drive robot from start to goal location.



5 In which context we can use optimization methods like genetic algorithms and simulated annealing?

PART B

Answer any 5 Questions. Each question carries 7 Marks

6 (i) Find the rank of the following matrix using
(ii) echelon form and (ii) canonical form

B = $[-123-22-5123-8525-12-16]$

7 Find the Eigen values and Eigen vectors of the matrix A=$[811280-72-1-3-7211124]$. Show that the matrix A can be diagonalised using these Eigen vectors.

8 Given the following 3D input data.

1 1 9

2 4 6

3 7 4

4 11 4

5 9 2

a. identify the principal component and
b. the transformed input along the first two principal component.

9 A manufacturing firm is engaged in the production of steel pipes in its three plants P_1, P_2, P_3. It produces 30% steel pipes from P_1, 45% from P_2 and 25% s from P_3. From the historical data it is found that P_1, P2, P3 produce 2%, 3% and 2% defective products. If a product is randomly selected what is the probability that it is defective? Also determine the probability that the defective product is from plant P_3.

10 Is this a linear or nonlinear programming problem?
Maximize $Z = 3x_1^2 - 2x_2$
Subject to

$$2x_1 + x_2 = 4$$
$$x_1^2 + x_2^2 \leq 40$$

$x_1, x_2 \geq 0$ and are integers.
Solve this problem by a suitable classical method.

11 Minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ from the starting point $X_1 = \{00\}$ using Powell's method.

12 Minimize $f(X) = (x_1 - 1)^2 + (x_2 - 5)^2$ subject to

$-x_1^2 + x_2 \leq 4$

$$-(x_1 - 2)^2 + x_2 \leq 3$$

Starting from the point $X_1 = \{11\}$ and using Zoutendijk's method. Complete two one-dimensional minimization steps.

Syllabus and Course Plan

Module 1

Linear Algebra: Introduction**:** Fields-System of Linear Equations Echelon matrices-invertible matrices. Vector Spaces and subspaces**:** bases and dimensions-summary of row equivalence-computations concerning subspaces. Linear transformations-isomorphism-double dual-transpose of linear transformations-pseudo inverse-application to regression.Orthogonality**:** Orthonormal subspaces-Gram Schmidt orthogonalisation-Projections onto sub-spaces -The Regression Least Square

Module 2

Matrix Algebra: Determinants-commutative rings-modules-multi linear functions-The grass man ring. Elementary canonical forms**-** introduction-characteristic values-invariant subspaces-simultaneous triangulation and simultaneous diagonalization-direct sum decomposition. Principal Component Analysis-image processing Eigen Faces -Markov Matrices and the Google Matrix.

Module 3

Probability and Statistical Theory: Introduction: Probability and counting-Conditional probability: Bayes' Rule and law of total probability -Random Variables and their distributions Expectation: Definition-Linearity of the expectation -Geometric and Negative Binomial- Indicator Random Variable and the Fundamental Bridge. Moments: Moment generating functions- generating moments-Transformations: convolutions-beta-gamma-beta gamma connections. Markov chains: Markov property and transition matrix-classification of states-stationary distribution-reversibility.Markov chain and Monte Carlo.

Module 4

Optimisation problem, Formulation of optimisation problems and linear optimization - Review only.

Classical Optimization Techniques Single variable optimization, Multivariable optimization with equality constraints- Direct substitution, method of Lagrange multipliers, Multivariable optimization with equality constraints- Kuhn-Tucker conditions.

Non-linear Programming: Unconstrained Optimization Techniques Direct Search Methods: Random search methods, Grid search method, Univariate method, Hookes and Jeeves' method, Powell's method; Indirect Search Methods: Steepest descent method, Fletcher-Reeves method, Newton's method

Module 5

Nonlinear Programming: Constrained Optimization Techniques Direct search methods: Random search methods, Basic approach in methods of feasible directions, Zoutendijk's method of feasible directions, Rosen's gradient projection method, Generalized Reduced gradient method, Sequential quadratic programming.

Recent developments in optimization techniques: Genetic Algorithm, Simulated Annealing, Neural Network based optimization, Particle Swarm Optimization, Ant colony Optimization.

No	Topic	No. of Lectures
1	**Linear Algebra**	
1.1	**Introduction:** Fields-System of Linear Equations Echelon matrices-invertible matrices.	2
1.2	**Vector Spaces and subspaces:** bases and dimensions-summary of row equivalence-computations concerning subspaces. Linear transformations-isomorphism-double dual-transpose of linear transformations-pseudo inverse-application to regression	3
1.3	**Orthogonality:** Orthonormal subspaces-Gram Schmidt orthogonalisation-Projections onto sub-spaces -The Regression Least Square	3
2	**Matrix Algebra**	

2.1	**Determinants**-commutative rings-modules-multi linear functions-The grass man ring.	1
2.2	**Elementary canonical forms-** introduction-characteristic values-invariant subspaces-simultaneous triangulation and simultaneous diagonalization-direct sum decomposition	3
2.3	Principal Component Analysis-image processing Eigen Faces - Markov Matrices and the Google Matrix.	4
3	**Probability and Statistical Theory:**	
3.1	**Introduction**: Probability and counting-**Conditional probability:** Bayes' Rule and law of total probability -Random Variables and their distributions **Expectation**: Definition-Linearity of the expectation -Geometric and Negative Binomial-Indicator Random Variable and the Fundamental Bridge	2
3.2	**Moments:** Moment generating functions- generating moments-**Transformations:** convolutions-beta-gamma-beta gamma connections.	3
3.3	**Markov chains:** Markov property and transition matrix-classification of states-stationary distribution-reversibility. Markov chain and Monte Carlo.	3
4		
4.1	Optimisation problem, Formulation of optimisation problems and linear optimization - Review only.	1
4.2	**Classical Optimization Techniques** Single variable optimization, Multivariable optimization with equality constraints- Direct substitution, method of Lagrange multipliers, Multivariable optimization with equality constraints- Kuhn-Tucker conditions.	3
4.3	**Non-linear Programming: Unconstrained Optimization Techniques** Direct Search Methods: Random search methods, Grid search method, Univariate method, Hookes and Jeeves' method, Powell's method; Indirect Search Methods: Steepest descent method, Fletcher-Reeves method, Newton's method	4
5		
5.1	**Nonlinear Programming: Constrained Optimization Techniques** Direct search methods: Random search methods, Basic approach in methods of feasible directions	2
5.2	Zoutendijk's method of feasible directions, Rosen's gradient projection method, Generalized Reduced gradient method, Sequential quadratic programming.	4
5.3	Recent developments in optimization techniques: Genetic Algorithm, Simulated Annealing, Neural Network based optimization, Particle Swarm Optimization, Ant colony Optimization.	2

Reference Books

1. G. Strang, Introduction to Linear Algebra. Wellesley, MA: Wellesley Cambridge Press, fifth ed., 2016.
2. K. Hoffman and R. Kunze, Linear algebra. Prentice-Hall mathematics series, Prentice-Hall India Ltd, 2015.

3. J. Blitzstein and J. Hwang, Introduction to Probability. Chapman & Hall/CRC Texts in Statistical Science, CRC Press, 2014.
4. Singiresu S Rao, *Engineering Optimization Theory and Practice*,5/e, John Wiley & Sons 2020.
5. Edwin K P Chong, Stanislaw H Zak, *An introduction to Optimization*, 2e, Wiley India

221TEC104	FUNDAMENTALS OF ROBOTICS	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1	Familiarize with anatomy, specifications and types of Robots
CO2	Describe the direct and inverse kinematics in modeling and controlling of robot Manipulators
CO3	Understand the differential motion of robots.
CO4	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion
CO5	Understand the dynamics in robot motion

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	P07
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution Pattern

Total marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz	:	10 marks
Test paper, 1 no	:	10 marks

End Semester examination Pattern	**:**	
Total	**:**	**60 marks**
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper : Fundamentals of Robotics

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) 25 marks

1. Discuss the Jacobian matrix and its role in robotics.
2. What is the role of position sensors in robotics?
3. Explain the geometric constraints in task and motion planning.
4. Discuss different types of robot drive systems.
5. State Lagrangian formulation.

Part B (Answer any 5. Each question carries 7 marks) 35 marks

6. Discuss the difference between forward kinematics and inverse kinematics in the field of modelling and controlling of robot manipulators.
7. Derive the Jacobian matrix for a 2D 2-link manipulator.
8. Derive the Euler- Lagrange equation for a single degree of freedom system. Discuss with the help an example.
9. Derive the Newton-Euler formulation for analysing the dynamics of robot manipulators.
10. Explain Jacobian and Potential Energy expression.
11. Explain the three types of Robot Singularities.
12. Represent the position and orientation of a Robotic system.

SYLLABUS

Module 1 - Basic Concepts

Brief history, Types of Robots, Technology, Robot Configurations and Robot classifications, Familiarization of terminology used in robotics, Various manipulators, End effector tools, Programming languages. Position Orientation-Frames-Mapping-Changing Description from Frames to Frames. Transformation arithmetic's -Translation-rotation-transformation- transformation of the vectors - homogeneous transformation matrix.

Module 2 - Direct and Inverse Kinematics:

Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF), Inverse kinematics- general properties of solutions, Problems (upto 3DOF)

Module 3 - Manipulator Differential Motion:

Robot Manipulators – Motion control and Differential motion of manipulators, Overview of Jacobian matrix, Wrist and arm singularity - Static analysis – Calculation of force and torque

Module 4 - Path Planning and Trajectory generation:

Trajectory generation - Basic Problem, Solution space – Joint space and Cartesian space, Planning in any space, Polynomial trajectory in Robotics, Cubic polynomial, Cubic polynomial for a path, Joint space trajectory generation using single degree polynomial

Module 5 - Dynamics and Control:

Manipulator dynamics in robots, Lagrange's formulation – Kinetic Energy expression, velocity, Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Newton-Euler formulation for analysing the dynamics of robot manipulators (Dynamic model of planar and spatial serial robots upto 2 DOF can be given as assignment), Control problem of robot manipulators, independent joint control, Closed loop system with PD/PID control

Syllabus and course plan (Total hours: 37)

No	Topic	No. of Lectures.
1	**Module 1-8 hours**	
1	Brief history, Types of Robots, Technology, Robot Configurations.	**1**
2	Robot classifications, Familiarization of terminology used in robotics.	**1**
3	Various manipulators, End effector tools.	**1**
4	Programming languages.	**1**
5	Position Orientation-Frames-Mapping-Changing Description from Frames to Frames.	**1**
6	Transformation arithmetic's -Translation-rotation-transformation.	**1**
7	Transformation of the vectors	**1**
8	Homogeneous transformation matrix.	**1**
2	**Module 1-7 hours**	
1	Kinematic parameters.	**1**
2	The Denavit-Hartenberg (D-H) representation.	**1**
3	The arm equation.	**1**
4	Direct kinematics problems (upto 3DOF).	**1**
5	Inverse kinematics- general properties of solution.	**1**
6	Problems (upto 3DOF)	**2**

3	**Module III-6 hours**	
1	Robot Manipulators.	**1**
2	Motion control and Differential motion of manipulators	**1**
3	Overview of Jacobian matrix,	**1**
4	Wrist and arm singularity	**1**
5	Static analysis	**1**
6	Calculation of force and torque.	**1**
4	**Module IV-8 hours**	
1	Trajectory generation - Basic Problem.	**1**
2	Solution space – Joint space and Cartesian space, Planning in any space.	**2**
3	Polynomial trajectory in Robotics.	**1**
4	Cubic polynomial.	**1**
5	Cubic polynomial for a path.	**1**
6	Joint space trajectory generation using single degree polynomial.	**2**
5	**Module V-8 hours**	
1	Manipulator dynamics in robots.	**1**
2	Lagrange's formulation – Kinetic Energy expression, velocity.	**1**
3	Jacobian and Potential Energy expression.	**1**
4	Generalised force, Euler-Lagrange equation.	**1**
5	Newton-Euler formulation for analysing the dynamics of robot manipulators.	**1**
6	Control problem of robot manipulators.	**1**
7	Independent joint control.	**1**
8	Closed loop system with PD/ PID control.	**1**

Textbook:

1. John J. Craig, " Introduction to Robotics , Mechanics and Control", Pearson Education International, 2008

2. Dileep Kumar Pratihar, "Fundamentals of Robotics", Narosa Book, 2017

3. Niku S. B., "Introduction to Robotics, Analysis, Control, Applications", John Wiley, 2011.

4. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, " Robot Dynamics and Control" Wiley India Edition, 2004

221EIA015	ARTIFICIAL INTELLIGENCE FOR ROBOTICS	CATEGORY	L	T	P	CREDIT
		Program Elective	3	0	0	3

Preamble

This course will deal with the fundamental principles of Artificial Intelligence including knowledge representation, reasoning, decision making and programming techniques. The course will also support developing an understanding of the theoretical relationships between these algorithms.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Interpret supervised and unsupervised learning algorithms
CO 2	Use CNN and RNN for different robotic applications
CO 3	Use computer vision for robotic applications
CO 4	Localise a robot in any scenario
CO 5	Use RL for robotic applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	2	3	3	3	-
CO 2	3	-	2	3	3	3	-
CO 3	3	-	2	3	3	3	-
CO 4	3	-	2	3	3	3	-
CO 5	3	-	2	3	3	3	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern :

Total	**:**	60 marks
Part A: Answer all – 5 questions × 5 marks	**:**	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	**:**	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

SLOT

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY
SECOND SEMESTER M.TECH DEGREE EXAMINATION
MONTH &YEAR

Course code: 221EIA015

Course Name:**Artificial Intelligence for Robotics**

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all Questions. Each question carries 5 Marks

1 Consider the following set of training examples:

Instance	Classification	a_1	a_2
1	+	T	T
2	+	T	T
3	-	T	F
4	+	F	F
5	-	F	T
6	-	F	T

What is the information gain of a_2 relative to these training examples? Provide the equation for calculating the information gain as well as the intermediate results.

2 In a reinforcement learning problem, it is decided to describe the state space using an approximate function and to minimize the RMSE close to zero, uniformly throughout the state space. Is it a wise design? Elaborate your answer.

3 Distinguish between the Roberts Cross Edge and Sobel Edge Detector.

4 A mobile robot, working in an indoor environment, wants to rank unexplored regions and to make rational choices. How can it be done? Explain the method in detail.

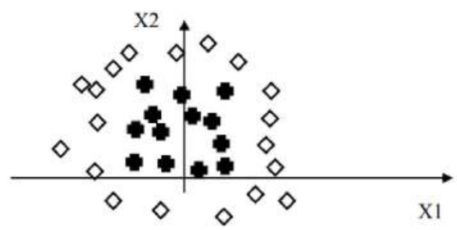
5 How policy evaluation and policy iteration are done in Dynamic Programming?

PART B

Answer any 5 Questions. Each question carries 7 Marks

6 Derive the gradient descent training rule assuming that the target function representation is: $o_d = w_0 + w_1x_1 + \ldots + w_nx_n$. Define explicitly the cost/error function E, assuming that a set of training examples D is provided, where each training example $d \in D$ is associated with the target output t_d.

7 Suppose that we want to build a neural network that classifies two dimensional data (i.e., X = [x1, x2]) into two classes: diamonds and crosses. We have a set of training data that is plotted as follows:



Draw a network that can solve this classification problem. Justify your choice of the number of nodes and the architecture. Draw the decision boundary that your network can find on the diagram.

8 A 4 x 4 gray-scale image is given below:

5	6	7	8
0	6	7	8
5	6	15	8
5	6	7	8

Filter the image with a 3x3 median filter, after zero padding.

9 Describe image formation in the eye with brightness adaptation and discrimination.

10 Explain in detail how the non-linearity in state transition and measurements is accounted in Extended Kalman Filter algorithm.

11 Explain the Bayesian method of using sensor model to update the occupancy grid.

12 Consider the standard grid problem, where a robot is required to traverse a grid of 4×4 dimensions to reach its goal (1 or 16). There are 2 terminal states here: 1 and 16 and 14 non-terminal states given by [2, 3,…., 15]. We need to evaluate a random policy, in which the probability of every action {up, down, left, right} is equal to 0.25. The reward is -1 for all transitions. Start by initializing values of all states as zeros. Take discount factor as 1. Using Bellman equation, find the value of the state 6, after the second and third iterations.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	**16**

Syllabus

Module 1

Probability and Expectation Basics, Bayes Optimal, Stochastic Average Approximation, Stochastic Gradient Descent; Supervised Learning Algorithms, Unsupervised Learning Algorithms, Reinforcement based learning-overview with basic elements agent, environment, action, state, reward only; Challenges Motivating Deep Learning.

Module 2

Deep Feedforward Networks, Convolutional Networks-basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets - Need for sequence models, basic RNN architecture and types

Case study-line follower robot using CNN, Speech Recognition using RNN overview

Module 3

Machine vision - Introduction, Computer vision – Introduction.

Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. challenges in image detection, Image features optimization.
Case study- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection.

Module 4

Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains
Case study- Use of AI in typical pick and place task, localization of a differential drive robot.

Module 5

Reinforcement learning Overview, Policy based and Value based approaches , Monte Carlo Methods, Temporal-Difference Learning (Q-learning, SARSA).
Case study- Role of RL in typical pick and place task, RL for stabilization of bipedal humanoid

1) Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press, 2016
2) Stuart J. Russell and Peter Norvig, Artificial Intelligence - A Modern Approach Third Edition,Pearson, 2016
3) Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
4) Berthold Klaus, Paul Horn “Robot vision” The MIT Press, 1987.
5) Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer; 2011th edition (19 October 2010).
6) Grigorescu, Sorin, et al. "A survey of deep learning techniques for autonomous driving." Journal of Field Robotics 37.3 (2020): 362-386.

Course plan

No	Topic	
1.1	Probability and Expectation Basics, Bayes Optimal, Stochastic Average Approximation, Stochastic Gradient Descent	2
1.2	Supervised Learning Algorithms, Unsupervised Learning Algorithms,Reinforcement based learning-overview with basic elements agent, environment, action, state, reward only; Challenges Motivating Deep Learning	4
2.1	Deep Feedforward Networks, Convolutional Networks-basic outline and functions of each layers only, SequenceModeling: Recurrent and Recursive Nets - Need for sequence models, basic RNN architecture and types **Case study**-line follower robot using CNN, Speech Recognition using RNN overview	4
3.1	Machine vision - Introduction, Computer vision - Introduction	1
3.2	Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. challenges in image detection, Image features optimization.	4
3.3	**Case study**- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection	2
4.1	Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains	5
4.2	**Case study**- Use of AI in typical pick and place task, localization of a differential drive robot	2
5.1	Reinforcement learning Overview, Policy based and Value based approaches , Monte Carlo Methods, Temporal-Difference Learning (Q-learning, SARSA)	4
5.2	Case study- Role of RL in typical pick and place task, RL for stabilization of bipedal humanoid	3

221LEC102	**ROBOTICS SIMULATION LAB**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			0	**0**	**2**	**2**

Course Outcomes: After the completion of the course the student will be able to

CO1	Use ROS to simulate a wandering robot.
CO2	Apply ROS to simulate a robot that can avoid obstacles.
CO3	Demonstrate using ROS a simulation of a teleoperated mobile robot.
CO4	Operate ROS to simulate a line follower robot.
CO5	Implement using ROS a simulation of a new robot that navigates autonomously.
CO6	Execute using ROS a simulation of a new robotic arm.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	P07
CO1	3	2	2	2	1	1	-
CO2	3	2	2	2	1	1	-
CO3	3	2	2	2	1	1	-
CO4	3	2	2	2	1	1	-
CO5	3	2	2	2	1	1	-
CO6	3	2	2	2	1	1	-

Assessment Pattern

Bloom's category	Continuous Internal evaluation
Apply	20
Analyze	20
Evaluate	20
Create	40

Mark Distribution Pattern

Total Marks	**Continuous Internal Evaluation**	**End Semester Examination**
100	**100**	

Continuous Internal Evaluation Pattern (Laboratory):

The laboratory courses will be having only Continuous Internal Evaluation and carry 100 marks. The final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

LIST OF EXPERIMENTS

Conduct **ANY EIGHT** of the following experiments on any computing system using ROS.

SI NO	Experiment title	CO Mapping
1	Simulate the turtlebot robot that alternates between driving forward and stopping.	**CO1**
2	Simulate the turtlebot robot that finds the distance to an obstacle in front of the robot.	**CO2**
3	Simulate the turtlebot robot that wanders the environment avoiding obstacles.	**CO2**
4	Simulate the turtlebot robot that moves according to keyboard teleoperation commands.	**CO3**
5	Simulate the turtlebot robot that follows a line.	**CO4**
6	Create a new mobile robot.	**CO5**
7	Simulate the new mobile robot to navigate autonomously.	**CO5**
8	Create a new robotic arm.	**CO6**
9	Simulate a new robotic arm to move as per plan.	**CO6**

SEMESTER I:
PROGRAM ELECTIVE 1

221EEC109	ROBOTICS SYSTEM CONFIGURATION	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1	Obtain kinematic model of a robotic manipulator
CO2	Develop dynamic model of a robotic manipulator
CO3	Plan a trajectory in joint space and Cartesian space
CO4	Do the forward and inverse kinematic analysis
CO5	To design a controller for a robotic manipulator

Mapping of Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	P05	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution Pattern

Total marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : 40 marks

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper: Robotics System Configuration

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. List down the classification of robots.
2. What are the general properties of the solution of the inverse kinematics problem?
3. Differentiate joint space and Cartesian space techniques.
4. What is impedance control?
5. Mention the major industrial applications of robots.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Discuss the work envelope of different robots.
7. Explain the Arm equation for the kinematic analysis of robots.
8. Explain the Jacobian matrix for tool configuration.
9. Explain the dynamic model of Robots using Lagrange's equation.
10. What are the steps for building a servo motor-controlled robotic arm?
11. Describe the features of robot vision.
12. Explain different types of sensors used in robots.

SYLLABUS

Module 1

Introduction - Definitions, Robot Elements - links, joints, end effector, actuators, sensors, hydraulic, pneumatic, electric drive systems, Robot specifications, Work envelope of different robots, Classification of Robots. Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations, Kinematic parameters, Direct Kinematics-The D-H representation.

Module 2

The Arm equation-Kinematic analysis of a typical robot. The inverse kinematics problem – general properties of solutions, Inverse kinematics of a typical 3 DOF Robot. Linear and angular velocities of a rigid body; Manipulator Jacobian; linear and angular velocities of planar 3R manipulator.

Module 3

Tool configuration vector, Workspace analysis, trajectory planning steps in trajectory planning, joint space techniques, Cartesian space techniques, The pick and place operation –Continuous path motion, Tool configuration Jacobian matrix.

Module 4

Manipulator Dynamics - Dynamic model of a robot using Lagrange's Equation, 1DOF and 2 DOF manipulator dynamic modelling, State space model of 1 DOF and 2DOF manipulators. Steps for building servomotor controlled robot arm.

Module 5

Feedback control of a single link manipulator- PID control and digital control of a single link manipulator; Nonlinear Control - PD gravity control, Computed torque control, Variable Structure control, Impedance control.

Sensors in Robotics- status sensors, environment sensors, quality control sensors, safety sensors etc. Robot vision - Image representation, Perspective and inverse perspective Transformations. Robot Applications- Industrial Applications- Material handling, Processing, Assembly, Inspection etc.

Syllabus and course plan (Total hours: 43)

No	Topic	No. of Lectures.
1	**Module I- 10 hours**	
1.1	Introduction – Definitions.	**1**
1.2	Robot Elements - links, joints, end effector, actuators, sensors, hydraulic, pneumatic, electric drive systems.	**2**
1.3	Robot specifications.	**1**
1.4	Classification of Robots.	**1**
1.5	Work envelope of different robots.	**1**
1.6	Robot Coordinate Systems- Fundamental and composite rotations.	**1**
1.7	Homogeneous co-ordinates and transformations.	**1**
1.8	Kinematic parameters.	**1**
1.9	Direct Kinematics-The D-H representation.	**1**
2	**Module II -8 hours**	
2.1	The Arm equation-Kinematic analysis of a typical robot.	**1**
2.2	The inverse kinematics problem – general properties of solutions.	**2**
2.3	Inverse kinematics of a typical 3 DOF Robot.	**1**
2.4	Linear and angular velocities of a rigid body.	**1**
2.5	Manipulator Jacobian.	**1**
2.6	Linear and angular velocities of planar 3R manipulator.	**2**

3	**Module III -8 hours**	
3.1	Tool configuration vector.	**1**
3.2	Workspace analysis.	**1**
3.3	Trajectory planning steps in trajectory planning.	**1**
3.4	Joint space techniques.	**1**
3.5	Cartesian space techniques.	**1**
3.6	The pick and place operation –Continuous path motion.	**1**
3.7	Tool configuration Jacobian matrix	**2**
4	**Module IV -7 hours**	
4.1	Manipulator Dynamics.	**1**
4.2	Dynamic model of a robot using Lagrange's Equation.	**2**
4.3	1DOF and 2 DOF manipulator dynamic modelling.	**1**
4.4	State space model of 1 DOF and 2DOF manipulators.	**1**
4.5	Steps for building servomotor controlled robot arm.	**2**
5	**Module V -10 hours**	
5.1	Feedback control of a single link manipulator- PID control and digital control of a single link manipulator.	**2**
5.2	Nonlinear Control - PD gravity control.	**1**
5.3	Computed torque control, Variable Structure control.	**1**
5.4	Impedance control.	**1**
5.5	Sensors in Robotics- status sensors, environment sensors, quality control sensors, safety sensors etc.	**2**
5.6	Robot vision - Image representation, Perspective and inverse perspective Transformations.	**2**
5.7	Robot Applications- Industrial Applications- Material handling, Processing, Assembly, Inspection etc.	**1**

Text Books

1. Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996

2. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.

3. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.

4. Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.

221EEC110	**MICROCONTROLLER ARCHITECTURE AND PROGRAMMING**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1	Explain ARM-32 bit microcontroller architecture
CO2	Use ARM Cortex M3 instruction set
CO3	Describe embedded system components
CO4	Explain embedded system design concepts
CO5	Use RTOS and IDE for embedded system design

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	1	1	1	-
CO2	1	1	2	2	1	1	-
CO3	1	1	2	1	1	1	-
CO4	1	1	2	2	1	1	-
CO5	1	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern :

Total	**:**	60 marks
Part A: Answer all – 5 questions × 5 marks	**:**	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	**:**	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper: Microcontroller Architecture and Programming

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. List down the interrupts in ARM.
2. What is memory mapping?
3. List the major applications of embedded system.
4. What are the quality attributes of embedded systems?
5. What is thread pre-emption?

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Briefly explain the architecture of ARM Cortex M3.
7. Comment on the interrupt list in ARM.
8. Explain the classification of embedded systems.
9. Differentiate between embedded and general computing systems.
10. Describe the characteristics of an embedded system.
11. Comment on different types of operating systems for robotics.
12. How can we choose an RTOS?

SYLLABUS

Module 1 - ARM-32 bit Microcontroller:

Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, Debugging support, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence

Module 2 - ARM Cortex M3 Instruction Sets and Programming:

Assembly basics, Instruction list and description, Useful instructions, Memory mapping, Bit-band operations and CMSIS, Assembly and C language Programming

Module 3 - Embedded System Components:

Embedded Vs General computing system, Classification of Embedded systems, Major applications and purpose of ES. Core of an Embedded System including all types of processor/controller, Memory, Sensors, Actuators, LED, 7 segment LED display, Optocoupler, Relay, Piezo buzzer, Push button switch, Communication Interface (onboard and external types), Embedded firmware, Other system components.

Module 4 - Embedded System Design Concepts:

Characteristics and Quality Attributes of Embedded Systems, Operational and non-operational quality attributes, Embedded Systems-Application and Domain specific, Hardware Software Co-Design and Program Modelling (excluding UML), Embedded firmware design and development (excluding C language).

Module 5 - RTOS and IDE for Embedded System Design:

Operating System basics, Types of operating systems, Task, process and threads (Only POSIX Threads with an example program), Thread preemption, Preemptive Task scheduling techniques, Task Communication, Task synchronization issues – Racing and Deadlock, Concept of Binary and counting semaphores (Mutex example without any program), How to choose an RTOS, Integration and testing of Embedded hardware and firmware, Embedded system Development Environment – Block diagram (excluding Keil), Disassembler/decompiler, simulator, emulator and debugging techniques.

Syllabus and course plan (Total hours: 42)

No	**Topic**	**No. of Lectures.**
	Module I- 8 hours	
1.1	Thumb-2 technology and applications of ARM.	**1**
1.2	Architecture of ARM, Cortex M3.	**1**
1.3	Various Units in the architecture.	**1**
1.4	Debugging support.	**1**
1.5	General Purpose Registers.	**1**
1.6	Special Registers.	**1**
1.7	Exceptions, Interrupts.	**1**
1.8	Stack operation, reset sequence.	**1**
2	**Module II-8 hours**	
2.1	Assembly basics.	**1**
2.2	Instruction list and description.	**1**
2.3	Useful instructions.	**1**
2.4	Memory mapping.	**1**

2.5	Bit-band operations.	**1**
2.6	CMSIS.	**1**
2.7	Assembly and C language Programming.	**2**
3	**Module III -8 hours**	
3.1	Embedded Vs General computing system.	**1**
3.2	Classification of Embedded systems.	**1**
3.3	Major applications and purpose of ES.	**1**
3.4	Core of an Embedded System including all types of processor/controller, Memory, Sensors, Actuators, LED, 7 segment LED display, Optocoupler, Relay, Piezo buzzer, Push button switch, Communication Interface (onboard and external types), Embedded firmware, Other system components.	**5**
4	**Module IV - 8 hours**	
4.1	Characteristics and Quality Attributes of Embedded Systems.	**1**
4.2	Operational and non-operational quality attributes.	**2**
4.3	Embedded Systems-Application and Domain specific.	**2**
4.4	Hardware Software Co-Design and Program Modelling (excluding UML).	**2**
5	Embedded firmware design and development (excluding C language).	**1**
5	**Module V - 12 hours**	
5.1	Operating System basics. Types of operating systems, Task, process and threads (Only POSIX Threads with an example program).	**1**
5.2	Thread pre-emption.	**1**
5.3	Pre-emptive Task scheduling techniques.	**1**
5.4	Task Communication.	**1**
5.5	Task synchronization issues – Racing and Deadlock.	**1**
5.6	Concept of Binary and counting semaphores (Mutex example without any program).	**1**
5.7	How to choose an RTOS.	**1**
5.8	Integration and testing of Embedded hardware and firmware.	**1**
5.9	Embedded system Development Environment – Block diagram (excluding Keil).	**1**

5.10	Disassembler/decompiler, simulator, emulator and debugging techniques.	**1**

Text Books:

1. Joseph Yiu, ―The Definitive Guide to the ARM Cortex-M3, 2nd Edition, Newnes, (Elsevier), 2010.

2. Shibu K V, ―Introduction to Embedded Systems, Tata McGraw Hill Education Private Limited, 2nd Edition.

221EEC111	**MECHATRONICS SYSTEM DESIGN**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1	Understand how mechatronics integrates the knowledge from different disciplines.
CO2	Acquire the ability to design electro mechanical systems using sensors and actuators.
CO3	Be able to work with mechanical systems that uses digital and analog electronics as data acquisition.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	1	1	-
CO2	1	1	2	2	1	1	-
CO3	1	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern :

Total : 60 marks

Part A: Answer all – 5 questions × 5 marks : 25 marks

Part B: Answer 5 of 7: 5 questions × 7 marks : 35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Mechatronics System Design

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. What is adaptive control?
2. What is over framing?
3. Briefly explain the use of open-source hardware.
4. Comment on skip control of a CD player.
5. Explain the working of bar code reader.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Explain the concept of industrial design and ergonomics.
7. Comment on man-machine interface.
8. How can we use open-source hardware?
9. Explain any one case study on Data Acquisition and control.
10. How can we control motion using a DC motor?
11. How do we control the temperature of a cold or hot reservoir? Give it as a case study
12. Briefly explain the displacement calibration system.

SYLLABUS

MODULE 1-Mechanical Systems and Design

Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.

MODULE-2-Real time interfacing

Introduction Elements of data acquisition and control Overview of I/O process-Installation of I/O card & software - Installation of application software - Over framing.

MODULE-3-Microcontrollers

Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages; web and mobile phone apps.

MODULE-4-Case studies on Data Acquisition

Transducer calibration system for Automotive applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers. Case studies on Data Acquisition and Control - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.

MODULE-5-Case studies on design of Mechatronics products

Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

Syllabus and course plan (Total hours: 41)

No	Topic	No. of Lectures.
	Module I- 8 hours	
1.1	Mechatronics approach - Control program control, adaptive control and distributed systems	**2**
1.2	Design process - Types of Design	**1**
1.3	Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation	**1**
1.4	Man machine interface	**1**
1.5	Industrial design and ergonomics.	**1**
1.6	Information transfer from machine from machine to man and man to machine,	**1**
1.7	Safety	**1**
2	**Module II- 8 hours**	
2.1	Introduction Elements of data acquisition and control	**2**
2.2	Overview of I/O process	**1**
2.3	Installation of I/O card & software	**2**
2.4	Installation of application software	**2**
2.5	Over framing	**1**

3	**Module III- 8 hours**	
3.1	Introduction to use of open source hardware (Arduino & Raspberry Pi)	**1**
3.2	Shields/modules for GPS	**1**
3.3	GPRS/GSM	**1**
3.4	Bluetooth, RFID, and Xbee.	**2**
3.5	Integration with wireless networks.	**1**
3.6	Databases and web pages	**1**
3.7	Web and mobile phone apps.	**1**
4	**Module IV- 11 hours**	
4.1	Transducer calibration system for Automotive applications	**1**
4.2	Strain Gauge weighing system	**1**
4.3	Solenoid force	**1**
4.4	Displacement calibration system	**1**
4.5	Rotary optical encoder	**1**
4.6	Inverted pendulum control	**1**
4.7	Controlling temperature of a hot/cold reservoir	**1**
4.8	Pick and place robot - Carpark barriers.	**1**
4.9	Case studies on Data Acquisition and Control - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.	**3**
5	**Module V- 6 hours**	
5.1	**Case studies on design of Mechatronics products** Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.	**6**

TEXT BOOKS

1. W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.

2. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997

3. Bradley, D. Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products

4. and Processes, Chapman and Hall, London, 1991.

5. Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.

6. Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher.

SEMESTER I:
PROGRAM ELECTIVE 2

221EEC201	DIGITAL IMAGE PROCESSING AND COMPUTER VISION	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1 K2	Describe digital image formation and low level image processing techniques.
CO2 K2	Explain depth estimation and multi-camera views.
CO3 K3	Execute feature extraction.
CO4 K3	Demonstrate image segmentation.
CO5 K3	Implement motion analysis.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	1	2	1	1	-
CO2	1	1	2	3	1	1	-
CO3	1	1	2	2	1	1	-
CO4	1	1	2	2	1	1	-
CO5	1	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Digital Image Processing and Computer Vision

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Explain the fundamentals of image formation.
2. What is auto-calibration?
3. Explain Gabor Filter.
4. What is texture segmentation?
5. What is background subtraction and modelling in computer vision?

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Discuss Fourier Transform in the context of digital image.
7. What is the role of epipolar geometry in sterio vision?
8. Briefly explain the scale-space analysis of Gaussian Derivative Filters.
9. Describe the region-growing method of segmentation.
10. Discuss the concept of spatio-temporal analysis.
11. Explain the Hough transform in the context of line detectors.
12. Comment on motion parameter estimation.

SYLLABUS

Module 1 - Digital Image Formation and low-level processing

Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.

Module 2 - Depth estimation and Multi-camera views

Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.

Module 3 - Feature Extraction

Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Module 4 - Image Segmentation

Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

Module 5 - Motion Analysis

Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Syllabus and course plan (Total hours: 42)

No	**Topic**	**No. of Lectures.**
1	**Module I- 10 hours**	
1.1	Fundamentals of Image Formation.	**1**
1.2	Transformation: Orthogonal, Euclidean, Affine, Projective, etc.	**3**
1.3	Fourier Transform1	**1**
1.4	Convolution and Filtering.	**2**
1.5	Image Enhancement.	**1**
1.6	Restoration	**1**
1.7	Histogram Processing.	**1**
2	**Module II-8 hours**	
2.1	Perspective, Binocular Stereopsis: Camera and Epipolar Geometry.	**2**
2.2	Homography.	**1**
2.3	Rectification.	**1**
2.4	DLT.	**1**
2.5	RANSAC.	**1**
2.6	3-D reconstruction framework.	**1**
2.7	Auto-calibration.	**1**
3	**Module III -8 hours**	
3.1	Edges - Canny, LOG, DOG.	**1**

3.2	Line detectors (Hough Transform).	**1**
3.3	Corners - Harris and Hessian Affine.	**1**
3.4	Orientation Histogram.	**1**
3.5	SIFT, SURF.	**1**
3.6	HOG, GLOH.	**1**
3.7	Scale-Space Analysis- Image Pyramids and Gaussian derivative filters.	**1**
3.8	Gabor Filters and DWT.	**1**
4	**Module IV - 8 hours**	
4.1	Region Growing.	**2**
4.2	Edge Based approaches to segmentation.	**1**
4.3	Graph-Cut.	**1**
4.4	Mean-Shift.	**1**
4.5	MRFs.	**1**
4.6	Texture Segmentation.	**1**
4.7	Object detection.	**1**
5	**Module V - 8 hours**	
5.1	Background Subtraction and Modeling.	**2**
5.2	Optical Flow.	**2**
5.3	KLT	**1**
5.4	Spatio-Temporal Analysis	**1**
5.5	Dynamic Stereo.	**1**
5.6	Motion parameter estimation.	**1**

Text Books:

1. E.R. Davies, Computer and Machine Vision -Theory Algorithm and Practicalities, Academic Press, 2012

2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2011.

3. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India, 2002.

221EEC202	DEEP LEARNING TECHNIQUES	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1 K2	Describe linear classifiers.
CO2 K2	Explain optimization techniques used in deep learning.
CO3 K2	Discuss basic deep networks like CNN, auto encoder.
CO4 K2	Recognize the recent trends in deep networks.
CO5 K3	Implement the techniques learned in various application areas.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

=

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : 40 marks

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks**.**

Model Question Paper: Deep Learning Techniques

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Explain Bayesian learning with real-life examples.
2. What is optimization in neural networks?
3. What are the building blocks of CNN in deep learning?
4. Discuss recent trends in deep learning architectures.
5. Explain semantic segmentation.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Discuss the benefits, use, and applications of Variational Autoencoder.
7. What is hinge loss function and how is it used in linear machines?
8. Explain the concept of back-propagation of neural networks.
9. List out the benefits and drawbacks of skip connections.
10. Explain the concept of generative modelling with Deep Learning
11. Discuss various normalization techniques in deep neural networks.
12. What is the LSTM model in Deep Learning?

SYLLABUS

Module 1: Introduction to Deep Learning and Linear Classifiers

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss.

Module 2: Network Optimization

Optimization Techniques, Gradient Descent, Batch Optimization, Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Revisiting Gradient Descent, Momentum Optimizer, RMS Prop, Adam, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

Module 3: Basic Networks

Unsupervised Learning with Deep Network, Autoencoders, Convolutional Neural Network, Building blocks of CNN, Transfer Learning

Module 4: Advanced Networks

Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc., LSTM Networks, Variational Autoencoder, Generative Adversarial Network

Module 5: Applications

Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc., Generative Modeling with DL

No	Topic	No. of Lectures.
1	**Module I-8 hours**	
1.1	Introduction to Deep Learning.	**2**
1.2	Bayesian Learning.	**2**
1.3	Decision Surfaces.	**1**
1.4	Linear Classifiers.	**1**
1.5	Linear Machines with Hinge Loss	**2**
2	**Module II- 12 hours**	
2.1	Optimization Techniques, Gradient Descent, Batch Optimization,	**3**
2.2	Introduction to Neural Network.	**1**
2.3	Multilayer Perceptron.	**1**
2.4	Back Propagation Learning.	**1**
2.5	Revisiting Gradient Descent.	**1**
2.6	Momentum Optimizer.	**1**
2.7	RMS Prop, Adam, Effective training in Deep Net- early stopping.	**2**
2.8	Dropout, Batch Normalization, Instance Normalization, Group Normalization	**2**
3	**Module III -6 hours**	
3.1	Unsupervised Learning with Deep Network.	**1**
3.2	Autoencoders.	**2**
3.3	Convolutional Neural Network.	**1**
3.4	Building blocks of CNN.	**1**
3.5	Transfer Learning.	**1**
4	**Module IV - 8 hours**	

4.1	Recent Trends in Deep Learning Architectures.	**1**
4.2	Residual Network.	**1**
4.3	Skip Connection Network.	**1**
4.4	Fully Connected CNN etc.	**1**
4.5	LSTM Networks.	**1**
4.6	Variational Autoencoder.	**2**
4.7	Generative Adversarial Network	**1**
5	**Module V - 5 hours**	
5.1	Classical Supervised Tasks with Deep Learning	**1**
5.2	Image Denoising.	**1**
5.3	Semantic Segmentation.	**1**
5.4	Object Detection.	**1**
5.5	Generative Modeling with DL	**1**

Text Books:

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press

2. Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc.

221EEC203	ALGORITHMS FOR BIG DATA PROCESSING	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1	Understand the basics of big data analytics and intelligent systems.
CO2	Familiarize with analytic models for data science and big data tools.
CO3	Familiarize with predictive modelling and machine learning algorithms for big data.
CO4	Understand social semantic web mining and application of big data analytics in IoT.
CO5	Apply big data analysis in banking and capital markets.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	1	1	1	-
CO2	1	1	2	2	1	1	-
CO3	1	1	2	2	1	1	-
CO4	1	1	2	2	1	1	-
CO5	1	1	2	3	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Algorithms for big data processing

Total:60

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. What is Hadoop?
2. Explain the difference between predictive and descriptive analytics.
3. Discuss applications of predictive modelling.
4. Comment on security, privacy issues, and challenges in IoT.
5. How Banks Can Benefit from Big Data Analytics?

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Discuss the applications of machine learning algorithms.
7. Comment on infrastructure for integration of IoT.
8. What is HDFS in Big data?
9. Differentiate supervised and unsupervised learning for Big Data.
10. Explain knowledge representation techniques and platforms in the semantic web.
11. Briefly describe functional Programming.
12. Discuss the concept of Fog computing.

SYLLABUS

Module 1- Big Data Analytics and Intelligent Systems

Introduction- What Is Big Data? , Disruptive Change and Paradigm Shift in the Business Meaning of Big Data, Hadoop, Silos, HDFS overview, Hadoop Ecosystem, Decision Making and Data Analysis in the Context of Big Data Environment,Machine Learning Algorithms, Evolutionary Computing (EC), Intelligent SystemsIntroduction Open-Source Data Science Machine Intelligence and Computational Intelligence ,Data Engineering and Data Sciences,Data Stream Systems and Stream Mining,Ubiquitous Computing Infrastructures.

Module-2 -Analytics models for Data Science and Big Data tools

Introduction Data Models Data Products Data Munging, Descriptive Analytics Predictive Analytics ,Data Science Network Science, Computing Models Data Structures for Big DataFeature Engineering for Structured Data, Computational Algorithm Programming Models Parallel Programming , Functional Programming, Distributed Programming, Big Data Tools-Introduction, Hadoop Ecosystem, HDFS Commands, MapReduce, Pig , Flume, Sqoop, Mahout- The Machine Learning Platform from Apache, GANGLIA-The Monitoring Tool,Kafka-The Stream Processing Platform, Spark ,NoSQL Databases .

Module 3- Predictive Modeling for Unstructured Data and Machine Learning Algorithms for Big Data

Predictive Modeling fir Unstructured Data-Introduction ,Applications of Predictive Modeling,Natural Language Processing, Computer Vision ,Information Retrieval ,Speech Recognition ,Feature Engineering Feature Extraction and Weighing Feature Selection, Pattern Mining for Predictive Modeling, Probabilistic Graphical Models, Deep Learning, Convolutional Neural Networks (CNN) , Recurrent Neural Networks (RNNs), Deep Boltzmann Machines (DBM) , Autoencoders,

MachineLearning Algorithms for big data-Introduction, Generative Versus Discriminative Algorithms,Supervised Learning for Big Data, Unsupervised Learning for Big Data,Semi-supervised Learning for Big Data, Reinforcement Learning Basics for Big Data , Online Learning for Big Data.

Module-4- Social Semantic Web mining,IoT and Big Data Analytics

Introduction, What Is Semantic Web?, Knowledge Representation Techniques and Platforms in Semantic Web, Web Ontology Language (OWL) , Object Knowledge Model (OKM), Architecture of Semantic Web and the Semantic,Web Road Map, Social Semantic Web Mining,Conceptual Networks and Folksonomies or Folk,Taxonomies of Concepts/Subconcepts, SNA and ABM, e-Social Science, Opinion Mining and Sentiment Analysis, Semantic Wikis,Research Issues and Challenges for Future IoT and Big Data Analysis Analytics- Analytics from the Edge to Cloud, Security and Privacy Issues and Challenge in Internet of Things (IOT), Access, Cost Reduction, Opportunities and Business Model, Content and Semantics,Data-Based Business Models Coming Out of IOT, Future of IOT-Technology Drivers , Future Possibilities, Challenges and Concerns, Big Data Analytics and IOT -Infrastructure for Integration of Big Data with IOT ,Fog Computing

Module-5 Big Data Analytics in Banking and Capital Markets

Big Data Analytics for Financial Services and Banking-Introduction,Customer Insights and Marketing Analytics, Sentiment Analysis for Consolidating Customer Feedback Predictive Analytics for Capitalizing on Customer Insights,Model Building, Fraud Detection and Risk Management,Integration of Big Data Analytics into Operations , How Banks Can Benefit from Big Data Analytics?, Best Practices of Data Analytics in Banking for Crises,Redressal and Management , Bottlenecks

Capital Market Use Cases of Big Data Technologies,Prediction Algorithms,Research Experiments to Determine Threshold Time for Determining Predictability, Experimental Analysis Using Bag of

Words and Support ,Vector Machine (SVM) Application to News Articles ,Textual Representation and Analysis of News Articles, Named Entities, Object Knowledge Model (OKM), Application of Machine Learning Algorithms,Sources of Data .

Syllabus and course plan (Total hours: 44)

No	Topic	No. of Lectures.
1	**Module I- 10 hours**	
1.1	Introduction- What Is Big Data? Disruptive Change and Paradigm Shift in the Business .	1
1.2	Meaning of Big Data, Hadoop, Silos.	1
1.3	HDFS overview, Hadoop Ecosystem, Decision Making and Data Analysis in the Context of Big Data Environment.	1
1.4	Machine Learning Algorithms.	1
1.5	Evolutionary Computing (EC).	1
1.6	Intelligent Systems-Introduction	1
1.7	Open-Source Data Science	1
1.8	Machine Intelligence and Computational Intelligence	1
1.9	Data Engineering and Data Sciences.	1
1.10	Data Stream Systems and Stream Mining. Ubiquitous Computing Infrastructures.	1
	Module II-8 hours	
2.1	Introduction Data Models Data Products Data Munging.	1
2.2	Descriptive Analytics Predictive Analytics.	1
2.3	Data Science Network Science, Computing Models Data Structures for Big DataFeature Engineering for Structured Data.	1
2.4	Computational Algorithm Programming Models Parallel Programming.	1
2.5	Functional Programming, Distributed Programming.	1
2.6	Big Data Tools-Introduction, Hadoop Ecosystem.	1
2.7	HDFS Commands, MapReduce, Pig , Flume, Sqoop, Mahout- The Machine Learning Platform from Apache.	1
2.8	GANGLIA-The Monitoring.	1
3	**Module III -9 hours**	
3.1	Predictive Modeling for Unstructured Data-Introduction.	1

3.2	Applications of Predictive Modeling.	**1**
3.3	Natural Language Processing, Computer Vision, Information Retrieval.	**1**
3.4	Speech Recognition, Feature Engineering Feature Extraction and Weighing Feature Selection.	**1**
3.5	Pattern Mining for Predictive Modeling, Probabilistic Graphical Models, Deep Learning, Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNNs), Deep Boltzmann Machines (DBM) , Autoencoders.	**2**
3.6	MachineLearning Algorithms for big data-Introduction, Generative Versus Discriminative Algorithms.	**1**
3.7	Supervised Learning for Big Data, Unsupervised Learning for Big Data,Semi-supervised Learning for Big Data, Reinforcement Learning Basics for Big Data , Online Learning for Big Data.	**2**
4	**Module IV - 8 hours**	
4.1	Introduction, What Is Semantic Web? Knowledge Representation Techniques and Platforms in Semantic Web, Web Ontology Language (OWL) , Object Knowledge Model (OKM).	**1**
4.2	Architecture of Semantic Web and the Semantic, Web Road Map, Social Semantic Web Mining.	**1**
4.3	Conceptual Networks and Folksonomies or Folk.	**1**
4.4	Taxonomies of Concepts/Subconcepts, SNA and ABM, e-Social Science, Opinion Mining and Sentiment Analysis, Semantic Wikis.	**1**
4.5	Research Issues and Challenges for Future IoT and Big Data Analysis	**1**
4.6	Analytics- Analytics from the Edge to Cloud, Security and Privacy Issues and Challenge in Internet of Things (IOT), Access, Cost Reduction, Opportunities and Business Model, Content and Semantics.	**1**
4.7	Data-Based Business Models Coming Out of IOT, Future of IOT-Technology Drivers , Future Possibilities, Challenges and Concerns.	**1**
4.8	Big Data Analytics and IOT -Infrastructure for Integration of Big Data with IOT ,Fog Computing.	**1**
5	**Module V - 9 hours**	
5.1	Big Data Analytics for Financial Services and Banking-Introduction,	**1**

	Customer Insights and Marketing Analytics.	
5.2	Sentiment Analysis for Consolidating Customer Feedback Predictive Analytics for Capitalizing on Customer Insights,Model Building.	**1**
5.3	Fraud Detection and Risk Management, Integration of Big Data Analytics into Operations.	**1**
5.4	, How Banks Can Benefit from Big Data Analytics?, Best Practices of Data Analytics in Banking for Crises,Redressal and Management , Bottlenecks.	**1**
5.5	Capital Market Use Cases of Big Data Technologies.	**1**
5.6	Prediction Algorithms, Research Experiments to Determine Threshold Time for Determining Predictability.	**1**
5.7	Experimental Analysis Using Bag of Words and Support Vector Machine (SVM) Application to News Articles , Textual Representation and Analysis of News Articles, Named Entities, Object Knowledge Model (OKM).	**2**
5.8	Application of Machine Learning Algorithms,Sources of Data.	**1**

Text Books

1. Big Data Analytics: Systems, Algorithms and Applications- Springer Press,C. S. R. Prabhu,Aneesh Sreevallabh Chivukula ,Aditya Mogadala , Rohit Ghosh ,L. M. Jenila Livingston.

2. Big Data Analysis: New Algorithms For A New Society-Springer International Publishing AG-Nathallie Japkovicz, Jerzy Stefanowisky Edwards.

3. Algorithms for Big Data-World Scientific Publishing Co Pte Ltd, Moran Feldman.

SEMESTER II

221TIA003	KINEMATICS, DYNAMICS AND CONTROL OF ROBOTS	CATEGORY	L	T	P	CREDIT
		Core	3	0	0	3

Preamble

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

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Familiarise with anatomy, specifications and standard robot configurations
CO 2	Obtain the forward and inverse kinematic model of a robotic manipulator
CO 3	Plan trajectories for robots
CO 4	Obtain the dynamic model of robots
CO 5	Design controllers for robotic manipulators
CO 6	Design controllers for mobile robots

Mapping of course outcome and program outcome

	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7
CO 1	3	-	2	-	1	1	-
CO 2	3	-	2	-	1	1	-
CO 3	3	-	2	3	1	1	-
CO 4	3	-	2	3	1	1	-
CO 5	3	-	2	3	1	1	-
CO 6	3	-	2	3	1	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution pattern

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: **40 marks**

Preparing a review article based on peer reviewed Original publications

(minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
(Test paper shall include minimum 80% of the syllabus.)

End Semester Examination Pattern:

End Semester Examination :**60 marks**
Part A: 5 numerical/short answer questions with 1 question from each module, (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.
Each question can carry 5 marks.

Part B: 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five.
Each question can carry 7 marks.

Slot: B

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M.TECH DEGREE EXAMINATION
MONTH & YEAR
Course code: **221TIA003**
Course Name: **Kinematics Dynamics and Control of Robots**

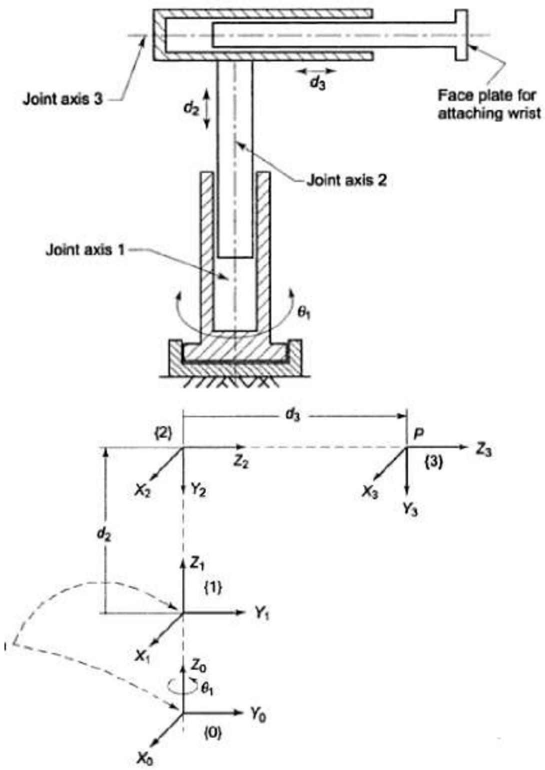
Max. Marks: 60 **Duration: 2.5 Hours**

PART A
Answer all Questions. Each question carries 5 Marks

1 What do you mean by DOF? What are redundant manipulators? Explain with the help of an example.
2 If a point $P - [30 - 11]^T$, find the new location of the point P, if it is (i) rotated by π about z-axis of fixed frame and then translated by 3 units along y axis (ii) it is first translated by 3 units along y axis and then rotated about z axis by π. Are the two locations same. Explain why the final position in two cases is same or different.
3 One revolute joint of SCARA robotic manipulator is to move from $30^0$to 120^0 in 7 seconds. If the joint has initial and final velocity of 1.0deg/sec and 1.2deg/s respectively. Determine the cubic polynomial to interpolate a smooth trajectory. Also obtain the velocity and acceleration profiles of the joint.
4 Compare position vs force control.
5 Compare a differential drive WMR and a car like WMR.

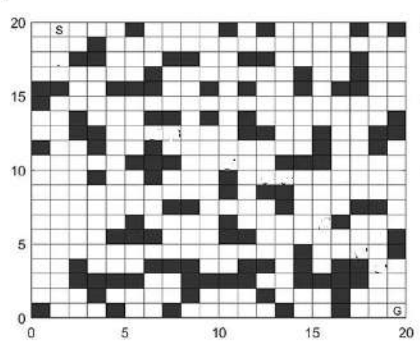
PART A
Answer any 5 Questions. Each question carries 7 Marks

6 Explain how robots are classified based on work envelope geometries and drive technologies.
7 For the following cylindrical robot arm, compute the position and orientation of the tool tip.



8 Determine the joint angles θ_1, θ_2, θ_3 of a 3 axis robot if the origin of {3} is located at $[0.707, 1.707, 0.000]^T$ and the orientation of {3} with respect to {0} is given by the rotation matrix $R = [0.5 - 0.86600.8660.50001]$. Given $T_0^3 = [C_{123} - S_{123} 0 L_1 C_1 + L_2 C_{12} S_{123} C_{123} 0 L_1 S_1 + L_2 S_{12} 00100001]$

9 Which algorithm can be used to find a path from start to goal in the following scenario? Explain the algorithm.



10 Obtain the dynamic model of a 1DOF robotic manipulator.

11 Suppose a robotic manipulator is to be designed to erase a white board, which control scheme can be used? Give the details of the controller.

12 Design a control scheme to drive a differential drive robot to follow a circular trajectory

Syllabus

Module I:

Introduction

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 considerations for an application, Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on drive technologies and motion control methods.

Case study- sensors and actuators of robots (demo/assignment only)

Module II

Kinematics

Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics, Necessity of kinematic modelling, The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF. The inverse kinematics problem, general properties of solutions, Inverse kinematics of robots up to 3 DOF. Tool configuration vector and Jacobian.

Linear and angular velocities of rigid body, Linear and angular velocities of 3R manipulator, relation between joint and end effector velocities.

Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only)

Module III

Trajectory Planning and Dynamics of Robots

Trajectory Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms.

Dynamics- Necessity of dynamic modelling, dynamic model of a robot using Lagrange's equation, dynamic modelling of 1DOF robot, modelling including motor and gearbox, 2R planar manipulator.

Module IV

Control of robotic manipulators

Necessity of a control system in a robot, block diagram typical robot control system, position control, force control.

PID control, PD gravity control, Computed torque control, Variable Structure control, Impedance control, digital control of a single link manipulator.

Case study- Control of a single link and two link manipulator using MATLAB/ROS. (Assignment/demo only)

Module V

Control of mobile robots

Basic understanding of Differential-Drive WMR, Car-Like WMR, Three-Wheeled Omnidirectional Mobile Robot, Kinematic model of a differential drive and a steered mobile robot.

Control of mobile robots- Control of differential drive robot and steered robot based on its kinematic model, Control of differential drive robot to move to a point, follow a line, follow a trajectory, to achieve an orientation. Control of a steered robot to move to a point, follow a line, follow a trajectory, to achieve an orientation.

Case study- design and implementation of a controller for a differential drive robot capable of moving to a point, following a line and following a path using MATLAB (Assignment/demo only)

References

1. Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
2. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
3. Introduction to Robotics by S K Saha, Mc Graw Hill Education
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. AshitavaGhosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
6. Introduction to Autonomous Mobile Robots , R Siegwart, IR Nourbakhsh, D Scaramuzza, , MIT Press, USA, 2011.
7. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB

No	Topic	No. of Lectures
1	**Introduction**	
1.1	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;	2
1.2	Robot considerations for an application- Number of Axes, Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision and Accuracy, Operating environment	1
1.3	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.	2
1.4	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on drive technologies and motion control methods. Case study- sensors and actuators of robots (demo/assignment only)	3
2	**Kinematics**	
2.1	Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations	2
2.2	Kinematic parameters, D-H representation, Direct Kinematics, Necessity of kinematic modelling, The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF.	2
2.3	The inverse kinematics problem, general properties of solutions, Inverse kinematics of robots up to 3 DOF.	1
2.4	Tool configuration vector and Jacobian, Linear and angular velocities of rigid body, Linear and angular velocities of 3R manipulator, relation between joint and end effector velocities.	2
2.5	Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only)	1
3	**Trajectory Planning and Dynamics of Robots**	
3.1	Trajectory Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends;	2

3.2	Cartesian space planning	1
3.3	Obstacle avoidance methods- Artificial Potential field, A* algorithms	2
3.4	Dynamics- Necessity of dynamic modelling, dynamic model of a robot using Lagrange's equation, dynamic modelling of 1DOF robot, modelling including motor and gearbox, 2R planar manipulator.	3
4	**Control of robotic manipulators**	
4.1	Necessity of a control system in a robot, block diagram typical robot control system, position control, force control.	3
4.2	PID control, PD gravity control, Computed torque control, Variable Structure control, Impedance control, digital control of a single link manipulator	4
4.3	Case study- Control of a single link and two link manipulator using MATLAB/ROS. (Assignment/demo only)	1
5	**Control of mobile robots**	
5.1	Basic understanding of Differential-Drive WMR, Car-Like WMR, Three-Wheeled Omnidirectional Mobile Robot, Kinematic model of a differential drive and a steered mobile robot.	2
5.2	Control of mobile robots- Control of differential drive robot and steered robot based on its kinematic model,	2
5.3	Control of differential drive robot to move to a point, follow a line, follow a trajectory, to achieve an orientation.	2
5.4	Control of a steered robot to move to a point, follow a line, follow a trajectory, to achieve an orientation.	1
5.5	Case study- design and implementation of a controller for a differential drive robot capable of moving to a point, following a line and following a path using MATLAB (Assignment/demo only)	1

222TEC103	**ADVANCED AI AND APPLICATIONS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1 K2	Describe advanced deep learning techniques
CO2 K2	Discuss AI techniques for robot control
CO3 K2	Discuss AI techniques for robot localisation and mapping
CO4 K2	Interpret the state of the art AI models
CO5 K2	Identify the responsibility concerns related to AI

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	1
CO5	2	1	2	2	1	1	1

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark distribution pattern

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern :

Total	**:**	60 marks
Part A: Answer all – 5 questions × 5 marks	**:**	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	**:**	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper :Advanced AI and Applications

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. What is multimodal AI?
2. Discuss feedback linearization control
3.Introduce SLAM.
4. Explain LIME.
5. State Lagrangian formulation.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Discuss the optimization techniques for large-scale AI models.
7. What is Proportional-Integral-Derivative control?
8. Describe the probabilistic frameworks used for SLAM.
9. With the help of an example explain reinforcement learning.
10. Discuss the importance of explainability and transparency in AI decision-making.
11. Discuss the safety and security concerns in AI systems
12. What are the ethical considerations in AI development and deployment?

SYLLABUS

Module 1: Deep Learning Frontiers

Advanced architectures: Transformers, GANs, recurrent neural networks for complex tasks, Unsupervised learning for data representation and generation, Multimodal AI: Processing and integrating different data modalities (text, images, audio), Optimization techniques for large-scale models and efficient training.

Module 2: Robot Control with AI

Proportional-Integral-Derivative (PID) control, Tuning PID gains for optimal performance, model predictive control, feedback linearization control.

Module 3: Simultaneous Localization and Mapping (SLAM)

Introduction to SLAM, Sensor Modalities for SLAM, Probabilistic Framework for SLAM, SLAM Algorithms - Kalman Filter, Extended Kalman Filter (EKF), Particle Filter, Mapping algorithms: Occupancy grids, landmark-based maps, SLAM for dynamic environments, Loop closure detection.

Module 4: Explainable AI

Importance of explainability and transparency in AI decision-making, Techniques for model interpretability: LIME, SHAP, Integrated Gradients, Counterfactual explanations and causal inference in AI, Explainable reinforcement learning and interpretable deep learning models.

Module 5: Responsible AI

Ethical considerations in AI development and deployment: fairness, bias, discrimination, Privacy-preserving AI: techniques for data anonymization and differential privacy, Safety and security concerns in AI systems: adversarial attacks, explainability for robustness, Responsible AI development frameworks and best practices.

Syllabus and course plan (Total hours: 39)

No	Topic	No. of Lectures.
1	**Module I- 7 hours**	
1.1	Advanced architectures: Transformers, GANs.	**2**
1.2	Recurrent neural networks for complex tasks.	**1**
1.3	Unsupervised learning for data representation and generation.	**1**
1.4	Multimodal AI: Processing and integrating different data modalities (text, images, audio).	**1**
1.5	Optimization techniques for large-scale models and efficient training.	**2**
2	**Module II-8 hours**	
2.1	Proportional-Integral-Derivative (PID) control,	**2**
2.2	Tuning PID gains for optimal performance	**2**
2.3	Model predictive control,	**2**
2.4	Feedback linearization control.	**2**
3	**Module III -8 hours**	
3.1	Introduction to SLAM.	**1**
3.2	Sensor Modalities for SLAM	**1**
3.3	Probabilistic Framework for SLAM	**1**
3.4	SLAM Algorithms - Kalman Filter, Extended Kalman Filter (EKF), Particle Filter	**2**
3.5	Mapping algorithms: Occupancy grids, landmark-based maps	**1**

3.6	SLAM for dynamic environments	**1**
3.7	Loop closure detection	**1**
4	**Module IV - 7 hours**	
4.1	Importance of explainability and transparency in AI decision-making,	**1**
4.2	Techniques for model interpretability: LIME, SHAP,	**2**
4.3	Integrated Gradients	**1**
4.4	Counterfactual explanations and causal inference in AI	**2**
4.5	Explainable reinforcement learning and interpretable deep learning models.	**1**
5	**Module V – 9 hours**	
5.1	Ethical considerations in AI development and deployment: fairness, bias, discrimination	**2**
5.2	Privacy-preserving AI: techniques for data anonymization and differential privacy	**2**
5.3	Safety and security concerns in AI systems: adversarial attacks,	**2**
5.4	Explainability for robustness	**1**
5.5	Responsible AI development frameworks and best practices.	**2**

Textbook:

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Pearson, 2022 (4th Edition).

2. Nick Bostrom, Superintelligence: Paths, Dangers, Strategies, Oxford University Press, 2016.

3. Bishop, C. M, Pattern Recognition and Machine Learning, Springer, 2006.

4. Theodoridis, S. and Koutroumbas, K., Pattern Recognition, Academic Press, 2003.

5. Choset H. et al., Principles of Robot Motion Theory, Algorithms, and Implementation, MIT Press, 2005.

222PEC100	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PROJECT	0	0	4	2

Mini project can help to strengthen the understanding of student's fundamentals throughapplicationoftheoreticalconceptsandtoboosttheirskillsandwidenthe horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Program Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee-Program Coordinator, One Senior Professor and Guide.

Sl.No	Typeofevaluations	Mark	Evaluationcriteria
1	Interim valuation1	20	
2	Interim valuation2	20	
3	Finale valuation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than25%)
5	Supervisor/Guide	10	
Total Marks		100	

222LEC104	AI LAB	CATEGORY	L	T	P	CREDIT
			0	**0**	**2**	**2**

Course Outcomes: After the completion of the course the student will be able to

CO1	Use sklearn functions and built-in datasets to train and evaluate ML models
CO2	R Perform clustering using typical ML techniques
CO3	Implement classification using typical ML techniques
CO4	Use deep learning models for classification
CO5	Apply ttransfer learning for classification

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	3	1	1	-
CO2	2	3	2	3	1	1	-
CO3	2	3	2	3	1	1	-
CO4	2	3	2	3	1	1	-
CO5	2	3	2	3	1	1	-

Assessment Pattern

Bloom's category	Continuous Internal evaluation
Apply	20
Analyze	20
Evaluate	20
Create	40

Mark Distribution

Total Marks	Continuous Internal Evaluation	End Semester Examination
100	**100**	

Continuous Internal Evaluation Pattern (Laboratory):

The laboratory courses will be having only Continuous Internal Evaluation and carry 100 marks. The final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

LIST OF EXPERIMENTS

Conduct **ALL** of the following experiments using Python

1. Reduce Features Using Principal Components and Matrix factorization

2. Train and evaluate the regression models using Boston housing dataset

3. Use k-means clustering to group observations and evaluate the performance

4. Train, evaluate and visualize a decision tree classifier

5. Train and evaluate classification model using a forest of randomized decision trees

6. Train and evaluate a CNN classification model to classify MNIST digit dataset

7. Apply transfer learning on a CNN classification model to classify any relevant dataset

SI No	Experiment Title	CO Mapping
1	Reduce Features Using Principal Components and Matrix factorization	CO1
2	Train and evaluate the regression models using Boston housing dataset	CO1
3	Use k-means clustering to group observations and evaluate the performance	CO2
4	Train, evaluate and visualize a decision tree classifier	CO3
5	Train and evaluate classification model using a forest of randomized decision trees	CO4
6	Train and evaluate a CNN classification model to classify MNIST digit dataset	CO4
7	Apply transfer learning on a CNN classification model to classify any relevant dataset	CO5

SEMESTER II:
PROGRAM ELECTIVE 3

222EEC301	**NON-LINEAR AND ADAPTIVE CONTROL SYSTEMS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1	Understand more details about various non linearities present in the system.
CO2	Understand Phase Plane Analysis.
CO3	Analyze the stability of Nonlinear Systems.
CO4	Familiar with various stability criteria and understand the basic concepts of variable structure control systems.
CO5	Understand the development of adaptive control system and self tuning regulators.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's category	**Continuous Internal evaluation**
Apply	20
Analyze	20
Evaluate	20
Create	40

Mark Distribution

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : 40 marks

Micro project/ Course based project	:	20 marks
Course based task/seminar/Quiz	:	10 marks
Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Non-Linear and Adaptive Control Systems

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Write down the characteristics of nonlinear systems.
2. Explain the types of singular points.
3. How is the stability of a nonlinear system analysed?
4. Briefly explain sliding mode control.
5. What is the MIT rule?

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Describe the common nonlinearity of the system.
7. Explain the construction of phase portrits.
8. Explain the construction of the Lyapunov function.
9. Describe the basic concepts of variable structure control systems.
10. Comment on the role of index performance in adaptive systems.
11. What is gain scheduling?
12. What is Popov's stability criterion?
12. Represent the position and orientation of a robotic system.

SYLLABUS

Module 1

Features of linear and non-linear systems- Common nonlinearities Characteristics of Nonlinear systems - Limit cycles - stability, jump resonance - Describing function Analysis – Describing function of different non linearities - saturation, dead zone, relay, hysteresis

Module 2

Phase plane analysis - Singular points – types - Construction of Phase portrits – Isocline, Delta methods.

Module 3
Stability analysis of Nonlinear systems, Liapunov stability analysis Construction of Liapunov function- variable gradient method.

Module 4
Popov's stability criterion, Circle criterion, Variable structure control systems-basic concepts-Sliding mode control.

Module 5
Introduction- Development of adaptive control problem- The role of Index performance(IP) in adaptive systems- Gain scheduling- Model Reference Adaptive Systems- The MIT rule, Self tuning regulators- Adaptive predictive control. Determination of Adaptation gain Back stepping approach to Stabilization.

Syllabus and course plan (Total hours: 40)

No	Topic	No. of Lectures.
1	**Module I-8 hours**	
1.1	Features of linear and non-linear systems.	**2**
1.2	Common nonlinearities	**1**
1.3	Characteristics of Nonlinear systems	**1**
1.4	Limit cycles - stability, jump resonance.	**2**
1.5	Describing function Analysis.	**1**
1.6	Describing function of different non linearities - saturation, dead zone, relay, hysteresis.	**1**
2	**Module II-8 hours**	
2.1	Phase plane analysis.	**3**
2.2	Singular points – types.	**1**
2.3	Construction of Phase portrits.	**1**
2.4	Isocline.	**1**
2.5	Delta methods.	**2**
3	**Module III -8 hours**	
3.1	Stability analysis of Nonlinear systems	**2**
3.2	Liapunov stability analysis	**3**
3.3	Construction of Liapunov function- variable gradient method.	**3**
4	**Module IV - 8 hours**	

4.1	Popov's stability criterion.	**3**
4.2	Circle criterion.	**1**
4.3	Variable structure control systems-basic concepts	**2**
4.4	Sliding mode control.	**2**
5	**Module V - 8 hours**	
5.1	Introduction- Development of adaptive control problem	**1**
5.2	The role of Index performance(IP) in adaptive systems	**1**
5.3	Gain scheduling	**1**
5.4	Model Reference Adaptive Systems	**1**
5.5	The MIT rule.	**1**
5.6	Self tuning regulators- Adaptive predictive control.	**1**
5.7	Determination of Adaptation gain Back stepping approach to Stabilization.	**2**

Text Books

1 Jean-Jacques Slotine&WeipingLi,"Applied Nonlinear Control", Prentice- Hall .
2. Shankar Sastry, "Nonlinear System Analysis, Stability and Control", Springer.
3. Hassan K Khalil, "Nonlinear systems", MACMILLAN Publishing company

222EEC302	ADVANCED ROBOTICS AND APPLICATIONS	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO 1	Summarise the fundamentals of robotics, and identify the under-actuated robot models
CO2	Illustrate the different robot-learning approaches
CO3	Differentiate various aspects of soft-robotics
CO4	Apply the knowledge of Human-robot interaction in the applications in society
CO5	Identify and apply the knowledge of drones to design a basic drone for a given situation

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	3	1	1	-
CO5	2	1	2	3	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern :

Total : 60 marks

Part A: Answer all – 5 questions × 5 marks : 25 marks

Part B: Answer 5 of 7: 5 questions × 7 marks : 35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Advanced Robotics and Applications

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Explain the fundamentals of kinematics.
2. Comment on soft actuators and sensors.
3. Explain planning and control in multi-robot systems.
4. What is Bernoulli's principle?
5. Explain the anatomy of Quadcopters.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Explain the problem formulation and modelling of under-actuated robots.
7. Differentiate model-based and model-free learning approaches.
8. What are the methods for learning coordination and cooperation in multi-agent systems?
9. List the classification of unmanned aerial systems.
10. Explain fixed wind RPA systems.
11. What are the basic design problems in multi-rotor drones?
12. Briefly explain the design of a drone.

SYLLABUS

Module 1

Introduction, History and landscape of robotics; Fundamentals of kinematics, dynamics, and planning.

Underactuated Robotics: Problem formulation and modelling, Control approaches, Case studies.

Module 2

Robot Learning and Adaptation: Model-based learning approaches, Model-free learning approaches.

Soft Robotics: Soft material/body robot modelling, Soft actuators and sensors, Control and learning of soft robots

Module 3

Human-Robot Interaction: Theoretical frameworks- spatial, nonverbal, verbal interactions; applications, robots in society

Distributed Robotics: Multi-Agent Systems, Planning and control in multi-robot systems, Methods for learning coordination and cooperation in multi-agent systems.

Module 4

Drone essentials: Unmanned Aerial Systems (UAS); The Aircraft Act, The Aircraft Rules, UAS: Classification - by size, range and altitude

Drone Design: Airfoil, Chord line, Relative wind, Centre of pressure, Angle of attack, Angle of incidence, Centre of lift, Centre of gravity, Bernoulli's principle, Wing design, Control surfaces, Axis of flight

Module 5

Fixed wing Drones: Introduction – Fixed wind RPA Systems, basic controls, propulsion, fuel and control systems, Operation and Manoeuvres – Circuit patterns. Fixed wing Vs Multi-copters.

Multi-Rotor Drones: Quadcopters – Anatomy – Propellers, Motors, ECS, Flight Controller, Camera, basic design problems

Syllabus and course plan (Total hours: 39)

No	Topic	No. of Lectures.
1	**Module I-8 hours**	
1.1	Introduction, History and landscape of robotics.	**2**
1.2	Fundamentals of kinematics, dynamics, and planning.	**2**
1.3	**Underactuated Robotics**: Problem formulation and modelling,	**2**
1.4	Control approaches, Case studies.	**2**
2	**Module II-8 hours**	
2.1	**Robot Learning and Adaptation**: Model-based learning approaches,	**2**
2.2	Model-free learning approaches.	**2**
2.3	**Soft Robotics**: Soft material/body robot modelling.	**2**

2.4	Soft actuators and sensors	**1**
2.5	Control and learning of soft robots.	**1**
3	**Module III -7 hours**	
3.1	**Human-Robot Interaction**: Theoretical frameworks.	**1**
3.2	Spatial, nonverbal, verbal interactions.	**1**
3.3	Applications, robots in society.	**1**
3.4	**Distributed Robotics**: Multi-Agent Systems.	**2**
3.5	Planning and control in multi-robot systems.	**1**
3.6	Methods for learning coordination and cooperation in multi-agent systems.	**1**
4	**Module IV - 8 hours**	
4.1	**Drone essentials:** Unmanned Aerial Systems (UAS).	**1**
4.2	The Aircraft Act, The Aircraft Rules.	**1**
4.3	UAS: Classification - by size, range and altitude.	**1**
4.4	**Drone Design**: Airfoil, Chord line, Relative wind, Centre of pressure, Angle of attack, Angle of incidence, Centre of lift, Centre of gravity, Bernoulli's principle, Wing design, Control surfaces, Axis of flight.	**5**
5	**Module V - 8 hours**	
5.1	**Fixed wing Drones**: Introduction	**1**
5.2	Fixed wind RPA Systems, basic controls, propulsion, fuel and control systems.	**1**
5.3	Operation and Manoeuvres – Circuit patterns. Fixed wing Vs Multi-copters.	**2**

5.4	**Multi-Rotor Drones:** Quadcopters – Anatomy – Propellers, Motors, ECS, Flight Controller, Camera, basic design problems.	**4**

Reference

1. Ronald C. Arkin 1949. Behavior-Based Robotics / Ronald C. Arkin. Cambridge, Mass. : MIT Press, c1998.; 1998.
2. Bruno Siciliano 1959; Oussama Khatib editor., eds. Springer Handbook of Robotics / Edited by Bruno Siciliano, Oussama Khatib. 2nd Edition. Cham : Springer International Publishing, 2016.; 2016.
3. Rolf Pfeifer. Understanding Intelligence / Rolf Pfeifer and Christian Scheier ; with Figures by Alex Riegler and Cartoons by Isabelle Follath. (Christian Scheier, ed.). MIT Press; 1999.
4. Fantoni, Isabelle, Lozano, Rogelio, Non-linear Control for Underactuated Mechanical Systems, Springer, 2002

5. Yasmina Bestaoui Sebbane, A First Course in Aerial Robots and Drones, Chapman & Hall/CRC, ISBN-13: 978-0367631383, 2022
6. Adam Juniper, The Complete Guide to Drones, Extended 2nd Edition, Ilex Press, ISBN-13: 978-1781575383, 2018

222EEC303	**MOBILE ROBOTICS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarise types of locomotion for mobile Robots
CO 2	Derive the kinematic model of mobile robots
CO 3	Derive dynamic model of mobile robots
CO 4	Choose appropriate Sensors for mobile robot navigation
CO 5	Perform navigation and path planning mobile robots
CO 6	Control the mobile robots to follow different paths

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	3	1	1	-
CO5	2	1	2	3	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper: Mobile Robotics

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Comment on under water robots.
2. Explain three wheel omnidirectional mobile robots.
3. Explain the dynamics of WMR with slip.
4. List down the classification of sensors
5. Differentiate local and global path planning.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Comment on legged mobile robots.
7. Differentiate holonomic and non-holonomic robots.
8. Explain Newton-Euler methods.
9. Briefly describe Kalman method.
10. Explain Dijkstra's algorithm.
11. What are the basics of swarm robots?
12. Explain Bug algorithm for obstacle avoidance.

SYLLABUS

Module I

Introduction, key issues for locomotion, Wheeled Mobile Robots, Wheeled locomotion: The design space, wheeled locomotion: Case studies. Mobile manipulators, Legged Mobile Robots- Leg configurations and stability, Examples of legged robot locomotion, aerial robots, underwater robots and surface water robots

Module 2

Basic understanding of Differential-Drive WMR, Car-Like WMR, Three-Wheel Omnidirectional Mobile Robot, Four Mecanum-Wheel Omnidirectional Robot

Kinematic model of a differential drive and a steered mobile robot, degree of freedom and manoeuvrability, Degree of steerability, different wheel configurations, holonomic and non-holonomic robots. Omnidirectional Wheeled Mobile Robots.

Module 3

Dynamics of mobile robot: Lagrange-Euler method, Newton-Euler methods, Differential-Drive WMR, Dynamics of WMR with Slip, Car-Like WMR Dynamic Model, Three-Wheel Omnidirectional Mobile Robot.

Computer based dynamic (numerical) simulation of different wheeled mobile robots.-Demo/Assignment only

Module 4

Sensors for mobile robot navigation: Sensor classification, Characterizing sensor performance, Wheel /motor sensors, Heading sensors, Accelerometers, IMUs, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors.

Robot navigation: Localization, Error propagation model, Probabilistic map based localisation-Kalman method, Autonomous map building, Simultaneous localization and mapping (SLAM).

Module 5

Path Planning- local vs global path planning, Graph search, Potential field-based path planning; Map based path planning- Dijkstra's algorithm, A*, D* algorithms.
Obstacle avoidance- Bug algorithm, Vector field histogram, Dynamic window approach.

Control of mobile robots- Control of differential drive robot and steered robot based on its kinematic model, Case study- design and implementation of a differential drive robot capable of moving to a point, following a line and following a path.

Basics of Swarm robots, cooperative and collaborative robots, mobile manipulators.

Syllabus and course plan (Total hours: 42)

No	Topic	No. of Lectures.
1	**Module I-9 hours**	
1.1	**Introduction**, key issues for locomotion,	**1**
1.2	Wheeled Mobile Robots,.	**1**
1.3	Wheeled locomotion: The design space, wheeled locomotion: Case studies.	**2**
1.4	Mobile manipulators	**1**
1.5	, Legged Mobile Robots- Leg configurations and stability, Examples	**4**

	of legged robot locomotion, aerial robots, underwater robots and surface water robots	
2	**Module II-8 hours**	
2.1	Basic understanding of Differential-Drive WMR, Car-Like WMR.	**1**
2.2	Three-Wheel Omnidirectional Mobile Robot.	**1**
2.3	Four Mecanum-Wheel Omnidirectional Robot	**1**
2.4	**Kinematic model** of a differential drive and a steered mobile robot.	**1**
2.5	Degree of freedom and manoeuvrability.	**1**
2.6	Degree of steerability, different wheel configurations.	**1**
2.7	holonomic and non-holonomic robots.	**1**
2.8	Omnidirectional Wheeled Mobile Robots.	**1**
3	**Module III - 7 hours**	
3.1	**Dynamics of mobile robot**: Lagrange-Euler method	**1**
3.2	Newton-Euler methods,	**1**
3.3	Differential-Drive WMR	**1**
3.4	Dynamics of WMR with Slip	**1**
3.5	Car-Like WMR Dynamic Model	**1**
3.6	Three-Wheel Omnidirectional Mobile Robot	**1**
3.7	Computer based dynamic (numerical) simulation of different wheeled mobile robots.-Demo.	**1**
4	**Module IV - 10 hours**	
4.1	**Sensors for mobile robot navigation**: Sensor classification	**1**
4.2	Characterizing sensor performance	**1**
4.3	Wheel /motor sensors	**1**
4.4	Heading sensors, Accelerometers, IMUs	**1**
4.5	Ground-based beacons	**1**
4.6	Active ranging, Motion/speed sensors, Vision-based sensors.	**1**
4.7	**Robot navigation**: Localization, Error propagation model, Probabilistic map based localisation-Kalman method	**2**

	Autonomous map building, Simultaneous localization and mapping (SLAM).	**2**
5	**Module V - 8 hours**	
5.1	**Path Planning**- local vs global path planning,	**1**
5.2	Graph search, Potential field-based path planning; Map based path planning- Dijkstra's algorithm, A*, D* algorithms.	**2**
5.3	Obstacle avoidance- Bug algorithm, Vector field histogram, Dynamic window approach.	**1**
5.4	**Control of mobile robots-** Control of differential drive robot and steered robot based on its kinematic model,	**1**
5.5	Case study- design and implementation of a differential drive robot capable of moving to a point, following a line and following a path.	**1**
5.6	Basics of Swarm robots, cooperative and collaborative robots, mobile manipulators.	**2**

Reference Books

7. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011.
8. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.
9. Spyros G. Tzafestas, Introduction to Mobile Robot Control, Elsevier.
10. S. M. La Valle, "Planning Algorithms", Cambridge University Press, 2009.
11. Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005.
12. Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012.
13. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005.

SEMESTER II:
PROGRAM ELECTIVE 4

222EEC401	ADVANCED WIRELESS COMMUNICATION	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO 1	Summarise the fundamentals of advanced communication techniques
CO2	Illustrate the UWB communication designs and issues
CO3	Decide and derive parameters of OFDM Communication mechanism
CO4	Decide and design parameters for MIMO communications
CO5	Identify and apply the knowledge Cognitive Radio and Adhoc network for a given situation

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	1	1	1	1	-
CO2	2	1	2	1	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	3	3	1	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

: 40 marks

Mark Distribution

Total marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no : 10 marks

End Semester examination Pattern	**:**	
Total	**:**	60 marks
Part A: Answer all – 5 questions × 5 marks	**:**	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	**:**	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper : Advanced Wireless Communication

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. What is cognitive radio?
2. Discuss the UWB channel model.
3.What is OFDM?
4. Explainthe angle spread.
5. Discuss the applications of ad-hoc networks.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Explain the multi-antenna technologies.
7. Explain theUWB transmitter and receiver structures.
8. Describe the interference issues in UWB.
9. Explain the coherent receiver design of OFDM.
10. What is adaptive beam forming? Explain with the help of diagrams.

SYLLABUS

Module 1

Overview of wireless communication systems, requirements, trends; Wireless channel characteristics; Fundamentals of UWB, OFDM, CDMA, and Multi-antenna technologies; Overview of Ad-hoc and wireless sensors network, Cognitive and Software defined radio

Module 2

UWB communication: UWB channel model, UWB transmitter and receiver structures, Correlator and Rake reception of UWB signals, Low complexity and non-coherent transceiver designs, Multiple access issues in UWB, Interference issues in UWB,UWB antenna and pulse generation issues

Module 3

OFDM communication: Transceiver basics; Power amplifier and peak-to-average ratio issues, Coherent receiver design including timing and frequency offset synchronization, channel estimation, and data detection.

OFDM based technologies: 802.11a/g (Hyperlan-2), WiMax

Module 4

Antenna Diversity: Combining techniques, Smart antennas and adaptive beamforming, Angle spread, spatial correlation, and multi-antenna channel models,

MIMO: transceiver design, MIMO channel model, MIMO capacity, MIMO receiver architectures, Space-time processing; Massive MIMO signal model

Module 5

Cognitive Radio and SDR: SDR Architecture, Information Theoretic limit of cognitive network, OFDM based Cognitive Radio, Cognitive radio platforms and testbeds (GNU radio).

Ad-hoc networks and wireless sensors networks: requirements, Applications, Network, MAC, and physical layer issues, Power aware design issues and techniques, Cross-layer design issues

Syllabus and course plan (Total hours: 43)

No	**Topic**	**No. of Lectures.**
1	**Module I- 9 hours**	
1.1	Overview of wireless communication systems	**1**
1.2	Requirements, trends.	**1**
1.3	Wireless channel characteristics.	**1**
1.4	Fundamentals of UWB, OFDM, CDMA, and Multi-antenna technologies.	**2**
1.5	Overview of Ad-hoc and wireless sensors network.	**1**
1.6	Cognitive and Software defined radio	**3**
2	**Module II-8 hours**	
2.1	**UWB communication:** UWB channel model,	**1**
2.2	UWB transmitter and receiver structures.	**2**
2.3	Correlator and Rake reception of UWB signals.	**1**
2.4	, Low complexity and non-coherent transceiver designs.	**1**
2.5	Multiple access issues in UWB.	**1**
2.6	Interference issues in UWB.	**1**
2.7	UWB antenna and pulse generation issues.	**1**

3	**Module III -8 hours**	
3.1	**OFDM communication**: Transceiver basics.	**1**
3.2	Power amplifier and peak-to-average ratio issues.	**1**
3.3	Coherent receiver design including timing and frequency offset synchronization, channel estimation, and data detection.	**4**
3.4	OFDM based technologies: 802.11a/g (Hyperlan-2), WiMax	**2**
4	**Module IV - 10 hours**	
4.1	**Antenna Diversity**: Combining techniques.	**1**
4.2	Smart antennas and adaptive beamforming.	**1**
4.3	Angle spread, spatial correlation, and multi-antenna channel models.	**2**
4.4	**MIMO**: transceiver design, MIMO channel model, MIMO capacity**.**	**2**
4.5	MIMO receiver architectures.	**2**
4.6	Space-time processing.	**1**
4.7	Massive MIMO signal model	**1**
5	**Module V - 8 hours**	
5.1	**Cognitive Radio and SDR**: SDR Architecture.	**2**
5.2	Information Theoretic limit of cognitive network,	**1**
5.3	OFDM based Cognitive Radio, Cognitive radio platforms and testbeds (GNU radio).	**2**
5.4	**Ad-hoc networks and wireless sensors networks**: requirements,	**1**
5.5	Applications, Network, MAC, and physical layer issues, Power aware design issues and techniques, Cross-layer design issues	**2**

Reference:

1. R. Prasad, OFDM for Wireless Communications Systems, Artech House, ISBN: 1-58053-796-0, 2004.
2. J. Heiskala and J. Terry, OFDM Wireless LANs: A Theoretical and Practical Guide, Sams, December 2001.
3. G.J.Foschini and M.J. Gans, "On Limits of Wireless Communications in a Fading Environment when Using Multiple Antennas", Wireless Personal Communications, vol.6,pp.311-335, 1998.
   E. Telatar, Capacity of multi-antenna Gaussian channels", ATT-Bell Labs Murray Hill, Tech. Memo, 1995
4. D. Gesbert, M. Shafi, Da-shan Shiu, P. J. Smith, A. Naguib, "From theory to practice: an overview of MIMO space-time coded wireless systems", Selected Areas in Communications, IEEE Journal on , Volume: 21 Issue: 3 , April 2003, Page(s): 281 -302

5. S. M. Alamouti, "A simple transmit diversity technique for wireless communications", Selected Areas in Communications, IEEE Journal on , Volume: 16 Issue: 8, Oct. 1998, Page(s): 1451 -1458

6. Hseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems," Ser. Signals and Communication Technology, xviii, 470 p., I. edition, ISBN: 978-1-4020-5541-6, Springer, August 2007

7. Hasari Celebi and Huseyin Arslan "Enabling Location and Environment Awareness in Cognitive Radios," Elsevier Computer Communications-Special Issue on Advanced Location-Based Services, vol. 31, no. 6, pp. 1114-1125, April 2008.

8. Hasari Celebi and Huseyin Arslan "Cognitive Positioning Systems," IEEE Transactions on Wireless Communications, vol. 6, no. 12, pp.4475-4483, Dec. 2007.

222EEC402	REINFORCEMENT LEARNING	CATEGORY	L	T	P	CREDIT
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1 K2	Explain the core concepts of RL: Markov Decision Processes (MDPs), rewards, policies, value functions.
CO2 K3	Implement classic RL algorithms like Q-learning and SARSA.
CO3 K2	Understand model-free vs. model-based approaches.
CO4 K2	Explore deep reinforcement learning and applications.
CO5 K3	Analyze ethical considerations and challenges in RL.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's category	Continuous Internal evaluation
Apply	20
Analyze	20
Evaluate	20
Create	40

Mark Distribution

Total marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : 40 marks

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper: Reinforcement Learning

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Discuss trade-off between exploration and exploitation.
2. Explain Monte Carlo methods for value estimation.
3. Comment on Deep Q-Network and their applications.
4. What are the challenges of Deep Reinforcement Learning?
5. Explain accountability of Reinforcement learning.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. What is Reinforcement Learning?
7. Discuss Q-function and state-value function.
8. Explain reinforce and its variants.
9. What are ethical considerations surrounding RL applications.
10. Discuss Q-learning and SARSA algorithms with exploration strategies.
11. Explain Deep Deterministic Policy Gradient.
12. Discuss actor-critic architectures.

SYLLABUS

Module 1: Introduction to Reinforcement Learning

What is RL? Applications and impact, MDPs: States, actions, rewards, transitions, Agent-environment interaction, Rewards and discounting, Exploration vs. exploitation trade-off.

Module 2: Value-Based Methods

Value functions: Q-function and state-value function, Dynamic Programming for optimal solutions in small MDPs, Monte Carlo methods for value estimation, Q-learning and SARSA algorithms with exploration strategies, Case studies: Gridworld and bandit problems.

Module 3: Policy-Based Methods

Action selection and policy representation, Policy gradient methods: REINFORCE and its variants, Actor-Critic architectures, Deep Q-Networks (DQNs) and their applications, Introduction to continuous control with Deep Deterministic Policy Gradient (DDPG).

Module 4: Advanced Topics

Function approximation with neural networks, Model-based vs. model-free approaches, Multi-agent Reinforcement Learning (MARL), Deep Reinforcement Learning (DRL) challenges and open questions, Safety and ethical considerations in RL.

Module 5: Responsible development and deployment of RL

Ethical considerations surrounding RL applications, including transparency, accountability, and potential societal implications.

Syllabus and course plan (Total hours: 34)

No	**Topic**	**No. of Lectures.**
1	**Module I- 7 hours**	
1.1	What is RL?	**1**
1.2	Applications and impact.	**1**
1.3	MDPs: States, actions, rewards, transitions.	**2**
1.4	Agent-environment interaction.	**1**
1.5	Rewards and discounting.	**1**
1.6	Exploration vs. exploitation trade-off.	**1**
2	**Module II-8 hours**	
2.1	Value functions: Q-function and state-value function	**1**
2.2	Dynamic Programming for optimal solutions in small MDPs	**1**
2.3	Monte Carlo methods for value estimation	**2**
2.4	Q -learning and SARSA algorithms with exploration strategies	**2**
2.5	Case studies: Gridworld and bandit problems.	**2**
3	**Module III -7 hours**	
3.1	Action selection and policy representation.	**1**
3.2	Policy gradient methods: REINFORCE and its variants.	**1**
3.3	Actor-Critic architectures.	**2**
3.4	Deep Q-Networks (DQNs) and their applications.	**1**

3.5	Introduction to continuous control with Deep Deterministic Policy Gradient (DDPG).	**2**
4	**Module IV – 7 hours**	
4.1	Function approximation with neural networks	**1**
4.2	Model-based vs. model-free approaches	**1**
4.3	Multi-agent Reinforcement Learning (MARL),	**2**
4.4	Deep Reinforcement Learning (DRL) challenges and open questions	**2**
4.5	Safety and ethical considerations in RL.	**1**
5	**Module V - 5 hours**	
5.1	Ethical considerations surrounding RL applications, including transparency, accountability, and potential societal implications.	**5**

Text Books:

1. Richard Sutton and Andrew Barto, "Reinforcement Learning: An Introduction"

222EEC403	**HARDWARE ARCHITECTURE FOR MACHINE LEARNING**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes: After the completion of the course the student will be able to

CO1	Obtain a good background knowledge about GPU architecture,memory, FPGA architecture etc.
CO2	Understand convolutional strategies
CO3	Understand the implementation of deep learning on various hardware platforms
CO4	Understand the memory efficiency and reliability of DNN accelerators
CO5	Understand memory related trade offs in DNN accelerators, Autonomous driving and DNN training.

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz : 10 marks

Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper: Hardware Architecture for Machine Learning

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Explain matrix multiplication using systolic array
2. Discuss FFT-based convolutional strategy
3. Comment on deep learning on an ASIC.
4. What are soft-errors?
5. Compare memory technologies**.**

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Explain roofline model in detail.
7. Discuss Winograd-based convolutional strategy.
8. Explain memristor-based processing-in-memory accelerators for deep-learning.
9. Comment on reliability of deep learning algorithms and accelerators.
10. What are system-challenges in autonomous driving.
11. How matrix multiplication is done using systolic array.
12. Explain deep learning on edge devices.

SYLLABUS

Module 1

Background topics: Approximate computing and storage, Roofline Model, Cache tiling (blocking), GPU architecture, CUDA programming, understanding GPU memory hierarchy, FPGA architecture, Matrix multiplication using systolic array

Module 2

Convolutional strategies: Direct, FFT-based, Winograd-based and Matrix multiplication based.

Module 3

Deep learning on various hardware platforms: Deep learning on FPGAs and case study of Microsoft's Brainwave, Deep learning on Embedded System (especially NVIDIA's Jetson Platform), Deep learning on Edge Devices (smartphones), Deep learning on an ASIC (especially Google's Tensor Processing Unit.), Deep-learning on CPUs and manycore processor (e.g., Xeon Phi), Memristor-based processing-in-memory accelerators for deep-learning.

Module 4

Memory-efficiency and reliability of DNN accelerators: Model-size aware Pruning of DNNs, Hardware architecture-aware pruning of DNNs, Understanding soft-errors. Understanding reliability of deep learning algorithms and accelerators

Module 5

Memory-related tradeoffs in DNN accelerators: Comparison of memory technologies (SRAM, DRAM, eDRAM, STT-RAM, PCM, Flash) and their suitability for designing memory-elements in DNN accelerator,.Autonomous driving and DNN training: Hardware/system-challenges in autonomous driving, Distributed training of DNNs and addressing memory challenges in DNN training.

Syllabus and course plan (Total hours: 38)

No	Topic	No. of Lectures.
1	**Module I-8 hours**	
1.1	Background topics: Approximate computing and storage.	1
1.2	Roofline Model.	1
1.3	Cache tiling (blocking).	1
1.4	GPU architecture.	1
1.5	CUDA programming.	1
1.6	understanding GPU memory hierarchy	1
1.7	FPGA architecture	1
1.8	Matrix multiplication using systolic array.	1
2	**Module II- 6 hours**	
2.1	Convolutional strategies: Direct, FFT-based	2
2.2	Winograd-based	2
2.3	Matrix multiplication based	2
3	**Module III - 8 hours**	
3.1	Deep learning on various hardware platforms: Deep learning on FPGAs and case study of Microsoft's Brainwave.	2
3.2	Deep learning on Embedded System (especially NVIDIA's Jetson Platform)	1

3.3	Deep learning on Edge Devices (smartphones)	**1**
3.4	Deep learning on an ASIC (especially Google's Tensor Processing Unit.)	**2**
3.5	Deep-learning on CPUs and manycore processor (e.g., Xeon Phi), Memristor-based processing-in-memory accelerators for deep-learning.	**2**
4	**Module IV - 8 hours**	
4.1	Memory-efficiency and reliability of DNN accelerators	**1**
4.2	Model-size aware Pruning of DNNs	**1**
4.3	Hardware architecture-aware pruning of DNNs,	**2**
4.4	Understanding soft-errors	**2**
4.5	Understanding reliability of deep learning algorithms and accelerators	**2**
5	**Module V - 8 hours**	
5.1	Memory-related tradeoffs in DNN accelerators	**2**
5.2	Comparison of memory technologies (SRAM, DRAM, eDRAM, STT-RAM, PCM, Flash) and their suitability for designing memory-elements in DNN accelerator,	**2**
5.3	Autonomous driving and DNN training: Hardware/system-challenges in autonomous driving	**2**
5.4	Distributed training of DNNs and addressing memory challenges in DNN training.	**2**

Text Books

1. Hennessy, J. L. ,& Patterson, D. A., Computer Architecture: A quantitative approach(SixthEdition),Elsevier

2. Brandon Reagen, Robert Adolf, Paul Whatmough, Gu-Yeon Wei, and David Brooks Deep Learning for Computer Architects Synthesis Lectures on Computer Architecture, August 2017, Vol. 12, No. 4, Pages 1-12

3. Tor M. Aamodt, Wilson Wai Lun Fung, and Timothy G. Rogers General- Purpose Graphics Processor Architectures, Synthesis Lectures on Computer Architecture, May 2018, Vol. 13, No. 2 , Pages 1-140 (https://doi.org/10.2200/S00848ED1V01Y201804CAC044)

INTERDISCIPLINARY ELECTIVE

222EEC501	INTRODUCTION TO ROBOTICS	CATEGORY	L	T	P	CREDIT
			3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO1	Familiarize with anatomy, specifications and types of Robots
CO2	Describe the direct and inverse kinematics in modeling and controlling of robot Manipulators
CO3	Understand the differential motion of robots.
CO4	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion
CO5	Understand the dynamics in robot motion

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	1	1	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution

Total marks	CIE	ESE	ESE Duration
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation : **40 marks**

Micro project/ Course based project : 20 marks

Course based task/seminar/Quiz	:	10 marks
Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Model Question Paper : Introduction to Robotics (Interdisciplinary Elective)

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) 25 marks

1. What are different types of robots?
2. Discuss the kinematic parameters relevant for robotics.
3. Explain how the Jacobian matrix is relevant in the motion of manipulators.
4. Explain the basic problem of trajectory generation.
5. State Lagrangian formulation.

Part B (Answer any 5. Each question carries 7 marks) 35 marks

6. Discuss the difference between direct kinematics and inverse kinematics in the field of modelling and controlling of robot manipulators.
7. Derive the Jacobian matrix for a 2D 2-link manipulator.
8. Derive the Euler- Lagrange equation for a single degree of freedom system. Discuss with the help an example.
9. Derive the Newton-Euler formulation for analysing the dynamics of robot manipulators.
10. Discuss closed loop system with PD/PID control.
11. Explain the control problem of robot manipulators.
12. Represent the position and orientation of a Robotic system.

SYLLABUS

Module 1 - Basic Concepts

Brief history, Types of Robots, Technology, Robot Configurations and Robot classifications, Familiarization of terminology used in robotics, Various manipulators, End effector tools, Programming languages. Position Orientation-Frames-Mapping-Changing Description from Frames to Frames. Transformation arithmetic's -Translation-rotation-transformation- transformation of the vectors - homogeneous transformation matrix.

Module 2 - Direct and Inverse Kinematics:

Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF), Inverse kinematics- general properties of solutions, Problems (upto 3DOF)

Module 3 - Manipulator Differential Motion:

Robot Manipulators – Motion control and Differential motion of manipulators, Overview of Jacobian matrix, Wrist and arm singularity - Static analysis – Calculation of force and torque

Module 4 - Path Planning and Trajectory generation:

Trajectory generation - Basic Problem, Solution space – Joint space and Cartesian space, Planning in any space, Polynomial trajectory in Robotics, Cubic polynomial, Cubic polynomial for a path, Joint space trajectory generation using single degree polynomial

Module 5 - Dynamics and Control:

Manipulator dynamics in robots, Lagrange's formulation – Kinetic Energy expression, velocity, Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Newton-Euler formulation for analysing the dynamics of robot manipulators (Dynamic model of planar and spatial serial robots upto 2 DOF can be given as assignment), Control problem of robot manipulators, independent joint control, Closed loop system with PD/PID control

Syllabus and course plan (Total hours: 44)

No	**Topic**	**No. of Lectures.**
1	**Module I- 8 hours**	
1.1	Brief history, Types of Robots, Technology	**1**
1.2	Robot Configurations and Robot classifications	**1**
1.3	Familiarization of terminology used in robotics	**1**
1.4	Various manipulators, End effector tools, Programming languages.	**2**
1.5	Position Orientation-Frames-Mapping-Changing	**1**
1.6	Description from Frames to Frames.	**1**
1.7	Transformation arithmetic's -Translation-rotation-transformation-transformation of the vectors - homogeneous transformation matrix.	**1**
2	**Module II-8 hours**	
2.1	Kinematic parameters	**1**
2.2	The Denavit-Hartenberg (D-H) representation	**2**
2.3	The arm equation	**1**

2.4	Direct kinematics problems (upto 3DOF)	**2**
2.5	Inverse kinematics- general properties of solutions	**1**
2.6	Problems (upto 3DOF)	**1**
3	**Module III - 9 hours**	
3.1	Robot Manipulators – Motion control	**2**
3.2	Differential motion of manipulators	**2**
3.3	Overview of Jacobian matrix	**2**
3.4	Wrist and arm singularity - Static analysis	**2**
3.5	Calculation of force and torque	**1**
4	**Module IV - 9 hours**	
4.1	Trajectory generation - Basic Problem	**1**
4.2	Solution space – Joint space and Cartesian space	**2**
4.3	Planning in any space	**1**
4.4	Polynomial trajectory in Robotics	**1**
4.5	Cubic polynomial	**1**
4.6	Cubic polynomial for a path	**1**
4.7	Joint space trajectory generation using single degree polynomial	**2**
5	**Module V - 10 hours**	
5.1	Manipulator dynamics in robot	**1**
5.2	Lagrange's formulation – Kinetic Energy expression, velocity, Jacobian and Potential Energy expression	**2**
5.3	Generalised force	**1**
5.4	Euler-Lagrange equation	**1**
5.5	Newton-Euler formulation for analysing the dynamics of robot manipulators (Dynamic model of planar and spatial serial robots upto 2 DOF can be given as assignment)	**2**
5.6	Control problem of robot manipulators	**1**
5.7	Independent joint control	**1**
5.8	Closed loop system with PD/PID control	**1**

Textbook:

1. John J. Craig, " Introduction to Robotics , Mechanics and Control", Pearson Education International, 2008

2. Dileep Kumar Pratihar, “Fundamentals of Robotics”, Narosa Book, 2017

3. Niku S. B., “Introduction to Robotics, Analysis, Control, Applications”, John Wiley, 2011.

4. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “ Robot Dynamics and Control” Wiley India Edition, 2004

222EEC502	**AI FOR ROBOTICS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
			3	**0**	**0**	**3**

Course Outcomes:
After the completion of the course the student will be able to

CO 1	Interpret supervised and unsupervised learning algorithms
CO 2	Use CNN and RNN for different robotic applications
CO 3	Use computer vision for robotic applications
CO 4	Localise a robot in any scenario
CO 5	Use RL for robotic applications

Mapping of course outcome and program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	2	1	1	-
CO2	2	1	2	2	1	1	-
CO3	2	1	2	2	1	1	-
CO4	2	1	2	2	1	1	-
CO5	2	1	2	2	1	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	30%
Analyse	30%
Evaluate	20%
Create	20%

Mark Distribution

Total marks	**CIE**	**ESE**	**ESE Duration**
100	**40**	**60**	**2.5 hours**

Continuous Internal Evaluation	:	**40 marks**
Micro project/ Course based project	:	20 marks
Course based task/seminar/Quiz	:	10 marks
Test paper, 1 no	:	10 marks
End Semester examination Pattern	:	
Total	:	60 marks
Part A: Answer all – 5 questions × 5 marks	:	25 marks
Part B: Answer 5 of 7: 5 questions × 7 marks	:	35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper :AI for Robotics (Interdisciplinary Elective)

Total: 60 marks

Part A (Answer all. Each question carries 5 marks) **25 marks**

1. Differentiate between supervised and unsupervised learning.
2. Discuss the need for sequence models.
3.Introduce the image formation model.
4. Explain the main elements of robotic perception.
5. Discuss the principle of reinforcement learning.

Part B (Answer any 5. Each question carries 7 marks) **35 marks**

6. Explain gradient descent method.
7. Explain the principle of recurrent and recursive nets.
8. Describe the techniques for edge and texture detection.
9. Explain the application of AI in ball Tracking in football games.
10. Discuss the robotic perception.
11. Discuss about localization of a differential drive robot.
12. Explain how reinforcement learning can be used for stabilisation of bipedal humanoid.

SYLLABUS

Module 1

Probability and Expectation Basics, Bayes Optimal, Stochastic Average Approximation, Stochastic Gradient Descent; Supervised Learning Algorithms, Unsupervised Learning Algorithms, Reinforcement based learning-overview with basic elements agent, environment, action, state, reward only; Challenges Motivating Deep Learning.

Module 2

Deep Feedforward Networks, Convolutional Networks-basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets - Need for sequence models, basic RNN architecture and types. Case study-line follower robot using CNN, Speech Recognition using RNN overview

Module 3

Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. challenges in image detection, Image features optimization. Case study- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection.

Module 4

Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains. Case study- Use of AI in typical pick and place task, localization of a differential drive robot.

Module 5

Reinforcement learning Overview, Policy based and Value based approaches , Monte Carlo Methods, Temporal-Difference Learning (Q-learning, SARSA). Case study- Role of RL in typical pick and place task, RL for stabilization of bipedal humanoid.

Syllabus and course plan (Total hours: 41)

No	**Topic**	**No. of Lectures.**
1	**Module I- 9 hours**	
1.1	Probability and Expectation Basics,	**1**
1.2	Bayes Optimal	**1**
1.3	Stochastic Average Approximation	**1**
1.4	Stochastic Gradient Descent.	**1**
1.5	Supervised Learning Algorithms	**1**
1.6	Unsupervised Learning Algorithms	**1**
1.7	Reinforcement based learning-overview with basic elements agent, environment, action, state, reward only	**2**
1.8	Challenges Motivating Deep Learning	**1**
2	**Module II-8 hours**	
2.1	Deep Feedforward Networks	**1**
2.2	Convolutional Networks-basic outline and functions of each layers only	**1**
2.3	Sequence Modeling: Recurrent and Recursive Nets	**2**
2.4	Need for sequence models,	**1**
2.5	Basic RNN architecture and types.	**1**
2.6	Case study-line follower robot using CNN	**1**
2.7	Speech Recognition using RNN overview	**1**
3	**Module III -8 hours**	
3.1	Image formation,	**1**

3.2	Basic image processing operations - edge detection, texture, optical flow, segmentation.	**3**
3.3	Challenges in image detection	**1**
3.4	Image features optimization.	**1**
3.5	Case study- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection.	**2**
4	**Module IV - 8 hours**	
4.1	Robotics - Robotic perception	**2**
4.2	Localization and mapping	**2**
4.3	Machine learning in robot perception	**2**
4.4	Application domains. Case study- Use of AI in typical pick and place task, localization of a differential drive robot.	**2**
5	**Module V - 8 hours**	
5.1	Reinforcement learning Overview	**1**
5.2	Policy based and Value based approaches	**1**
5.3	Monte Carlo Methods	**2**
5.4	Temporal-Difference Learning (Q-learning, SARSA)	**2**
5.5	Case study- Role of RL in typical pick and place task, RL for stabilization of bipedal humanoid.	**2**

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016

2. Stuart J. Russell and Peter Norvig, Artificial Intelligence - A Modern Approach, Third Edition, Pearson , 2016

3. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.

4. Berthold Klaus, Paul Horn “Robot vision” The MIT Press, 1987.

5. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer; 2011th edition (19 October 2010).

6. Grigorescu, Sorin, et al. "A survey of deep learning techniques for autonomous driving." Journal of Field Robotics 37.3 (2020): 362-386.