National Education Policy (NEP) Compliant Curriculum Structure

for

B. Tech. (Robotics & Artificial Intelligence)

(With effect from Academic Year 2024-25)

Department of Mechanical Engineering

COEP Technological University (COEP Tech)

A Unitary Public University of Government of Maharashtra

(Formerly College of Engineering Pune)

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Vision of the Department:

To be a leader amongst engineering institutions in India, offering value based world class education and constantly pursuing excellence

Mission of the Department:

M1: To offer state-of-the-art undergraduate, postgraduate and doctoral programmes

M2: To develop employable and skilled undergraduate to accept the global and societal challenges, while imparting quality education at postgraduate and research level.

M3: To Foster the passion of life-long learning in all facets of employability.

Program Educational Objectives (PEOs)

PEO1. ***Core Competence*****:** Fundamental and technical knowledge with skills in Robotics & Artificial Intelligence area to enable and empower to solve problems of the modern industrial world.

PEO2. ***Depth (Research culture)*****:** Imbibing a scientific perspective to make a decision of Robotic systems and Artificial Intelligence using Mathematical, Engineering, Computational & Simulation tools.

PEO3. ***Professionalism:*** Make acquaint with technical, managerial, and human skills and familiarize with professional issues like ethics and morality, Intellectual property Rights, Constitution of India and Environmental responsibility.

PEO4. ***Learning Environment:*** Motivation for entrepreneurship and inculcating a spirit of continuous lifelong learning for a successful professional career.

Program Outcomes

Program Outcomes of Engineering program as per norms (common to all UG/ PG Programme)

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: The problems: • that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline. • that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions. • that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (like: cost, power requirement, durability, product life, etc.). • which need to be defined (modeled) within appropriate mathematical frame work. • that often require use of modern computational concepts and tools.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change technological change.

Program Specific Objectives (PSOs)

PSO1 Design and Development: The ability to design and develop the products as per the need of the customers in the field of Mechanical and Allied Engineering Industries.

PSO2 Engineering Analysis and optimization: The ability to analyze and optimize the Mechanical systems/processes using various computational tools.

PSO3 Society: To strengthen Mechanical Engineering graduates who would value professional and ethical responsibilities while solving societal problems

List of Abbreviations

Abbreviation	Title
BS	Basic Science Course
ESC	Engineering Science Course
PCC	Programme Core Course (PCC)
PEC	Programme Elective Course (PEC)
OE/SE	Open/School Elective (OE/SE) other than particular program
MDM	Multidisciplinary Minor (MD M)
VSEC	Vocational and Skill Enhancement Course (VSEC)
HSMC	Humanities Social Science and Management
IKS	Indian Knowledge System (IKS)
VEC	Value Education Course (VEC)
RM	Research Methodology (RM)
--	Internship
--	Project
CEA	Community Engagement Activity (CEA)/Field Project
CCA	Co-curricular & Extracurricular Activities (CCA)

F.Y. B. Tech. Robotics & AI

[Level 4.5, UG Certificate] Semester -I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	BSC	MRAIBSC101	Matrix Algebra, Calculus and Probability	2	1	0	1	3	30	20	50	--	--
02	BSC	MRAIBSC102	Engineering Physics	2	0	2	1	3	30	20	50	CIE: 100	
03	ESC	MRAIESC103	Basic Electrical & Electronics Engineering	2	0	2	1	3	30	20	50	CIE: 100	
04	ESC	MRAIESC104	Engineering Drawing and Graphics	1	0	4	1	3	CIE: 100			CIE: 100	
05	ESC	MRAIESC105	Engineering Mechanics	3	0	2	1	4	30	20	50	CIE: 100	
06	AEC-I	MRAIAEC106	Communication Skill	1	0	2	0	2	CIE: 100			CIE: 100	
07	CCA		Liberal Learning Course-I	0	0	2	2	1	--	--	--	CIE: 100	
08	VESC-I		Manufacturing Practices/ Fab Lab - I	0	0	2	1	1	--	--	--	CIE: 100	
			Total	**11**	**01**	**16**	**08**	**20**					

[Level 4.5, UG Certificate] Semester -II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	BSC	MRAIBSC201	Engineering Chemistry	2	0	2#	1	3	30	20	50	CIE: 100	
02	BSC	MRAIBSC202	Ordinary Differential Equations and Multivariate Calculus	2	1	0	1	3	30	20	50	CIE: 100	
03	ESC	MRAIBSC203	Biology for Engineers	2	0	0	1	2	30	10	60	--	--
04	ESC	MRAIESC204	Systems in Mechanical Engineering	2	0	2	1	3	30	20	50	CIE: 100	
05	ESC	MRAIESC205	Programming for Problem Solving	1	0	2	2	2	CIE: 100			CIE: 100	
06	ESC	MRAIESC206	Design Thinking and Idea Lab	0	0	2	1	1	--	--	--	CIE: 100	
07	PCC	MRAIPCC207	Material Science	2	0	0	1	2	30	10	60	--	--
08	VSEC-II	MRAIVSEC208	Manufacturing Practices/ Fab Lab - II	0	0	2	0	1	--	--	--	CIE: 100	
09	IKS	MRAIIKS209	Indian Knowledge System	2	0	0	1	2	CIE: 100			--	--
10	CCA	MRAICCA210	Co-curricular/Office Automation/ Extracurricular Activity	0	0	2	0	1	--	--	--	CIE: 100	
11	CEA	MRAICEA211	Social Summer Internship-after Sem II-Exam in Sem III(60 Days)	0	0	0	0	0	--	--	--	--	--
			Total	**13**	**01**	**12**	**09**	**20**					

=> Combined Lab for Applied Chemistry and Material Science

Legends: **L**-Lecture, **T**-Tutorial, **P**-Practical, **S**-Self Study, **Cr**-Credits
ISE-In-Semester-Evaluation, **ESE**-End-Semester-Evaluation, **MSE**-Mid-Semester-Evaluation, **TA**-Teachers' Assessment, **CIE**-Continuous-Internal-Evaluation

For Exit after FY -- Additional Credits for Certificate (Any Four Skill Based Course)														
Sr. No.	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**S**	**Cr**	**Evaluation Scheme (Weightages in %)**				
									Theory			**Laboratory**	
									MSE	TA	ESE	ISE	ESE
01	VSEC	MRAIVSEC2E1	Computer Aided Geometric Modelling	1	0	2	0	2	30	10	60	50	50
02	VSEC	MRAIVSEC2E2	Additive Manufacturing	1	0	2	0	2	30	10	60	50	50
03	VSEC	MRAIVSEC2E3	Metallurgical Lab Practice - I	1	0	2	0	2	30	10	60	50	50
04	VSEC	MRAIVSEC2E4	Basics of CNC programming	1	0	2	0	2	30	10	60	50	50
05	VSEC	MRAIVSEC2E5	Basics of Robotics & AI	1	0	2	0	2	30	10	60	50	50
			Total	**18**	**01**	**22**	**9**	**30**					
*Summer internship (Industry / R&D / Academic Institute) after IV th semester during summer Vacation & Evaluation will be done in the starting of V th Semester													

S. Y. B. Tech. Robotics & AI

[Level 5, UG Regular] Semester -III

Sr. No.	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**S**	**Cr**	**Evaluation Scheme (Weightages in %)**				
									Theory			**Laboratory**	
									MSE	TA	ESE	ISE	ESE
01	PCC	MRAIPCC301	Basics of Robotics & AI	3	0	0	1	3	30	20	50	--	--
02	PCC	MRAIPCC302	Sensors for Industrial Robotics	2	0	2	1	3	30	20	50	50	50
03	PCC	MRAIPCC303	Industrial Robot Programming Lab	2	0	2	1	3	30	20	50	50	50
04	OE	MRAIOE304	Open Elective - I	3	0	0	1	3	30	20	50	--	--
05	AEC-II	MRAIAEC305	Indian language Sanskrit/Pali	2	0	0	1	2	CIE: 100			--	--
06	VEC-I	MRAIVEC306	Constitution of India and Universal Human Values	1	0	0	0	1	CIE: 100			--	--
07	HSMC	MRAIHSMC307	Principles of Entrepreneurship	2	0	0	1	2	CIE: 100			--	--
08	CEA	MRAICEA308	*Community Engagement Activity/ Field Project	2	0	0	1	2	--	--	--	CIE: 100	
			Total	**17**	**00**	**04**	**07**	**19**					

* => Field project (Social) after semester II during summer vacation and evaluation will be done at the start of the III semester.

[Level 5, UG Regular] Semester -IV

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	MRAIPCC401	Analog & Digital Electronics	2	0	2	0	3	30	20	50	50	50
02	PCC	MRAIPCC402	Control Systems	2	0	2	0	3	30	20	50	50	50
03	PCC	MRAIPCC403	Drives for Robot Systems	3	0	0	0	3	30	20	50	--	--
04	PCC	MRAIPCC404	Standards & Ethics for Robot Applications	2	0	0	2	2	CIE: 100			--	--
05	OE-II	MRAIOE405	Open Elective-II	2	0	0	0	2	30	10	60	--	--
06	MDM-I	MRAIMDM406	Multidisciplinary Minor -I	3	0	0	1	3	30	20	50	CIE: 100	
07	VSEC-III	MRAIVSEC407	Numerical Methods & Programming Language	1	0	2	1	2	CIE: 100			50	50
08	HSMC	MRAIHSMC408	Principles of Economics	2	0	0	1	2	30	10	60	--	--
09	VEC-II	MRAIVEC409	Environmental Studies	1	0	0	1	1	CIE: 100			--	--
			Total	**18**	**00**	**06**	**06**	**21**					

S. Y. B. Tech. Robotics & AI

[Level 5, UG Diploma] Semester -III Lateral Entry

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	MRAIPCC301	Basics of Robotics & AI	3	0	0	1	3	30	20	50	--	--
02	PCC	MRAIPCC302	Sensors for Industrial Robotics	2	0	2	1	3	30	20	50	50	50
03	PCC	MRAIPCC303	Industrial Robot Programming Lab	2	0	2	1	3	30	20	50	50	50
04	OE	MRAIOE304	Open Elective - I	3	0	0	1	3	30	20	50	--	--
05	AEC-II	MRAIAEC305	Indian language Sanskrit/Pali	2	0	0	1	2	CIE: 100			--	--
06	VEC-I	MRAIVEC306	Constitution of India and Universal Human Values	1	0	0	0	1	CIE: 100			--	--
07	BSC	MRAIBSC307	Mathematics	3	0	0	1	3	30	20	50		
08	HSMC	MRAIHSMC308	Principles of Entrepreneurship	2	0	0	1	2	30	10	60	--	--
			Total	**18**	**00**	**04**	**07**	**20**					

S. Y. B. Tech. Robotics & AI

[Level 5, UG Diploma] Semester -IV Lateral Entry

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	MRAIPCC401	Analog & Digital Electronics	2	0	2	0	3	30	20	50	50	50
02	PCC	MRAIPCC402	Control Systems	2	0	2	0	3	30	20	50	50	50
03	PCC	MRAIPCC403	Drives for Robot Systems	3	0	0	0	3	30	20	50	--	--
04	PCC	MRAIPCC404	Standards & Ethics for Robot Applications	2	0	0	2	2	CIE: 100			--	--
05	OE-II	MRAIOE405	Open Elective-II	2	0	0	0	2	30	10	60	--	--
06	MDM-I	MRAIMDM406	Multidisciplinary Minor -I	3	0	0	1	3	30	20	50	CIE: 100	
07	VSEC-III	MRAIVSEC407	Numerical Methods & Programming Language	1	0	2	1	2	CIE: 100			50	50
08	HSMC	MRAIHSMC408	Principles of Economics	2	0	0	1	2	30	10	60	--	--
09	VEC-II	MRAIVEC409	Environmental Studies	1	0	0	1	1	CIE: 100			--	--
10	HSMC	MRAIHSMC410	Communication Skills	1	0	2	0	2	CIE: 100			CIE: 100	
			Total	**19**	**00**	**08**	**06**	**23**					

For Exit after SY -- Additional Credits for Diploma													
Sr. No.	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**S**	**Cr**	**Evaluation Scheme (Weightages in %)**				
									Theory			**Laboratory**	
									MSE	TA	ESE	ISE	ESE
01	VSEC	MRAIVSEC4E1-L	Robotic Simulation Laboratory	0	1	2	0	2	--	--	--	50	50
02	VSEC	MRAIVSEC4E2-L	Arial Robotics Programming Lab	0	1	2	2	2	--	--	--	50	50
03	VSEC	MRAIVSEC4E3-L	Control Systems Laboratory	0	1	2	0	2	--	--	--	50	50
04	VSEC	MRAIVSEC4E4	Mini Project	0	2	0	0	2	--	--	--	CIE: 100	
			Total	**19**	**05**	**14**	**8**	**31**					
*Summer internship (Industry / R&D / Academic Institute) after IV th semester during summer Vacation & Evaluation will be done in the starting of V th Semester													

Legends: **L**-Lecture, **T**-Tutorial, **P**-Practical, **S**-Self Study, **Cr**-Credits
ISE-In-Semester-Evaluation, **ESE**-End-Semester-Evaluation, **MSE**-Mid-Semester-Evaluation, **TA**-Teachers' Assessment, **CIE**-Continuous-Internal-Evaluation

Semester -III

Course: Basics of Robotics and AI

Course Code	MRAIPCC301	**Scheme of Evaluation**	MSE, TA & ESE
Teaching Plan	**3-0-0-1**	**Mid Semester Exam**	30
Credits	3	**Teachers' Assessment**	20
		End Semester Evaluation	50

Course Outcomes:

Students who successfully complete this course will have demonstrated an ability to:

1. Differentiate types of robots and robot grippers and compare & classify types of Sensors, drives & Grippers
2. Apply robot kinematics principals for understanding manipulators tracking
3. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning by understanding AI, its current scope and limitations, and societal implications.
4. Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents, artificial neural networks.
5. Model forward and inverse kinematics of robot manipulator.

Syllabus:

Unit	**Contents**	**Lecture**
1	**Introduction:** Basics of Robotics, Definitions, Laws & Robotics-classification with respect to geometrical configuration (Anatomy), Industrial robots specifications. Selection based on the Application. Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability. Advances in Industrial Robotics Technology Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection.	7 Hrs
2	**Sensors** Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. **Controllers** Types of Controller and introduction to close loop controller. **Programming and Languages** Methods of robot programming, Introduction to various languages such as RAIL and VAL II …etc.	6 Hrs
3	**Drives** Types of drives. Advantages and Disadvantages of each type, Selection / suitability of drives for Robotic application. **Grippers** Classification of Grippers, Mechanical Gripper-Grasping force, mechanisms for actuation, Magnetic gripper vacuum cup gripper-considerations in gripper selection & design.	6 Hrs
4	**Introduction to Artificial Intelligence:**	6 Hrs

	Overview: foundations, scope, problems, and approaches of AI. Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.	
5	**Problem-solving Approaches:** Forward and backward, state-space, blind, heuristic, problem reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.	5 Hrs
6	**Knowledge Representation and Reasoning:** Ontologies, foundations of knowledge representation and reasoning, representing, and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.	6 Hrs

Suggested learning resources:

Textbooks:

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
2. Asitava Ghoshal, Robotics: Fundamental concepts & analysis, Oxford University Press, 2006
3. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
4. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2019
5. R. K. Mittal, et. al., Robotics & Control, TATA McGraw Hill Pub. Co Ltd, New Delhi 2003
6. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Ed), 2011
7. Vinod Chandra S.S., Anand H S, " Artificial Intelligence & Machine Learning", 2014

Reference Books:

1. S. K. Saha, Introduction to Robotics, TATA McGraw Hills Education ,2014
2. S. B. Nikku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020
3. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE , McGraw Hill Education (India) Pvt Ltd, 2012
4. R. D. Klafter, Thomas A. Chmielewski, and Michael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009
5. Russell, S & Norvig, Peter, Artificial Intelligence: A Modern Approach, Prentice Hall, 2003.
6. Aleksander, Igor and Burnett, Piers ,Thinking Machines Oxford, 1987.
7. Bench-Capon, T. J. M., Knowledge Representation: An approach to artificial intelligence Academic Press, 1990.
8. Genesereth, Michael R. and Nilsson, Nils J, Logical Foundations of Artificial Intelligence Morgan Kaufmann,1987.

Course: Sensors for Industrial Robotics

Course Code	MRAIPCC302	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-2-1	**Mid Semester Exam**	30
Credits	2	**Teachers' Assessment**	20
		End Semester Evaluation	50

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to:

1. Identify suitable sensor for robotic applications.

2. Compare & classify types of Sensors
3. Apply basic principles of system integration for system integration.
4. Demonstrate awareness and a fundamental understanding of all types robotic sensors.

Syllabus:

Unit	Contents	Lecture
1	**Sensor Fundamentals:** Overview of sensors and their role in robotics, Types of sensors used in robotics applications, Sensor characteristics: accuracy, precision, range, resolution, etc. Principles of sensing: electrical, optical, mechanical, etc. Sensor classification: contact, non-contact, proximity, etc., Sensor signal conditioning and amplification	6 Hrs
2	**Sensor Types and Applications:** Vision sensors and cameras, Range, and proximity sensors (ultrasonic, infrared, etc.), Force and tactile sensors. Motion and position sensors (encoders, accelerometers, etc.), Environmental sensors (temperature, humidity, etc.), Smart Sensors , Robot perception and environment sensing, Navigation and localization using sensors, Object detection and recognition, Grasping and manipulation with sensors, Human-robot interaction and sensing	6 Hrs
3	**Sensor Integration and Calibration:** Sensor mounting and placement in robotic systems, Sensor fusion and data integration, Sensor calibration and error compensation, Signal processing techniques for sensor data, Filtering and noise reduction, Feature extraction and pattern recognition.	6 Hrs
4	**Emerging Sensor Technologies and Trends:** Advancements in sensor technologies (e.g., LiDAR, depth sensors), MEMS Sensors, Sensor networks and Internet of Things (IoT) in robotics, Sensor-based feedback control and closed-loop systems, Biomimetic tactile Sensors based on Nanomaterials, Recent Advances in biomimetic sensing technology, Ionic Polymer and Metal composites as biomimetic Sensors and Actuators, Applications of Sensors	6 Hrs

Suggested learning resources:

Textbooks:

1 Patranabis D, “Sensors and Transducers”, 2nd Edition, PHI, New Delhi, 2013
2 Ernest O Doebelin, “Measurement Systems – Applications and Design”, Tata McGraw-Hill, 2009
3. Peter Elgar, "Sensors for Measurement & Control", Adison-Wesley Longman Ltd, 1998.

Reference Books:

1 Fraden, J., “Handbook of modern sensors : physics, designs, and applications”, Springer, New York, 2004
2 C. Sujatha Dyer, S. A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001
3 Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005
4 Toko, K., “Biomimetic sensor technology”, Cambridge Univ Press, Cambridge, 2000
5 Hans Kurt Tönshoff (Editor), Ichiro, “Sensors in Manufacturing” Volume 1, Wiley-VCH April 2001.

6 Richard Zurawski, “Industrial Communication Technology Handbook” 2nd edition, CRC Press, 2015
7 Robert B. Northrop , "Introduction to Instrumentation and Measurements", 3rd Edition, CRC Press, 2014.

Course: Sensors for Industrial Robotics Laboratory

Course Code	MRAIPCC302-L	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-2-0	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the principles behind various sensors used in industrial robotics.
2. Select appropriate sensors for different robotic applications.
3. Interface sensors with robotic systems and interpret their output.
4. Analyze sensor data to make decisions in robotic control systems.
5. Troubleshoot common issues related to sensor integration in industrial robotics.

Course Contents: Assignments / Practical based on:

Detailed Content : Any six experiments / assignments from the list below (Total Min. 24 Hours)

Expt. No.	**Contents**	**Contact Hours**
1	Proximity Sensors Understand principles of operation of capacitive, inductive, and optical proximity sensors and learn Calibration and testing of proximity sensors	4 Hrs
2	Vision Systems Understand machine vision and image processing for object detection and recognition	4 Hrs
3	Force/Torque Sensors Understand force and torque sensing principles and Types of force/torque sensors: strain gauge, piezoelectric, etc. and learn the force/torque sensing in industrial robotics	4 Hrs
4	Temperature and Pressure Sensors Understand temperature and pressure sensing technologies and attempt integration of temperature and pressure sensors in robotic systems.	4 Hrs
5	Motion and Position Sensors Understand principles of motion and position sensing, Encoders, accelerometers, and gyroscopes applications of motion and position sensors in robotics	4 Hrs
6	Sensor Fusion and Integration Understand Principles of motion and position sensing, encoders, accelerometers, and gyroscopes and implement applications of motion and position sensors in robotics	4 Hrs
7	Advanced Topics and Emerging Trends Short seminar on a Recent advancement in any one specific type of sensor technologies for industrial robotics, on an Integration of AI and machine learning with sensor data, on an Ethical considerations and challenges in	4 Hrs

	sensor-enabled robotics …etc	
8	Mini Project Work Students work on a mini project where they apply their knowledge of sensors in industrial robotics to solve a real-world problem or develop an innovative application.	4 Hrs

Text Books:

1. Sensors and Actuators in Mechatronics: Design and Applications" by Andrzej M. Pawlak, CRC Press, 2018
2. Introduction to Autonomous Robots: Mechanics, Sensors, Actuators, and Algorithms by Nikolaus Correll, Bradley Hayes, and Amirhossein Memarzadeh, Chapman and Hall/CRC, 2019
3. Industrial Sensors and Instrumentation by C. J. S. De Silva, CRC Press, 2017
4. Sensors for Mechatronics by Paul P. L. Regtien, Elsevier, 2012

Course: Industrial Robot Programming

Course Code	MRAIPCC303	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-2-1	**Mid Semester Exam**	30
Credits	2	**Teachers' Assessment**	20
		End Semester Evaluation	50

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to:

1. Identify and explain the core principles of industrial robots.
2. Program robots using different methods.
3. Implement fundamental robot programming concepts.
4. Apply advanced robot programming techniques.
5. Develop robot programs for industrial applications.

Unit	**Contents**	**Lecture**
1	**Introduction to Industrial Robotics** Fundamentals of Robotics: Definition, functions, advantages, disadvantages, applications of robots. Robot Anatomy: Classification (SCARA, Cartesian, Articulated etc.), components (manipulator, end-effector, controller, sensors, actuators). Robot Specifications: Work envelope, payload capacity, repeatability, degrees of freedom.	6 Hrs
2	**Robot Programming Fundamentals** Programming Methods: Lead-through programming, teach pendant, offline programming, text-based programming. Robot Programming Concepts: Motion control commands (MOVE, WAIT, SIGNAL, DELAY), subroutines, branching, error handling. Robot Programming Languages: Generations of robot languages, introduction to specific languages (e.g., VAL, RAIL, AML) and modern trends (Python, ROS).	6 Hrs
3	**Advanced Robot Programming Techniques**	6 Hrs

	Sensor Integration: Tactile, position, velocity, and force sensors for robot interaction and feedback. Path planning and Interpolation: Techniques for generating smooth robot motion paths between programmed points. Vision Systems for Robotics: Introduction to robot vision systems, image processing basics for object recognition and grasping. Safety Programming: Emergency stop procedures, safety interlocks, robot programming considerations for safe operation.	
4	**Industrial Robot Programming Applications** Case Studies: Programming examples for common industrial applications (e.g., welding, painting, material handling, assembly). Simulation and Offline Programming: Utilizing robot simulation software to create, test, and debug robot programs. Troubleshooting and Maintenance: Identifying and resolving common robot programming errors, basic robot maintenance procedures. Future Trends in Industrial Robotics: Advanced programming techniques, collaborative robots (cobots), and the integration of artificial intelligence (AI).	6 Hrs

Suggested learning resources:

1. Industrial Robotics by Yoram Koren (5th Edition)
2. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright and Matthew P. McLaughlin
3. Robotics, Vision & Control: Fundamentals & Advanced Applications by Farid Kendoul
4. Robot Programming: A Guide to Using RUIP with ABB Robots by Rick Young

Course: Industrial Robot Programming Laboratory

Course Code	MRAIPCC303-L	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-2-1	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to:

1. Use fundamental and technical knowledge of robot Programming
2. Learn Robot Programming using teach Pendant for various applications
3. Use RAPID Language and AML
4. Program a Robot for Industrial applications
5. Program using Robot studio software

Course Contents: Assignments / Practical based on:

Detailed Content: Any eight experiments / assignments from the list below (Total Min. 24 Hours)

Expt. No.	**Contents**	**Contact Hours**
1	Understand max reach and speed limits for each joint. Also identify the type of workspace accordingly.	2 Hrs
2	Robot Programming – Walk through programming	4 Hrs

3	Robot Programming using Teach Pendant- Lead through programming including Coordinate systems of Robot.	4 Hrs
4	Wrist Mechanism-Interpolation-Interlock commands	2 Hrs
5	VAL language commands motion control, hand control, program control, pick and place applications	4 Hrs
6	Palletizing applications	2 Hrs
7	Object detection and Sorting	2 Hrs
8	Robot welding application	4 Hrs
9	RAPID Language and AML	2 Hrs
10	Programming using Robot simulation software	4 Hrs

Suggested learning resources:

Textbooks:

1. Hughes Cameron, “Robot Programming”, Pearson Publishers, 2016
2. J. Srinivas, “Robotics: Control and Programming”, Narosa Publication, 2009

Reference Books:

1. Lentin Joseph, “Learning Robotics Using Python”, Second Edition Design, simulate, program, and prototype an autonomous mobile robot using ROS, OpenCV, PCL, and Python, Packt Publishing Paperback – 1 January 2018
2. Staple Danny, “Learn Robotics Programming”, Packt Publishing Limited, Feb 2021
3. Kailashi Chandra Mahajan, Prashant Kumar Patnaik, Raghvendra Kumar, “Robotics for Engineers”, Vikas Publishing House , 2016

Open Elective -I
Indian language Sanskrit/Pali
Constitution of India and Universal Human Values
Principles of Entrepreneurship
[Note- Above subject’s syllabus will be from respective department]

Semester -IV

Course: Analog & Digital Electronics

Course Code	MRAIPCC401	Scheme of Evaluation	MSE, PTE & ESE
Teaching Plan	2-0-2-0	**Mid Semester Exam**	30
Credits	2	**Teachers' Assessment**	20
		End Sem Exam	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to,

1. Design and Analyze Analog sub-circuits using BJT and FET.
2. Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc
3. Design the linear and non-linear applications of Op-Amp.
4. Design & analyze synchronous sequential logic circuits with FFs and combinatorial circuits.
5. Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc

Syllabus:

Unit	Contents	Lecture
1	**Physics of Bipolar Junction Transistors** Structure of NPN and PNP Transistors, Energy-Band Diagram, Operation of BJT, I/V characteristics, Large Signal model, Small signal model, Concept of transconductance, Early Effect. Bipolar amplifier: CE, CC &CB Physics of MOS Transistors: Structure of N and P MOSFET, Energy-Band Diagram, Operation of MOSFET, Channel Length Modulation, CMOS Technology, Comparison of Bipolar & MOS Devices	4 Hrs
2	**Fundamentals of Op-Amp** Op-Amp parameters Circuits with resistive feedback: Concept of feedback & their types, Inverting & non-inverting configurations, current to voltage converters, voltage to current converters, summing amplifier, difference amplifier, instrumentation amplifier. **Non-linear circuits** Schmitt trigger, Voltage comparators, comparator applications, precision rectifiers, analog switches, peak detectors, sample & hold circuits, Integrators & differentiators, Clippers and Clampers Feedback & Oscillator Circuit: Effect of positive and negative feedback, Analysis of practical feedback amplifiers, Sinusoidal Oscillators (RC, LC and Crystal), Multivibrators using 555 timer.	8 Hrs
3	**Logic Simplification and Combinational Logic Design** Review of Boolean Algebra and De Morgan's Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, Code Conversion. MSI devices like Multiplexers, Encoder, Decoder, Comparators, Half and Full Adders, Subtractors, BCD Adder, Barrel shifter and ALU. **Sequential Logic Design**	8 Hrs

	Building blocks like S-R, JK and D latch, Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM.	
4	**Logic Families and Semiconductor Memories** TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of PLDs like PAL, PLA, CPLDs, FPGA etc. Logic implementation using Programmable Devices (ROM, PLA)	4 Hrs

Suggested learning resources:

Textbooks:

1. Behzad Razavi , "Fundamentals of Microelectronics" , Second Edition; Wiley, 2016.
2. Ramakant A Gaikwad, "Op-Amps and Linear Integrated Circuits", PHI, 4th edition,2016

Reference Books:

1. Thomas L Floyd, "Electronic Devices", 10th edition, Pearson, 2017
2. G. B. Clayton, "Operational Amplifiers", International Edition, 2nd Edition,1979.
3. Anand Kumar, "Fundamentals of Digital circuits", PHI, Fourth edition, 2016.
4. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, fourth edition, 2010

Course: Analog & Digital Electronics Laboratory

Course Code	MRAIPCC401-L	**Scheme of Evaluation**	PTW
Teaching Plan	2-0-2-0	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Analyze and design various applications of Op-Amp.
2. Identify and characterize basic devices such as BJT and FET from their package information by referring to manufacturers' data sheets.
3. Design, simulate, built and debug complex sequential circuits based on an abstract functional specification.
4. Design, simulate, built and debug complex combinational circuits based on an abstract functional specification.

Course Contents: Assignments / Practical based on

Any Eight experiments / assignments from the list below (For Total Min. 24 Hours)

Expt. No.	**Contents**	**Contact Hours**
1	Input and Output Characteristics of BJT in CE configuration.	2 Hrs
2	Transfer and Drain Characteristics of MOSFET	2 Hrs
3	Design and simulate LC and RC oscillators.	4 Hrs
4	Build and test LC or RC oscillator.	2 Hrs
5	Op-amp applications-I: Integrator, Differentiators, Comparator, Schmitt trigger.	4 Hrs
6	Design different types of multivibrators using IC 555	2 Hrs

7	Simplification and implementation of a Boolean function using k -map technique e.g. code converter	2 Hrs
8	Use of Multiplexers, Encoders, Demultiplexer and decoders for implementing logic.	4 Hrs
9	Design and implementation of ripple and synchronous counters using JK and D FF and additional gates.	4 Hrs
10	Design of MOD counter using ICs like 7490/93 (ripple) and 74192/193(synchronous)	2 Hrs

Suggested learning resources:

Text Books:

1. Behzad Razavi , "Fundamentals of Microelectronics" , Second Edition; Wiley, 2016.
2. Ramakant A Gaikwad, "Op-Amps and Linear Integrated Circuits", PHI, 4th edition,2016

Reference Books:

1. Thomas L Floyd, "Electronic Devices", 10th edition, Pearson, 2017
2. G.B.Clayton, "Operational Amplifiers", International Edition, 2nd Edition,1979.
3. A. Anand Kumar, "Fundamentals of Digital circuits", PHI, Fourth edition, 2016.
4. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, fourth edition, 2010

Course: Control Systems

Course Code	MRAIPCC402	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-2-0	**Mid Semester Exam**	30
Credits	2	**Teachers' Assessment**	10
		End Sem Exam	60

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Appreciate the role of the control system.
2. Analyze the mathematical model of the control system.
3. Analyze stability of the system.
4. Use bode plot for frequency domain analysis.
5. Analyze the control system in state space.

Syllabus:

Unit	Contents	Contact Hours
1	**Introduction to Control System** Introduction to control system block diagram. Importance of Control Systems. Components of control. Explanation with the help of the liquid level control system. Significance of actuators and sensors. Types of actuators, Types of sensors. Open loop control and closed loop control. Use of relays, switches and contactors for simple and sequential control systems. **Control system representation** Mathematical representation of simple mechanical, electrical, thermal, hydraulic systems. Block diagram representation and reduction. Signal flow graph. Transfer function of these systems. Pole zero concepts	7 Hrs
2	**Time domain analysis**	5 Hrs

	Time response of first order, second order systems. Analysis of steady state error, Type of system and steady state error, Time response specifications. Effect of parameter variation on open loop and closed loop system response, sensitivity. Effect of feedback on system response, stability and disturbance	
3	**Stability** Concept of stability, Effect of pole zero location on stability, Routh- Hurwitz criterion. Root Locus method for analysis of gain margin, phase margin and stability. **Control system analysis in frequency domain** Concept of frequency domain behaviour, Bode Plot for analyzing systems in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification. Nyquist Analysis	7 Hrs
4	**State Space Approach** Representation of system in state space, Converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability.	5 Hrs

Suggested learning resources:

Text Books:

1. Nagrath & M. Gopal "Control System Engineering", Anshan, 2008
2. Norman S. Nice, "Control System Engineering", Wiley, 2008.

Reference Books:

1. Smarajit Ghosh, "Control Systems Theory & Applications", Pearson Education 2007
2. Katsuhiko Ogata," Modern Control Engineering", Prentice Hall, 2010.
3. Norman S. Nise, "Control System Engineering", Wiley, 2014

Course: Control Systems Laboratory

Course Code	MRAIPCC402-L	**Scheme of Evaluation**	PTW
Teaching Plan	2-0-2-0	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Develop the mathematical model of different components of linear feedback control system using simulation and experiments
2. Analyze the transient characteristics of different first order and second order systems using simulation and experiments
3. Determine the performance of system using root locus
4. Carry out the stability analysis of linear feedback control system using Bode plot and Nyquist plot
5. Analyze the different types of controllers like PI, PD, PID and tuning of these controllers using simulation and experiments

Course Contents: Assignments / Practical based on

Detailed Content :Any six experiments / assignments from the list below (For Total Min. 24 Hours)

Expt. No.	Contents	Contact Hours
1.	To study input out characteristic of various control system components	2 Hrs
2	To obtain step response and find time response specification of electrical system, hydraulic system, pneumatic system and thermal system.	2 Hrs
3	To obtain transfer function and poles zeros of DC motor experimentally.	2 Hrs
4	To obtain root locus experimentally.	4 Hrs
5	Use Matlab to study the effect of feedback gain on system response.	2 Hrs
6	Use Matlab to study the effect of damping factor zeta on time control performance specifications.	4 Hrs
7	Use Matlab to obtain root locus for a given system and find performance specifications there from. Study effect of addition of zero and pole on root locus	4 Hrs
8	Use Matlab to get a bode plot and obtain gain margin and phase margin for various systems.	2 Hrs
9	Use Matlab to obtain state space representation from transfer function, find Eigenvalues, Analyze controllability, observability and stability.	4 Hrs

Suggested learning resources:

Text Books:

1. Nagrath & M. Gopal “Control System Engineering”, Anshan, 2008
2. Norman S. Nice, “Control System Engineering”, Wiley, 2008.

Reference Books:

1. Smarajit Ghosh, “Control Systems Theory & Applications”, Pearson Education 2007
2. Katsuhiko Ogata,” Modern Control Engineering”, Prentice Hall, 2010.
3. Norman S. Nise, “Control System Engineering”, Wiley, 2014

Course: Drives for Robot Systems

Course Code	MRAIPCC403	**Scheme of Evaluation**	MSE,PTE & ESE
Teaching Plan	3-0-0-1	**Mid Semester Exam**	30
Credits	3	**Teachers’ Assessment**	20
		End Sem Exam	50

Course outcomes:

At the end of this course students will demonstrate the ability to:

1. Analyze DC drive, Induction and Synchronous Motors Drives.
2. Evaluate the steady state behavior and basic operating characteristics of A.C Machine.
3. Understand the basics of electric drives and fundamentals of drive dynamics.
4. Demonstrate analytical skills to assess machine performance in steady state.
5. Analyze the integration of the hydraulic drives & pneumatic drives in robotic systems

Syllabus:

Unit	Contents	Lecture
1	**D.C. Motors & Other Motors** Principles of working, Significance of back emf, Torque Equation, Types, Characteristics and Selection of DC Motors, Starting of DC Motors, Speed Control, Losses and Efficiency, Condition for Maximum Efficiency, Braking of DC Motors, Effect of saturation and armature reaction on losses; Applications, Permanent Magnet DC Motors, Type and Routine tests. PMAC and BLDC motor drives, Stepper motor drives, switched reluctance motor drives.	6 Hrs
2	**Synchronous Motors and Asynchronous Motor** Construction, types, armature reaction, circuit model of synchronous machine, determination of synchronous reactance, phasor diagram, power angle characteristics, parallel operation of synchronous generators, synchronizing to infinite bus bars, two axis theory, synchronous motor operation, dynamics, modeling of synchronous machine, PM synchronous machines. Types of induction motor, flux and mmf waves, development of circuit model, power across air gap, torque and power output, starting methods, speed control, induction generator, induction machine dynamics, high efficiency induction motors, Single phase IM, Modeling of induction machine.	6 Hrs
3	**Electric Drives, Dynamics and Control** Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications, Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability, Load epilation and selection motors.	6 Hrs
4	**Performance & Control of DC Motor** Dc motors and their performance starting, transient analysis, speed control, ward Leonard drives, Controlled rectifier fed drives, full controlled 3 phase rectifier control of dc separately excited motor], multi-quadrant operation, Chopper controlled drives Closed loop speed control of DC motor.	6 Hrs
5	**Performance & Control of Induction and Synchronous Motor Drives** Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, Slip power recovery – Static Kramer and Scherbius Drive, Single phase induction motor starting, braking and speed control. Synchronous motor operation with fixed frequency, variable speed drives.	6 Hrs
6	**Hydraulic and Pneumatic Drives** Overview of hydraulic and pneumatic drives in robot applications, Working principles and control of hydraulic and pneumatic drives, Advantages, limitations, and applications of hydraulic and pneumatic drives in robots, Advanced Drive Systems - Introduction to advanced drive systems (linear drives, magnetic drives, etc.), Emerging trends and technologies in robot drive systems, Integration of advanced drive systems with robot applications	6 Hrs

Suggested learning resources:
Text Books:

1. D. P. Kothari, I. J. Nagrath, "Electric Machines", Tata McGraw Hill Publication, Fourth edition, reprint 2012.
2. A.E. Fitzgerald, Charles Kingsley Jr., Stephen D. Umans, "Electric Machinery", Tata McGraw Hill Publication, sixth edition, 2002.

Reference Books:

1. M. G. Say, "Alternating current machines", fifth edition, E.L.B.S. Publication, 1987.
2. F. Puchstein, T.C. Lloyd, A.G. Conrad, "Alternating current machines", John Wiley and Sons, New York 1954.
3. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley and Sons Publication, second edition 1997.
4. M. H. Rashid,"Power Electronics-Circuits, devices & Applications", 3rd Ed, PHI Pub. 2004.
5. B. K. Bose, "Modern Power Electronics & AC Drives", Pearson Education, Asia, 2003
6. G. K. Dubey, "Fundamentals of Electrical Drives", Second edition (sixth reprint), Narosa Publishing house, 2001

Course: Standards & Ethics for Robot Applications

Course Code	MRAIPCC404	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	2-0-0-2	**Mid Semester Exam**	CIE: 100
Credits	2	**End Sem Exam**	

Course Outcomes :
Students who successfully complete this course will have demonstrated an ability to:

1. Study the fundamental concepts and terminologies related to standards and ethics in the context of robot applications.
2. Identify the key industry standards and regulatory frameworks governing robot design, safety, and performance.
3. Analyze the ethical challenges and implications associated with the development and use of robots.
4. Evaluate the societal impact of robots and assess their ethical implications on various stakeholders.
5. Comprehend the legal and liability considerations related to robots and their applications.

Syllabus:

Unit	Contents	Lecture
1	**Introduction** Introduction to Standards and Ethics in Robotics, Introduction to the field of robotics and its ethical dimensions, Overview of relevant industry standards and regulatory frameworks, The ISO (International Organization for Standardization) standard for robot safety is ISO 10218 - Robots for Industrial Environments - Safety Requirements	6 Hrs

2	**Robot Safety Standards** Overview of safety standards for robots in various environments (industrial, medical, etc.), Risk assessment and mitigation strategies for robot applications, Ethical considerations in ensuring robot safety Robot	6 Hrs
3	**Ethical Challenges in Robot Applications** Ethical dilemmas in robot design, deployment, and use, Privacy and data protection considerations in robot applications, Ethical implications of autonomous decision-making by robots. Societal Impact Of Robots: Understanding the social and economic implications of robots, Ethical considerations in robot automation and job displacement, Robot ethics and the digital divide.	6 Hrs
4	**Standards, Regulation, and the Future** Standards and Regulatory Landscape: Examining existing and emerging standards for robot safety and responsible development (e.g., ISO standards, national regulations). The Future of Robot Ethics: Exploring emerging trends in robotics and their ethical implications (e.g., artificial general intelligence, job displacement). Responsible Development and Deployment: Developing a framework for promoting ethical and responsible robot design, use, and governance.	6 Hrs

Suggested learning resources:

Textbook:

1. Peter Corke "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" Springer
2. Patrick Lin, Keith Abney, and Ryan Jenkins , "Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence" Oxford University Press
3. Patrick Lin, Keith Abney, and Ryan Jenkins , "Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence" Oxford University Press

Reference Books:

1. Ryan Calo, A. Michael Froomkin, and Ian Kerr (Eds.),"Robot Law" Edward Elgar publishing
2. Joseph E. Aoun, "Robot-Proof: Higher Education in the Age of Artificial Intelligence" The MIT Press
3. Joseph Migga Kizza, "Ethical and Social Issues in the Information Age" Springer
4. Joe Jones, Daniel Roth, and Charles E. Irwin, "Robot Programming: A Practical Guide to Behavior-Based Robotics" A K Peters/CRC Press
5. Brigette Tasha Hyacinth, "The Future of Leadership: Rise of Automation, Robotics, and Artificial Intelligence" Motivational Press
6. ISO 10218-1:2011 Robots and robotic devices - Safety requirements for industrial robots

Course: Numerical Methods & Programming Language

Course Code	MRAIBSC407	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	1-0-2-1	**Mid Semester Exam**	CIE: 100
Credits	1	**End Sem Exam**	

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the basic principles of numerical methods and their role in scientific and engineering computations.
2. Apply numerical techniques to solve mathematical problems, including root finding,

interpolation, differentiation, integration, and linear systems.
3. Implement numerical algorithms using a programming language to solve computational problems efficiently.
4. Analyze the accuracy, stability, and convergence of numerical methods.
5. Apply numerical methods and programming skills to solve real-world engineering and scientific problems.

Syllabus:

Unit	Contents	Lecture
1	**Numerical Methods and Programming** Introduction to a programming language for scientific computing, Basics of programming: variables, control structures, functions, and data types. Root Finding Methods Bisection method, Newton-Raphson method, Secant method, Comparison and analysis of root finding methods **Numerical Differentiation and Integration** Finite difference approximations, Numerical integration methods (Trapezoidal rule, Simpson's rule), Romberg integration, Error estimation and adaptive integration	6 Hrs
2	**Linear Systems of Equations** Gaussian elimination, Iterative methods (Jacobi, Gauss-Seidel, and SOR), Matrix factorizations and sparse systems, **Numerical Solutions of Ordinary Differential Equations** Euler's method, Runge-Kutta methods, Multistep methods (Adams-Bashforth, Adams-Moulton), Stability analysis and error control **Numerical Linear Algebra** Matrix computations (Eigen-values, singular value decomposition), Iterative methods for large linear systems, preconditioning techniques,	6 Hrs

Suggested learning resources:

Textbooks:

1. Advanced Engineering Mathematics (10th edition) by Erwin Kreyszig, Wiley eastern Ltd.
2. George Simmons, "Differential Equations with Applications and Historical notes", Tata Mc- Graw Hill publishing company Ltd, New Delhi, 2006.
3. C.R. Wylie, " Advanced Engineering Mathematics" , McGraw Hill Publications, New Delhi, 2017.

Reference Books

1. Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley.
2. Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi.
3. Conte, S. D. and De Boor, C., "Elementary Numerical Analysis", Mc Graw Hill Publisher.

Course: Numerical Methods & Programming Language Laboratory

Course Code	MRAIBSC407-L	**Scheme of Evaluation**	TW & OE
Teaching Plan	1-0-2-2	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Contents: Assignments / Practical based on

Unit	Contents	Contact Hours
1	**Interpolation and Curve Fitting** Polynomial interpolation (Lagrange and Newton), Least squares approximation, Spline interpolation, Error analysis and selection of interpolation methods,	3 Hrs
2	**Optimization Methods** Unconstrained optimization (gradient-based and gradient-free methods), Constrained optimization (linear and nonlinear programming), Introduction to optimization libraries and tools	3 Hrs
3	**Numerical Solutions of Partial Differential Equations** Finite difference methods, Finite element methods, Introduction to numerical methods for heat and wave equations,	3 Hrs
4	**Introduction to Numerical Probability and Statistics** Random number generation, Monte Carlo methods, Statistical analysis of numerical data	3 Hrs
5	**Introduction to Data Visualization and Plotting** Visualization libraries and tools, Data plotting and visualization techniques, Exploratory data analysis and presentation	3 Hrs
6	**Numerical Methods in Practice and Project Work** Application of numerical methods to real-world problems, Project work: implementation of a numerical algorithm, analysis of results, and presentation	3 Hrs

Suggested learning resources:

Textbooks:

1. Peter V. O' Neil, "Advanced Engineering Mathematics", (7th edition) , Thomson. Brooks / Cole, Singapore,1991.
2. Michael D. Greenberg, "Advanced Engineering Mathematics", (2nd edition), Pearson Education,1998.

Reference Books

1. Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication.

Open Elective

Entrepreneurship

Environmental Science

Summer Internship-after Sem IV-Exam in Sem V

Syllabus for Exit After SY -- Additional Credits for Diploma

Course: Robotic Simulation Laboratory

Course Code	MRAIVSEC4E1-L	Scheme of Evaluation	MSE & ESE
Teaching Plan	0-1-2-0	Term Work	50
Credits	1	Oral Exam	50

Course Contents: Assignments / Practical based on

Expt. No.	Contents	Contact Hours
1	Physics simulations of Robots with Gazebo, Mujoco and Pybullet C++/Python APIs	4 Hrs
2	Simulation of 6-dof manipulator in ROS	4 Hrs
3	Dynamic model development and simulation of simple mechanical systems using Matlab and Mathematical.	4 Hrs
4	Numerical simulation of simple mechanical systems.	4 Hrs
5	Stability analysis of simple mechanical systems using linear system theory namely root locus and Bode plot	4 Hrs
6	State space model development and dynamic simulation using Simulink	4 Hrs

Reference Books:

1. Corke, Peter I. Robotics, vision and control : fundamental algorithms in Matlab. 1st ed. New York: Springer, 2011. ISBN 978- 3-642-20143-1.
2. Devendra K Chaturvedi, ―Modelling and Simulation of Systems using MATLAB and Simulink , CRC press, 2010
3. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernandez, PACKT publishing, 2013
4. Programming Robots with ROS, Morgan Quigley, Brian Gerkey, & William D Smart, SPD Shroff Publishers and Distributors Pvt Ltd., 2016
5. Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System, Lentin Joseph, PACKT publishing, 2015

Course: Aerial Robotics Programming Laboratory

Course Code	MRAIVSEC4E2-L	Scheme of Evaluation	MSE & ESE
Teaching Plan	0-1-2-2	Term Work	50
Credits	1	Oral Exam	50

Course Contents: Assignments / Practical based on

Detailed Content :Any six experiments / assignments from the list below (For Total Min. 24 Hours)

Expt. No.	Contents	Contact Hours
1	Introduction to Drone Technology Lab Overview of the lab equipment and safety protocols Introduction to basic drone components (frame, motors, flight controller)	4 Hrs

	Familiarization with tools and software used in the lab	
2	Drone Assembly and Disassembly Step-by-step assembly of a drone kit Understanding the purpose and function of each component Disassembly of the drone for maintenance and troubleshooting	4 Hrs
3	Flight Controller Configuration Introduction to flight controller software (e.g., Betaflight, Ardupilot) Basic configuration and calibration of the flight controller Setting up flight modes and fail safes	4 Hrs
4	Basic Flight Maneuvers Practice basic flight maneuvers such as take-off, landing, and hovering Introduction to different flight modes (e.g., stabilized, acro) Understanding control inputs (pitch, roll, yaw)	4 Hrs
5	Autonomous Flight Introduction to autonomous flight modes (e.g., GPS-assisted flight) Planning and executing autonomous missions using mission planning software, Understanding geofencing and no-fly zones	4 Hrs
6	Payload Integration Introduction to different types of payloads (e.g., cameras, sensors) Mounting and integrating payloads onto the drone, Testing payload functionality in flight	4 Hrs
7	Advanced Flight Maneuvers Practice advanced flight maneuvers such as banked turns, figure-eight patterns, Introduction to acrobatic maneuvers (flips, rolls), Flight proficiency assessment	4 Hrs
8	Drone Maintenance and Repair Routine maintenance tasks (cleaning, propeller replacement, battery care) Diagnosing and troubleshooting common issues (motor failure, GPS signal loss), Repairing and replacing damaged components	4 Hrs
9	Data Collection and Analysis Introduction to data collection techniques (e.g., aerial photography, mapping), Processing and analyzing data collected by drones Applications of drone-collected data in various industries	4 Hrs

Reference Books:

1. Build Your Own Drone Manual: The practical guide to safely building, operating and maintaining an Unmanned Aerial Vehicle (UAV), by Alex Eliott, 2016, Publisher: Haynes Publishing
2. Introduction to UAV Systems, by Paul Fahlstrom and Thomas Gleason, 2012, CreateSpace Independent Publishing Platform
3. Quadcopter and Drone Photography: How to Bring Your Photography or Videography to the Next Level, by Eric Cheng, 2014, Peachpit Press
4. DIY Drones for the Evil Genius: Design, Build, and Customize Your Own Drones, by Ian Cinnamon and Romi Kadri, 2016, McGraw-Hill Education TAB

5. Drone Technology and Applications, edited by Changdon Kee and Hesham ElSayed, 2019, Wiley-IEEE Press
6. Small Unmanned Aircraft: Theory and Practice, by Randal W. Beard and Timothy W. McLain, 2012, Princeton University Press
7. Drones: Mastering Flight Techniques, by Brian Halliday, 2016, Wiley
8. Aerial Photography and Videography Using Drones, by Eric Cheng, 2015, Peachpit Press
9. Drone Technology: Types, Operations, and Applications, by Kevin Downing, 2020, Nova Science Publishers
10. Drone Operator's Handbook, by Kevin Jenkins, 2017, Independently published.

Course: Control System Laboratory

Course Code	MRAIVSEC4E3-L	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	0-1-2-0	**Term Work**	50
Credits	1	**Oral Exam**	50

Course Contents: Assignments / Practical based on
Detailed Content (Any Eight experiments / assignments from the list below)

Expt. No.	**Contents**	**Contact Hours**
1	Programming of HCS12 with Code warrior for Interrupts, Clock Functions	4 Hrs
2	TIM, RTI, SPI, LCD interfacing,	2 Hrs
3	Use of JTAG and Hardware Debuggers, Interfacing Keypad	4 Hrs
4	ADC, DAC, LCD, Real Time Clock	4 Hrs
5	Temperature Sensors with I2C and SPI bus	2 Hrs
6	Interface 7 segment LED to 8051 to generate flashing action	2 Hrs
7	Interface Analog to Digital converter to 8051 and display the result on LCD display	4 Hrs
8	Interface Digital to Analog converter to 8051 and view the output on CRO Interface stepper motor to 8051 it through given number of steps	4 Hrs
9	Perform serial communication using 8051	2 Hrs
10	Decentralized motion control and Centralized motion control	4 Hrs
11	Feed-forward compensation, Force control, Visual surveying	4 Hrs
12	Linear controller (P,PI,PD and PID) design for simple position control of mechanical systems.	4 Hrs

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

2. Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
3. I.J. Nagarath and M. Gopal, Control Systems Engineering, New Age International (P) Ltd.
4. M. Gopal, Digital Control and State Variable Methods, Tata Mc Graw-Hill Companies, 1997.

Course: Mini Project

Course Code	MRAIVSEC6E4	**Scheme of Evaluation**	MSE & ESE
Teaching Plan	**0-2-0-0**	**Term Work**	50
Credits	2	**Oral Exam**	50

Course Outcomes:

Students who successfully complete this course will have an ability to:

1. Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
2. Design, implement and test the prototype/algorithm in order to solve the conceived problem.
3. Write a comprehensive report on mini project work.

Guidelines:

1. The mini-project is a team activity having 3-4 students in a team. Mini projects should include mainly Mechanical Engineering but can be multi disciplinary too.
2. The mini project may be a complete hardware or a combination of hardware and software. The software part in the mini project should be less than 50% of the total work.
3. Mini Project should cater to a small system required in laboratory or real life.
4. It should encompass components, devices etc. with which functional familiarity is introduced.
5. After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of the mini-project.
6. Students are expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within the first week of the semester.
7. The student is expected to exert on design, development and testing of the proposed work as per the schedule.
8. Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Open Elective-II
Multidisciplinary Minor - I
Numerical Methods & Programming Language

Principles of Economics

Environmental Studies

[Note- Above subject’s syllabus will be from respective department]

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