MAULANA AZAD
NATIONAL INSTITUTE OF TECHNOLOGY, Bhopal - 462003

DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech in Automation and Robotics

PROPOSED SCHEME M.Tech (w.e.f. July 2024)

First Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
AR24511	Metaheuristic Techniques	3	-	-	3
AR24512	Fundamentals in Robotics	3	-	-	3
AI24562	Sensors, Microcontrollers, and Embedded Systems	3	-	-	3
	Departmental Elective – 1	3	-	-	3
	Departmental Elective – 2	3	-	-	3
AR24513	Automation and Robotics Lab-I	-	-	2	1
AR24514	Mechatronics Lab.	-	-	2	1
AR24515	Seminar-I	-	-	2	1
AR24516	Minor Project-1 (Self Learning)	-	-	-	2
HUM24511	Communication Skills (Audit Course)	2	-	-	0
Total Hours: 23 **Total Credits: 20**		**Total Semester Credits**			**20**

Second Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
AR24521	Robot Dynamics and Control	3	-	-	3
AR24522	Automation in Manufacturing	3	-	-	3
	Departmental Elective – 3	3	-	-	3
	Departmental Elective – 4	3	-	-	3
	Open Elective	3	-	-	3
AR24523	Automation and Robotics Lab. II	-	-	2	1
AR24524	Robotic Programming Lab.	-	-	2	1
AR24525	Seminar-II	-	-	2	1
AR24526	Minor Project-2 (Self Learning	-	-	-	2
Total Hours: 23 **Total Credits: 40**		**Total Semester Credits**			**20**

Third Semester:

Course No.	Subjects	Scheme of studies period per week			Total Credits
		L	T	P	
AR24611	Dissertation Phase-I	-	-	40	40
Total Hours: 40 **Total Credits: 60**		**Total Semester Credits**			**20**

Fourth Semester:

Course No.	Subjects	Scheme of studies period per week			Total Credits
		L	T	P	
AR24621	Dissertation Phase-II	-	-	40	20
Total Hours: 40 **Total Credits: 80**		**Total Semester Credits**			**20**

List of Department Electives

Course No.	Subject	Course No.	Subject
AR24551	Soft Robotics	AI24521	Deep Learning
AR24552	Control Systems for Robots	AI24581	Robotics and Planning Algorithms
AR24553	Micro Manufacturing	AI24512	Machine Learning
AR24554	Mechatronics	AI24522	Computer Vision
AR24555	Digital Manufacturing	AI24577	Internet of Things
AR24556	CAD/CAM and CIM	CS24505	Digital Image Processing
AR24557	Multibody Dynamics	VED24101	VLSI Design
AR24558	Autonomous Robot Technologies	SM24551	Micro-electro Mechanical Systems
AR24559	Additive Manufacturing Technologies	ME24524	Research Methodology

List of Open Electives

ARP24581	Introduction to Urban Planning
BSE24581	Bioprocess Engineering
BSE24582	Biophysics Tools and Techniques
CHE24581	Analytical Techniques
CHE24582	Green Technology & Processes
CE24581	Solid Waste Management
CE24582	Basic Concept of GIS
CE24583	Road Safety
CSE24582	Advanced Data Structures and Algorithms
PHY24581	Nanotechnology and Nanoscience
EE24581	Electric Machines & Applications
EE24582	Control and Instrumentation
ECE24581	Introduction to Fuzzy Logic
ECE24582	Neural Networks and its Applications
EC24581	Energy Resource Technologies
HUM24581	Intellectual Property Rights for Engineers
HUM24582	Applied Psychology: Human Centered Design and Engineering
MTH24581	Advanced Operations Research
MTH24582	Computing Technologies
MME24581	Advanced Instrumentation Methods for Material Analysis
MME24582	Smart Materials and their Application
MBA24581	Engineering Startup Management

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Name of Program	**M Tech in Automation and Robotics**	**Semester I**	**Year I**
Name of Course	**Metaheuristic Techniques**		
Course Code	AR24511		
Core / Elective / Other	Core		

Prerequisite if any:	
1.	Operations Research
2.	

Course Outcomes: At the end of the course, the student shall be able to:	
1.	Understand the concept of evolutionary computation to Improve Data Analysis Solutions.
2.	Neural Networks, architecture, functions and various algorithms involved
3.	Fuzzy Logic, Various fuzzy systems and their functions.
4.	Genetic algorithms, its applications and advances
5.	The unified and exact mathematical basis as well as the general principles of various evolutionary techniques

Description of Contents in brief:	
Unit 1.	Introduction: What is Evolutionary Computing? How it is different from conventional optimization? Application of EC in Robotics
Unit 2.	Neural Networks: What is Neural Network, Learning rules and various activation functions, Single layer Perceptrons , Back Propagation networks, Architecture of Backpropagation(BP) Networks, Backpropagation Learning, Variation of Standard Back propagation Neural Network, Introduction to Associative Memory, Adaptive Resonance theory and Self Organizing Map, Recent Applications
Unit 3.	Fuzzy Systems: Fuzzy Set theory, Fuzzy versus Crisp set, Fuzzy Relation, Fuzzification, Minmax Composition, Defuzzification Method, Fuzzy Logic, Fuzzy Rule based systems, Predicate logic, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification.
Unit 4.	Genetic Algorithm: History of Genetic Algorithms (GA), Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Convergence of GA, Bit wise operation in GA, Multi-level Optimization.
Unit 5.	Genetic Programming, Artificial immune systems, multi-objective optimization, particle swarm optimization, simulated annealing.
Unit 6	Ant Colony Optimization, Bacterial foraging optimization, Grey wolf optimization and their applications in Robotics.

List of Text Books:	
1.	Evolutionary computation techniques and optimization by Ashish M Gujarathi, B.V.Babu, Routledge publications

2.	Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S.Rajasekaran, G. A. Vijayalakshami, PHI
3.	Genetic Algorithms: Search and Optimization, E. Goldberg.
4.	Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI.
5.	Soft Computing Techniques by D.K Pratihar, Narso Publishers
List of Reference Books:	
1.	Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI.
2.	Build_Neural_Network_With_MS_Excel_sample by Joe choong
3.	James A. Freeman and David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques", Pearson Edn.,
4.	Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing", Prentice-Hall of India,
5.	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic-Theory and Applications", Prentice Hall
URLs:	
Lecture Plan (about 40-50 Lectures):	

Lecture No.	**Topic**	**Remarks**
1.	Introduction, what is Soft Computing?	
2.	Difference between Hard and Soft computing,	
3.	Requirement of Soft computing,	
4.	Major Areas of Soft Computing,	
5.	Applications of Soft Computing	
6.	What is Neural Network,	
7.	Learning rules and various activation functions,	
8.	Single layer Perceptrons	
9.	Back Propagation networks,	
10.	Architecture of Back propagation (BP) Networks,	
11.	Back propagation Learning,	
12.	Variation of Standard Back propagation Neural Network,	
13.	Introduction to Associative Memory,	
14.	Adaptive Resonance theory and Self Organizing Map,	
15.	Recent Applications	
16.	Fuzzy Set theory,	
17.	Fuzzy versus Crisp set,	
18.	Fuzzy Relation,	
19.	Fuzzification, Minmax Composition,	
20.	Defuzzification Method, Fuzzy Logic,	
21.	Fuzzy Rule based systems, Predicate logic,	
22.	Fuzzy Decision Making,	
23.	Fuzzy Control Systems,	
24.	Fuzzy Classification	
25.	History of Genetic Algorithms (GA),	
26.	Working Principle, Various Encoding methods,	
27.	Fitness function, GA Operators- Reproduction,	
28.	Crossover, Mutation, Convergence of GA,	
29.	Bit wise operation in GA,	
30.	Multi-level Optimization	
31.	Sequential Hybrid Systems, Auxiliary Hybrid Systems,	
32.	Embedded Hybrid Systems	
33.	Neuro-Fuzzy Hybrid Systems,	
34.	Neuro-Genetic Hybrid Systems,	

35.	Fuzzy-Genetic Hybrid Systems.	
36.	LR type Fuzzy numbers,	
37.	Fuzzy Neuron,	
38.	Fuzzy BP Architecture,	
39.	Learning in Fuzzy BP,	
40.	Application of Fuzzy BP Networks	

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
9	Any other		

Name of Program	M. Tech in Automation and Robotics	Semester-I	Year- I
Name of Course	**Fundamentals in Robotics**		
Course Code	AR24512		
Core / Elective / Other	**Core**		

Prerequisite if any:	
1.	Students should have knowledge on Theory of Machines
2.	Students should have knowledge on Basic mathematics such as, Matrices, Differentiation and Integration
Course Outcomes: At the end of the course, the student will be able to:	
CO1	Understand robots and their kinematics.
CO2	Formulate the solutions for determining the position and orientation of the end effector using mathematical concepts.
CO3	Select the suitable grippers and tools for suitable applications.
CO4	Acquire knowledge about various sensors & working of actuators.
CO5	Understand the concept of robots used for various industrial applications.
CO6	Awareness, knowledge and various industrial and non-industrial applications of automation.
Description of Contents in brief:	
Unit 1	Automation: Industrial definition, advantages, goals, types, need, principles and elements of automation, Strategies of automation in Production System. Levels of automations. Role of robotics in Industrial Automation.
Unit 2	Introduction to robotics: Historical development of Robotics, Definition, type and classification of robots, Robot Joints and symbols, Degrees of Freedom, Robot configurations, Robot Components, Work space and work envelope, Robot reference frames, Resolution, accuracy and precision of robot.
Unit 3	Robot Kinematics - Manipulators Kinematics, Rotation, Translation, Rotation Matrix multiple transformation, Homogenous Transformation Matrix, Direct and Kinematics for industrial robots. D-H representation of robots.
Unit 4	Drive system- hydraulic, pneumatic and electric systems, Sensors – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors.
Unit 5	End effectors - Mechanical, Adhesive, Vacuum, Magnetic grippers. Gripper design. Active and passive grippers. Robot Inverse kinematics.
Unit 6	Differential Kinematics for planar serial robots, Basics of Trajectory Planning. Industrial case examples on automation and robotics applications.
List of Text Books:	
1.	R.K. Mittal &I.J.Nagrath, "Robotics and Control", 2nd ed., Tata McGraw Hill, 8th reprint 2014.
2.	Spong M. and Vidyasagar M., "Robot Dynamics and Control", 2nd ed., John Wiley & Sons, 2014.
3.	Mikell P. Groover, Mitchell Weiss, "Industrial Robotics, Technology, Programming and Applications", 2nd ed., Mc.Graw Hill International, 2008.
List of Reference Books:	
1.	K.S. Fu., R.C.Gonalez and C.S.G.Lee, "Robotics Control sensing, Vision and Intelligence", 1st ed., McGraw Hill International, 2nd reprint 2008.
2.	Saeed B.Niku, "Introduction to Robotics Analysis, Systems, Applications", 2nd ed., PHI Learning Publication, 2009.
3.	S.K. Saha, "Introduction to Robotics", 2nd ed., Tata McGraw Hill, 2009.

4.	D. K Pratihar, "Fundamentals of Robotics", Narsa Publishers, 2018.
URLs:	
1.	https://youtu.be/rYWJdZ5qg6M
2.	https://nptel.ac.in/courses/112/101/112101099/
3.	https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/lecture-notes/

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	Remarks
1.	Automation, Industrial Definition, advantages, goals	
2.	Types, needs, principles, and elements of automation	
3.	Strategies of automation in production systems	
4.	Levels of automations. Role of robotics in Industrial Automation.	
5.	Introduction to Robotics, History, Laws.	
6.	Automation, Classifications by coordinate system, robot Components	
7.	Concepts of work space, basic robot motions	
8.	Coordinate frames, mappings: changing descriptions from frame to frame	
9.	Translations, rotations and transformations, kinetic modelling of the manipulator, D-H representation	
10.	Forward kinematics, inverse kinematics, classification of end effectors, tools etc.	
11.	Translations, Rotations and Transformations,	
12.	Kinematic Modelling of the manipulator, D-H Representation,	
13.	Drive system for grippers, Mechanical	
14.	Adhesive, Vacuum, Magnetic grippers.	
15.	Gripper force analysis and gripper design.	
16.	Gripper force analysis and gripper design.	
17.	Active and passive grippers.	
18.	Introduction to Jacobian, Jacobians for serial manipulators,	
19.	Jacobians for serial manipulators, inverse Jocobian	
20.	Lagrangian formulation for equations of motion for serial manipulators (Energy method)	
21.	Lagrangian-Euler dynamic model (Matrix Method),	
22.	Trajectory planning	
23.	Introduction to actuators and sensors,	
24.	Pneumatic actuators	
25.	Hydraulic actuators	
26.	Electrical actuators	
27.	Sensors. Types and applications	
28.	Position sensors,	
29.	Potentiometers,	
30.	Force sensors,	
31.	Encoders	
32.	Introduction to control systems, Open loop and closed loop systems.	
33.	Robot applications in Machining	
34.	Robot applications in Welding	
35.	Robot applications in Assembly and Material handling	
36.	Robot applications in Loading and unloading and spray painting	
37.	Robot applications in Medical, Mining and Space	

38.	Robot applications in Underwater and Defense.	

***Min 36 (for three credit course)**

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

Name of Program	**M. Tech in Automation and Robotics**	**Semester-I**	**Year- I**
Name of Course	**Sensors, Microcontrollers, Robotics & Embedded System Course**		
Course Code	**AI24562**		
Core / Elective / Other	**Core**		

Prerequisite if any:	
1.	Not any
2.	
Course Outcomes: At the end of the course, the student will be able to:	
CO1	Explain the micro-controllers, robotics, embedded system, and their applicability.
CO2	Build the various robots using Robot Operating System.
CO3	Implement the various Robotics system using microcontroller and ROS.
Description of Contents in brief:	
Unit 1	Application of microcontrollers, Embedded system, application of robotics, Arduino: architecture, serial port, serial communication, device control using serial communication, Arduino sensors, humidity, temp., water detector, ultrasonic, LDR, Arduino secondary integration, relay, DC motor etc., pulse width modulation (PWM)
Unit 2	I2C communication protocol, B1750; digital light sensor, parallel communication, Arduino UART, GSM, GPRS module, Raspberry Pi: Architecture, raspberry pi port identification, raspberry pi GPIO, transistorized switching, accepting digital input on raspberry pi, enabling I2C to Raspberry Pi, Analog, and digital sensors, BMP 180 with pi.
Unit 3	Sensors interface with Pi LDR, Sensors interface with Pi DHTT11, Sensors interface with Pi using sense HAT, Fundamentals of Robotics, Robot Operating System (ROS), ROS Essentials: ROS Topics, ROS: Services, Actions, Nodes, Build Robot Environment
Unit 4	Unified Robot Description Format (URDF), ROS parameter server, ROS Services, and parameters, Recording and playing back, reading messages from a bag file, using rosed to edit files in ROS, ROS msg and srv.
Unit 5	Simple Publisher and Subscriber, Examining the Simple Publisher and Subscribe, Simple Service and Client, Examining the Simple Service and Client, Motion in ROS (ROS Noetic), Working with Pluginlib, Nodelets, and Gazebo Plugins, Robot Navigation (moveit), Grasping, Grasping using MoveIt!, Creating a pick and place task, Grasping in the Real Robot, ROS Controllers and Visualization Plugins.
List of Text Books:	
1.	Simon Monk, Raspberry Pi Cookbook: Software and Hardware Problems and Solutions 3rd Edition,O'Reilly Media, 2019. ISBN: 978-1492043225.
2.	Wyatt Newman, *A Systematic Approach to Learning Robot Programming with ROS* (1 ed.), Chapmanand Hall/CRC, 2017. ISBN 9781498777827.
List of Reference Books:	
1.	Anis Koubaa, *Robot Operating System (ROS): The Complete Reference (Volume 2)*, Springer, 2017,ISBN: 3319549286.
URLs:	
Lecture Plan (about 40-50 Lectures):	

Lecture	**Topic**	**Remarks**

No.		
1.	Automation, Industrial Definition, advantages, goals	
2.	Types, needs, principles, and elements of automation	
3.	Strategies of automation in production systems	
4.	Levels of automations. Role of robotics in Industrial Automation.	
5.	Introduction to Robotics, History, Laws.	
6.	Automation, Classifications by coordinate system, robot Components	
7.	Concepts of work space, basic robot motions	
8.	Coordinate frames, mappings: changing descriptions from frame to frame	
9.	Translations, rotations and transformations, kinetic modelling of the manipulator, D-H representation	
10.	Forward kinematics, inverse kinematics, classification of end effectors, tools etc.	
11.	Translations, Rotations and Transformations,	
12.	Kinematic Modelling of the manipulator, D-H Representation,	
13.	Drive system for grippers, Mechanical	
14.	Adhesive, Vacuum, Magnetic grippers.	
15.	Gripper force analysis and gripper design.	
16.	Gripper force analysis and gripper design.	
17.	Active and passive grippers.	
18.	Introduction to Jacobian, Jacobians for serial manipulators,	
19.	Jacobians for serial manipulators, inverse Jocobian	
20.	Lagrangian formulation for equations of motion for serial manipulators (Energy method)	
21.	Lagrangian-Euler dynamic model (Matrix Method),	
22.	Trajectory planning	
23.	Introduction to actuators and sensors,	
24.	Pneumatic actuators	
25.	Hydraulic actuators	
26.	Electrical actuators	
27.	Sensors. Types and applications	
28.	Position sensors,	
29.	Potentiometers,	
30.	Force sensors,	
31.	Encoders	
32.	Introduction to control systems, Open loop and closed loop systems.	
33.	Robot applications in Machining	
34.	Robot applications in Welding	
35.	Robot applications in Assembly and Material handling	
36.	Robot applications in Loading and unloading and spray painting	
37.	Robot applications in Medical, Mining and Space	
38.	Robot applications in Underwater and Defense.	

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		

5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

Name of Program	M. Tech in Automation and Robotics	Semester First	Year First
Name of Course	Automation and Robotics Lab I		
Course Code	AR24513		
Core / Elective / Other	Core Laboratory		
Prerequisite if any:			
1.	None		
Description of Contents in brief:			
Expt 1.	Verify the Position & Orientation of the end effector of the 3-DOF (RPR) manipulator using Robo-Analyzer.		
Expt 2.	Obtain the joint angles of 3-DOF (RRR) manipulator by using Robo-Analyzer		
Expt 3.	Development of Trajectory for 2-DOF manipulator using Robo-Analyzer software		
Expt 4.	Write a program for 3-wheeled mobile robot to move forward, stop, turn left and turn right using Arduino.		
Expt 5.	Control of an autonomous line following robot using IR sensors		
Expt 6	Control of an autonomous obstacle avoidance robot using ultrasonic sensor.		
Expt 7	Write the program using Arduino for Human Following Robot.		
Expt 8	Development of control algorithm for 4-DOF robotic Manipulator.		
Expt 9	Calculate the Gait angles and dynamic balance margin of 16 DOF Humanoid Robot		

Name of Program	M. Tech in Automation and Robotics	Semester First	Year First
Name of Course		**Mechatronics Lab.**	
Course Code		**AR513**	
Core / Elective / Other		**Core Laboratory**	
Prerequisite if any:			
1.	None		
CO1	To measure the physical quantity such as displacement, force and temperature and also the operation of signal conditioning circuits		
CO2	To apply a suitable sensor and image processing technique for Mechatronics systems		
CO3	To design suitable circuits to automate and control the hydraulic, pneumatic and electric actuators		
CO4	To apply PLC, PID and 8085 microcontrollers as a control unit Mechatronics system		
Description of Contents in brief:			
Expt 1.	Assemble language programming of 8085 Microprocessor and perform operations such as Addition – Subtraction – Multiplication – Division – Sorting – Code Conversion		
Expt 2.	Stepper motor interface through Arduino		

Expt 3.	Study of various types of transducers.
Expt 4.	Study of hydraulic, pneumatic and electro-pneumatic circuits.
Expt 5.	Modelling and simulation of basic hydraulic, pneumatic and electrical circuits using software.
Expt 6	Perform pneumatic and electro pneumatic experiments using trainer kit
Expt 7	Study of PLC and its applications.
Expt 8	Ladder diagram and PLC simulation
Expt 9	Study of image processing for industrial automation (Case studies)

Name of Program	M. Tech in Automation and Robotics	Semester: I	Year First
Name of Course	**Communication Skills**		
Course Code	**HUM24511**		
Core / Elective / Other	**Audit Course**		

Prerequisite:

1.	None

Course Outcomes:

1.	To help postgraduate students improve their technical communication skills related to listening, Speaking, reading, writing.
2.	To enable students to organise, comprehend, write, and present short and long forms of any technical work within the broad framework of the scientific method
3.	To help students adhere to ethical norms of scientific communication.

Description of Contents in brief:

1.	**Unit I: Scientific Method and its Relationship to Technical Communication** Basics of technical communication, Formulation of hypothesis, Paragraph organisation, Argument development, Evidence and elaboration
2.	**Unit II: Listening and Reading Skills** Note taking, Survey of literature, Different reading strategies
3.	**Unit III: Writing Skills** Report writing, Peer review skills, Summary and abstract writing, Bibliography and references, Data Analysis and Presentation, Visual communication
4.	**Unit IV: Speaking Skills** Elevator pitch, Oral presentation, Slides for presentation, Group discussions, Interview Skills
5.	**Unit V: Ethics in Communication** Ethics in education and research, Copyrights and plagiarism, Authorship, Gender and diversity, Net etiquettes and workplace communication

List of Text Books:

1.	Arora, V.N., and Lakshmi Chandra. Improve your Writing. 1981. New Delhi: Oxford UP, 2001.
2.	Graff Gerald, and Birkenstein Cathy. "They Say I Say"-The Moves That Matter in Academic Writing. W.W.Norton and Company. Fourth edition. 2018
3.	Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills forEmpowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-HillPublishing Company Ltd., 2002.
List of Reference Books:	
1.	Graff Gerald, and Birkenstein Cathy. "They Say I Say"-The Moves That Matter in Academic Writing. W.W.Norton and Company. Fourth edition. 2018
2.	Kumar Sanjay, and Lata Pushp. Communication Skills. 2011. Oxford University Press,

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Name of Program	**M. Tech in Automation & Robotics**	**Semester- II**	**Year- I**
Name of Course	**Robot Dynamics and Control**		
Course Code	**AR24521**		
Core / Elective / Other	**Core**		
Prerequisite if any:			
1.	Students should have knowledge in basics in robotics.		
2.	Students should have knowledge on Basic mathematics such as, Matrices, Differentiation and Integration		
Course Outcomes:			
CO1	Understand the procedure to obtain the linear and angular velocity of each joint of the robotic arm.		
CO2	Formulate the Lagrangian-Euler formulation to estimate the torque required for joint.		
CO3	Explore the knowledge on trajectory planning algorithms.		
CO4	Acquire the knowledge on robotic vision system & various path planning algorithms.		
CO5	Understand the concepts of robots are useful in various applications.		
Description of Contents in brief:			
Unit 1.	Introduction to Linear and angular velocity of a rigid body - Manipulator Jacobians for serial manipulators - Jacobian Inverse - Jacobian Singularities - Problems related Jacobian analysis: 2RR and 3RRR Manipulators.		
Unit 2.	Mass and inertial of links, Lagrangian formulation for equations of motion for serial manipulators, Kinetic and potential energy, Lagrangian-Euller dynamic mode., Problems related 2RR Manipulator.		
Unit 3.	Introduction to Trajectory planning, Definitions and planning tasks– Joint space techniques – Cartesian space techniques – Position and orientation trajectories, Point-to-point planning – Continuous path generation: Problems related cubic and fifth order polynomials.		
Unit 4.	Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.		
Unit 5.	Introduction-Path planning & Navigation, overview- Road map path planning-Cell decomposition path Planning-Potential field path Planning-Obstacle avoidance.		
Unit 6	Introduction to various types of mobile robots- wheeled and legged robots, Robot applications in house hold, medical, space, military, agricultural, underwater, societal.		

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List of Text Books:

S.No	Title of Book	Author, publication year and publisher
1.	Robotics and Control	R.K. Mittal & I.J.Nagrath, 2nd ed., Tata McGraw Hill, 8th reprint 2014.
2.	Robot Dynamics and Control	Spong M. and Vidyasagar M., "", 2nd ed., John Wiley & Sons, 2014.
3.	Industrial Robotics, Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, , 2nd ed., Mc.Graw Hill International, 2008.
4.	Introduction to Robotics	S.K. Saha,, 2nd ed., Tata McGraw Hill, 2009.
5.	Fundamentals of Robotics	D. K Pratihar, Narsa Publishers, 2018.

List of Reference Books:

S.No	Title of Book	Author, publication year and publisher
1.	Robotics Control sensing, Vision and Intelligence	K.S. Fu., R.C.Gonalez and C.S.G.Lee, , 1st ed., McGraw Hill International, 2nd reprint 2008.
2.	Introduction to Robotics Analysis, Systems, Applications	Saeed B.Niku, 2nd ed., PHI Learning Publication, 2009.

URLs:

1.	https://youtu.be/rYWJdZ5qg6M
2.	https://nptel.ac.in/courses/112/101/112101099/
3.	https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/lecture-notes/

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	Introduction to Linear and angular velocity of a rigid body	UNIT 1
2.	Manipulator Jacobians for serial manipulators	
3.	Manipulator Jacobians for serial manipulators -Problems	
4.	Jacobian Inverse	
5.	Jacobian Inverse- Problems	
6.	Jacobian Singularities	
7.	Problems related Jacobian analysis: 2RR and 3RRR Manipulators.	
8.	Problems related Jacobian analysis: 2RR and 3RRR Manipulators.	
9.	Introduction to Mass and inertial of links	UNIT 2
10.	Lagrangian formulation for equations of motion for serial manipulators,	
11.	Kinetic and potential energy,	
12.	Kinetic and potential energy, Problems on 2RR manipulator	
13.	Lagrangian-Euller dynamic model	
14.	Problems related 2RR Manipulator	

15.	Problems related 2RR Manipulator	
16.	Problems related 2RR Manipulator	
17.	Introduction to Trajectory planning, Definitions and planning tasks– Joint space techniques	UNIT 3
18.	Introduction to Trajectory planning, Definitions and planning tasks– Joint space techniques	
19.	Cartesian space techniques – Position and orientation trajectories, Point-to-point planning	
20.	Cartesian space techniques – Position and orientation trajectories, Point-to-point planning	
21.	Continuous path generation: Problems related cubic and fifth order polynomials.	
22.	Robotic vision systems, image representation, object recognition and categorization,	UNIT 4
23.	Robotic vision systems, image representation, object recognition and categorization,	
24.	Robotic vision systems, image representation, object recognition and categorization,	
25.	depth measurement, image data compression, visual inspection, software considerations.	
26.	depth measurement, image data compression, visual inspection, software considerations.	
27.	depth measurement, image data compression, visual inspection, software considerations.	
28.	Introduction-Path planning & Navigation, overview- Road map path planning-	UNIT 5
29.	Introduction-Path planning & Navigation, overview- Road map path planning-	
30.	Introduction-Path planning & Navigation, overview- Road map path planning-	
31.	Introduction-Path planning & Navigation, overview- Road map path planning-	
32.	Cell decomposition path Planning-Potential field path Planning-Obstacle avoidance.	
33.	Cell decomposition path Planning-Potential field path Planning-Obstacle avoidance.	
34.	Cell decomposition path Planning-Potential field path Planning-Obstacle avoidance.	
35.	Introduction to various types of mobile robots- wheeled and legged robots,	UNIT 6
36.	Introduction to various types of mobile robots- wheeled and legged robots,	
37.	Introduction to various types of mobile robots- wheeled and legged robots,	
38.	Introduction to various types of mobile robots- wheeled and legged robots,	
39.	Robot applications in house hold, medical, space, military, agricultural, underwater, societal.	
40.	Robot applications in house hold, medical, space, military,	

	agricultural, underwater, societal.	
41.	Robot applications in house hold, medical, space, military, agricultural, underwater, societal.	

Evaluation Criteria:

S.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10 M	
2	Mid Semester Test	30 M	
3	Assignment if any		
4	Tutorial if any		
5	Seminar, Viva voce if ay	10 M	
6	End Semester Examination	50 M	

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Name of Program	**M.Tech in Automation & Robotics**	**Semester II**	**Year I**
Name of Course	Automation in Manufacturing		
Course Code	AR24522		
Core / Elective / Other	Core		
Prerequisite if any:			
1.	Should have studied Mechanical, Production, Industrial Engineering, Mechatronics Engineering		
2.	Knowledge of basic electronics and electrical engineering.		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	Students will understand the process of automation and the types		
2.	Students will get exposure to the workstation, which refers to the location in the factory where some well-defined task or operation is accomplished by an automated machine		
3.	Worker-and-machine combination or a worker using hand tools		
4.	Understand the Automated Material handling equipment and types		
5.	Student gets exposure to portable power tools.		
Description of Contents in brief:			
Unit 1.	Introduction: Importance of automation in the manufacturing industry. Use of mechatronics Systems required.		
Unit 2.	Design of an automated system: Building blocks of an automated system, working principle and examples.		
Unit 3.	Fabrication: Fabrication or selection of various components of an automated system. Specifications of various elements. Use of design data books and catalogues. Sensors: the study of various sensors required in a typical automated system for manufacturing Construction and principle of operation of sensors.		
Unit 4.	Microprocessor Technology: signal conditioning and data acquisition, use of microprocessor or microcontrollers. Configurations. Working. Drives: electrical drives - types, selection criteria, construction and operating principle.		
Unit 5.	Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts. Mechanisms: Electronic cams, indexing mechanisms, tool magazines, and transfer systems. Hydraulic systems: hydraulic power pack, pumps, valves. Hydraulic systems: designing of hydraulic circuits.		
Unit 6	Pneumatic systems: configurations, compressors, valves, distribution and conditioning. CNC technology: basic elements, interpolators and programming.		
List of Text Books:			
1.	M.P.Groover 3e - Automation, Production Systems and Computer-Integrated Manufacturing, PHI,2009.		
2.	Frank Lamb - Industrial Automation, Mc Graw Hill,2013		

3.	W. Buekinsham – Automation
List of Reference Books:	
1.	Nick Dawkins - Automation and Controls

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2.	Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - Computer Aided Manufacturing, Pearson 2009
3.	Peter G. Martin and Gregory Hale - Automation Made Easy

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction: Importance of automation in the manufacturing industry.	Unit 1
2.		
3.		
4.	Use of mechatronics Systems required	
5.		
6.	Design of an automated system	Unit 2
7.	Building blocks of an automated system,	
8.		
9.	working principle and examples	
10.		
11.	Fabrication: Fabrication or selection of various components of an automated system. Specifications of various elements.	Unit 3
12.		
13.		
14.		
15.	Use of design data books and catalogues.	
16.		
17.	Sensors: the study of various sensors required in atypical automated system for manufacturing	
18.		
19.		
20.	Construction and principle of operation of sensors.	
21.		
22.	Microprocessor Technology: signal conditioningand data acquisition, use of microprocessor or microcontrollers. Configurations.	Unit 4
23.		
24.		
25		
26		
27		
28.	Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts.Mechanisms: Electronic cams, indexing mechanisms, tool magazines, and transfer systems. Hydraulic systems: hydraulic power pack, pumps, valves. Hydraulic systems: designing ofhydraulic circuits.	
29.		
30		
31		
32		
33		
34	Pneumatic systems: configurations, compressors, valves, distribution and conditioning. CNC technology: basic elements, interpolators and programming.	
35.		
36		
37		

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Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test		
2	Mid Semester Test		
3	Assignment if any		
4	Tutorial if any		
5	Quiz if any		
6	Seminar, Viva voce if ay		
7	End Semester Examination		
8	Experiments if any (for practical courses)		
8	Any other		

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Name of Program	**M. Tech in Automation and Robotics**	**Semester** II	**Year** I
Name of Course	Automation and Robotics Lab. II		
Course Code	AR24523		
Core / Elective / Other	Core		
Prerequisite if any: NIL			
Course Outcomes: At the end of the course, the student will be able to:			

01	Geometrical modelling software – BASICS
02	Starting with Geometrical modelling software- Various Draw commands
03	2-D solid models creation using Geometrical modelling software- solidworks/creo etc.,
04	3-D solid models creation using Geometrical modelling software- solidworks/creo etc.,
05	Assembling
06	Process simulation for CNC turning based subtractive manufacturing processes using open-source software
07	Process simulation for CNC Milling based subtractive manufacturing processes using open-source software
08	Process simulation for solid based additive manufacturing processes using open-source software
09	Process simulation for powder based additive manufacturing processes using open-source software
10	Robot simulation using open-source software

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Name of Program	M. Tech in Automation and Robotics	**Semester**- II	**Year**- I
Name of Course	Robot Programming Lab		
Course Code	AR24524		
Core / Elective / Other	Core		
Prerequisite if any: NIL			
Course Outcomes: At the end of the course, the student will be able to:			
CO1	Understanding and Preparation of Programs in MATLAB etc.		
CO2	Understand the measurement of 2D and 3D cavity.		
CO3	Apply the programming on real time robotic movement.		
CO4	Create the interlinking between the machine and the robot.		
List of Experiments			

1. Introduction to programming in Python, ROS, C, C++, MATLAB, etc
2. Creation of arrays
3. Mathematical operations with arrays
4. Creation of 2D plots
5. Creation of 3D plots
6. Curve fitting with polynomials
7. Programming applications in numerical analysis
8. Robot Programming and path planning
9. Controlling of robotic manipulator using arduino/robot programming
10. Do it yourself (DIY) experiments (Students should take the real-world issue and they have to think, decide and do things independently)

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Lab record	20	
2	Lab experiments	30	
3	Assignment if any		
4	Tutorial if any		
5	Quiz if any		
6	Viva voce if ay	30	
7	End Semester experimentation	20	
8	Any other		

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Name of Program	Automation and Robotics	**Semester I**	**Year I**
Name of Course	SOFT ROBOTICS		
Course Code	AR24551		
Core / Elective / Other	Elective		

Prerequisite if any:	
1.	Fundamentals of Mechanics
2.	Fundamentals of Mathematics

Course Outcomes:
At the end of the course, the student shall be able to:

1.	Independently identify active unanswered questions in soft robotics.
2.	Model soft robot mechanics in custom or commercial analytical and/or numerical tools.
3.	Fabricate soft robot subsystems using 3D printing and elastomer casting.
4.	May create a press-ready report for presentation/conference publications.

Description of Contents in brief:	
Unit 1.	Soft versus Hard Robots, Soft actuators: History, current status, and infrastructure; Natural and artificial muscles; Smart materials for soft actuators
Unit 2.	Hyperelasticity modeling techniques of soft materials; Mechanics of soft elastomeric materials, Viscoelasticity modeling techniques of soft materials
Unit 3.	Soft sensors (Fluidic, solid, composites, textiles); Smart material selection for soft machine design
Unit 4.	Fabrication recipes for soft machines using different possible methods
Unit 5.	Applications of soft machines in different possible areas; Fabrication of soft robot subsystems using 3D printing and elastomer (silicon) casting; Mechanical characterization of silicone rubber; Soft manipulator arms
Unit 6	Soft gripper fabrication and testing; Fludo-Jelly fabrication (Jellyfish-like soft robot enabled by soft pneumatic composite); Pneumatic wrist brace fabrication and testing; Fabrication and testing of fiber-braided soft actuator

List of Text Books:	
1.	Bar-Cohen, Yoseph. "Electroactive polymer actuators as artificial muscles." SPIE, Washington (2001).
2.	Volokh, Konstantin. Mechanics of soft materials. Singapore: Springer, 2016.
3.	Marchese, Andrew D., Robert K. Katzschmann, and Daniela Rus. "A recipe for soft fluidic elastomer robots." Soft robotics 2.1 (2015): 7-25.

List of Reference Books:	
1.	C. J. Payne, et al., "Wearable Soft Robotic Device Supports the Failing Heart In Vivo," The 9th Hamlyn Symposium on Medical Robotics. 2017.

2.	C. J. Payne, et al., "An Implantable Extracardiac Soft Robotic Device for the Failing Heart: Mechanical Coupling and Synchronization," Soft Robotics, vol. 4, no. 3, pp. 241-250, 2017.
3.	Kumar, D. Mathematical Modeling of Smart Materials-A Continuum Mechanics Approach Diss. IIT Patna, 2019.
URLs:	
1.	https://www.youtube.com/watch?v=PDqmGHHKkWw

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Soft robots Vs Rigid robots	Unit 1
2.	Soft actuators: History	
3.	Soft actuators: current status, and infrastructure;	
4.	Natural and artificial muscles	
5.	Smart materials for soft actuators	
6.	Hyperelasticity: Intro	Unit 2
7.	Hyperelasticity modeling techniques of soft materials	
8.	Hyperelasticity modeling techniques of soft materials	
9.	Hyperelasticity modeling techniques of soft materials	
10.	Different Energy Density Functions used in soft material Modeling	
11.	Different Energy Density Functions used in soft material Modeling	
12.	Different Energy Density Functions used in soft material Modeling	
13.	Viscoelasticity : Intro	
14.	Viscoelastic Models for Soft Materials	
15.	Viscoelastic Models for Soft Materials	
16.	Viscoelasticity modeling techniques of soft materials	Unit 3
17.	Viscoelasticity modeling techniques of soft materials	
18.	Viscoelasticity modeling techniques of soft materials	
19.	Soft sensors (Fluidic, solid, composites, textiles);	
20.	Soft sensors (Fluidic, solid, composites, textiles);	
21.	Soft sensors (Fluidic, solid, composites, textiles);	
22.	Smart material selection for soft machine design	
23.	Smart material selection for soft machine design	
24.	Smart material selection for soft machine design	
25.	Fabrication recipes for soft machines using different possible Methods	Unit 4
26.	Fabrication recipes for soft machines using different possible Methods	
27.	Fabrication recipes for soft machines using different possible	
	Methods	
28.	Fabrication recipes for soft machines using different possible Methods	
29.	Fabrication recipes analysis for soft machines	
30.	Fabrication recipes analysis for soft machines	
31.	Applications of soft machines in different possible areas;	
32.	Applications of soft machines in different possible areas;	
33.	Fabrication of soft robot subsystems using 3D printing and	

	elastomer (silicon) casting
34.	Mechanical characterization of silicone rubber
35.	Mechanical characterization of silicone rubber; Soft manipulator arms
36.	Soft gripper fabrication and testing
37.	Soft gripper fabrication and testing
38.	Pneumatic wrist brace fabrication and testing
39.	Pneumatic wrist brace fabrication and testing
40.	Fabrication and testing of fiber-braided soft actuator

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any		
5	Quiz if any		
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

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Name of Program	**M Tech in Automation & Robots**	**Semester I/II**	**Year I**
Name of Course	CONTROL SYSTEMS FOR ROBOTS		
Course Code	AR24552		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Fundamentals of Mathematics		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	To be able to obtain a working mathematical model of a system of robot		
2.	To understand and design feedback systems in control systems		
3.	To be able to design control systems for robots that meet design specifications.		
Description of Contents in brief:			
Unit 1.	**Introduction:** Motivation, examples of control systems, feedback control systems.		
Unit 2.	**Mathematical modelling:** Mathematical modelling of: electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-space modelling of dynamical systems. Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, time-invariance versus nonlinearity and time-variance. Linearization. Distributed parameter systems.		
Unit 3.	**Time response of dynamical systems:** Obtaining solutions from mathematical models. Poles and zeros and their effects on solutions. Step response of standard second order systems, time-domain specifications and their formulae.		
Unit 4.	**Stability:** Definition of stability. Routh-Hurwitz test. Lyapunov theory.		
Unit 5.	**Properties of feedback:** Basic idea of feedback control systems. Error analysis. P, PI, PD, PID controllers. **Frequency domain analysis:** Bode plot, Nyquist plot, Nyquist stability criterion, gain and phase margins, robustness.		
Unit 6	**Design of controllers:** The root-locus technique, steps in obtaining a root-locus. Design of controllers using root-locus. Pole placement with state feedback, controllability. Pole placement with output feedback, observability, Luenberger observer. LQR control.		
List of Text Books:			
1.	K.Ogata, Modern Control Engineering, 5th Addition, Pearson, 2015		
2.	R.K.Mittal and I.J.Nagrath, Robotics and Control, McGraw Hill education, 2017		
List of Reference Books:			
1.	Sudhir Gupta, Elements of Control Systems, Pearson, 2021		

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Name of Program	**M. Tech. in Automation and Robotics**	**Semester: I**	**Year: I**
Name of Course	Deep Learning		
Course Code	AI24521		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Linear Algebra, Calculus & Probability Theory.		
2.	Pattern Recognition & Machine Learning.		
3.	Neuroscience of vision module& Perception psychology.		
4.	Non-linear Optimization.		
Course Outcomes:			
1.	The objective of this course is to cover the fundamentals of neural networks as well as some advanced topics such as recurrent neural networks, long short term memory cells and convolution neural networks.		
2.	The students will be able to implement these popular 4 model of deep learning RNN, CNN, RBM and autoencoder		
3.	Understanding of Generative model- Variational autoencoders (VAEs) & Generative Adversarial Networks (GANs)		
4	Exposure with different model of CNN & RNN. The course also requires students to implement programming assignments related to these topics.		
Note:	Use of Steam Tables, Molier diagram and Charts will be allowed in examination		
Description of Contents in brief:			
Unit 1.	**Basics:** Biological Neuron, Idea of computational units, McCulloch–Pitts unit and thresholding logic, Rosenberg perceptron, Perceptron Learning Algorithm, Linear separability, Convergence theorem for Perceptron Learning Algorithm, Shallow versus Deep network, overfitting versus under fitting, Bias variance tradeoff, loss function. **Feedforward Networks:** Multilayer Perceptron, Gradient Descent, Backpropagation, Vanishing & exploding gradient problem, Empirical Risk Minimization, regularization. **Autoencoders:** Dimensionality reduction, Inter and intra class classification, PCA and LDA, Limitation of PCA, Autoencoder, Different type of autoencoders- Overcomplete, undercomplete, denoising, Sparse, contactive autoencoder.		
Unit 2.	**Deep Neural Networks:** Difficulty of training deep neural networks, Greedy layer wise training. **Better Training of Neural Networks:** Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).		
Unit 3.	**Generative models:** Restrictive Boltzmann Machines (RBMs), Bayesian probability network , Markov Model, Difference between Bayesian probability network and Markov model, Directional and undirected graph, factorization and probability distribution, RMBs architecture and Energy based model, Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines.		
Unit 4.	**Convolution Neural Networ**ks: CNN Architecture and operations (convolution operation and different kind of filters (edge detection, vertical, horizontal, diagonal, sharpen and Gaussian) operations , down sampling/ pooling(max, avg, sum), padding, flatten operation, fully connected layer), Relu and softmax activation function,		

	Different popular convolution neural networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. **Recurrent Neural Networks: RNN vs CNN,** Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs.
Unit 5.	**Recent trends:** Variational Autoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning. **Reinforcement Learning:** Markov decision processes, Value/policy function, Bellman equation, Value iteration algorithm, Maximum likelihood estimate, Q-learning.
List of Text Books:	
1.	**Deep Learning**, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016.
2.	**"Learning deep architectures for AI"** Foundations and trends in Machine Learning 2.1 Bengio, Yoshua. (2009):
List of Reference Books:	
1.	**Neural Networks**: A Systematic Introduction, Raúl Rojas, 1996.
2.	**Pattern Recognition and Machine Learning**, Christopher Bishop, 2007.
3.	**Deep Learning with Python**, Francois Chollet, 2017.
URLs:	
1.	https://pytorch.org/tutorials/beginner/deep_learning_60min_blitz.html
2.	https://github.com/fchollet/deep-learning-with-python-notebooks
3.	https://sites.google.com/site/wwwvbsemwalcom/course-material-question-paper
4.	https://nptel.ac.in/courses/106105216/
5.	https://towardsdatascience.com/computer-vision-for-beginners-part-1-7cca775f58ef
6.	https://www.tutorialspoint.com/artificial_intelligence_with_python/artificial_intelligence_with_pyth on_computer_vision.htm
7.	https://www.mathworks.com/products/matlab.html

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	**Basics:** Biological Neuron, Idea of computational units, McCulloch–Pitts unit and thresholding logic,	
2.	Rosenberg perceptron, Perceptron Learning Algorithm, Linear separability,	
3.	Convergence theorem for Perceptron Learning Algorithm,	
4.	Shallow versus Deep network, overfitting versus under fitting, Bias variance tradeoff, loss function.	
5.	**Feedforward Networks:** Multilayer Perceptron, Gradient Descent, Backpropagation, Vanishing & exploding gradient problem, Empirical Risk Minimization, regularization.	
6.	**Feedforward Networks:** Multilayer Perceptron, Gradient Descent, Backpropagation, Vanishing & exploding gradient problem, Empirical Risk Minimization, regularization.	
7.	**Feedforward Networks:** Multilayer Perceptron, Gradient Descent, Backpropagation, Vanishing & exploding gradient problem, Empirical	

	Risk Minimization, regularization.	
8.	**Autoencoders:** Dimensionality reduction, Inter and intra class classification, PCA and LDA, Limitation of PCA,	
9.	Autoencoder, Different type of autoencoders- Overcomplete, undercomplete, denoising, Sparse, contactive autoencoder.	
10.	Autoencoder, Different type of autoencoders- Overcomplete, undercomplete, denoising, Sparse, contactive autoencoder.	
11.	**Deep Neural Networks:** Difficulty of training deep neural networks, Greedy layer wise training	
12.	**Better Training of Neural Networks:** Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam	
13.	NAG), second order methods for training, Saddle point problem in neural networks,	
14.	Regularization methods (dropout, drop connect, batch normalization).	
15.	Regularization methods (dropout, drop connect, batch normalization).	
16.	**Generative models:** Restrictive Boltzmann Machines (RBMs), Bayesian probability network	
17.	Ma rkov Model, Difference between Bayesian probability network and Markov model,	
18.	Directional and undirected graph, factorization and probability distribution,	
19.	RMBs architecture and Energy based model,	
20.	Introduction to MCMC and Gibbs Sampling,	
21.	**Convolution Neural Networ**ks: CNN Architecture and operations Convolution	
22.	operation and different kind of filters edge detection, vertical, horizontal, diagonal,	
23.	sharpen and Gaussian) operations , down sampling/ pooling(max, avg, sum),	
24.	padding, flatten operation, fully connected layer),	
25.	Relu and softmax activation function, Different popular convolution neural networks, LeNet	
26.	AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.	
27.	**Recurrent Neural Networks: RNN vs CNN,** Back propagation through time, Long Short Term Memory,	
28.	Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs	
29.	**Recent trends:** Variational Autoencoders,	
30.	Generative Adversarial Networks,	
31.	Multi- task Deep Learning, Multi-view Deep Learning.	
32.	**Reinforcement Learning:** Markov decision processes,	
33.	Value/policy function, Bellman equation,	
34.	Value iteration algorithm, Maximum likelihood estimate, Q-learning.	
35.	Value iteration algorithm, Maximum likelihood estimate, Q-learning.	
36.	Value iteration algorithm, Maximum likelihood estimate, Q-learning.	

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Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	Nil	
5	Quiz if any	10	
6	Seminar, Viva voce if any	Nil	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	Nil	
9	Any other	Nil	

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Name of Program	**M. Tech. in Automation and Robotics**	**Semester: I**	**Year: I**
Name of Course	Robotics and Planning algorithms		
Course Code	AI24581		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Search techniques in artificial intelligence, general principles of artificial intelligence & algorithms.		
2.	Soft Computing & Coordinate geometry.		
3.	Introduction to mobile robotics.		
Course Outcomes:			
1.	The student will be able to learn about mobile robot and basic of path planning algorithms.		
2.	More understanding of Configuration Spaces, Collision Detection & search algorithm of Artificial Intelligence		
Description of Contents in brief:			
Unit 1.	**Introduction to Mobile Robotics:** Hardware, Software, Vision, Localization, Mapping, Planning, Control, HRI, real life examples, and related topics. **Introduction to Robot Motion Planning:** Variants, Optimality, Completeness, Soundness, Mathematical Formulation, Real World Examples, Planning and Re-planning, Online Planning, Workspace and Configuration Space, Smoothness, Path Cost, Clearance, Structured and Unstructured Environments, Deliberative and Reactive methods, Anytime Algorithms. **Configuration Spaces:** Definitions, Representations, Walkthrough with examples involving different kinds of robots and multirobot system, Holonomic and Non-holonomic Constraints, Topology, Homeomorphism, Diffeomorphism, Manifolds.		
Unit 2.	**Collision Detection:** Topological Maps, Structured Maps, Un-structured Maps, Distance Functions, Mesh and Bounded Box Approaches, Collision detection between different regular shaped objects/regular objects in an unstructured environment. **Bug Algorithms:** Bug0/Bug Zapper, Bug 1, Bug 2, Tangent Bug, Assessment of optimality and completeness.		
Unit 3.	**A* Algorithm - An Introduction & A* Algorithm in Robot Motion Planning:** States, Actions, Graph Formulation, Costs, Heuristics, Pseudo-code and Working of A*Algorithm, Problem Formulation, Resolution-optimality, Resolution-completeness, Effect of resolution, Planning for non point robots, Planning with robot's dynamics, Post-processing and smoothing techniques.		
Unit 4.	**Potential Approaches:** Potential Modeling, Artificial Potential Fields, Gradient Descend, Examples with robots with proximity sensors and vision based approaches, Problems on narrow corridors, equi-potential/getting un-stuck, Bushfire Algorithm, Wave-front planner, Navigation Functions, Implementations in Workspace and Configuration Spaces, Elastic Strip **Roadmap Approaches**: Roadmaps, Visibility graphs, Deformation Retracts, Voronoi, Generalized Voronoi Diagram, Generalized Voronoi Graph		
Unit 5.	**Sampling Based Approaches: Probabilistic Roadmaps I**ntroduction to sampling-based approaches, single query algorithms, multi-query algorithms, sampling, computing vertices, constructing edges, local planners, connection with k-closest		

	neighbors, connection with radius of k, edges by reversible and non-reversible local planner, collision-checking, post-processing, smoothing, probabilistic completeness, probabilistic optimality **Reinforcement Learning: -** Markov decision processes, Value/policy function, Bellman equation, Value iteration algorithm, Maximum likelihood estimate, Q-learning.
List of Text Books:	
1.	H. Choset, K. M. Lynch, S. Hutchinson, G. A. Kantor, W. Burgard, L. E. Kavraki, S. Thrun (2005) Principles of Robot Motion: Theory, Algorithms, and Implementations, MIT Press, Cambridge, MA.
2.	Planning Algorithms by Steven M. LaValle, Cambridge University Press
List of Reference Books:	
1.	R. Kala (2013) Intelligent Planning for Mobile Robotics: Algorithmic Approaches, IGI Global Publishers
2.	S. M. LaValle (2006) Planning Algorithms, Cambridge University Press, Cambridge, UK
URLs:	
1.	http://rkala.in/rmp.php#pre
2.	http://rkala.in/codes.php
3.	http://planning.cs.uiuc.edu/book.html

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	**Introduction to Mobile Robotics:** Hardware, Software, Vision, Localization,	
2.	Mapping, Planning, Control, HRI, real life examples, and related topics.	
3.	**Introduction to Robot Motion Planning:** Variants, Optimality, Completeness,	
4.	Soundness, Mathematical Formulation, Real World Examples, Planning and Re- planning,	
5.	Online Planning, Workspace and Configuration Space, Smoothness,	
6.	Path Cost, Clearance, Structured and Unstructured Environments, Deliberative and Reactive methods, Anytime Algorithms.	
7.	**Configuration Spaces:** Definitions, Representations, Walkthrough with examples involving different kinds of robots and multirobot system,	
8.	Holonomic and Non- holonomic Constraints, Topology, Homeomorphism, Diffeomorphism, Manifolds.	
9.	**Collision Detection:** Topological Maps, Structured Maps, Un-structured Maps	
10.	Distance Functions, Mesh and Bounded Box Approaches	
11.	Collision detection between different regular shaped objects/regular objects in an unstructured environment.	
12.	**Bug Algorithms:** Bug0/Bug Zapper, Bug 1, Bug 2, Tangent Bug, Assessment of optimality and completeness.	
13.	**A* Algorithm - An Introduction & A* Algorithm in Robot Motion Planning:** States, Actions, Graph Formulation	
14.	Costs, Heuristics, Pseudo-code and Working of A*Algorithm,	

15.	Problem Formulation, Resolution-optimality, Resolution-completeness, Effect of resolution,	
16.	Planning for non point robots, Planning with robot's dynamics, Post-processing and smoothing techniques.	
17.	Planning for non point robots, Planning with robot's dynamics, Post-processing and smoothing techniques.	
18.	Planning for non point robots, Planning with robot's dynamics, Post-processing and smoothing techniques.	
19.	**Potential Approaches:** Potential Modeling, Artificial Potential Fields, Gradient Descend,	
20.	Examples with robots with proximity sensors and vision based approaches,	
21.	Problems on narrow corridors, equi-potential/getting un-stuck,	
22.	Bushfire Algorithm, Wave-front planner,	
23.	Navigation Functions, Implementations in Workspace and Configuration Spaces, Elastic Strip	
24.	Navigation Functions, Implementations in Workspace and Configuration Spaces, Elastic Strip	
25.	Navigation Functions, Implementations in Workspace and Configuration Spaces, Elastic Strip	
26.	Navigation Functions, Implementations in Workspace and Configuration Spaces, Elastic Strip	
27.	**Sampling Based Approaches: Probabilistic Roadmaps I**ntroduction to sampling-based approaches, single query algorithms,	
28.	multi-query algorithms, sampling, computing vertices, constructing edges,	
29.	local planners, connection with k-closest neighbors,	
30.	connection with radius of k, edges by reversible and non-reversible local planner	
31.	connection with radius of k, edges by reversible and non-reversible local planner	
32.	connection with radius of k, edges by reversible and non-reversible local planner	
33.	collision-checking, post-processing, smoothing, probabilistic completeness, probabilistic optimality	
34.	collision-checking, post-processing, smoothing, probabilistic completeness, probabilistic optimality	
35.	**Reinforcement Learning: -** Markov decision processes, Value/policy function, Bellman equation,	
36.	Value iteration algorithm, Maximum likelihood estimate, Q- learning.	

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	Nil	

5	Quiz if any	10	
6	Seminar, Viva voce if any	Nil	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	Nil	
9	Any other	Nil	

MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY
BHOPAL - 462003

Name of Program **M.Tech** **Semester: II** **Year: I**
Name of Course Computer Vision
Course Code AI24522

Core / Elective / Other Elective

Prerequisite:

1. Good Knowledge of digital Image Processing, Matlab programing
2. Linear algebra, Probabilities and Statistics
3. (Computer graphics), (Mathematical Methods for Visual Computing), or equivalent courses from other departments. I will expect you to be familiar with the Fourier transform (or be willing to learn it quickly), and basic linear algebra (eigen-analysis, matrix inverse)

Course Outcomes:

1. Recognize and describe both the theoretical and practical aspects of computing with images. Connect issues from Computer Vision to Human Vision.
2. Describe the foundation of image formation and image analysis. Understand the basics of 2D and 3D Computer Vision.
3. Become familiar with the major technical approaches involved in computer vision. Describe various methods used for registration, alignment, and matching in images.
3. Get an exposure to advanced concepts leading to object and scene categorization from images.
4. Build computer vision applications.

Description of Contents in brief:

1. **Digital Image Formation and low-level processing:**
   Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc. Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.
2. **Depth estimation and Multi-camera views**, **Multiple View Geometry**
   Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.
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.
4. **Image Segmentation**
   Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

5. **Pattern Analysis**
   Clustering: K-Means, K-Medoids , Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.
6. **Motion Analysis**
   Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.
7. **Shape from X**
   Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges.

List of Text Books:

1. Digital Image Processing using MATLAB, By: Rafael C. Gonzalez, Richard Eugene Woods, 2nd Edition, Tata McGraw-Hill Education 2010
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
3. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, 2003.

List of Reference Books:

1. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
2. K. Fukunaga; Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990.
3. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992.

URLs:

1. https://nptel.ac.in/courses/106105216/
2. https://towardsdatascience.com/computer-vision-for-beginners-part-1-7cca775f58ef
3. https://www.tutorialspoint.com/artificial_intelligence_with_python/artificial_intelligence_with_python_computer_vision.htm
4. https://www.mathworks.com/products/matlab.html

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY,BHOPAL - 462003

IoT (Internet of Things)

Name of Program: M.Tech.
Name of Course IoT (Internet of Things)
Course Code AI24577
Core / Elective / Other **Group A: Electives**
Prerequisite:

1. Programming Languages

Course Outcomes:

1. Upon completion of this course, students will be able to understand the technology and standards relating to IoTs.
2. Ability to develop prototypes for the applications of IoT in real time scenarios.
3. Ability to analyze IoT data

Description of Contents in brief:

1. Introduction of IoT, IoT Building Blocks
2. Sensors and Actuators
3. Microcontrollers and IoT Boards
4. Networks for IoT
5. Edge/Fog Computing, Cloud Computing
6. Introduction to IoT Data Analytics and Machine Learning
7. Various Applications of IoT

List of Reference Books:

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
2. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)

URLs:

1. https://nptel.ac.in/courses/106/105/106105166/

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY,
BHOPAL - 462003

Name of Program	**M Tech in Automation & Robots**	**Semester I/II**	**Year-1**
Name of Course	MULTIBODY DYNAMICS		
Course Code	AR24557		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Fundamentals of Mathematics		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	To derive equations of motion for interconnected bodies in multi-body systems with three-dimensional motion.		
2.	To implement and analyze methods of formulating equations of motion for interconnected bodies.		
3.	To simulate and analyze all types of static and dynamic behaviors of the multi-body systems including the kineto-static analysis.		
Description of Contents in brief:			
Unit 1.	**Basic concepts in 3-D rigid-body mechanics Degrees-of-freedom;** Rigid body vs flexible body; Spatial kinematics (3-D rotation transformations); Euler theorem, rotation parameterization, Rodriguez formula; 11 Moments and products of inertia; Newton-Euler equations of motion; Lagrange Equation; Generalized forces.		
Unit 2.	**Inter-connected rigid bodies:** Kinematic pairs (joints) with classification of constraints; holonomic and non-holonomic constraints; Springs, dampers, actuators and controllers with brief introduction of controls theory.		
Unit 3.	**Formulation of equations of motion for inter-connected bodies:** Relative coordinates, generalized coordinates, Cartesian co-ordinates ; Lagrange' s equations and other approaches; Differential equations (ODE) and differential algebraic equations (DAE); Co-ordinate partitioning and Lagrange multipliers; Types of analyses (kinematic, static, quasi-static, kineto-static, dynamic and linear dynamic).		
Unit 4.	**Application of numerical methods:** NR method, Jacobian, ODE integrators (Euler methods and Implicit methods); Stability, accuracy and Dahlquist's tradeoff criteria; Stiffness and damping - physical vs numerical; Lock-up, bifurcation and singularities.		
Unit 5.	**Flexible Multibody Systems:** Dynamic analyses using classical approximation, FEM		
List of Text Books:			
1.	Kuo B.C., Automatic Control Systems, Prentice-Hall of India Pvt Ltd., New Delhi, 6th edition, 1991.		
2.	Franklin G.F., Powell J.D., Emami-Naeini A., Feedback Control of Dynamic Systems, Pearson, Upper Saddle River, New Jersey, 5th edition, 2006.		
List of Reference Books:			
1.	Computational dynamics, Shabana A. A., John Wiley & Sons.		
2.	Dynamics of Multibody Systems, Roberson R. E., and Richard S., Springer-Verlag.		

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY,
BHOPAL - 462003

Name of Program	**M Tech in Automation and Robotics**	**Semester I/II**	**Year I**
Name of Course	**Autonomous Robot Technologies**		
Course Code	AR24558		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Introduction to Robots		
2.			
Course Outcomes: At the end of the course, the student shall be able to:			
1.	Learn principles of working of autonomous robots		
2.	Demonstrate the sensing, perception, and cognition of autonomous robots		
3.	Understand anatomy of autonomous robots		
4.	Understand operation of Humanoid robot		
5.	Understand principles of operation of telecheric robots		
Description of Contents in brief:			
Unit 1.	Introduction to the fundamentals of mobile robotics, basic principles of locomotion, Kinematics and Mobility, Classification of mobile robots, AI for Robot Navigation.		
Unit 2.	Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots, mobile manipulators,		
Unit 3.	Current challenges in mobile robotics. Autonomous Mobile Robots – need and applications, sensing, localisation, mapping, navigation and control.		
Unit 4.	The Basics of Autonomy (Motion, Vision and PID), Programming Complex Behaviors (reactive, deliberative, FSM), Robot Navigation (path planning),		
Unit 5.	Robot Navigation (localization), Robot Navigation (mapping), Embedded electronics, kinematics, sensing, perception, and cognition,		
Unit 6	Telecheric robots – Concepts of teleoperations, Need and applications of Telecheric robots, Humanoid Robots, Swarm Robotics, Robot Applications and Ethics.		
List of Text Books:			
1.	Designing Autonomous Mobile Robots, John M Holland, Elsevier, 2004		
2.	Morgan Quigley , Brian Gerkey, Programming Robots with ROS, Quigley et al, O'Rielly Publishers, Murphy 2000.		
3.	Autonomous Mobile Robots, Edited by Shuzhi Sam Ge, Frank L Lewis, Taylor and Francis, 2006		
List of Reference Books:			
1.	Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, Introduction to Autonomous Mobile Robots", MIT Press, 2nd Edition, 2011		

2.	Peter Corke, Robotics Vision and Control, Springer 2011.

URLs:

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	Remarks
1	Introduction to Robotics	
2	Introduction to the fundamentals of mobile robotics	
3	basic principles of locomotion	
4	Kinematics and Mobility	
5	Classification of mobile robots	
6	AI for Robot Navigation.	
7	AI for Robot Navigation	
8	Introduction to modern mobile robots	
9	Swarm robots	
10	Swarm robots	
11	Cooperative and collaborative robots	
12	Cooperative and collaborative robots	
13	Mobile manipulators	
14	Mobile manipulators	
15	Current challenges in mobile robotics	
16	Autonomous Mobile Robots – need and applications,	
17	Sensing	
18	Localisation	
19	Mapping	
20	Navigation and control	
21	Navigation and control	
22	The Basics of Autonomy (Motion, Vision and PID)	
23	The Basics of Autonomy (Motion, Vision and PID)	
24	Programming Complex Behaviors (reactive, deliberative, FSM)	
25	Programming Complex Behaviors (reactive, deliberative, FSM)	
26	Programming Complex Behaviors (reactive, deliberative, FSM)	
27	Robot Navigation (path planning)	
28	Robot Navigation (path planning)	
29	Robot Navigation (localization)	
30	Robot Navigation (mapping)	
31	Embedded electronics	
32	KinematicsSensing	
33	Sensing	
34	Perception	
35	Cognition	
36	Telecheric robots – Concepts of teleoperations	
37	Need and applications of Telecheric robots,	
38	Humanoid Robots	
39	Humanoid Robots	
40	Swarm Robotics	
41	Swarm Robotics	

42	Robot Applications and Ethics.	

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
9	Any other		

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY,
BHOPAL - 462003

Name of Program	M Tech in Automation and Robotics	Semester I/II	Year I
Name of Course	Additive Manufacturing Technologies		
Course Code	AR24559		
Core / Elective / Other	Elective		
Prerequisite if any: NIL			
Course Outcomes: At the end of the course, the student will be able to:			
CO1	Understand the basics of various of additive manufacturing (AM) technologies.		
CO2	Design machine and select the suitable materials for AM technologies.		
CO3	Apply mathematical elements of geometric modeling for AM technologies.		
CO4	Analyze the influence of pre and post processing parameters on performances of Rapid Tooling (RT)		
CO5	Explore the applications of RE in AM		
Description of Contents in brief:			
Unit 1.	Introduction to additive manufacturing, Traditional manufacturing v/s Additive Manufacturing (AM), Break-even analysis for different manufacturing processes, Classification of AM technologies: solid, liquid and powder based technologies, Benefits and limitations of AM technologies, AM technologies with Interdisciplinary Applications		
Unit 2.	Design of AM machine- necessary parts, Functional description and design analysis, Build process, Future improvements, Materials: The Building block for AM, State of material working principle for AM technologies, Importance of Materials, Materials for AM, Materials Selection Considerations, Technology specific materials		
Unit 3.	Pre-processing of geometric model, Orientation of geometric model, volumetric error, shape deviations, staircase effect, surface roughness, material shrinkage or swelling, warpage, etc., AM data formats, STL format, STL file problems, STL file repair, Model slicing and contour data organization, Support structure generation, Direct and adaptive slicing, Tool path generation		
Unit 4.	Post processing of AM parts: Mechanical, thermal, chemical and laser based techniques. Rapid tooling (RT), Differences between Conventional and RT, Classification of RT: Direct and Indirect Tooling methods; Applications of RT and case studies.		
Unit 5.	Geometrical modeling: point, line, surface and solids, Reverse engineering (RE), Introduction of CAD/RE software, Measuring devices, Computer aided design (CAD) model construction from point cloud, Data handling and reduction methods, applications of Reverse engineering (RE) in AM and case studies		
List of Text Books:			
1.	Chua C K, Leong K F, Chu S L, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific.		
2.	Noorani R, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons.		
3.	D. F. Rogers and J. A. Adams, Mathematical Elements for Computer Graphics, McGraw Hill, 2002.		
List of Reference Books:			
1.	Liou W L, Liou F W, Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press.		
2.	Kamrani A K, Nasr E A, Rapid Prototyping: Theory and practice, Springer		
3.	Gibson D W Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid		

	Prototyping to Direct Digital Manufacturing, Springer.
4.	Gibson, I., Software Solutions for Rapid Prototyping, Professional Engineering Publishing Limited, 2002
URLs:	
1.	https://nptel.ac.in/courses/112/104/112104265/
2.	http://www.nptelvideos.com/lecture.php?id=14981

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	Remarks
1.	Introduction to Additive Manufacturing: Inception of rapid prototyping, From prototyping to manufacturing,	
2.	Basic principle of additive manufacturing, Fundamental difference between additive manufacturing and subtractive manufacturing,	
3.	Generic process flow of Additive Manf. process, Steps of AM,	
4.	Key considerations in AM steps: Orientation,	
5.	Slicing and supported/supportless building,	
6.	Classification of Additive Manufacturing processes, Solid based AM processes,	
7.	Liquid-based AM processes,	
8.	Powder based AM processes	
9.	Additive Manufacturing Materials: Materials for solid-based processes: Polymers and copolymers,	
10.	Materials for solid-based processes: Metals, Composites, Nanocomposites	
11.	Materials for liquid-based processes: Photopolymer resins, Colloidal suspensions, Biocompatible materials,	
12.	Materials for powder-based processes: Polymeric powders,	
13.	Materials for powder-based processes: Metallic powders,Metal alloys	
14.	Selection criterion and influence of Process Parameters for additive manufacturing:	
15.	Machine parameters: Machine parameters for solid, liquid and powder-based processes,	
16.	Software parameters: layer thickness, Infill density, raster angle, build orientation, infill pattern.	
17.	Computer-aided-design for additive manufacturing: Understanding the basics of CAD concepts,	
18.	Data exchange formats,	
19.	AM file format, Tessellated models, STL File issues,	
20.	STL File manipulation and repair algorithms,	
21.	Design for additive manufacturing, AM data processing: Calculating and Sorting the intersection points,	
22.	Constructing a two-dimensional contour and generating support structure,	
23.	Fundamentals of adaptive slicing,	

24.	AM Weakness/difficulties: Volumetric Error, Shape deviation,	
25.	AM Weakness/difficulties: Surface roughness, Material shrinkage or swelling, Staircase effect, Warpage, etc.,	
26.	Reverse engineering in AM: Point cloud and point cloud to the object,	
27.	Software solutions for AM	
28.	Post processing and economical aspect of AM parts: Post-processing: polishing, abrasive flow, chemical treatment, etc,	
29.	Ease of post-processing: soluble and breakaway support, etc.,	
30.	Post-processing challenges,	
31.	Rapid Tooling (RT): advantages and constraints,	
32.	Methods of RT,	
33.	Methods of RT,	
34.	AM benchmarks parts and types,	
35.	Cost model,	
36.	Build time model,	
37.	Break-even analysis for product-AM technology fit	
38.	Additive manufacturing in Smart Manufacturing/Industry 4.0	
39.	Application of AM in: Prototyping,	
40.	Application of AM: rapid tooling,	
41.	Application of AM: direct part fabrication,	
42.	AM applications in aerospace industry,	

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY, BHOPAL - 462003

Name of Program	**M Tech in Automation and Robotics**	**Semester First**	**Year First**
NAME OF COURSE	CAD/CAM/CIM		
Course Code	AR24556		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	None		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	To impart knowledge about the integration of interdisciplinary fields of computer aided design, computer aided manufacturing, automatic identification system		
2.	Automatic storage & retrieval system as a whole. To design and analysis various Automatic		
3.	Material handling systems and to make the students aware about various techniques of data collection and its availability to automated subsystems.		
Description of Contents in brief:			
Unit 1.	Introduction and components of Computer aided design (CAD)/Computer aided manufacturing (CAM)/Computer Integrated Engineering (CIM) Computer aided engineering (CAE) systems; Basic concepts of graphics programming; Transformation matrix; Rendering; Graphical user interface;		
Unit 2.	Computer aided drafting systems; Geometric modeling systems – wireframe, surface and solid modeling systems; Nonmanifold systems; Assembly and web-based modeling systems; Representation and manipulation of conic sections Introduction to optimization; CAD/CAM/CIM integration; Numerical control – Concepts for manual and computer assisted part programming; Virtual engineering – components and applications;		
Unit 3.	Concept of CAD/CAM/CIM: Introduction to CAD/CAM/CIM, Types of Manufacturing, CAD/CAM/CIM hardware and software, Elements of CAD/CAM/CIM, Product development through CAD/CAM/CIM 2. CIM database: Introduction, Database requirements of CIM, Database, Database management, Database Models, Product Data Management (PDM), Advantage of PDM		
Unit 4.	Work Cell: Manufacturing cell, Group Technology, Cellular Manufacturing. 4. Flexible Manufacturing System: Introduction to FMS, Manufacturing integration model, flexible manufacturing strategy, Components of Flexible Manufacturing- Pallets and fixtures, machining centers, inspection equipment, material handling stations, storage system,		
Unit 5.	In-process storage, manually operated stations, allied operation centers, FMS system design. 5. Robots in CIM: integration of the industrial robot into CIM system, product design of automatic manufacture of robots, computer aided		

	inspection using robots.
Unit 6	Networking in CIM: Principles of networking, Network Techniques, Local area network (LAN), networking standards, Design Activities in a networked environment, networking in a manufacturing company, hardware elements of networking, Collaboration Engineering
List of Text Books:	
1.	Groover, M. P., Automation, Production systems and Computer Integrated Manufacturing, Pearson Education Asia (2009)
2.	P. Radhakrishnan, S. Subramanyan, and V. Raju, CAD/CAM/CIM , 2nd edition,New Age, 2000.
3.	Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison Wesley, 1999.
4.	Vajpayee, K.S., Principles of Computer Integrated Manufacturing, Prentice Hall (2006).
List of Reference Books:	
1.	Mark E. Coticchia, George W. Crawford, and Edward J. Preston, CAD/CAM/CAE systems: justification, implementation and productivity measurement, 2nd edition, New York, Marcel Dekker, 1993.
	Chris Macmahon and Jimmie Browne CADCAM: principles, practice and manufacturing management, 2nd edition, Addison Wesley, 1998.
	Mikell P. Groover and Emory W. Zimmers, CAD/CAM: Computer aided design manufacturing, Prentice Hall, 1996.
2.	4. Rao, P. N., Tewari, N. K. and Kundra, T. K., Computer Integrated Manufacturing, McGraw Hill (1998).
3.	Paul G. Ranky, The design and operation of FMS, I.F.S. Publi 1983 Harrington J, C.I.M. m Krieger 19792. Richard shover, An analysis of CAD/ CAM Application with introduction to C.I.M.
4.	Groover, M. P. and Zimmers, E. W., CAD/ CAM, Dorling Kingsley (2008).
5.	Scolz B. Reiter C.I.M interfaces Chapman & Hall 1992 David L. Goetsch, fundamental of CIM technology, Delmer Publication 1988
	Prentice hall inc.Engelwood Cliffs NJ David Bedworth et.al Computer integrated design and manufacturing McGraw hill 1991
URLs:	
Lecture Plan (about 40-50 Lectures):	

***Lecture No.**	**Topic**	**Remarks**
1.	Introduction and components of Computer aided design (CAD)/Computer aided manufacturing (CAM)/Computer Integrated Engineering (CIM) Computer aided engineering (CAE) systems;	Unit 1
2.		
3.		
4.	Basic concepts of graphics programming; Transformation matrix; Rendering; Graphical user interface;	
5.		

6.		
7.	Computer aided drafting systems; Geometric modeling systems – wireframe, surface and solid modeling systems; Nonmanifold systems; Assembly and web-based modeling systems; Representation and manipulation of conic sections Introduction to optimization; CAD/CAM/CIM integration; Numerical control – Concepts for manual and computer assisted part programming; Virtual engineering – components and applications;	Unit 2
8.		
9.		
10.		
11.		
12.		
13.		
14.	Concept of CAD/CAM/CIM: Introduction to CAD/CAM/CIM, Types of Manufacturing, CAD/CAM/CIM hardware and software, Elements of CAD/CAM/CIM, Product development through CAD/CAM/CIM CIM database: Introduction, Database requirements of CIM, Database, Database management, Database Models, Product Data Management (PDM), Advantage of PDM	Unit 3
15.		
16.		
17.		
18.		
19.		
20.		
21.	Work Cell: Manufacturing cell, Group Technology, Cellular Manufacturing. Flexible Manufacturing System: Introduction to FMS, Manufacturing integration model, flexible manufacturing strategy, Components of Flexible Manufacturing-Pallets and fixtures, machining centers, inspection equipment, material handling stations, storage system,	Unit 4
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.	In-process storage, manually operated stations, allied operation centers, FMS system design. 5. Robots in CIM: integration of the industrial robot into CIM system, product design of automatic manufacture of robots, computer aided inspection using robots.	Unit 5
30.		
31.		
32.		
33.		
34.		
35.		
36.	Networking in CIM: Principles of networking, Network Techniques, Local area network (LAN), networking standards, Design Activities in a networked environment, networking in a manufacturing company, hardware elements of networking, Collaboration Engineering	Unit 6
37.		
38.		
39.		
40.		
41.		
42.		

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	5	
2	Mid Semester Test	20	
3	Assignment if any	10	

4	Tutorial if any		
5	Quiz if any	5	
6	Seminar, Viva voce if ay	10	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

MAULANA AZAD NATIONAL INATITUTE OF TECHNOLOGY,
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Name of Program	**M. Tech in Automation & Robotics**	**Semester II**	**Year I**

Name of Course	Digital manufacturing
Course Code	AR24555
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Should have studied Mechanical, Production, Industrial Engineering,Mechatronics Engineering
2.	Knowledge of basic electronics and electrical engineering.

Course Outcomes: At the end of the course, the student shall be able to:	
1.	Students will understand the process of automation and the types
2.	Students will get exposure to the workstation, which refers to the location in the factory where some well-defined task or operation is accomplished by an automated machine
3.	Worker-and-machine combination or a worker using hand tools
4.	Understand the Automated Material handling equipment and types
5.	Student gets exposure to portable power tools.

Description of Contents in brief:	
Unit 1.	Introduction to manufacturing and web based manufacturing system-building blocks ofautomation, mechanization of parts handling, manufacturing systems, batch, mass, group, cellular systems, process planning and CAPP,
Unit 2.	Computer network for manufacturing- integration of design and manufacturing, design assignment and practice based on process planning and CAPP.
Unit 3.	MEMS overview and working, design and manufacturing of electromechanical systems, application of MEMS, concurrent engineering- teamwork;
Unit 4.	Interfacing of manufacturing and design, design for manufacturability; project management; design for assembly.
Unit 5.	Rapid manufacturing and prototyping technologies- generic process of product development, prototype tooling - process comparison, virtual prototyping, product architecture,
Unit 6	Design for manufacturing- industrial design and design for manufacturing, considerations, activity based costing; networking technologies.

List of Text Books:	
1.	Syan, Chanan S., and Unny Menon, eds. Concurrent engineering: concepts, implementation and practice. Springer Science & Business Media, 2012.
2.	Radhakrishnan, Pezhingattil, S. Subramanyan, and V. Raju. CAD/CAM/CIM. New Age International, 2008.
3.	Tai Ran Hsu, MEMS and Microsystems- Design and manufacturing, Tata McGraw Hill, 2001.

4.		
List of Reference Books:		
1.	Chandrakant D Patil and Chun Hsien and Chen, "Digital Manufacturing- The Industrialization of Art to Part 3D Additive Printing", 2022, Elsevier Publishers	
URLs:		
Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1.	Introduction to manufacturing and web based manufacturingsystem-building blocks of automation,	Unit 1
2.		
3.		
4.		
5.		
6.	mechanization of parts handling, manufacturing systems, batch, mass, group, cellular systems, process planning and CAPP,	Unit 2
7.		
8.		
9.		
10.		
11.	Computer network for manufacturing- integration of design and manufacturing, design assignment and practice based on processplanning and CAPP.	Unit 3
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.	MEMS overview and working, design and manufacturing of electromechanical systems, application of MEMS, concurrentengineering-teamwork;	Unit 4
20.		
21.		
22.		
23.		
24.		
25.		
26.	Interfacing of manufacturing and design, design for manufacturability; project management; design for assembly.	
27.		
28.		

29.	Rapid manufacturing and prototyping technologies- generic process of product development, prototype tooling - processcomparison, virtual prototyping, product architecture,	Unit 5
30.		
31.		
32.		
33.		
34.		
35.	Design for manufacturing- industrial design and design for manufacturing, considerations, activity based costing; Networking technologies.	Unit 6
36.		
37.		
38.		
39.		
40.		

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test		
2	Mid Semester Test		
3	Assignment if any		
4	Tutorial if any		
5	Quiz if any		
6	Seminar, Viva voce if ay		
7	End Semester Examination		
8	Experiments if any (for practical courses)		
8	Any other		

Name of Program	M Tech in Automation and Robotics	Semester I/II	Year I
Name of Course	Micro-manufacturing		
Course Code	AR24553		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Manufacturing Processes I, II		
2.	Unconventional Processes		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	Identify the challenges of micro/nano domain of manufacturing		
2.	Apply the knowledge of advance machining processes in micro domain		
3.	Understand the application of different machining processes for nano-finishing		
4.	Utilize the concept of forming and welding in micro-manufacturing scale		
5.	Determine the dimensional measurement related to micro manufacturing		
Description of Contents in brief:			

Unit 1.	Introduction and classification of micro-manufacturing, Challenges in Meso-, Micro-, and Nano-manufacturing. Traditional micro-machining:- Micro-turning, Micro-milling, Micro-grinding.
Unit 2.	Advanced Micro-machining processes:- Electric discharge micromachining, Electrochemical micromachining, Abrasive water jet micromachining, Ultra Sonic Micro Machining, Chemical and Electro Chemical Micro Machining
Unit 3.	Nano-finishing:- Abrasive Flow finishing ,Magnetic Abrasive Finishing, Magneto rheological finishing, Magnet Rheological abrasive flow finishing,chemo mechanical Polishing.
Unit 4.	MICRO FORMING AND WELDING - Micro extrusion, Micro and Nano structured surface development by Nano plastic forming and Roller Imprinting , Micro bending with LASER–LASER micro welding ,Electronbeam for micro welding
Unit 5.	RECENT TRENDS AND APPLICATIONS - Dimensional Metrology for Micro/Mesoscale Manufacturing, Generalized applications

List of Text Books:	
1.	Jain V. K., Micro Manufacturing Processes, CRC Press, Taylor & FrancisGroup, 2012
2.	Janocha H., Actuators – Basics and applications, Springer publishers – 2012
3.	Jain V.K., Introduction to Micro machining' Narosa Publishing House, 2011
4.	Bandyopadhyay. A.K., Nano Materials, New age international publishers,New Delhi, 2008.
List of Reference Books:	
1.	Bandyopadhyay. A.K., Nano Materials, New age international publishers,New Delhi, 2008, ISBN:8122422578
2.	Mark J. Jackson, Microfacbrication&Nanomanufacturing, CRC Press
URLs:	
1.	https://onlinecourses.nptel.ac.in/noc20 me15
2.	https://onlinecourses.nptel.ac.in/noc20 bt37

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction to the Course & Classification of Micromanufacturing Processes	Unit 1
2.		
3.	Challenges in Meso-, Micro-, and Nanomanufacturing	
4.	Microturning	
5.		
6.	Micromilling	
7.	Microgrinding	
8.		
9.	Electric discharge micromachining	Unit 2
10.		
11.	Electrochemical micromachining	
12.		
13.	Ultra Sonic Micro Machining	
14.		
15.	Magnetorheological and Allied Finishing Processes and their theoretical analysis	Unit 3
16.		

17.		
18.	Theoretical Analysis of Abrasive Flow Finishing	
19.		
20.		
21.	Chemo mechanical polishing	
22.		
23.	Introduction to microjoining	Unit 4
24.		
25.	Laser Microwelding	
26.		
27.	Electron Beams Microwelding and Applications	
28.		
29.	Introduction to Microforming	
30.		
31.	Microextrusion	
32.	Microbending with Laser	
33.	Microcasting	
34.		
35.		
36.	Dimensional Metrology for Micro/Mesoscale Manufacturing	Unit 5
37.		
38.		
39.		
40.	Generalised applications	
41.		

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	5	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	5	
6	Seminar, Viva voce if ay	10	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
9	Any other		

Name of Program	**M. Tech in Automation and Robotics**	**Semester First**	**Year First**
Name of Course	Micro-Electro Mechanical Systems		
Course Code	SM24551		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	None		
Course Outcomes: At the end of the course, the student shall be able to:			
1.	Understand the concept of semiconductors and solid mechanics to fabricate MEMS devices.		
2.	Learn the concept Micro systems.		
3.	Acquire the knowledge about various sensors and actuators.		
4.	Understand the applications of MEMS to disciplines beyond Electrical and Mechanical Engineering		
Description of Contents in brief:			
Unit 1.	Definition - MEMS materials. Laws of scaling. The multi-disciplinary nature of MEMS. Survey of materials central to micro engineering. Applications of MEMS in various industries. MEMS devices. Silicon as a MEMS material - mechanical properties of silicon. Mechanical components in MEMS.		
Unit 2.	Design concepts of mechanical components. Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication.		
Unit 3.	Scaling laws – Scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity-fluid mechanics and heat transfer.		
Unit 4.	Materials for MEMS and Microsystems. Fabrication technologies – Photolithography - Ion implantation – diffusion – oxidation – CVD - Physical Vapor Deposition – Etching.		
Unit 5.	Micro manufacturing - Bulk and surface micro machining - LIGA.		
Unit 6	Microsystems Design - Design considerations - Process design - Mechanical Design – CAD - Micro system packaging – Levels – Bonding – Interfaces - Assembly – Selection of Packaging Materials.		
List of Text Books:			
1.	Tai–Ran Hsu - ‘Mems & Microsystems Design and Manufacturing’ - John Wiley & Sons - 2008 - 2nd Edition		
2.	Chang Liu, ‘Foundations of MEMS’, Pearson Education Inc., 2012.		
3.	Stephen D Senturia, ‘Microsystem Design’, Springer Publication, 2000.		
4.	Tai Ran Hsu, “MEMS & Micro systems Design and Manufacture” Tata McGraw Hill, New Delhi, 2002.		
List of Reference Books:			
1.	Nadim Maluf,“ An Introduction to Micro Electro Mechanical System Design”, Artech House, 2000.		
2.	Mohamed Gad-el-Hak, editor, “ The MEMS Handbook”, CRC press Baco Raton, 2001.		

3.	Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4.	James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5.	Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 20

URLs:

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	Definition - MEMS materials.	Unit 1
2.	Laws of scaling. The multi-disciplinary nature of MEMS.	
3.	Survey of materials central to micro engineering.	
4.	Applications of MEMS in various industries. MEMS devices.	
5.	Silicon as a MEMS material - mechanical properties of silicon.	
6.	Mechanical components in MEMS.	
7.	Design concepts of mechanical components.	Unit 2
8.	Design concepts of mechanical components.	
9.	Working Principles of Microsystems.	
10.	Engineering Science for Microsystems design and Fabrication	
11.	Scaling laws	Unit 3
12.	Scaling in geometry,	
13.	Rigid body dynamics,	
14.	Electrostatic forces,	
15.	Electromagnetic forces,	
16.	Electricity-fluid mechanics.	
17.	Heat transfer	
18.	Materials for MEMS and Microsystems.	Unit 4
19.	Fabrication technologies	
20.	Photolithography	
21.	Ion implantation	
22.	Diffusion	
23.	Oxidation	
24.	CVD	
25.	Physical Vapor Deposition.	
26.	Etching	
27.	Micro manufacturing	Unit 5
28.	Bulk and surface micro machining	
29.	LIGA	
30.	Microsystems Design	Unit 6
31.	Design considerations	
32.	Process design	
33.	Mechanical Design – CAD	
34.	Micro system packaging – Levels	
35.	Bonding – Interfaces	

36.	Assembly – Selection of Packaging Materials.	

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	5	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	5	
6	Seminar, Viva voce if ay	10	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
8	Any other		

Name of Program	M. Tech in Automation and Robotics	Semester: I/II	Year: I
Name of Course	**RESEARCH METHODOLOGY**		
Course Code	**ME24524**		
Core / Elective / Other	**Elective**		
Prerequisite if any:			
1.	Graduation in a sciences		
2.	Graduation in a Technologies		
Course Outcomes:			
1.	Student will be able to apply knowledge Research Methodology different field and research		
2.	Student will be able to design always the research problem with different quantities and qualitative method of data collection tool and techniques		
3.	Student will be able to apply knowledge and Research Methodology to write research paper.		
4	Student will be able to identified the tools , software and techniques for data analysis and data validation.		
Description of Contents in Brief:			
Unit 1.	Research Meaning, Objectives, Motivation, Types of Research, Research Approach, Research and Scientific Methods, Identification of Problem, Significance of Defining Research Problem, Research Design, Research Ethics		
Unit 2.	Data Collection Methods, Primary Data, Secondary Data, Questionnaire Preparation, Case Study Method, Measurement Scales, Levels of measurement – Nominal, Ordinal, Interval, Ratio Measures of Central Tendency (Mean, medium, Mode), Measures of Dispersion (range, mean deviation, standard deviation), Graphical Representation of Data, Tabular Presentation of Data, Oral Presentation, Posters Presentation		
Unit 3.	Sampling Design, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample, Research Question, Normal Probability Curve, Standard Error, Confidence Intervals		
Unit 4.	Significance of correlation, Pearson's Product Moments Correlation. Regression and Multiple Regression equations, Hypothesis Formation, Hypothesis Testing, Testing the Significance of difference between means(z and 't' test), Analysis of Variance (ANOVA) -concept and applications, Chi Square Test steps, Type I and Type II errors,		
Unit 5.	Writing Research Report:, Interpretation, Significance of Report Writing, Steps In Writing Report, Types of Report, Technical Report Writing, Review of Related Literature, Structure of The Research Report, Precaution In Writing Report, Layout of Research Paper, Format and Style, Impact Factor of Journals, Suitability of Journal for Publication, Plagiarism, Citation, Reference Writing, IPR, Copyright, Patents,		

Unit 6	Introduction of Softwares used for Research like Matlab,SPSS, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism, Google Scholar, Research Gate,

List of Text Books:

1.	Research Methodology: Methods and Techniques, Kothari, C.R, New Age International Publishers, 2010 , 2010
2.	Fundamentals of Mathematical Statistics, Gupta, S. C. and Kapoor, V. K, Sultan Chand and Sons, New Delhi. , 2010
3.	Theory and Application of Statistics, Bruce E. Wampold and Difford J. Drew, McGraw-Hill International Editions. , 2010

List of Reference Books:

1.	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
2.	Business Research Methods – Alan Bryman& Emma Bell, Oxford University Press
3.	Business Research Methods, Naval Bajpai, Pearson

URLs:

2.	https://swayam.gov.in/nd1_noc19_ge21/preview
3.	https://www.youtube.com/watch?v=Yzfl3rtF0SM

Lecture Plan (about 40-50 Lectures):

Lecture No.	**Topic**	**Remarks**
1-2	Research Meaning,Objectives	
3-4	Motivation	
5-6	Types of Research, Research Approach,Research and Scientific Methods	
7-8	Identification of Problem, Significance of Defining Research Problem,	
9-10	Research Design, Research Ethics	
11-12	Data Collection Methods, Primary Data, Secondary Data,	
13	Questionnaire Preparation, Case Study Method,	
14-15	Measurement Scales, Levels of measurement – Nominal, Ordinal, Interval,	
16-17	Ratio Measures of Central Tendency (Mean, medium, Mode), Measures of Dispersion (range, mean deviation, standard deviation),	
18	Graphical Representation of Data, Tabular Presentation of Data,	
19-20	Oral Presentation, Posters Presentation	

21	Sampling Design, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling.	
22	Determining size of the sample, Research Question, Normal Probability Curve, Standard Error, Confidence Intervals	
23	Significance of correlation, Pearson's Product Moments Correlation.	
24	Regression and Multiple Regression equations,	
25-26	Hypothesis Formation, Hypothesis Testing, Testing the Significance of difference between means(z and 't' test),	
27-28	Analysis of Variance (ANOVA) -concept and applications, Chi Square Test steps, Type I and Type II errors,	
29-30	Writing Research Report:, Interpretation, Significance of Report Writing, Steps In Writing Report, Types of Report,	
31	Technical Report Writing, Review of Related Literature, Structure of The Research Report, Precaution In Writing Report,	
32-33	Layout of Research Paper, Format and Style, Impact Factor of Journals, Suitability of Journal for Publication, Plagiarism, Citation, Reference Writing, IPR, Copyright, Patents,	
34	Introduction of Softwares used for Research like Matlab, SPSS,	
35	Reference Management Software like Zotero/Mendeley,	
36	Software for paper formatting like LaTeX/MS Office,	
37	Software for detection of Plagiarism, Google Scholar, Research Gate, ,	

***Min 36 (for three credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Attendance/Assignment if any	10	
4	Tutorial if any		

5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
9	Any other		

Name of Program	M. Tech in Automation and Robotics	**Semester** - I	**Year** - I
Name of Course	Mechatronics		
Course Code	AR24554		
Core / Elective / Other	Elective		
Prerequisite if any:			
1.	Basics of Electrical and Electronics		
2.	Basic Mechanical Engineering		
Course Outcomes: At the end of the course, the student shall be able to:			
CO1	Understand the concept of Mechatronics systems		
CO2	Learn the concept of system integration.		
CO3	Acquire the knowledge about various pneumatics, hydraulics circuits, sensors and actuators.		
CO4	Understand the applications of Mechatronics as per industry standards.		
CO5	After undergoing this course, the students are in a position to understand how mechatronics systems can be designed and developed.		
Description of Contents in brief:			
Unit 1.	**Introduction:** Mechatronics, history, applications, and trends. Definition of Mechanical Systems, Systems and Design: Mechatronic approach, Integrated Product Design, Modeling, Analysis and Simulation, Man-Machine Interface.		
Unit 2.	**Fundamental of electronics for Mechatronics:** Data conversion devices, sensors, microsensors, transducers, electrical contacts, actuators, and switches, contactless input devices, signal processing devices; relays, contactors, timers, output devices. Microprocessors and controllers.		
Unit 3.	**Sensors and transducers:** Classification, Development in Transducer technology, Sensors for - Position & Speed Measurement, Stress & Strain measurement, Temperature Measurement, Vibration &Acceleration measurement, Opto- Electronics-Shaft encoders, Vision System, etc.		
Unit 4.	**Pneumatic and hydraulic actuators:** Pneumatics: Production, distribution and conditioning of compressed air. control valves, cylinders and rotary actuators for pneumatics and hydraulics. Hydraulics: Hydraulic elements, walls, actuators, and various other elements. Hydraulic powder packs, pumps. Design of hydraulic circuits.		
Unit 5.	**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. Basic closed-loop control: open-loop, on-off, PID control, Mechatronic systems integration.		
List of Text Books:			
1.	David G.Alciatore,MichaelB.Histand, Introduction to Mechatronics and Measurement Systems, 4e, McGraw Hill Education Ltd. 2014		
2.	Appukuttan K.K, Introduction to Mechatronics,Oxford Higher Education,, 2007 Press		
3.	Mechatronics: A Multidisciplinary Approach, William Bolton, Pearson Education		

4.	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, William Bolton, Prentice Hall.
5	Mechatronics System Design, Devdas Shetty & Richard A. Kolk, PWS Publishing Company (Thomson Learning Inc.)
List of Reference Books:	
1.	Satya Bir Singh,PrabhatRanjan,Alexander V. Vakhrushev,A. K. Haghi, Mechatronics Systems Design and Solid Materials
2.	Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son Ltd, 2002.
3.	Nadim Maluf, "An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
URLs:	
1.	NPTEL: Mechatronics & Manufacturing Automation Dr. Shrikrishna N. Joshi IIT Guwahati.

Lecture Plan (about 36-42 lectures)

Lecture No.	Topic	Remarks
1	Introduction: Mechatronics	
2	History, applications, and trends	
3	Definition of Mechanical Systems,	
4	Systems and Design: Mechatronic approach	
5	Integrated Product Design	
6	Modeling, Analysis and Simulation	
7	Man-Machine Interface.	
8	Fundamental of electronics for Mechatronics	
9	Data conversion devices	
10	Sensors, microsensors, transducers	
11	Electrical contacts, actuators, and switches	
12	Contactless input devices	
13	Signal processing devices	
14	Relays, contactors, timers, output devices. Microprocessors and controllers.	
15	Sensors and transducers: Classification	
16	Development in Transducer technology,	
17	Sensors for - Position & Speed Measurement	
18	Stress & Strain measurement	

19	Temperature Measurement,	
20	Vibration & Acceleration measurement	
21	Opto- Electronics-Shaft encoders,	
22	Vision System	
23	Introduction to pneumatic and hydraulic actuators	
24	Pneumatics: Production, distribution and conditioning of compressed air	
25	Control valves	
26	Cylinders and rotary actuators for pneumatics and hydraulics.	
27	Hydraulics: Hydraulic elements, walls, actuators, and various other elements.	
28	Hydraulic powder packs	
29	Hydraulic pumps.	
30	Design of hydraulic circuits.	
31	Introduction to microcontrollers	
32	Introduction to use of open-source hardware (Arduino & Raspberry Pi)	
33	Shields/modules for GPS, GPRS/GSM,	
34	Bluetooth, RFID, and Xbee, integration with wireless networks,	
35	Databases and web pages.	
36	Basic closed-loop control: open-loop, on-off	
37	PID control	
38	Mechatronic systems integration.	

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay		
7	End Semester Examination	50	
8	Experiments if any (for practical courses)		
9	Any other		

Name of the program: M.Tech in Automation and Robotics Semester –I/II Year - I

Name of the Course: Machine Learning
Course Code: AI24512
Core/Elective/Other: Elective
Prerequisite:

1. Basic programming skills (in Python)
2. Basics of probability and statistics

Course outcomes:

1. Ability to analyze mathematical models of Machine Learning
2. Ability to develop Machine Learning models for real life applications

Description of contents in brief:

Unit-I

Introduction to Machine Learning, Revision of probability theory, random variables and linear Algebra

Unit -II

Supervised Learning, Hypothesis space, Evaluation of Learning algorithms, Regression, Linear Regression, Gradient descent algorithm

Unit-III

Classification, Logistic Regression, Multi class classification, Regularization, Naive Bayes Classifier, Decision Tree, K nearest neighbor algorithm, Ensemble Learning, Bagging and Boosting, ADA boost

Unit-IV

Feature selection, Branch & Bound, sequential forward, sequential backward and bidirectional, Feature Extraction, Principal Component Analysis, Support Vector Machine, Hard and Soft margin SVMs

Unit-V

Unsupervised Learning, Clustering, K means, Fuzzy K means and hierarchical clustering, Neural Network, Evolutionary Algorithms. Machine Learning Applications

List of Books:

1. Pattern Recognition and Machine Learning, Bishop, C.M.Springer
2. An Introduction to Statistical Learning with Applications in Python, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibsherani, Jonathan Taylor, Springer Texts in Statistics

List of Reference Books:

1. Foundations of Machine Learning, Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, MIT Press
2. Machine Learning, Mitchell, T., McGraw Hill

URLs:

1. https://nptel.ac.in/courses/106/106/106106139/
2. https://nptel.ac.in/courses/106/105/106105152/
3. https://nptel.ac.in/courses/106/106/106106213/

Name of the program: M.Tech in Automation and Robotics Semester - I Year - I

Name of the Course: Digital Image Processing
Course Code: CS24505
Core/Elective/Other: Elective
Prerequisite: NIL
Course outcomes:

1. To articulate image enhancement and restoration techniques
2. To examine image compression techniques
3. To implement image segmentation techniques
4. To represent and recognize different images.

Description of contents in brief:

Unit-1: Digital Image Fundamentals: Digital image representation, fundamental steps, elements of visual perception, image sensing and acquisition, image sampling and quantization, relationship between pixels and colour models.

Unit-2: Image Enhancement, Morphological operations: Spatial domain, gray level transformations, histogram processing, basics of spatial filtering – smoothing and sharpening frequency domain filters

Unit-3: Image Segmentation: noise models, mean filters, order statistics, adaptive filters, band reject filters, optimum notch filtering, inverse filtering, wiener filtering, segmentation: edge detection, edge linking and boundary detection, region-based segmentation, morphological – erosion and dilation.

Unit-4: Image Compression: Compression fundamentals, image compression models, error free compression, Lossy compression, image compression standards.

Unit-5: Morphological operations in image processing, Feature analysis, Deep Learning and Machine Learning methods for image processing

List of Textbooks:

1. R.C.Gonzalez and R.E.Woods, Digital Image Processing, Prentice Hall, 3rd edition

List of Reference Books:

1. A.K. Jain, Fundamentals of Digital Image Processing, Prentice Hall.
2. S.Sridhar, Digital Image Processing, Oxford University Press

Name of the program: M.Tech in Automation and Robotics Semester I/II Year I

Name of the Course: VLSI Design
Course Code: VED24101
Core/Elective/Other: Elective
Prerequisite: NIL
Course outcomes:

1) To understand and prepare CMOS circuits
2) To design CMOS and prepare design layouts
3) To learn concepts of design of VLSI sub-systems

Description of contents in brief:

Unit-I

Introduction to MOS Technology - CMOS fabrication. Basic Electrical Properties - NMOS Inverter, Zpu/Zpd ratio, CMOS Inverter, Regions of Operation, BiCMOS Inverters.

Unit-II

Scaling - Scaling models and factors, scaling factors for various device parameters. MOS circuits and logic design: Switching logic, gate logic, Two/Three input NMOS, CMOS & BiCMOS, NAND & NOR gates,

Unit-III

CMOS logic structures - Pseudo nMOS, dynamic CMOS, clocked CMOS, CMOS domino, NP-domino logic, clocking strategies.

Unit-IV

Introduction of VLSI Design Methodologies - Design Description domains.

Unit-V

System design and methods - CMOS design methods, CMOS design options. Layout design rules and Stick diagrams. Introduction to ASIC Design

List of Textbooks:

1. Basic VLSI Design Douglas A. Pucknell & Kamran Eshraghian
2. Principles of CMOS VLSI design Neil H.E. Weste & Kamran Eshraghian

List of Reference Books:

1. CMOS VLSI Design Harris, Weste, Banerjee
2. CMOS Circuit design Jacob baker, Harry wili & David Boyce