V. E. S. Institute of Technology

T.E.

Automation and Robotics

(Semester – V & VI)

Autonomy Syllabus

Effective A. Y. 2024-25

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Semester V

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARC501	Power Electronics and Drives	20	20	60	2	25	--	125
ARC502	Industrial Processes & Control system	20	20	60	2	--	--	100
ARC503	Robot Kinematics & Dynamics	20	20	60	2	--	--	100
ARC504	Digital Signal Processing	20	20	60	2	25	--	125
ARDLO501X	Departmental Level optional course -I	20	20	60	2	--	--	100
ARL501	Power Electronics and Drives & Digital Signal Processing Lab	--	--	--	--	--	25	25
ARL502	Industrial processes & Control system Lab	--	--	--	--	25	25	50
ARL503	Robot Kinematics and Dynamics Lab	--	--	--	--	25	25	50
ARSBL501	Professional Communication & Ethics Lab	--	--	--	--	25	25	50
ARPBL501	Mini Project -III	--	--	--	--	25	25	50
Total		**100**	**100**	**300**	**--**	**150**	**125**	**775**

*Should be conducted batch wise

$ indicates workload of Learner (Not Faculty), Faculty Load: 1 hour per week per four groups

SBL- Skill based Laboratory

PBL -Project based Laboratory

Departmental Level optional course -I

Course Code	Departmental Level optional course -I
ARDLO5011	Data Structures and Algorithms
ARDLO5012	Optimization Techniques
ARDLO5013	Advanced Sensors
ARDLO5014	Analytical Instrumentation

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Semester V

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARC601	Robotic Control system (RCS)	20	20	60	2	--	--	100
ARC602	Unit Operations & Control	20	20	60	2	--	--	100
ARC603	Manufacturing using Computer Aided Design	20	20	60	2	--	--	100
ARC604	Machine Learning (ML)	20	20	60	2	--	--	100
ARDLO602X	Departmental Level optional course -II	20	20	60	2	--	--	100
ARL601	Robotic Control system Lab	--	--	--	--	25	25	50
ARL602	Unit Operations & Control lab	--	--	--	--	25	25	50
ARL603	Machine Learning Lab	--	--	--	--	25	25	50
ARLSBL601	CAD Modelling and 3D printing lab	--	--	--	--	25	25	50
ARPBL601	Mini Project-IV	--	--	--	--	25	25	50
Total		**100**	**100**	**300**	--	**150**	**125**	**750**

*Should be conducted batch wise
$ indicates workload of Learner (Not Faculty), Faculty Load: 1 hour per week per four groups

SBL- Skill based Laboratory

PBL -Project based Laboratory

Course Code	Departmental Level optional course -II
ARDLO6021	Database Management System (DBMS)
ARDLO6022	Industrial Robotics and Material handling systems
ARDLO6023	Metal Forming Technology
ARDLO6024	Biomedical Instrumentation

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

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Power Electronics and Drives

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC501	Power Electronics and Drives	20	20	60	2	25	--	125

Course Code:	Course Title	Credit
ARC501	Power Electronics and Drives	03

Prerequisite: Knowledge of Faraday's laws, Lenz's law. Semiconductor devices such as diodes and transistors and their characteristics.

Course Objectives:	
1	To equip the students with the knowledge of semiconductor devices & their applications
2	To learn the basic concepts and characteristics of Electrical motors and their respective drives.

Course Outcomes:
On successful completion, of course, learner/student will be able to:

1.	Compare basic characteristics and ratings of various power electronic devices
2.	Use controlled rectifiers with different loads for various applications.
3.	Implement Inverters & choppers with various techniques on different loads.
4.	Explain working of electric drives, various motors and study their characteristics
5.	Describe the working principle of DC drives.
6.	Illustrate working of AC drives.

Module	Detailed Content	No. of Hours
01	**Power Electronic Devices:** Basic operation of silicon controlled rectifier, Static characteristics, two transistor analogy, Dynamic characteristics, Firing circuits (R,RC, Ramp triggering using UJT), Commutation circuits, Protection circuit of SCR. Other devices of Thyristor family: Basic operation and characteristics of DIAC, TRIAC, GTO, UJT, PUT, SUS, SBS, SCS, LASCR, Power diodes, power BJTs, power MOSFETs, IGBTs, Safe Operation Area (SOA) for each device, Silicon Carbide (SiC) and GaN devices, Comparison of devices, selection of devices for various applications, Conduction and switching losses.	07
02	**Controlled Rectifiers:** Basic working principle and applications Single phase half wave rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load, freewheel diode, Rectification and inversion mode of single phase fully controlled rectifier, single phase dual converter, three phase semi converter and full converter with R load, Applications, calculation of output voltage, single phase PWM rectifier, Selection of converter circuit	07
03	**Inverter:** Classification based on source and power level, Series and Parallel Inverter, CSI and VSI Inverter, Comparison of VSI and CSI, PWM techniques Converters: Introduction, switching mode regulators – Buck, Boost, Buck-Boost, Cycloconverter. Choppers: Introduction, Basic chopper operation and its classification, Step up and Step-down Chopper, Jone's Chopper, Morgan's Chopper	08
04	**Basics of Electric Drives** Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Introduction	08

	of drive system, structure of drive system, Necessity of drive system, different types of drive system. Electrical Actuation System: Solenoids, D.C. motors and its characteristics, A.C. motors and its characteristics, Stepper motors, Servomotors (AC and DC), stepper motors, BLDC and its characteristics, Permanent Magnet Synchronous Motor (PMSM)	
05	**DC Drives** DC Drive Operation: Introduction to Four quadrant operation – Motoring, Plugging, Dynamic and Regenerative Braking. Control of DC Drive by phase-controlled converter: Speed control of DC drives, Single phase, semi/ full converter drive for separately excited dc motor. Control of DC Drive by Chopper regulators: Single quadrant, two – quadrant and four quadrant chopper fed dc separately excited motors, Continuous current operation, Output voltage and current waveforms, Speed torque expressions, speed torque characteristics.	**06**
06	**AC Drives:** Induction Motor Characteristics, Current Source Inverter fed Induction motor drive, Speed control methods: Stator voltage, Variable frequency, Rotor resistance, V/F control, PWM Control, Closed-loop control.	**03**
	Total	**39**

Text Books:	
1	P.S. Bhimbra, Power Electronics, Khanna publishers, 2004
2	M. H. Rashid, Handbook of Power Electronics, 2nd Edition, PHI, 2005
3	M.D. Singh, Khanchandani, Power Electronics, Tata Mcgraw-Hill Education
4	Nagrath I.J., Kothari D.P., Electrical Machines, second edition, Tata McGraw Hill, New Delhi.
5	B. L. Theraja, Fundamentals of Electrical & Electronics, S.Chand, Technical.
6	V.K. Mehta, Rohit Mehta, Principles of Electrical Engg. & Electronics, S.Chand
7	G. K. Dubey, Fundamentals of Electrical Drives,Narosa Publication.
8	S. K. Pillai, First Course on Electrical Drives, New Age International
References:	
1	Say M. G.,The performance & Design of Alternating Current Machines, 3rd edition, Oxford University

2	P.C. Sen, Power Electronics, Tata McGraw Hill, 2005
3	Mohan Undeland Robbins, Power Electronics- Converters application & Design, Wiley Eastern,1996
4	Dubey, Dorald, Thyristorised Power Controller, Wiley Eastern Ltd.1993
5	S.K. Bhattacharya, Industrial Electronics & Control, TATA McGraw Hill, 2007
6	Bose, Modern power Electronics & AC Drives Pearson Education Inc.2002
7	NPTEL Lectures.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teachers.The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Industrial Processes & Control system

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC502	Industrial Processes & Control system	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC502	Industrial Processes & Control system	20	20	60	2	--	--	100

Industrial Processes & Control system

Course Code:	Course Title	Credit
ARC502	Industrial Processes & Control system	03

Course Objectives:	
1	To explain the Industrial processes.
2	To make the students familiar with Fundamentals of Chemical Process control.
3	To familiarize the student with process control actions and controllers.
4	To provide an understanding of the various control schemes.
5	To familiarize the student with Discrete state process control.

6	To Explore students with Hazardous area classification.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Explain the significance of Industrial processes.
2.	Describe the Fundamentals of chemical process controls.
3.	Describe the basic and composite control actions and implementation of the same using controllers.
4.	Explain the working of different control schemes
5.	Explain significance of Discrete state process control.
6.	Understand and discuss Hazardous areas in the industry.

Module	**Detailed Content**	**No. of Hours**
01	**Overview of Industrial Processes** Introduction, components of Industrial processes, Types-Refining, chemical, Electrolysis, cutting, Metal working, Molding, separation, Distillation, Machining, Mining, Joining, Forming, Types of Manufacturing processes	**06**
02	**Fundamentals of Chemical Process Control** Process Control Terminology, Development of Typical Process control loops like Pressure, Temperature, flow & Level. Process characteristics, control system parameters, Dynamic elements in a control loop, Dead time processes and smith predictor compensator. Inverse response behavior of processes and compensator. Dynamic Behavior of first and second order systems. Interacting and non- interacting systems.	**06**
03	**Process control actions & controller** Need for control action, Types-Discontinuous, continuous (P, I, D) and composite control actions (PI, PD, and PID), Effects of control actions on control loop, selection criteria. **Controllers:** Need for controller, General features, specifications, classification working of Pneumatic and Electronic controllers. controller Tuning Methods-Process reaction curve, Ziegler-Nichol's method.	**08**

04	**Control schemes** Continuous process control: Feedback, Feed forward, cascade, Ratio, split range, selective control, inferential control, and selection Guidelines.	**07**
05	**Discrete state process control** Need for Discrete state process control systems, Relay Logic symbols, Development of Relay ladder Logic diagram and case study examples.	**06**
06	**Hazardous area classification** Area and material classification as per IEC and NEC standard, techniques used to reduce explosion hazards, intrinsic safety, and installation of intrinsically safe systems.	**06**
	Total	**39**

Text Books:	
1	Curtis D. Johnson, “Process Control Instrumentation Technology”, PHI /Pearson Education 2002.
2	George Stephanopoulos, “Chemical process control”, PHI-1999
3	Fieldbus and Networking in Process Automation: - Sunit Kumar Sen
4	Lawrence M Thompson, Industrial Data Communication, 2nd edition, 1997.
5	D. A. Neamen, Micro Electronic Circuit Analysis and Design, McGraw-Hill, New Delhi, 2010
6	Elements of workshop technology. Vol. 1 & II by S K Hajra Choudhury
7	Manufacturing Science by Ghosh and Malik
8	Production Technology by P C Sharma
References:	
1	Workshop technology Vol-. I, II & III by Chapman, Edward Arnold Education
2	Manufacturing technology – Serope Kalpak Jian & Steven R. Schmid Pearson.
3	Production Technology – R. K. Jain Khanna publications.
4	Manufacturing technology – HMT.
5	Bela G. Liptak, “Instrument Engineer‟s Handbook – Process Control”, Chilton Company, 1995
6	Andrew S. Tanenbaum, Computer Networks, 4th edition, PHI/Pearson Education,2002.
7	Behrouz A. Forouzan, Data Communications and Networking, 2nd update edition, Tata McGraw

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teachers.The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Robot Kinematics and Dynamic

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC503	Robot Kinematics and Dynamic	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC503	Robot Kinematics and Dynamics	20	20	60	2	--	--	100

Course Code	Course Title	Credit
ARC503	Robot Kinematics & Dynamics	03

Prerequisite: Basic knowledge of electronics

Course Objectives:	
1	Develop a comprehensive understanding of robot components and their respective functionalities.
2	Cultivate the ability to comprehend mapping and transformations between rotated and translated frames.
3	Develop a clear understanding of direct kinematic modeling and inverse kinematics for robots.

4	Disseminate the fundamental principles of dynamic modeling for robots.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Recognize the functionalities of different robot components and analyze the degree of freedom of a robot.
2.	Comprehend the mapping of translational and rotating frames, as well as vectors in those frames.
3.	Construct the direct kinematic model for a robot.
4.	Verify the solvability of the inverse kinematic model and successfully solve the inverse kinematic problem.
5.	Understand linear and angular differential motions of a manipulator.
6.	Model the dynamics of a robot using Lagrange-Euler and Newton's methods.

Module		**Content**	**Hrs.**
1		**INTRODUCTION TO ROBOTICS**	**04**
	1.1	Evolution of Robots and Robotic, Laws of Robotic, what is and What is not a robot.	
	1.2	Robot Anatomy: Links, Joints and Joint Notation Scheme, Degrees of Freedom (DOF), Required DOF in a Manipulator, Arm Configuration, Wrist Configuration, The End-Effector, Human Arm Characteristics.	
	1.3	Design and Control Issues, Manipulation and Control, Sensors and Vision, Programming Robots.	
2		**COORDINATE FRAMES, MAPPING AND TRANSFORMS**	**07**
	2.1	Coordinate Frames: Mapping, Mapping Between Rotated Frames, Mapping Between Translated Frames, Mapping Between Rotated and Translated Frames.	
	2.2	Description of Objects in Space	
	2.3	Transformation of Vectors: Rotation of Vectors, Translation of Vectors, Combined Rotation and Translation of Vectors, Composite Transformation.	
	2.4	Inverting a Homogeneous Transform	
	2.5	Fundamental Rotation Matrices: Principal Axes Rotation, Fixed Angle Representation, Euler Angle Representations, Equivalent Angle Axis Representation.	
3		**SYMBOLIC MODELING OF ROBOTS - DIRECT KINEMATIC MODEL**	**07**
	3.1	Mechanical Structure and Notations.	
	3.2	Description of Links and Joints.	
	3.3	Kinematic Modeling of the Manipulator.	

	3.4	Denavit-Hartenberg Notation.	
	3.5	Kinematic Relationship between Adjacent Links.	
	3.6	Manipulator Transformation Matrix	
4		**THE INVERSE KINEMATICS**	**08**
	4.1	Manipulator Workspace	
	4.2	Solvability of Inverse Kinematic Model	
	4.3	Existence of Solutions	
	4.4	Multiple Solutions	
	4.5	Solution Techniques	
	4.6	Closed Form Solution	
	4.7	Guidelines to Obtain Closed Form Solutions	
5		**MANIPULATOR DIFFERENTIAL MOTION AND STATICS**	**05**
	5.1	Linear and Angular Velocity of a Rigid Body: Linear Velocity, Angular Velocity, Linear Velocity due to Angular Motion, Combined Linear and Angular Motion.	
	5.2	Relationship Between Transformation Matrix and Angular Velocity	
	5.3	Mapping Velocity Vector	
	5.4	Velocity Propagation Along Links: Linear Velocity of a Link Angular Velocity of a Link	
	5.5	Manipulator Jacobian, Jacobian Computation, The Prismatic Joint Jacobian, The Rotary Joint Jacobian, Jacobian Inverse, Jacobian Singularities.	
	5.6	Static Analysis: Force and Moment Balance, The Jacobian in Statics	
	5.7	Linear and Angular Velocity of a Rigid Body: Linear Velocity, Angular Velocity, Linear Velocity due to Angular Motion, Combined Linear and Angular Motion.	
6		**DYNAMIC MODELING**	**08**
	6.1	Lagrangian Mechanics, Two Degree of Freedom Manipulator- Dynamic Model	
	6.2	Lagrange-Euler Formulation: Velocity of a Point on the Manipulator, The Inertia Tensor, The Kinetic Energy, The Potential Energy, Equations of Motion, The LE Dynamic Model Algorithm.	
	6.3	Newton-Euler Formulation: Newton's Equation, Euler's Equation, Kinematics of Links, Link Acceleration, Recursive Newton-Euler Formulation, Forward Iteration, Backward Iteration.	
	6.4	Comparison of Lagrange-Euler and Newton-Euler Formulations	
	6.5	Inverse Dynamics	
	Total		**39**

Text Books:	
1	Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
2	Lynch, Kevin M., and Frank C. Park. Modern Robotics: Mechanics, Planning, and Control 1st ed. Cambridge University Press, 2017.
3	John J. Craig, “Introduction to Robotics”, 3rd Edition, Addison Wesley, ISE 2008.
References:	
1	S K Saha, Introduction to Robotics, Tata McGraw-Hill, Second Edition, 2017.
2	Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2017.
3	Arthor Critchlow, “Introduction to Robotics”, 1st edition, Macmillan, 2009.
4	Mohsen Shahinpoor, “A Robot Engineering Text book”, 1st edition, Harper and Row, 2004.
5	Deb S.R., “Robotics Technology and Flexible Automation”, 2nd edition, Tata McGraw - Hill Publisher Robotics: Control and Programming.
6	J. Srinivas, R. V. Dukkipati, K., “Robotics: Control and Programming”, Narosa Publishing House, 2009.
7	Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001 8. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor - Based integration, Academic Press, 1999.
8	Hartenberg and Denavit, "Kinematics and Synthesis of Linkages", McGraw Hill Book Co.
9	J. E. Shigley and J.J.Uicker Jr., Theory of Machines and Mechanism, McGraw Hill [ISBN019515598X]
10	G K Grover’, “Mechanical Vibration”, Nemchand and brothers. [ISBN8185240752]
11	S. S. Ratan, Theory of Machines, Tata McGraw Hill [ISBN0070591202]
12	Yoram Koren, "Robotics for Engineers", McGraw Hill Book Co.
13	Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology-Programming and Applications", McGraw Hill Book Co

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8.	Multiple Choice Questions (Quiz)	5 marks

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Program Structure for Third Year Automation and

Robotics Scheme for Autonomous Program

(With Effect from 2024-2025)

Digital Signal Processing

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC504	Digital Signal Processing	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC504	Digital Signal Processing	20	20	60	2	25	--	125

Course Code:	Course Title	Credit
ARC504	**Digital Signal Processing**	**03**

Course Objectives:	
1	To make conversant with the fundamentals of digital signal processing
2	To familiarize with the transforms used in Digital Signal Processing
3	To familiarize with the design techniques and performance analysis of digital filters
4	To introduce digital signal processors and applications

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Apply the concept of DT Signal and DT Systems.
2.	Classify and analyze discrete time signals and systems.
3.	Implement Digital Signal Transform techniques DTFT, DFT and FFT.
4.	Design IIR digital filters to meet arbitrary specifications and Develop algorithms for implementation.
5.	Design FIR digital filters to meet arbitrary specifications and Develop algorithms for implementation.
6.	Use signal processing techniques and digital signal processors in various applications.

Module	**Detailed Content**	**No. of Hours**
01	**Discrete-Time Signal and Discrete-Time Systems** Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals, Signal Manipulations-shifting, reversal, scaling, addition, multiplication. Classification of Discrete-Time Signals, Classification of Discrete- Systems, LTI system, Impulse Response. Linear Convolution, Circular Convolution- Emphasis on graphical method, linear convolution using Circular Convolution. Software simulation - Impulse Response, Step Response, convolution, Correlation.	**08**
02	**Frequency Domain Analysis using DTFT and Z Transform** Introduction to DTFT. Properties of DTFT. Z transform - definition, properties of unilateral and bilateral Z Transform, Z transform of standard signals, ROC, poles and zeros of transfer function, Inverse Z transform. Analysis and characterization of LTI system using Z transform, impulse and step response, causality, stability, stability of causal system	**07**

03	**Discrete Fourier Transform and Fast Fourier Transform** DFT, Relation between DFT and DTFT, IDFT. Properties of DFT, circular convolution of sequences using DFT. Fast Fourier transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, inverse FFT.	**06**
04	**IIR Digital Filters** Comparison of IIR and FIR filters, Types of IIR Filters, Analog filter approximations Butterworth, Chebyshev I and II. Mapping of S-plane to Z-plane, impulse invariance method, bilinear transformation method, Design of IIR digital filters from analog filters with examples, Software simulation – Design of IIR Filters. Analog and digital frequency transformations.	**09**
05	**FIR Digital Filters** Characteristics of FIR digital filters, Minimum Phase, Maximum Phase, Mixed Phase and Linear Phase Filters Frequency response, location of the zero of linear phase FIR filters. Design of FIR filters using window techniques -Rectangular, Hamming, Hanning, Blackman, Bartlett, Software simulation – Design of FIR Filters.	**05**
06	**DSP Processors and Applications** General purpose digital signal processors, DSP processor architecture, Selecting digital signal processors, Special purpose DSP hardware. Applications of DSP: Radar Signal Processing and Speech Processing.	**04**
	Total	**39**

Text Books:	
1	Emmanuel C. Ifeachor, Barrie W. Jervis, “Digital Signal Processing”, A Practical Approach by, Pearson Education – Second edition
2	Tarun Kumar Rawat, “Digital Signal Processing”, Oxford University Press, 2015
3	S Salivahanan, A Vallavaraj, C Gnanapriya. “Digital Signal Processing” – TMH, 2007
References:	
1	Proakis J., Manolakis D., Digital Signal Processing, 4th Edition, Pearson Education
2	Sanjit K. Mitra, “Digital Signal Processing – A Computer Based Approach”, edition 4e McGraw Hill Education (India) Private Limited.

Internal Assessment:

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Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

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8.	Multiple Choice Questions (Quiz)	5 marks

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Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Data Structures and Algorithms

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO5011	Data Structures and Algorithms	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO5011	Data Structures and Algorithms	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO5011	Data Structures and Algorithms	03

Course Objectives:	
1	To improve the logical ability
2	To teach efficient storage mechanisms of data for easy access.
3	To design and implementation of various basic and advanced data structures and algorithm analysis.
4	To introduce various techniques for representation and analysis of the data in the real world.

5	To develop applications using data structures and algorithms and analysis.
6	To teach the concept of protection and management of data.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Choose appropriate data structure as applied to specified problem definition and analyze the algorithm.
2.	Handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures and algorithm analysis.
3.	Apply concepts learned in various domains like DBMS, compiler construction etc.
4.	Use linear and non-linear data structures like stacks, queues, linked list etc
5.	Assess different sorting algorithms and select depending on application
6.	Apply graph algorithms to solve real-world challenges

Module	**Detailed Content**	**No. of Hours**
01	**Introduction:** Introduction, Mathematics Review, Exponents, Logarithms, Series, Modular Arithmetic, The P Word, A Brief Introduction to Recursion, Recursion and Induction. Algorithm Analysis: Mathematical Background, Model, what to Analyze, Running Time Calculations, General Rules, Solutions for the Maximum Subsequence Sum Problem, Logarithms in the Running Time, Euclid's Algorithm, Exponentiation, Checking Your Analysis, A Grain of Salt.	**06**
02	**Stacks, Queues and List:** Stacks, Queues, Linked Lists, Double-ended Queues. Abstract Data Type (ADT), The List ADT, Simple Array Implementation of Lists, Linked Lists, Programming Details, Common Errors, Doubly Linked Lists, Circularly Linked Lists, Examples, Cursor Implementation of Linked Lists, The Stack ADT, Implementation of Stacks, Applications, The Queue ADT, Array Implementation of Queues, Applications of Queues.	**09**
03	**Trees and Search Trees:** Tree, Implementation of Trees, Tree Traversals with an Application, Binary Trees, Expression Trees, the Search Tree ADT-Binary Search Trees, AVL Trees, Single Rotation, Double Rotation, Red-Black Trees, External searching in B-Trees, Tree Traversals, B-Trees	**09**
04	**Priority queues:** The priority queues Abstract data Type, Implementing a Priority queues with a List, Heaps, Adaptable priority queues.	**04**

05	**Sorting Sets, and Selection:** Insertion Sort, Shell sort, Heapsort, Quicksort, Bucket Sort, Merge Sort and radix Sort, and A Lower Bound on comparison-based Sorting and radix Sort, the complexity of some sorting algorithms, comparison of Sorting Algorithms, The Set ADT and union / file Structures	**04**
06	**Graphs:** The graph Abstract Data Type, Data Structures for Graphs, Graph Traversals, Directed Graphs, Weighted Graphs, Shortest Paths, and Minimum spanning Trees. Applications of DFS and BSF, Shortest-Path Algorithms, Dijkstra's Algorithm, Graphs with Negative Edge Costs, Acyclic Graphs, Network Flow Problems, Minimum Spanning Tree	**07**
	Total	**39**

Text Books:	
1	Mark Allien Weiss, "Data Structure and Algorithm Analysis in C", Person.
2	Micheal Goodrict, Roberto Tamassia," Data Structure and Algorithm in C++", Wiley India
3	Data Structures: A Pseudocode Approach with C, Richard F. Gilberg & Behrouz A. Forouzan, second edition, CENGAGE Learning.
4	Data Structures Using C & C++, Rajesh K. Shukla, Wiley- India
5	Data Structures using C, Reema Thareja, Oxford University press.
6	Introduction to Data Structure and its Applications Jean-Paul Tremblay, P. G. Sorenson
References:	
1	Ellis Horowitz, Sarataj Sahni, S. Rajasekaran," Fundamentals of computer algorithm", University Press.
2	Mark Allen Weiss, "Data Structure & Algorithm Analysis in C++", 3rd Edition, Pearson Education.
3	Data Structures Using C, ISRD Group, Second Edition, Tata McGraw-Hill.
4	Data Structure Using C, Balagurusamy.
5	C & Data Structures, Prof. P.S. Deshpande, Prof. O.G. Kakde, Dreamtech press.
6	Data Structures, Adapted by: GAV PAI, Schaum's Outlines.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and

Robotics Scheme for Autonomous Program

(With Effect from 2024-2025)

Optimization Techniques

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO5012	Optimization Techniques	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO5012	Optimization Techniques	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO5012	Optimization Techniques	03

Course Objectives:	
1	To Understand the need and origin of the optimization methods.
2	To understand various linear, nonlinear and other optimization techniques.
3	To understand various multi criterion and multi-objective decision making methods.
4	To understand recent tools in optimization

	Course Outcomes:
On successful completion, of course, learner/student will be able to:	
1.	Identify the types of optimization problems and apply the calculus method to single variable problems.
2.	Formulate the problem as a Linear Programming problem and analyze the sensitivity of a decision variable.
3.	Apply various linear and non-linear techniques for problem solving in various domains.
4.	Apply multi-objective decision making methods for problems in the manufacturing environment and other domains.
5.	Apply multi criterion decision making methods for problem in the manufacturing environment and other domains.
6.	Apply Design of Experiments method for Optimization.

Module	Detailed Content	No. of Hours
01	**Basic Concepts:** Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems. Classical Optimization Techniques: Single variable optimization.	06
02	**Linear Programming Problem:** Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP Transportation and Assignment Models.	07
03	**Integer Programming Model:** Gomory's cutting plane method, Branch & Bound Technique. **Non-L.P. Model:** Lagrangian method & Kuhn tucker Method, Newton's method. **Discrete Event Simulation:** Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	07
04	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness **(Only concepts)**	06

05	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization, Simple Additive Weighting (SAW) Method Weighted Product Method (WPM), Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method, TOPSIS Method PROMETHEE	**06**
06	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2*k* design, The general 2*k-p* fractional factorial design Application of related software (Minitab, Design Expert or MATLAB)	**07**
	Total	**39**

Text Books /References:	
1	S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2	Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press.
3	Pablo Pedregal, "Introduction to Optimization", Springer.
4	L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5	Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6	R V Rao, “Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making” (Springer Publication).
7	Ritter, H., Martinetz, T., Schulten, K., Addison,“Neural Computation and Self-Organizing Maps”-Wesley Publishing Company.
8	Douglas C.Montgomery,“Design and analysis of experiments”(John Wiley & Sons Inc.)
9	Saravanan R,“Manufacturing Optimization through Intelligent Techniques”, Taylor & Francis (CRC Press)- 2006.

Internal Assessment:
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Advanced Sensors

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO5013	Advanced Sensors	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO5013	Advanced Sensors	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO5013	Advanced Sensors	03

Course Objectives:	
1	To expose the students to the concepts of smart sensors and microsensors.
2	To provide sufficient knowledge about the sensor fabrication.
3	To create awareness about the various application fields of smart sensors.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Explain the various principles employed in transducers.
2.	Examine the methods of fabricating a sensor.
3.	Apply knowledge in designing smart sensors.
4.	Discuss the techniques of fabrication and application of MEMS.
5.	Describe the various applications of smart sensors.
6.	Discuss advanced sensing technology.

Module	**Detailed Content**	**No. of Hours**
01	**Review of Fundamental of Sensors:** Principle of physical and chemical transduction, sensor classification, characterization of mechanical, electrical, optical, thermal, magnetic, chemical and biological sensors, their calibration and determination of characteristics	**07**
02	**Sensor Fabrication**: Design considerations and selection criterion as per standards, Sensor fabrication techniques, process details and latest trends in sensor fabrication. Thick film sensing and system design.	**06**
03	**Smart Sensors:** Smart sensor basics, signal conditioning and A/D conversion for sensors, examples of available ICs (DHT, Smart analog IC 500, ADXL345) and their applications.	**07**
04	**Micro Sensors:** Introduction, Intrinsic characteristics of MEMS, common fabrication techniques, application of MEMS in sensing systems including pressure sensors, accelerometers, gyroscopes and strain gauges.	**06**
05	**Advanced Sensor Applications:** Temperature & Humidity measurement using DHT Sensor in environment monitoring, Acceleration measurement using ADXL345 for automotive industry, MEMS Temperature sensors for automotive applications, MEMS chemical sensors for survey meters, MEMS pressure sensors for medical applications	**07**

06	**Advanced Sensing Technology:** Sensors, instruments and measurement techniques for emerging application areas such as environmental measurement like DO (dissolved oxygen), BOD (biological oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), Cox (carbon dioxides), NOx (nitrogen oxide), for navigation and inertial measurements, for agricultural measurements such as soil moisture, wind speed, leaf wetness duration, sensors for food processing like smell or odour, taste.	**06**
	Total	**39**

Text Books:	
1	Chang Liu, Foundations of MEMS, Pearson Education Inc.,2012.
2	Stephen D Senturia, Microsystem Design, Springer Publication,2000.
3	Tai Ran Hsu, MEMS & Microsystems Design and Manufacture, Tata Mc Graw Hill, New Delhi,2002.
4	Jacob Fraden, Handbook of Modern Sensors, 5th Edition, Springer.
5	S. M. Sze, Semiconductor Sensors, Wiley
6	M J Usher, Sensors and Transducers, MacMillan,1985.
References:	
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, Microsensors 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 to MEMS, Fabrication and Application, Springer,2010

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Analytical Instrumentation

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO5014	Analytical Instrumentation	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO5014	Analytical Instrumentation	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO5014	Analytical Instrumentation	03

Course Objectives:	
1	Introduce the basic concept of qualitative and quantitative analysis of a given sample.
2	Study various spectroscopic techniques and its instrumentation.
3	Study the concept of separation science and its applications.
4	Study the concept of radiochemical analysis along with industrial analyzers.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Define and explain various fundamentals of spectroscopy, qualitative and quantitative analysis.
2.	Discuss the terms, principle, instrumentation, operation and applications of Molecular spectroscopic techniques.
3.	Differentiate between principle, instrumentation and operation of Atomic absorption and emission Spectroscopy.
4.	Explain the various Separation techniques and its instrumentation.
5.	Describe the principle and working of various Radiation detectors.
6.	Discuss the principle and working of various Gas analyzers.

Module	**Detailed Content**	**No. of Hours**
01	**Introduction:** Introduction to analytical Instrumentation. Fundamentals of Spectroscopy: Nature of Electromagnetic Radiation, Electromagnetic spectrum, Beer Lambert 's Law statement and derivation. Deviations from Beer 's law. Numerical on EMR and laws of photometry. Interaction of radiation with matter. Instrumentation of spectroscopic analytical systems – Radiation sources, Wavelength selectors, Detectors, signal processors and readout modules. Scintillation detector	**9**
02	**Molecular Spectroscopy:** Molecular Energy levels, correlation of energy levels with transitions. **Electronic transitions and Vibrational transitions –** Introduction to UV-VIS molecular spectroscopy – basics of single beam, double beam spectrophotometer and filter photometer, its instrumentation and applications. Basic principle, components and instrumentation of Fluorimeters, Phosphorimeters and Raman spectrometers.	**9**
03	**Molecular Spectroscopy – Nuclear/Rotational transitions** – Nuclear Magnetic Resonance (NMR) spectroscopy, basic principle and numerical problems based on NMR principle, instrumentation and constructional details of NMR Spectrometer. **Electron Spin Resonance (ESR) Spectroscopy** – Basic principle and construction of ESR spectrometer.	**4**

04	**Atomic Spectroscopy:** Atomic Energy levels, atomic absorption spectrometers-components, working and absorption spectra. Atomic Emission spectrometers – components, working and emission spectra, comparison between AAS and AES.	**3**
05	**Separation Science:** **Chromatography:** Fundamentals of chromatographic Separations, Classification, Gas chromatographic system with components, factors affecting separation, applications. Analysis of Gas Chromatogram. HPLC – Its principle and instrumentation. **Mass Spectrometers:** Basic principle, components and types of mass spectrometers, sample handling techniques for liquids and solids, resolution and numerical problems based on resolution.	**9**
06	**Industrial Gas Analyzers:** Oxygen Analyzer, Combustion Gas Analyzers (COX, NOX, SOX, hydrocarbons), Gas density analyzer - Pollution Control of Gas emission - Limits of emission.	**5**
	Total	**39**

Text Books:	
1	Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS Publishers & Distributors, New Delhi, 7th Edition.
2	Khandpur R. S., Handbook of Analytical Instruments, Tata McGraw–Hill Publications, 3rd Edition.
References:	
1	Skoog, Holler, Niemen, Thomson Principles of Instrumental Analysis, Books-Cole Publications, 5th Edition.
2	Ewing Galen W., Instrumental Methods of Chemical Analysis, McGraw-Hill Book Company, 5th Edition.
3	Braun Robert D., Introduction to Instrumental Analysis, McGraw-Hill Book Company.
4	Sherman R.E., Analytical Instrumentation, ISA Publication.
5	B. R. Bairi, Balvinder Singh, N.C.Rathod, P.V.Narurkar, Handbook nuclear medical Instruments, McGraw Hill Book Company

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Power Electronics and Drives & Digital Signal Processing Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL501	Power Electronics and Drives & Digital Signal Processing Lab	–	2	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL501	Power Electronics and Drives & Digital Signal Processing Lab	--	--	--	--		25	25

Lab Code	Lab Name	Credit
ARL501	Power Electronics and Drives & Digital Signal Processing Lab	01

Prerequisite:	
Lab Objectives:	
1	To equip the students with the knowledge of semiconductor devices & their applications.
2	To learn the basic concept and characteristics of Electrical motors and their drives.
3	Study simulation software platform for digital signal processing and Plot different type of signals.
4	To understand the concept of linear, circular convolution, correlation and simulate it by computer software.
5.	To understand Fourier transform and its algorithms such as FFT and IFFT and simulate it.
6.	To design and implement filters for both FIR and IIR using computer simulation.
Lab Outcomes:	
1	Compare basic characteristics and ratings of power electronic devices.
2	Use controlled rectifiers, Inverters & choppers with different loads.
3	Illustrate working of AC & DC drives.
4	Demonstrate convolution and correlation concepts using simulation software.
5.	Analyze frequency response of LTI systems using DTFT. Perform Discrete Fourier Transform of signals.
6.	Design and implement FIR and IIR filters using computer simulation software platforms.

Suggested Experiments: Students are required to complete at least 10 experiments.		
Sr. No.	**Name of the Experiment**	**CO Mapping**
1	Plot V-I characteristics of SCR.	**CO1**
2	Plot V-I characteristics of DIAC/TRIAC.	**CO1**
3	Plot V-I characteristics of IGBT	**CO1**
4	Half wave & full wave-controlled rectifier.	**CO2**
5	SCR Based Inverter	**CO2**

6	Stepper Motor Control	**CO3**
7	BLDC Motor Control	**CO3**
8	DC Motor Control	**CO3**
9	Write a Program to implement Linear Convolution of the two given sequences.	**CO4**
10	Write a Program to obtain the auto-correlation and Cross-correlations of the given sequences.	**CO4**
11	Write a Program to obtain the circular convolution of the two given sequences.	**CO4**
12	Write a Program to obtain the linear convolution using circular convolution of two given sequences.	**CO4**
13	Write a Program to find the DFT of the given sequences. Plot its magnitude and phase plot. Also find its IDFT to obtain the original sequence.	**CO5**
14	Write a Program to obtain the DFT of the given sequences using the DIT-FFT algorithm and plot its magnitude and phase spectrum.	**CO5**
15	Write a Program to design low-pass and high-pass FIR filters using window functions.	**CO6**
16	Write a Program to design a digital IIR low-pass filter using Butterworth/Chebyshev approximations.	**CO6**

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Industrial Processes & Control system Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL502	Industrial Processes & Control system Lab	--	2	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL502	Industrial Processes & Control system Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARL502	Industrial Processes & Control system Lab	

Prerequisite:	
Lab Objectives:	
1	To study the need Basic Manufacturing Processes.
2	To study various types cutting and joining operation
3	To make the students familiar with various industrial processes.
4	To give them an overview of hazardous materials, areas and their classification.
5.	To study advanced Technologies in manufacturing processes
Lab Outcomes:	
1	Understand various safety instructions, measuring Instruments and working instructions of Machine shop.
2	Illustrate working principles and applications Lathe Machine, Drilling Machine, Milling Machine Processes.
3	Explain the welding operation and use the various types of Forging tools .
4	Explain heating process working of heat exchanger, evaporators and boilers.
5.	Elaborate heat and mass transfer process and working of distillation, dryers and reactors.
6.	Classify hazardous areas in the industry.

Suggested Experiments: Students are required to complete at least 10 experiments.		
Sr. No.	**Name of the Experiment**	**CO Mapping**
1	Study of Safety & Working instruction in a Machine shop.	**CO1**
2	Study of Measuring Instruments and cutting tools	**CO1**
3	Report on machining processes performed on lathe machines.	**CO2**
4	One Job consisting of Plain and Taper Turning operations performed on mild steel, cylindrical components on lathe Machine.	**CO2**
5	Report on machining processes performed on Drilling Machine	**CO2**
6	Fabrication of one simple job on Milling Machine	**CO2**

7	Preparation of lap joint of GI sheet using Spot compressive Welding.	**CO3**
8	Report on forging tools.	**CO3**
9	Demonstrate the operation of Heat exchanger, evaporator, boilers.	**CO4**
10	Assignments based on Heat transfer Processes and Equipment.	**CO4**
11	Demonstrate the operation of distillation column, dryer, reactors.	**CO5**
12	Assignments based on Heat and Mass transfer Processes and Equipment.	**CO5**
13	Develop charts on hazardous area classification.	**CO6**
14	Assignments based on Hazardous Area classification.	**CO6**

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Robot Kinematics and Dynamics Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL503	Robot Kinematics and Dynamics Lab	--	2	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL503	Robot Kinematics and Dynamics Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARL503	Robot Kinematics and Dynamics Lab	01

Prerequisite:	
Lab Objectives:	
1	To introduce types of mechanisms for various robotic applications.
2	To get knowledge about basic Geometrical and Algebraic approach to solve forward kinematics of serial manipulator
3	To get knowledge about advanced forward kinematics of serial manipulators.
4	To get knowledge about inverse kinematics of various serial manipulators.
5.	To get knowledge about design of robot manipulators based on dynamic analysis
Lab Outcomes:	
1	Select the type of mechanism for the robotic applications
2	Explain and analyze the Coordinate frames, transformations and Forward kinematics of robots
3	Explain & Analyze the Inverse kinematics of robots
4	Design of robot manipulators based on dynamic analysis
5.	Measure the mass moment of inertia and balancing of masses of robotic links
6.	Demonstrate understanding of fundamentals of industrial automation

Suggested Experiments: Students are required to complete at least 10 experiments.		
Sr. No.	**Name of the Experiment**	**CO Mapping**
1	Computer program for analysis and synthesis of any mechanism and test it	**CO1**
2	Determination of holding torque in epicyclic gear train.	**CO1**
3	Design of cams and followers	**CO1**
4	Forward kinematics of robots using roboanalyzer	**CO2**
5	Understanding coordinate frames and transformations using roboanalyzer	**CO2**
6	Inverse kinematics of robots using roboanalyzer	**CO3**

7	Case Study: Kinematics of MTAB Mini Robot	**CO3**
8	Inverse and Forward dynamics of robots using robo-analyzer	**CO4**
9	Determination of mass moment of inertia and radius of gyration of robotic links.	**CO5**
10	Experiment on balancing of mass	**CO5**
11	Assignment / Case study on Industrial Automation	**CO6**

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Professional Communication and Ethics – II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARSBL501	Professional Communication and Ethics - II	--	2 *+2	--	2	--	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARSBL501	Professional Communication and Ethics - II	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARSBL501	Professional Communication and Ethics - II	02

Prerequisite:	
Lab Objectives:	
1	Discern and develop an effective style of writing important technical/business documents.
2	Investigate possible resources and plan a successful job campaign.
3	Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4	Develop creative and impactful presentation skills.
5.	Analyze personal traits, interests, values, aptitudes and skills.
6.	Understand the importance of integrity and develop a personal code of ethics.
Lab Outcomes:	
1	Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2	Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3	Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4	Deliver persuasive and professional presentations.
5.	Develop creative thinking and interpersonal skills required for effective professional communication.
6.	Apply codes of ethical conduct, personal integrity and norms of organizational behavior.

Suggested Experiments: Students are required to complete at least 10 experiments.		
MODULE	**DETAILS**	**HOURS**
MODULE 1 - ADVANCED TECHNICAL WRITING: PROJECT/PROBLEM BASED LEARNING (PBL)		
1.1. Purpose and Classification of Reports	**Classification on the basis of:** ● Subject Matter (Technology, Accounting, Finance, Marketing, etc.) ● Time Interval (Periodic, One-time, Special) ● Function (Informational, Analytical, etc.) ● Physical Factors (Memorandum, Letter, Short & Long)	
1.2. Parts of a Long Formal Report	● Prefatory Parts (Front Matter) ● Report Proper (Main Body) ● Appended Parts (Back Matter)	
1.3. Language and Style of Reports	● Tense, Person & Voice of Reports ● Numbering Style of Chapters, Sections, Figures, Tables and Equations ● Referencing Styles in APA & MLA Format ● Proofreading through Plagiarism Checkers	
1.4. Definition, Purpose & Types of Proposal s	● Solicited (in conformance with RFP) & Unsolicited Proposals ● Types (Short and Long proposals)	
1.5. Parts of a Proposal	● Elements ● Scope and Limitations ● Conclusion	
1.6. Technical Paper Writing	● Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) ● Language and Formatting ● Referencing in IEEE Format	
MODULE 2 - EMPLOYMENT SKILLS		
2.1. Cover Letter &	● Parts and Content of a Cover Letter ● Difference between Bio-data, Resume & CV	

Resume	● Essential Parts of a Resume ● Types of Resumes (Chronological, Functional & Combination)	
2.2 Statement of Purpose	● Importance of SOP ● Tips for Writing an Effective SOP	
2.3 Verbal Aptitude Test	● Modelled on CAT, GRE, GMAT exams	
2.4. Group Discussions	● Purpose of a GD ● Parameters of Evaluating a GD ● Types of GDs (Normal, Case-based & Role Plays) ● GD Etiquettes	
2.5. Personal Interviews	● Planning and Preparation ● Types of Questions ● Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) ● Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
MODULE 3 - BUSINESS MEETINGS		
3.1. Conducting Business Meetings	● Types of Meetings ● Roles and Responsibilities of Chairperson, Secretary and Members ● Meeting Etiquette	
3.2. Documentation	● Notice ● Agenda ● Minutes	
MODULE 4 -TECHNICAL/ BUSINESS PRESENTATIONS		
	● Defining Purpose ● Analyzing Audience, Location and Event	

4.1. Effective Presentation Strategies	● Gathering, Selecting And Arranging Material ● Structuring a Presentation ● Making Effective Slides ● Types of Presentations Aids ● Closing a Presentation ● Platform Skills	
4.2 Group Presentations	● Sharing Responsibility in a Team ● Building the contents and visuals together ● Transition Phases	
MODULE 5 - INTERPERSONAL SKILLS		
5.1. Interpersonal Skills	● Emotional Intelligence ● Leadership & Motivation ● Conflict Management & Negotiation ● Time Management ● Assertiveness ● Decision Making	
	● Financial Literacy ● Risk Assessment ● Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	
MODULE 6 - CORPORATE ETHICS		
6.1. Intellectual	● Copyrights ● Trademarks ● Patents ● Industrial Designs	

	● Geographical Indications ● Integrated Circuits ● Trade Secrets (Undisclosed Information)	
6.2. Case Studies	● Cases related to Business/ Corporate Ethics	

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Mini Project -III

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARPBL501	Mini Project -III	--	4$	--	2	--	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARPBL501	Mini Project -III	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARPBL501	Mini Project -III	02

Prerequisite:	
Lab Objectives:	
1	To acquaint yourself with the process of identifying the needs and converting it into the problem.
2	To familiarize the process of solving the problem in a group.
3	To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4	To inculcate the process of self-learning and research.
Lab Outcomes:	
1	Identify problems based on societal/research needs.
2	Apply Knowledge and skill to solve societal problems in a group.
3	Develop interpersonal skills to work as a member of a group or leader.
4	Draw the proper inferences from available results through theoretical/experimental/simulations.
5.	Analyze the impact of solutions in societal and environmental context for sustainable development.
6.	Use standard norms of engineering practices
7	Excel in written and oral communication.
8	Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9	Demonstrate project management principles during project work.

Guidelines for Mini Project

Students shall form a group of 3to4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.

● Students should do surveys and identify needs, which shall be converted into problem statements for mini projects in consultation with faculty supervisor/head of department/internal committee of faculties.
● Students shall submit implementation plans in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini projects.
● A log book to be prepared by each group, wherein the group can record weekly work progress, guide/supervisor can verify and record notes/comments.
● Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
● Students in a group shall understand problems effectively, propose multiple solutions and select the best possible solution in consultation with the guide/supervisor.
● Students shall convert the best solution into a working model using various components of their domain and demonstrate.
● The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
● With the focus on self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e., Mini Project 1 & 2 in semester III and IV. Similarly, Mini Project 3 & 4 in semesters V and VI.
● However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be opted on a case-by-case basis.

Guidelines for Assessment of Mini Project:

Term Work

The review/ progress monitoring committee shall be constituted by the Head of departments of each institute. The progress of the mini project to be evaluated on a continuous basis, minimum two reviews in each semester.
In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
Distribution of Term work marks for both semesters shall be as below; o Marks awarded by guide/supervisor based on logbook 10 o Marks awarded by review committee 10 o Quality of Project report 05
Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

In the first semester the entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on the presentation given by the student group. § First shall be for finalization of problem § Second shall be on finalization of the proposed solution of the problem.
In the second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester. § First review is based on the readiness of building a working prototype to be conducted. Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

In this case in one semester students' group shall complete project in all aspects including, o Identification of need/problem o Proposed final solution

o Procurement of components/systems o Building prototype and testing
Two reviews will be conducted for continuous assessment, § First shall be for finalization of problem and proposed solution

Half-year project: Assessment criteria of Mini Project:

Mini Project shall be assessed based on following criteria;

1.	Quality of survey/need identification
2.	Clarity of Problem definition based on need.
3.	Innovativeness in solutions
4.	Feasibility of proposed problem solutions and selection of best solution
5.	Cost effectiveness
6.	Societal impact
7.	Innovativeness
8.	Cost effectiveness and Societal impact
9.	Full functioning of working model as per stated requirements
10.	Effective use of skill sets
11.	Effective use of standard engineering norms
12.	Contribution of an individual's as member or leader
13.	Clarity in written and oral communication
In **one year, project**, first semester evaluation may be based on the first six criteria and the remaining may be used for the second semester evaluation of performance of students in the mini project.	
In the case of a half **year project** all criteria in generic may be considered for evaluation of performance of students in the mini project.	

Guidelines for Assessment of Mini Project Practical/Oral Examination:

● Report should be prepared as per the guidelines issued by the University of Mumbai.
● Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry orresearchorganisationshavingexperienceofmorethanfiveyearsapproved by head of Institution.
● Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1.	Quality of problem and Clarity
2.	Innovativeness in solutions
3.	Cost effectiveness and Societal impact
4.	Full functioning of working model as per stated requirements
5.	Effective use of skill sets
6.	Effective use of standard engineering norms
7.	Contribution of an individual's as member or leader
8.	Clarity in written and oral communication

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

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Semester VI

Robotic Control system

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC601	Robotic Control system	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA *					
ARC601	Robotic Control system	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARC601	Robotic Control system	03

Course Objectives:	
1	To make the students familiar with dynamic modeling of robots.

2	To make the students understand Nonlinear control of manipulators.
3	To make students understand Force control of manipulators.
4	To make the students understand the Kinematic model of a steered robot.
5	To make the students study Vision based control.
6	To make students understand PID control of single link manipulator and planar 2R manipulator.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Learn basic concepts in dynamic modeling of robots.
2.	Understand and design Nonlinear control of manipulators.
3.	Design Force control of manipulators
4.	Analyze Kinematic model of steered robot and differentially driven mobile robot.
5.	Understand Vision based control systems.
6.	Design PID control of single link manipulator and planar 2R manipulator.

Module	**Content**	**Hrs**
1	**Review of dynamic modeling of robots:** Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control. Linear control of manipulators - closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory- following control, Feedback control of single link manipulator, closed loop control of wall following robot- block schematic- sensor selection etc.	**08**
2	**Nonlinear Control of manipulators** PD Gravity Control, Computed Torque Control, adaptive control Task Space Control Schemes – resolved motion rate control and resolved motion acceleration control.	**07**
3	**Force control of manipulators** Introduction, application of industrial robots to assembly tasks, force control of a mass—spring system, the hybrid position/force control problem, the hybrid position/force control scheme.	**06**

4	**Kinematic model of steered robot and differentially driven mobile robot** Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose, Dynamic model of quad copter, Controller design to track any desired trajectory.	**07**
5	**Vision based Control** Configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration, Position based visual servoing, Image based visual servoing, Hybrid visual servoing.	**08**
6	**Case study -** PID Control of single link manipulator and planar 2R manipulator, resolved motion rate control of 2R manipulator, force control of peg in whole assembly task, control of any industrial robot.	**03**
	Total	**39**

Text Books:	
1	Robotics and Control, R K Mittal, I J Nagrath
2	Nonlinear systems, Hassan K. Khalil, Pearson
3	Introduction to Robotics Mechanics and Control, John J. Craig, 3e, Pearson.
4	Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford
5	Robotics- Modelling planning and control- Bruno Siciliano , Lorenzo Sciavicco Luigi Villani, Giuseppe Oriolo, Springer-Verlag London.
6	Peter Corke, “Robotics, Vision and Control-Fundamental Algorithms in MATLAB”, Springer Tracts in Advanced Robotics, volume 73.
7	The Robotics Primer-Maja J Mataric, The MIT Press
References:	
1	Probabilistic Robotics: Sebastian Thrun, Wolfram Burgard, Dieter Fox, MIT Press
2	Modern Robotics Mechanics, Planning and Control, Kevin M. Lynch, Frank C. Park, Cambridge University Press, 2017.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

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Unit operations & control

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC602	Unit operations & control	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC602	Unit operations & control	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARC602	Unit operations & control	03

Course Objectives:	
1	To impart the knowledge of different industrial unit operations.
2	To make the students capable to design and develop instrumentation and control schemes for industrial processes
3	To give them an overview of various process industries, hazardous areas and their classification

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Explain working and control of heat exchanger and evaporator
2.	Explain working and control boiler and furnace
3.	Elaborate working and control of distillation and reactor
4.	Explain working and control of dryer and crystallizer
5.	Describe the processes of batch and continuous process industries and instrumentation involved in them.
6.	Explain the significance of renewable energy, green energy and carbon storage

Module	Contents	Hrs.
1.	**Heat transfer unit operations-I:** Introduction to unit operations and processes, concept of heat transfers and energy balance, heat transfer coefficient. **Heat exchanger control:** classification as per fluid flow arrangement and construction, feedback, feed-forward, bypass control schemes, fouling in heat exchangers. **Evaporator control:** Evaporator terminologies, Types of Evaporators, control systems for Evaporator – feedback, cascade, feed forward and selective control.	**06**
2.	**Heat transfer unit operations-II:** **Boiler control:** Types, working and operation of boilers, Terms related- Shrink and swell effect and excess oxygen, boiler efficiency, Boiler controls- Drum level control- Single, two and three elements, and Combustion Control-Type 1, 2, 3 and 4, steam temperature control, boiler pressure control, furnace draft control. **Furnace Control:** Start- up heaters, fired reboilers, process and safety controls.	**06**
3.	**Heat and mass transfer unit operations-I:** **Distillation column:** Basic principle, Distillation equipment and its accessories. Batch and continuous distillation, Binary product distillation, multi-product distillation, Vacuum distillation. **Distillation column control strategies**- Top and bottom product composition controls-inferential and direct, Pressure controls, Vapors recompression, Feed controls- Column feed controls, economizer. **Reactor control:** Reactor characteristics, runaway reaction, various schemes of temperature control of reactors.	**08**

4.	**Heat and mass transfer unit operations-II:** **Dryer control:** Process of drying, types and control strategies of dryer- Tray, fluidized bed, rotary and spray dryer. **Crystallizers control:** Process of crystallization, Super-saturation methods, types of crystallizer and control strategies- evaporating crystallizer, cooling crystallizers, vacuum crystallizers.	**07**
5.	**Process Industries:** **Refinery Industry:** Process flow diagram, separation, conversion methods, sensors and control schemes. **Iron and steel Industry**: Process flow diagram, Sensors and Control schemes. **Fertilizer Industry:** Process flow diagram, sensors and control schemes. Overview of Effluent and sewage Treatment plant and its Automation.	**06**
6.	**Renewable Energy sources** - Overview, sources and types, Carbon capture, Utilization and storage in industry, **Green hydrogen Technology.**	**06**
	Total	**39**

Text Books:	
1	Curtis D. Johnson, "Process Control Instrumentation Technology", PHI /Pearson Education 2002.
2	George Stephanopoulos, "Chemical process control", An introduction to theory and practice PHI- 1999.
References:	
1	Bela G. Liptak, "Instrument Engineer‟s Handbook – Process Control", Chilton Company, 3rdEdition,1995.
2	G. F. (Jerry) Gilman, "Boiler control system Engineering" Second Edition.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7. .	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Manufacturing using Computer Aided Design

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC603	Manufacturing using Computer Aided Design	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC603	Manufacturing using Computer Aided Design	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARC603	Manufacturing using Computer Aided Design	03

Course Objectives:	
1	To familiarize with basic concepts of computer graphics.
2	To acquaint with the process of using biomedical data for 3D modeling.
3	To study programming aspects of the subtractive manufacturing process.
4	To familiarize with the basic process of additive manufacturing in particular 3D printing.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Identify suitable computer graphics techniques for 3D modeling.
2.	Transform, manipulate objects & store and manage data.
3.	Develop a 3D model using various types of available biomedical data.
4.	Create the CAM Toolpath for specific given operations.
5.	Build and create data for 3D printing of any given object using rapid prototyping and tooling processes.
6.	Illustrate understanding of various cost-effective alternatives for manufacturing products.

Module	**Detailed Contents**	**Hrs.**
1.	Computer Graphics 1.1 Introduction: Scope of CAD/CAM in product life cycle, CAD/CAM hardware and software, 2D and 3D computer graphics representation, Mapping of Geometric Models. 1.2 Parametric representation of curves and surfaces: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves. Surface representation. 1.3 Solid Modeling: Constructive solid geometry (CSG), Boundary Representation (BRep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, Feature based modeling, Constraint Based Modeling.	**07**
2.	**Geometric Transformation** 2.1 Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D geometric transformation (Translation, Reflection, Scaling, Rotation)	**07**
3.	**Modeling based on Biomedical data** 3.1 Introduction to medical imaging: Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Non-Contact surface scanning, Medical scan data, Point cloud data 3.2 Working with medical scan data: Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	**06**

4.	**Subtractive Manufacturing** 4.1 Introduction: NC/CNC/DNC machines, Machining Centers, Coordinate system 4.2 CNC machining practices and programming: setup, and operation of two- and three axes. CNC machines programming using manual part programming method, Canned Cycles.	**07**
5.	**Additive Manufacturing** 5.1 Rapid Prototyping: Introduction, Classification of RP Processes, Advantages & disadvantages. RP Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication. 5.2 Working Principle, Application, Advantages & disadvantages: of Stereolithography Apparatus (SLA) Selective Laser Sintering (SLS), 3D Printing, Fused Deposition Modeling (FDM), and Laminated Object Manufacturing (LOM)	**07**
6.	**Virtual Manufacturing** 6.1 Virtual Manufacturing: Introduction, Scope, Socio-economic Aspects and Future Trends	**05**
	Total	**39**

References:

1	CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
2	CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
3	CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
4	CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers
5	Medical Modeling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
6	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
7	Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers
8	Advanced Machining and Manufacturing Processes, Kaushik Kumar Divya Zindani, J. Paulo Davim, Springer International Publishing

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/112/102/112102101/
2. https://nptel.ac.in/courses/106/102/106102065/
3. https://nptel.ac.in/courses/106/102/106102065/
4. https://nptel.ac.in/courses/112/102/112102103/
5. https://nptel.ac.in/courses/112/105/112105211/
6. https://nptel.ac.in/courses/112/104/112104265/
7. https://www.youtube.com/watch?v=2cCMty9v3Tg
8. https://www.youtube.com/watch?v=2zPh26Q1BT8

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

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(With Effect from 2024-2025)

Machine Learning

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARC604	Machine Learning	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARC604	Machine Learning	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARC604	Machine Learning	03

Course Objectives:	
1	To familiarize students with basic concepts of Machine learning.
2	To provide understanding of the concepts of regression, classification, clustering and machine learning algorithms
3	To introduce the students to various applications of Machine learning for industrial automation and robotics

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Introduce concepts of Artificial Intelligence and Machine learning
2.	Explain statistical tools and development of model for ML
3.	Explain and analyze the various algorithms for Supervised learning
4.	Explain and analyze the various algorithms for Unsupervised learning.
5.	Explain and analyze the algorithms of Artificial NN.
6.	Apply ML algorithms for industrial automation and robotics.

Module	**Contents**	**Hrs.**
1.	**Introduction to Machine Learning:** Introduction to Artificial Intelligence, Machine learning and Deep learning, Types of machine learning – Supervised, Unsupervised and Reinforcement learning	**05**
2.	**Design of Machine Learning System:** Collection of data, Data statistics – mean, variance, covariance, standard deviation, random variable, probability distribution function, data pre-processing, data scaling, training of data, testing of data and its validation. Evaluation Metrics – Confusion matrix, precision, recall, F-score.	**08**
3.	**Supervised Learning:** Linear Regression, Multiple linear regression, Polynomial regression, Logistic Regression, Regularization techniques.	**06**
4.	**Unsupervised Learning and Classification:** K-means and Hierarchical Clustering, Decision trees, Naïve-Bayes, SVM for linearly separable data, Kernel SVM for non-linearly separable data Dimensionality Reduction: LDA, Principal Component Analysis (PCA)	**07**
5.	**Artificial Neural Networks:** The Neurons and the Brain, Neural Networks and Representation: Perceptron, Multilayer perceptron, Gradient Descent, back- propagation.	**07**
6.	**Application of ML algorithms in Industrial Automation and Robotics:** ML algorithms applied for Factory automation, autonomous cars, automated robotic arm, process control, Data screening, feature engineering, model design, limitations.	**06**
	Total	**39**

Text Books:	
1	Harrington, Peter. Machine learning in action. Simon and Schuster, 2012.
2	Zheng, Alice, and Amanda Casari. Feature engineering for machine learning: principles and techniques for data scientists. " O'Reilly Media, Inc.", 2018.
3	Jiang, Hui. Machine Learning Fundamentals: A Concise Introduction. Cambridge University Press, 2021.
4	Huyen, C. “Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications”, O'Reilly Media, 2022.
5	Gupta, Itisha, and Garima Nagpal. Artificial Intelligence and Expert Systems. Stylus Publishing, LLC, 2020.
References:	
1	Pandey, Yogendra Narayan, et al. Machine Learning in the Oil and Gas Industry. press, Texas, 2020.
2	Bangert, Patrick, ed. Machine learning and data science in the oil and gas industry: Best practices, tools, and case studies. Gulf Professional Publishing, 2021.
3	Das, Santosh Kumar, et al., eds. Machine learning algorithms for industrial applications. Cham: Springer, 2021.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Database Management Systems

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO6021	Database Management Systems	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO6021	Database Management Systems	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO6021	Database Management Systems	03

Course Objectives:	
1	Learn and practice data modeling using the entity-relationship and developing database designs.
2	Understand the use of Structured Query Language (SQL) and learn SQL syntax

3	Apply normalization techniques to normalize the database
4	Understand the needs of database processing and learn techniques for controlling the consequences of concurrent data access.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	To describe data models and schemas in DBMS.
2.	Explain the features of database management systems and Relational databases.
3.	Use SQL- the standard language of relational databases.
4.	Identify the functional dependencies and design a database.
5.	Describe the concept of Transactions Management and Concurrency.
6.	Explain the concept of Query Processing and Optimization.

Module	**Detailed content**	**Hours**
1	**Introduction Database Concepts:** Introduction, Characteristics of databases, File system V/s Database system, Users of Database system, Concerns when using an enterprise database, Data Independence, DBMS system architecture, Database Administrator **Entity–Relationship Data Model:** Introduction, Benefits of Data Modeling, Types of Models, Phases of Database Modeling, The Entity-Relationship (ER) Model, Generalization, Specialization and Aggregation, Extended Entity-Relationship (EER) Model.	**06**
2	**Relational Model and Algebra:** Introduction, Mapping the ER and EER Model to the Relational Model, Data Manipulation, Data Integrity, Advantages of the Relational Model, Relational Algebra, Relational Algebra Queries, Relational Calculus.	**06**
3	**Structured Query Language (SQL):** Overview of SQL, Data Definition Commands, Set operations, aggregate function, null values, Data Manipulation commands, Data Control commands, Views in SQL, Nested and complex queries.	**07**
4	**Integrity and Security in Database:** Domain Constraints, Referential integrity, Assertions, Trigger, Security, and authorization in SQL **Relational–Database Design:** Design guidelines for relational schema, Function dependencies, Normal Forms- 1NF, 2 NF, 3NF, BCNF and 4NF	**08**

5	**Transactions Management and Concurrency:** Transaction concept, Transaction states, ACID properties, Implementation of atomicity and durability, Concurrent Executions, Serializability, Recoverability, Implementation of isolation, Concurrency Control: Lock-based, Timestamp-based, Validation-based protocols, Deadlock handling, Recovery System: Failure Classification, Storage structure, Recovery & atomicity, Log based recovery, Shadow paging.	**07**
6	**Query Processing and Optimization:** Overview, Issues in Query Optimization, Steps in Query Processing, System Catalog or Metadata, Query Parsing, Query Optimization, Access Paths, Query Code Generation, Query Execution, Algorithms for Computing Selection and Projection, Algorithms for Computing a Join, Computing Aggregation Functions, Cost Based Query Optimization.	**05**
	Total	**39**

Text Books:	
1	G. K. Gupta:" Database Management Systems", McGraw – Hill.
2	Korth, Slberchatz,Sudarshan, :"Database System Concepts", 6th Edition, McGraw – Hill
3	Elmasri and Navathe, "Fundamentals of Database Systems", 5thEdition, PEARSON Education.
4	Peter Rob and Carlos Coronel, "Database Systems Design, Implementation and Management", Thomson Learning, 5th Edition
References:	
1	Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g, Black Book, Dreamtech Press Mark L. Gillenson, Paulraj Ponniah, "Introduction to Database Management",Wiley
2	Sharaman Shah," Oracle for Professional", SPD.
3	Raghu Ramkrishnan and Johannes Gehrke, "Database Management Systems",TMH
4	Debabrata Sahoo "Database Management Systems" Tata McGraw Hill, Schaum's Outline

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Industrial Robotics and Material Handling System

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO6022	Industrial Robotics and Material Handling System	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO6022	Industrial Robotics and Material Handling System	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO6022	Industrial Robotics and Material Handling System	03

Course Objectives:	
1	To introduce the basic concepts, parts of robots and types of robots.
2	To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
3	To discuss the various applications of robots, justification and implementation of robots.
4	Concepts of material handling, principles and considerations in material handling systems design

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	To introduce the basic concepts, parts of robots and types of robots
2.	To make the student familiar with the various drive systems for robots, sensors and their applications in robots and programming of robots.
3.	To discuss the various applications of robots, justification and implementation of robots.
4.	Explain the gripper force analysis and design.
5.	To introduce the basic concepts, principles and design considerations
6.	Implement safety regulations in material handling systems.

Module	**Detailed Contents**	**Hrs.**
01	Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.	**05**
02	Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.	**07**
03	Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.	**07**
04	Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers. Selection of Robot: Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.	**06**

05	Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems (ASRS), barcode technology, radio frequency identification technology.	**07**
06	Factors affecting selection of material handling equipment, Material handling equation, Choices of Material Handling Equipment, General Procedure for Selection, Basic Analytical techniques, Selection of suitable types of material handling systems, Functions and Parameters, affecting service, packing and storage material, Selection of Material Handling Equipment in Green Sand Moulding Foundry, Sugar Manufacturing Industry.	**07**

Text Books:	
1	Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, "Robotic Engineering – An integrated Approach" Prentice HallIndia, New Delhi, 2001.
2	Mikell P. Groover," Automation, Production Systems, and Computer Integrated Manufacturing ", 2nd Edition, John Wiley & sons, Inc, 2007.
3	Industrial Automation and Robotics by Er. A. K. Gupta and S. K. Arora, University Science Press, Laxmi Publishing Pvt. Ltd.
4	James Apple, Material Handling System Design, John Wiley
5	Theodore H., Allegre Sr., Material Handling Principles and Practice, CBS Publishers and Distributors.
References:	
1	James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002.
2	Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.
3	Robotics and Control by R. K. Mittal and I. J. Nagrath, McGraw Hill Education (India) Private Limited.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher.The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Metal Forming Technology

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO6023	Metal Forming Technology	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO6023	Metal Forming Technology	20	20	60	2	–	--	100

Course Code:	Course Title	Credit
ARDLO6023	Metal Forming Technology	03

Course Objectives:	
1	To conversant with the basic knowledge on fundamentals of metal forming process

2	To study various metal forming processes
3	Understanding plastic deformation and technical analysis of forming processes

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Understand the concept of different metal forming processes.
2.	Explain the concept of Rolling processes both analytically and numerically
3.	Explain the concept of forging processes both analytically and numerically
4.	Explain the concept of Extrusion processes both analytically and numerically
5.	Explain the concept of Drawing processes both analytically and numerically.
6.	Explain the Sheet Metal Forming principle, process parameters and their applications.

Module	**Contents**	**Hrs.**
1	**Introduction to Metal Forming:** Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, effects of temperature, strain rate, microstructure and friction in metal forming-yield criteria and their significance, Classification of Metal Forming Processes, Advantages and Limitations, Stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms, Hot and Cold Working Processes and Its Effect on Mechanical Properties.	**08**
2	**Rolling:** Introduction and Classification, Types of Rolling Mills, Forces and Geometrical Relationships in Rolling, Calculation of Rolling Load, Roll Pass Design, and Defects in Rolled Products.	**07**
3	**Forging:** Introduction and Classification, operation and principle of Forging Processes and Equipment, Methods of forging, Open and Closed Die Forging Processes, Defects, Structure and Properties of Forged Products. Force Analysis in forging.	**07**
4	**Extrusion:** Introduction and Classification, Extrusion Equipment, Forces in extrusion, Analysis of Extrusion Process, Extrusion of components including Seamless Pipes and Tubes. Extrusion of pipes by cold working.	**06**
5	**Drawing:** Introduction and Classification, Wire Drawing, Rod Drawing, Tube Drawing, Deep Drawing, Analysis of Wire Drawing Process and Load Calculations.	**05**

6	**Sheet Metal Forming:** Principle, process parameters, equipment and application of the following processes: spinning, stretch forming, plate, V and edge bending, Curling, Ironing, Roll Bending, Metal Spinning. Press brake forming, explosive forming, Hydroforming, electro hydraulic forming, and magnetic pulse forming. High Velocity forming of metals and High energy Rate forming	**06**
	Total	**39**

Text Books:	
1	Lin D Balint M Pietrzyk, Microstructure Evolution in Metal Forming Processes 1st Edition
2	Amitabha Ghosh and Asok Kumar Mallick, Manufacturing Science, Affiliated East-West Press
3	Christian Brecher and Ozdemir, Advances in Production Technology, Springer Publications
4	P.C. Sharma, A Text Book on Production Engineering, S. Chand Publications
5	P. N. Rao, "Manufacturing Technology", Tata McGraw Hill
6	Aviter, "Fundamental of Metal Working", McGraw Hill Publisher
7	Dieter, "Mechanical Metallurgy"

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/107/112107250/ - Principles of Metal Forming Technology, IIT Roorkee https://nptel.ac.in/courses/112/106/112106153/ - Forming, IIT Madras.

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher.The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Biomedical Instrumentation

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARDLO6024	Biomedical Instrumentation	3	--	3	--		3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Ex Dur (Hrs)			
		Mid Test (MT)	CA*					
ARDLO6024	Biomedical Instrumentation	20	20	60	2	-	--	100

Course Code:	Course Title	Credit
ARDLO6024	Biomedical Instrumentation	03

Prerequisite: Biology and human physiology.

Course Objectives:	
1	To make students understand the Identification, classification, and working principle of various Biomedical Instruments used for Bio-potential measurement
2	To make students understand the application of the various biomedical instruments in diagnosis, therapeutic and imaging fields

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1.	Identify various Bio-potential with their specifications and perform their measurements.
2.	Discuss various Physiological systems and to identify their parameters and related measurements.
3.	Explain the principle and working of various cardiovascular parameters and their measurement techniques with applications.
4.	Distinguish between the various medical imaging techniques based on the principles and concepts involved in them.
5.	Relate between the different life support instruments and to describe their applications.
6.	Describe the significance of electrical safety in biomedical measurement.

Module	**Contents**	**Hrs.**
1	**Bio-Potentials and their Measurement:** Structure of Cell, Origin of Bio-potential, electrical activity of cell and its characteristics and specifications. Measurement of RMP and AP. Electrode-Electrolyte interface and types of biopotential electrodes.	**05**
2	**Physiological Systems and Related Measurement:** Respiratory system- Physiology of respiration and measurements of respiratory related parameters. Nervous system- Nerve cell, neural communication, nerve-muscle physiology, Generation of EEG and study of its characteristics. Normal and abnormal EEG, evoked potential and epilepsy. Muscular system- Generation of EMG signal and measurement. Cardiovascular system- Structure of Heart, Electrical and Mechanical activity of Heart, ECG measurements and Cardiac arrhythmias, Heart sound measurement. Design of ECG amplifiers.	**08**
3	**Cardiovascular Measurement:** Blood Pressure measurement using Direct and Indirect techniques. Blood Flow meters- Electromagnetic and Ultrasonic types. Blood Volume measurement - Plethysmography. (Impedance) Cardiac Output measurement - Fick method, Dye-dilution and Thermo- dilution type	**08**
4	**Imaging Techniques: *** X-Ray tube construction, working and its application. CT scan- CT Number, Block Diagram, scanning system and application. MRI – concept, working and its application Working principle of Ultrasound Imaging- Modes of scanning and their application.	**08**

5	Life support Instruments: Pacemaker- modes of pacing and its application. Defibrillator- AC and DC Defibrillators and their application. Heart Lung machine and its application during surgery. Hemodialysis system and the precautions to be taken during dialysis. Ventilator system and its important parameters for monitoring	**08**
6	Significance of Electrical Safety: Physiological effects of electrical current, Shock Hazards from electrical equipment and methods of accident prevention.	**02**
	Total	**39**

*** A Hospital Visit is recommended.**

Text Books:	
1	Leslie Cromwell, ―Biomedical Instrumentation and Measurements‖, 2nd Edition, Pearson Education, 1980.
2	John G. Webster, ―Medical Instrumentation‖, John Wiley and Sons, 4th edition,2010.
3	R. S. Khandpur, ―Biomedical Instrumentation‖, TMH,2004

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The rubrics for assessment will be considered on approval by the subject teacher. The rubrics can be any 2 or max 4 of the following:

Sr No	Rubrics	Marks
1.	*Certificate course for 4 weeks or more:NPT EL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Robotic Control System Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL601	Robotic Control System Lab	--	2	--	1		1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL601	Robotic Control System Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARL601	Robotic Control System Lab	01

Prerequisite:	
Lab Objectives:	
1	To make the students familiar with the dynamic modeling of robots.
2	To make the students understand Nonlinear Control of manipulators
3	To make students understand Force control of manipulators.
4	To make the students understand the Kinematic model of a steered robot.
5.	To make the students understand Vision based Control.
6.	To make students understand PID Control of single link manipulator and planar 2R manipulator.
Lab Outcomes:	
1	Learn basic concepts in dynamic modeling of robots.
2	Understand and design Nonlinear control of manipulators.
3	Design Force control of manipulators
4	Analyze Kinematic model of steered robot and differentially driven mobile robot.
5.	Understand Vision based control systems.
6.	Design PID control of single link manipulator and planar 2R manipulator.

Suggested Experiments: Students are required to complete at least 10 experiments

Sr. No.	List of Experiments	CO Mapping
1	Creating robot joint trajectories	**CO1**
2	Study Inverse and Forward dynamics of robots	**CO1**
3	Design stiffness control for 3-link planar manipulator.	**CO2**
4	Design trajectory following controller for a given system.	**CO3**
5	Design trajectory following controller for a linear system or using linearized model of the system.	**CO3**
6	Study of Forward Kinematics of a 5R Robot Manipulator	**CO3**
7	Study of Inverse Kinematics of a 5R Robot Manipulator	**CO3**

8	Design of controller for Multi-Link Manipulator	**CO3**
9	Design of Line follower robot control.	**CO4, CO5**
10	Design of Navigation control of mobile robot using Neural Network algorithm.	**CO4, CO5**
11	Design Control a virtual robot using a joystick	**CO6**
12	Study workspace Analysis of a 6-axis robot	**CO6**
13	Design PID Controller for single link manipulator	**CO6**
14	Case study on any Industrial Robot	**CO6**

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Unit Operations and Control lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL602	Unit Operations and Control lab	–	2	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL602	Unit Operations and Control lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARL602	Unit Operations and Control lab	01

Prerequisite:	
Lab Objectives:	
1	To impart the knowledge of different industrial unit operations.
2	To make them capable to design and develop instrumentation and control schemes for industrial processes.
3	To give them exposure to work in the process industry

4	To explain students about hazardous area and safety design system

Lab Outcomes:	
1	To impart the knowledge of different industrial unit operations.
2	To make them capable to design and develop instrumentation and control schemes for industrial processes.
3	To give them exposure to work in the process industry
4	To explain students about hazardous area and safety design system
5.	To impart the knowledge of different industrial unit operations.
6.	To make them capable to design and develop instrumentation and control schemes for industrial processes.

Suggested Experiments: Students are required to complete at least 10 experiments

Sr. No.	**List of Experiments**	**CO Mapping**
1	Demonstrate the operation and control scheme of Heat exchanger	**CO1**
2	Learn working of various Unit Operations (Boilers/furnace / Distillation column etc.) using online learning resources.	**CO2**
3	Demonstrate the reactor control system.	**CO2, CO3**
4.	Demonstrate the operation & control scheme of dyer/crystallizer.	**CO4**
5	Prepare a report on any one industry.	**CO5**
6.	Develop some charts on carbon storage	**CO6**
7	Assignment/Exercise on heat transfer and mass unit operations	**CO1**
8	Assignment/Exercise on heat transfer unit operations-boiler, furnace.	**CO2**
9	Assignment/Exercise on heat and mass transfer unit operations-Distillation, reactor.	**CO3**
10	Assignment/Exercise on heat and mass transfer unit operations-Crystallization, dryer.	**CO4**
11	Assignment/Exercise on continuous or batch process industries.	**C05**

12	Assignment/Exercise on renewable energy	**CO6**

Any other experiment based on syllabus which will help students to understand the topic/concept

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Machine Learning Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARL603	Machine Learning Lab	–	2	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARL603	Machine Learning Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARL603	Machine Learning Lab	01

Prerequisite:	
Lab Objectives:	
1	To familiarize students with basic concepts of Machine learning.
2	To provide understanding of the concepts of regression, classification, clustering and machine learning algorithms.
3	To introduce the students to various applications of Machine learning for industrial automation and robotics
Lab Outcomes:	
1	Develop programs to perform statistical analysis of data sets.
2	Implement algorithms based on Supervised learning.
3	Implement algorithms based on Unsupervised learning.
4	Execute classification algorithms on a given data set.
5.	Develop programs based on Artificial NN.
6.	Apply ML algorithms for industrial automation and robotics.

Suggested Experiments: Students are required to complete at least 10 experiments

Sr. No.	List of Experiments	CO Mapping
1.	Write a python program to determine mean, variance and standard deviation of a given data set.	**CO1**
2.	Write a python program to implement linear regression with one variable for a given data set.	**CO1**
3.	Write a python program to implement linear regression with two variables for a given data set.	**CO1**
4.	Implement regularized regression techniques such as LASSO or Ridge for given dataset	**CO2**
5.	Write python programs to implement logistic regression for any given dataset.	**CO2**
6.	Write python programs to implement K-means clustering algorithm for image compression	**CO3**
7.	Write python programs to implement Hierarchical clustering for any application	**CO3**

8.	Implement SVM for any classification application	**CO4**
9.	Implement decision tree or random forest algorithm for data classification	**CO4**
10.	Implement ANN for hand-written digit recognition	**CO5**
11.	Write a program for application of ML algorithm for automation application	**CO6**
12.	Case study/ mini-project on applying ML algorithms for any robotic application	**CO6**

Any other experiment based on syllabus which will help students to understand the topic/conc

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

CAD Modeling, CNC and 3-D Printing Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARLSBL601	CAD Modeling, CNC and 3-D Printing Lab	–	2* + 2	–	2	–	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARLSBL601	CAD Modeling, CNC and 3-D Printing Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARLSBL601	CAD Modeling, CNC and 3-D Printing Lab	02

Prerequisite:	
Lab Objectives:	
1	To impart the 3D modeling skills for development of 3D models of basic engineering components.
2	To introduce Product data exchange among CAD systems.
3	To familiarize with production drawings with important features like GD&T, surface finish, heat treatments etc.
4	To familiarize with subtractive manufacturing processes in particular CNC systems.
5.	To acquaint, with the basic part of the programming process for specific operations.
6.	To familiarize with the additive manufacturing process in particularly 3D printing.
Lab Outcomes:	
1	Illustrate basic understanding of types of CAD model creation, visualize and prepare 2D modeling of a given object using modeling software.
2	Build a solid model of a given object using 3D modeling software.
3	Generate assembly models of given objects using assembly tools of a modeling software and can perform product data exchange among CAD systems.
4	Develop and execute part programing for any given specific operation and can build any given object using various CNC operations.
5.	Demonstrate CAM Tool path and prepare NC- G code.
6.	Build any given real-life object using the 3D printing process.

Suggested Experiments: Students are required to complete at least 10 experiments

Sr. No.	Exercises	CO Mapping
1.	**CAD Introduction** CAD models Creation, Types and uses of models from different perspectives. Parametric modeling.	**CO1**
2.	**2D Modeling** Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	**CO1**
3	**Solid Modeling** 3D Geometric modeling of an Engineering component, demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc.	**CO2**
4.	**Assembly** Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	**CO3**
5.	**Data Exchange** CAD data exchange formats Like IGES, PDES, PARASOLID, DXF and STL along with their comparison and applicability.	**CO3**
6.	Part programming and part fabrication on CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.) (One job in a group of 4-5 students)	**CO4**
7.	Part programming and part fabrication on CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.) (One job in a group of 4-5 students)	**CO4**
8.	Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems.	**CO5**
9	Case Study: Report on a visit conducted to any Commercial CNC Machining Centre explaining the Design features, pre-processing in CAM software and its capabilities.	**CO5**
10	Development of physical 3D mechanical structure using any one of the rapid prototyping processes.	**CO6**

11	Check the constraints of any two RP systems for features like layer thickness, orientation of geometry, support generation, post processing etc.	**CO6**
12	Case Study: Usability of rapid tooling integrated investment casting process, with their advantages and limitations in any one of emerging areas of dentistry, jewelry, surgical implants, turbine blades, etc.	**CO6**

Any other experiment based on syllabus which will help students to understand the topic/conc

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** **(Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** **Continuous assessment exam** Based on the subject and related lab

Program Structure for Third Year Automation and Robotics

Scheme for Autonomous Program

(With Effect from 2024-2025)

Mini Project -IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract	Theory	Pract	Tut	Total
ARPBL601	Mini Project -IV	--	4$	--	2	--	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	CA*					
ARPBL601	Mini Project -IV	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
ARPBL601	Mini Project -IV	02

Prerequisite:	
Objectives:	
1	To acquaint yourself with the process of identifying the needs and converting it into the problem.
2	To familiarize the process of solving the problem in a group.
3	To acquaint yourself with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4	To inculcate the process of self-learning and research
Outcomes:	
1	Identify problems based on societal/research needs.
2	Apply Knowledge and skill to solve societal problems in a group.
3	Develop interpersonal skills to work as a member of a group or leader.
4	Draw the proper inferences from available results through theoretical/experimental/simulations.
5.	Analyze the impact of solutions in societal and environmental context for sustainable development.
6.	Use standard norms of engineering practices
7	Excel in written and oral communication.
8	Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9	Demonstrate project management principles during project work

Guidelines for Mini Project

• Students shall form a group of 3to4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
• Students should do surveys and identify needs, which shall be converted into problem statements for mini projects in consultation with faculty supervisor/head of department/internal committee of faculties.

• Students shall submit an implementation plan in the form of a Gantt/PERT/CPM chart, which will cover the weekly activity of the mini project.
• A log book to be prepared by each group, wherein the group can record weekly work progress, the guide/supervisor can verify and record notes/comments.
• Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
• Students in a group shall understand problems effectively, propose multiple solutions and select the best possible solution in consultation with the guide/supervisor.
• Students shall convert the best solution into a working model using various components of their domain and demonstrate.
• The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
• With the focus on self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e., Mini Project 1 & 2 in semester III and IV. Similarly, Mini Project 3 & 4 in semesters V and VI.
• However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be opted on a case-by-case basis.

Guidelines for Assessment of Mini Project:

Term Work

The review/ progress monitoring committee shall be constituted by the Head of departments of each institute. The progress of the mini project to be evaluated on a continuous basis, minimum two reviews in each semester.
In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
Distribution of Term work marks for both semesters shall be as below; o Marks awarded by guide/supervisor based on logbook 10 o Marks awarded by review committee 10 o Quality of Project report 05
Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

In the first semester the entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on the presentation given by the student group. § First shall be for finalization of problem § Second shall be on finalization of the proposed solution of the problem.
In the second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester. § First review is based on the readiness of building a working prototype to be conducted. Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

In this case in one semester students' group shall complete project in all aspects including, • Identification of need/problem • Propose final solution • Procurement of components/systems

• Building prototype and testing
Two reviews will be conducted for continuous assessment, § First shall be for finalization of problem and proposed solution

Assessment criteria of Mini Project:

Mini Project shall be assessed based on following criteria;

1.	Quality of survey/need identification
2.	Clarity of Problem definition based on need.
3.	Innovativeness in solutions
4.	Feasibility of proposed problem solutions and selection of best solution
5.	Cost effectiveness
6.	Societal impact
7.	Innovativeness
8.	Cost effectiveness and Societal impact
9.	Full functioning of working model as per stated requirements
10.	Effective use of skill sets
11.	Effective use of standard engineering norms
12.	Contribution of an individual's as member or leader
13.	Clarity in written and oral communication
In **one year, project**, first semester evaluation may be based on the first six criteria and the remaining may be used for the second semester evaluation of performance of students in the mini project.	
In the case of a half **year project** all criteria in generic may be considered for evaluation of performance of students in the mini project.	

Guidelines for Assessment of Mini Project Practical/Oral Examination:

• Report should be prepared as per the guidelines issued by the University of Mumbai.
• Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry orresearchorganisationshavingexperienceofmorethanfiveyearsapproved by head of Institution.
• Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1.	Quality of problem and Clarity
2.	Innovativeness in solutions
3.	Cost effectiveness and Societal impact
4.	Full functioning of working model as per stated requirements
5.	Effective use of skill sets
6.	Effective use of standard engineering norms
7.	Contribution of an individual's as member or leader
8.	Clarity in written and oral communication