PAAVAI ENGINEERING COLLEGE (Autonomous)
B.E. - ROBOTICS AND AUTOMATION
REGULATIONS – 2019 (CBCS)
CURRICULUM
SEMESTER V

S. No	Category	Course Code	Course Title	L	T	P	C
Theory							
1	HS	BA20151	Entrepreneurship Development	3	0	0	3
2	PC	RA20501	Design of Robot Elements	3	1	0	4
3	PC	RA20502	PLC and Automation	3	0	0	3
4	PC	RA20503	Robot Path Planning and Programming	3	0	0	3
5	PC	RA20504	Fluid Power Automation	3	0	0	3
6	PE	RA2015*	Professional Elective - I *	3	0	0	3
Practical							
7	PC	RA20505	Fluid Power System Laboratory	0	0	2	1
8	PC	RA20506	PLC and Automation Laboratory	0	0	2	1
9	EE	EN20501	Career Development Laboratory I	0	0	2	1
			Total	**18**	**1**	**6**	**22**

SEMESTER VI

S. No	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	RA20601	Automation System Design	3	0	0	3
2	PC	RA20602	Power Electronics	3	0	0	3
3	PC	RA20603	Embedded System Design	3	0	0	3
4	PC	RA20604	Robot Dynamics and Control	3	0	0	3
5	PE	RA2025*	Professional Elective - II *	3	0	0	3
6	OE	RA2090*	Open Elective - I*	3	0	0	3
Practical							
7	PC	RA20605	Power Electronics Laboratory	0	0	2	1
8	PC	RA20606	Robot Kinematics and Dynamics Laboratory	0	0	2	1
9	EE	EN20601	Career Development Laboratory II	0	0	2	1
			Total	**18**	**0**	**6**	**21**

PROFESSIONAL ELECTIVE COURSES (PE)

PROFESSIONAL ELECTIVE -I

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA20151	Microrobotics	3	0	0	3
2	PE	RA20152	Advanced Manufacturing Processes	3	0	0	3
3	PE	RA20153	Condition Monitoring and Fault Diagnostics	3	0	0	3
4	PE	RA20154	Process Planning and Cost Estimation	3	0	0	3

PROFESSIONAL ELECTIVE - II

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA20251	Sensor Networks	3	0	0	3
2	PE	RA20252	Additive Manufacturing	3	0	0	3
3	PE	RA20253	Robot Operating System	3	0	0	3
4	PE	RA20254	Product Design and Development	3	0	0	3

OPEN ELECTIVE COURSES (OE)

OPEN ELECTIVE – I

S. No	Category	Course Code	Course Title	L	T	P	C
1	OE	RA20901	Computer Aided Inspection and Testing	3	0	0	3
2	OE	RA20902	Smart mobility and Intelligent Vehicles	3	0	0	3

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Approved
BOARD OF STUDIES
Robotics and Automation
13/5/24
AUTONOMOUS

BA20151	ENTREPRENEURSHIP DEVELOPMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the Management principles.
2	build the entrepreneurial competencies & analyze the support rendered by government and other agencies in entrepreneurship development.
3	understand the business opportunities & to prepare a Feasibility Report.
4	propose a business plan.
5	appraise & comprehend the various factors to be considered for launching a small business.

UNIT I	BASICS OF MANAGEMENT	9

Management: Meaning, Definition, Nature and Importance; Roles of management - Functions of Management - Levels of Management - Functional areas of Management: Marketing, Finance, Production, HRM, IT, R & D.

The Evolution & Development of Management Thought: Classical, Neo -classical, System and Contingency Approaches - An Overview.

UNIT II	ENTREPRENEURIAL COMPETENCE & ENVIRONMENT	9

Entrepreneurial Competence: Entrepreneurship – Definition, Role and expectations – Entrepreneurial styles and types – Characteristics of the Entrepreneur - Entrepreneurial Competencies – Functions of an Entrepreneur.

Entrepreneurial Environment: Role of Socio-Cultural, Economic and Political Environment – Institutional Support for small entrepreneurs, Assistance Programme for Small Scale Units – Institutional Framework, Central and State Government Industrial Policies and Regulations.

UNIT III	ENTREPRENEURIAL DEVELOPMENT	9

Ownership Structures – Proprietorship, Partnership, Company, Co-operative, Franchise.

Identification of Business Opportunity – Preparation of Feasibility Report – Financial and Technical Evaluation – Project Formulation – Common Errors in Project Formulation – Specimen Project Report.

Entrepreneurial Development Programs — Role of SSI Sector in the Economy – IAS Units - Failure, Causes and Preventive Measures – Turnaround Strategies.

UNIT IV	BUSINESS PLAN PREPARATION, FINANCING VENTURES	9

Business Plan: Business opportunities-SWOT, Business plan process, Feasibility Study, Functional plan- Marketing plan, Operational plan, Organizational plan, financial plan, Evaluation Criteria.

Financing ventures: sources of raising capital, seed funding, venture capital funding, funding opportunities for startups in India.

UNIT V	WOMEN ENTREPRENEURSHIP AND ENTREPRENEURSHIP IN VARIOUS SECTORS	9

Women Entrepreneurship: Growth of women Entrepreneurship – Problems faced by Women Entrepreneurs – Development of women Entrepreneurship.

Entrepreneurship in Informal Sector: Rural Entrepreneurship – Entrepreneurship in Sectors like Agriculture, Tourism, Health care, Transport and allied services.

TOTAL PERIODS | **45**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	implement the necessary managerial skills to become an entrepreneur.	Applying (K3)
CO2	take up self-employment having been exposed to entrepreneurial environment.	Applying (K3)
CO3	select a best business idea by using appropriate methods to assess its viability.	Applying (K3)
CO4	formulate a business plan & deploy the resources for sustainable growth.	Analyzing (K4)
CO5	analyse channels and means of launching a small business in any sector.	Analyzing (K4)

TEXT BOOKS

1. Khanka S.S, "Entrepreneurial Development", S. Chand & Company Limited, New Delhi, 2016.
2. Saravanavel. P, "Entrepreneurial Development", Ess Pee Kay Publishing House, Chennai, 2013.

REFERENCES

1. Donald L. Sexton & Raymond W.Smilor, "The Art and Science of Entrepreneurship", Ballinger Publishing Company, 2008.
2. Clifford M.Baumback & Joseph R.Mancuso, "Entrepreneurship and Venture Management", Prentice Hall, 1975.
3. Gifford Pinchot, "Intrapreneuring" Harper & Row Publishers, New York, 2005.
4. Mathew Manimala, "Entrepreneurship Theory at the Crossroads", Paradigms & Praxis, Biztrantra, 2nd Edition, 2015.
5. Prasanna Chandra, "Projects – Planning, Analysis, Selection, Implementation and Reviews", Tata McGraw-Hill, 2013.
6. P.C.Jain, "Handbook for New Entrepreneurs", EDII, Oxford University Press, New Delhi, 2012.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												**PSO's**	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	-	-	3	1	-	2	2	2	-	2	3	2	3
CO2	-	2	2	-	2	1	-	-	-	-	1	1	1	3
CO3	-	1	1	-	1	1	1	-	1	1	1	3	-	3
CO4	1	1	-	-	-	-	1	-	3	1	1	3	1	2
CO5	1	1	1	-	1	1	2	-	2	1	-	3	-	1

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BOARD OF STUDIES
Master of Business Administration
17/7/20
AUTONOMOUS

RA20501	DESIGN OF ROBOT ELEMENTS	3	1	0	4

COURSE OBJECTIVES

To enable the students to

1	introduce the students to the fundamentals of machine design, material selection and to solve the basic design problems.
2	learn to design of flexible elements and bearing
3	know about design of shafts and threaded fasteners
4	learn and understand the design of gear and gear boxes.
5	Know about fundamentals design of robot grippers and end effectors

UNIT I	FUNDAMENTAL CONCEPTS IN DESIGN	12

Introduction to Robots - factors influencing robot design, selection of materials based on mechanical properties, Modes of failure: Factor of safety – stresses due to bending and torsion moment, Eccentric loading, Design against fluctuating loads; theories of failures.

UNIT II	DESIGN OF FLEXIBLE ELEMENTS AND BEARINGS	12

Introduction to flexible elements, Design of belt drives – Flat, Vee, and Timing Belts; Design of chain drives; Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Somerfield Number, Raimondi & Boyd graphs, Selection of Rolling Contact bearings

UNIT III	DESIGN OF SHAFTS AND THREADED FASTENERS	12

Shafts and Axles - Design of solid and hollow shafts based on strength, rigidity, and critical speed; Keys and splines; Threaded fasteners - Bolted joints, Simple and eccentrically loaded bolted joints.

UNIT IV	DESIGN OF GEARS AND GEAR BOXES	12

Design of Gears (Spur, Helical and Bevel) - Geometric progression, Standard step ratio, Ray diagram, kinematic layout - Design of sliding mesh gear box; Design of multi speed gear box for machine tool applications.

UNIT V	DESIGN OF ROBOT GRIPPERS AND END EFFECTORS	12

Types of End Effectors and Gripper Mechanisms, Force analysis, Miniature Grippers and Micro Grippers, Compliance; Selected case studies - Sheet metal handling, pretension of cuboid / cylindrical / objects, coils, irregular surfaces and flexible objects, handling castings, and medical applications.

	TOTAL PERIODS	60

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	understand cyber-physical control systems and their use in collision avoidance and autonomous vehicles.	Remembering (K1)
CO2	identify the concept of remote sensing and the required sensor technologies for its implementation.	Understanding (K2)
CO3	understand the concept of fully autonomous vehicles.	Applying (K3)

CO4	utilize fundamental principles of wireless communications and wireless data networks.	Applying (K3)
CO5	examine the concept of the connected vehicle and its significance in the realm of automated vehicles.	Analyzing (K4)

TEXT BOOKS

1. Bhandari. V.B, "Design of Machine Elements", Tata McGraw-Hill Education, 5th edition, 2020.
2. Joseph Edward Shigley, Charles R. Mischke, "Mechanical Engineering Design", McGraw Hill, 11th edition, 2020.

REFERENCES

1. Sundararajamoorthy T. V, Shanmugam .N, "Machine Design", Anuradha Publications, 2021.
2. Robert L.Norton, "Machine Design – An Integrated Approach", Prentice Hall International Edition, 5th edition, 2020.
3. Sharma. C.S, Purohit. K.,"Design of Machine Elements", Prentice-Hall of India, 2020.
4. Adam Morecki, JozeKnapczyk, "Basics of Robotics: Theory and Components of Manipulators and Robots", Springer, 2021.

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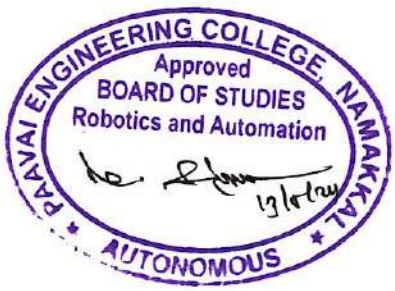
CO's	Programme Outcomes PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	2	-	1	-	-	-	-	-	2	2	3
CO2	3	2	2	1	-	2	-	-	-	-	-	1	2	2
CO3	3	2	1	2	-	1	-	-	-	-	-	2	2	1
CO4	3	2	2	1	-	2	-	-	-	-	-	1	2	2
CO5	3	2	1	2	-	1	-	-	-	-	-	2	2	2



RA20502	PLC AND AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand a clear view on Programmable Logic Controllers (PLC).
2	know the various instructions involved in automatic control and monitoring.
3	understand the PLC program for various applications.
4	familiarize with the importance in maintenance of PLC.
5	learn the concepts of SCADA.

UNIT I	PROGRAMMABLE LOGIC CONTROLLERS	9

Introduction; Parts of PLC; Principles of operation; PLC sizes; PLC hardware components - I/O section, Analog I/O modules, digital I/O modules; PLC programming Simple instructions; output control devices; latching relays; converting simple relay diagram into PLC ladder diagram.

UNIT II	PLC INSTRUCTIONS	9

Timer instructions - ON delay, OFF delay, Cascading timers and retentive Timers; Counter instructions - UP counter, DOWN Counter and cascading counters, Program control instructions; Data manipulating instructions; math Instructions.

UNIT III	AUTOMATION USING PLC	9

Simple materials handling applications; Automatic control of warehouse door; Automatic lubrication of supplier conveyor belt; Automatic car washing machine; Bottle Label detection and process control application.

UNIT IV	PLC MAINTENANCE	9

PLC maintenance – daily, preventive, periodic maintenance; Internal PLC faults; External PLC faults; Watch dogs; Safety - Hardware safety circuits; Troubleshooting; Electrical noise; leaky inputs and outputs; Grounding; Voltage variations and surges.

UNIT V	SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)	9

SCADA overview – Developer and runtime packages – Architecture - Tools - Tag - Internal & External graphics - Alarm logging - Tag logging - Trends – History - Report generation - Communication Protocols of SCADA - Proprietary and Open Protocols. OLE/OPC - DDE - Server/Client - Interfacing of SCADA with PLC and other field devices

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	label the different parts of PLC and its functions.	Remembering (K1)
CO2	classify the various timers and counters used in PLC.	Understanding (K2)
CO3	construct the PLC program for various applications.	Applying (K3)
CO4	analyze the various maintenance techniques in the field of PLC.	Analyzing (K4)
CO5	discover the integration of SCADA with automation systems.	Analyzing (K4)

TEXT BOOKS

1. Petruzella Frank D, Programmable Logic Controllers, Tata McGraw-Hill Publishing (P) Ltd., New Delhi, 2019.
2. R.S.Manoj , "Industrial Automation with SCADA : Concepts, Communications and Security", Notion Press, 2019.

REFERENCES

1. R.S.Manoj , "Industrial Automation with SCADA : Concepts, Communications and Security", Notion Press, 2019.
2. Rajesh Mehra , "PLCs & SCADA : Theory and Practice", Laxmi Publications, 2016.
3. Bolton, "Programmable Logic Controllers 6th Edition Elsevier India, 2016.
4. Madhuchhanda Mitra, Samarjt Sengupta, "Programmable Logic Controllers and Industrial Automation", Penram International Publishing, 2017

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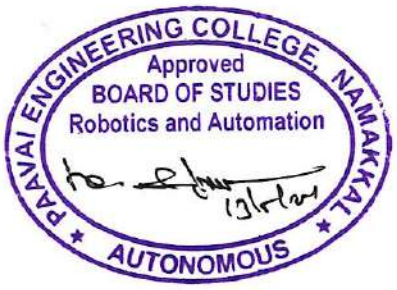
	Programme Outcomes PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	3	3	3	-	-	-	-	-	-	2	2	3
CO2	2	3	3	3	3	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	2	2
CO4	2	1	3	2	-	-	-	-	-	-	-	2	2	3
CO5	3	2	2	3	2	-	-	-	-	-	-	2	3	3



RA20503	ROBOT PATH PLANNING AND PROGRAMMING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce basic trajectory planning problems.
2	provide a basic review of various path planning theory of manipulator.
3	provide a basic review of various path planning theory of mobile robot.
4	introduction to the most widely used classical motion planning algorithms.
5	introduce sufficient terminology and concepts in ROS for robot programming.

UNIT I **TRAJECTORY PLANNING APPROACHES** **9**

Definitions – Task planning and Trajectory planning – Representation of end-effector: Cartesian and joint space schemes. Workspace Analysis: work envelope of a multi DOF manipulator. Applications: Point to point motion and continuous path motion.

UNIT II **TRAJECTORY PLANNING OF MANIPULATOR** **9**

Joint space techniques – Motion profiles – Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion - Cartesian space technique – Straight line and circular trajectories.

UNIT III **PATH PLANNING OF MOBILE ROBOT** **9**

Introduction - Representation of the Robot's Environment - Review of configuration spaces - Visibility Graphs - Voronoi diagrams - Potential Fields – Attractive and Repulsive – Cell Decomposition - Planning with moving obstacles - Probabilistic Roadmaps - Random trees - Execution of the Quadtree- Based Path Planner Program.

UNIT IV **PATH PLANNING ALGORITHMS** **9**

Planning - A*algorithm - the D*algorithm - Path control. Graph search and discrete planning algorithms. - Sensor-Based Motion Planning Algorithms – the "Bug" algorithms – the Tangent Bug algorithm.

UNIT V **ROS PROGRAMMING** **9**

Robot language classification - Programming methods: Lead through method, teach pendent method - Syntax features and applications of various programming languages – Examples - Inter locking commands - Safety features - Introduction to Robot Operating System (ROS) - ROS examples - Introduction to programming using ROS - Industrial ROS - ROS examples - Programming for point to point /continuous – operations - Case Study.

TOTAL PERIODS **45**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	recognize various trajectory planning and path planning for mobile robot and manipulator.	Remembering (K1)
CO2	classify trajectory planning and path planning for mobile robot and manipulator.	Understanding (K2)

CO3	choose appropriate path and trajectory planning algorithm for various industrial applications.	Understanding (K2)
CO4	plan the path and trajectory for various industrial robots and mobile robots for specific applications.	Applying (K3)
CO5	program the developed path and trajectory into real time robot applications.	Analyzing (K4)

TEXT BOOKS

1. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2019.
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard. Lydia Kavraki, Sebastian Thrun , "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2018.

REFERENCES

1. Steve LaValle, "Planning Algorithms", Cambridge Univ. Press, New York, 2016.
2. George A. Kantor, Howie Choset, Kevin M. Lynch, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Bradford Books, 2015.
3. J.C. Latombe, "Robot Motion Planning", The Springer International Series, Paperback, 2019.
4. Patnaik, Srikanta , "Robot Cognition and Navigation An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2017.

CO-PO MAPPING:

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	PO's												PSO's	
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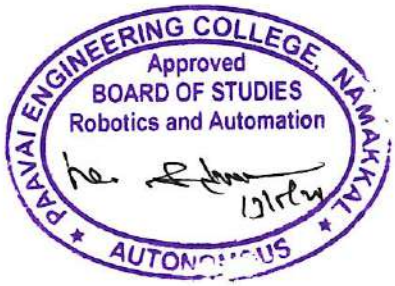
CO3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO4	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO5	2	2	1	3	-	-	-	-	-	-	-	2	2	2



RA20504	FLUID POWER AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	acquire the concepts of fluid power.
2	understand the fundamentals of hydraulic and pneumatic system.
3	impart knowledge on hydraulic circuit and system.
4	familiarize with the circuit design for pneumatic system.
5	learn about basics of trouble shooting and applications.

UNIT I **FLUID POWER SYSTEMS AND HYDRAULIC PUMPS** **9**

Introduction to Fluid power - Advantages and Applications - Fluid Power ANSI Symbols - Types of fluids - Properties of fluids - Pascal's law and Applications, Darcy's equation: Frictional losses. Losses in valves and fittings - Basics of Hydraulics - Principles of flow – Dynamic pump types-Positive displacement pump types -characteristics - Construction, Working, Selection criteria of pumps, Advantages, Disadvantages.

UNIT II **FLUID POWER ACTUATORS AND CONTROL VALVES** **9**

Hydraulic Actuators: Cylinders - Types and construction, Application, Hydraulic cushioning - Hydraulic motors Control Components: Types of valve -Direction control, Flow control and Pressure control valves - Types, Construction and Operation - Servo and Proportional valves – Applications.

UNIT III **HYDRAULIC CIRCUIT AND SYSTEMS** **9**

Intensifiers, Industrial hydraulic circuits - Regenerative, Pump Unloading, Double-pump, Counter balance valve application, Pressure Intensifier, Air - over oil, Reciprocation, Synchronization, Sequencing, Fail-safe circuit, Speed Control circuit, Hydraulic motor braking system, Hydrostatic transmission.

UNIT IV **CIRCUIT DESIGN FOR PNEUMATIC SYSTEMS** **9**

Properties of air - Perfect Gas Laws - Filter, Regulator, Lubricator - Pneumatic actuators, Design of pneumatic circuit cascade method, Step counter method - Electro pneumatic circuits; Accumulators: types and applications; Pneumatic vacuum systems and application.

UNIT V **TROUBLE SHOOTING AND APPLICATIONS** **9**

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

TOTAL PERIODS **45**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	show symbols and various pumps utilized in hydraulic and pneumatic systems.	Remembering (K1)

CO2	recognize suitable components for hydraulic and pneumatic systems.	Understanding (K2)
CO3	manage and uphold diverse hydraulic circuits in industrial settings.	Applying (K3)
CO4	create a pneumatic circuit for a straightforward application.	Applying (K3)
CO5	elaborate on fluid logic control systems and the maintenance of fluid systems.	Analyzing (K4)

TEXT BOOKS

1. Anthony Esposito, "Fluid power with applications", 7th edition. Pearson Education Inc. 2018.
2. Cassi Piccuillo, "Pneumatic system: principle and Maintenance: Pneumatic", Independently Published, 2021.

REFERENCES

1. Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 2017.
2. James L.Johnson, "Introduction to Fluid Power", Delmar Thomson Learning, 2018.
3. Avinash G. patil,Vinayak K.Gaikwad and Dr.Vikas V.Shinde, " Hydraulic and Pneumatic",2nd edition, Technical Publications.2019.
4. Ilango,Sivaraman, " Introduction to Hydraulics And Pneumatics", 3rd edition,PHI Learning.2017.

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CO's	Programme Outcomes PO's												PSO's	
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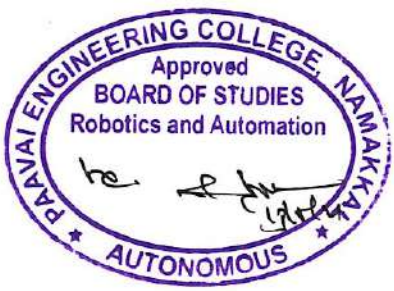
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3	2
CO3	2	2	2	3	2	-	-	-	-	-	-	3	2	3
CO4	3	3	2	2	2	-	-	-	-	-	-	3	3	2
CO5	2	3	3	2	3	-	-	-	-	-	-	2	3	2



RA20505	FLUID POWER SYSTEM LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	understand the role of pneumatic and hydraulic systems in a complex mechatronics system.
2	analyze pneumatic and hydraulic circuits, and identify basic components.
3	invent and provide hand on experience to students to design and test hydraulic circuit to control press.
4	design and test hydraulic, pneumatic circuits to perform basic operations.

LIST OF EXPERIMENTS

1. Study of fluid power standard, hydraulic and pneumatic systems components.
2. Design of pressure control of pneumatic circuit.
3. Design of meter in circuit and meter out circuit.
4. Design of speed control circuit for double acting pneumatic cylinder.
5. Design of hydraulic press circuit.
6. Design of hand operated pneumatic double acting cylinder using fluid power simulation software.
7. Design of hydraulic cylinder reciprocating system using fluid power simulation software.
8. Design and testing of pneumatic double acting cylinder sequencing circuit (A+ B+ A- B-) using fluid power simulation software
9. Design and testing of pneumatic double acting cylinder synchronization circuits (cylinders connected in series and parallel) using fluid power simulation software.
10. Design of pneumatic circuit for a drilling operation and simulate the operation in a fluid power simulation software.
11. Design fluid power circuits for an industrial application.
12. Design of hydraulic circuits with multi cylinders using fluid power simulation software.

TOTAL PERIODS	**30**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	discover the usage of typical hydraulic and pneumatic machines in industries.	Remembering (K1)
CO2	create fluid systems for diverse applications.	Understanding (K2)
CO3	contrast hydraulic, pneumatic, and mechanical systems.	Applying (K3)
CO4	develop a hydraulic or pneumatic system circuit using relevant software and conduct simulations.	Analyzing (K4)

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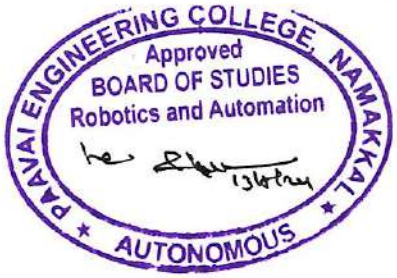
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3	2	-	-	2	2	2	-	2	3	2
CO2	2	2	2	2	2	-	-	3	2	2	-	2	2	3
CO3	2	2	2	2	2	-	-	2	2	3	-	2	2	2
CO4	2	2	2	2	3	-	-	2	3	2	-	2	2	3



RA20506	PLC AND AUTOMATION LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	understand a clear view on Programmable Logic Controllers (PLC).
2	acquire knowledge on PLC control principles and applications with field devices.
3	learn the ladder diagrams for automatic control and monitoring.
4	understand the interfacing of microcontroller with stepper motor.

LIST OF EXPERIMENTS

1. Study of Programmable Logic Controllers.
2. Sequential operation of pneumatic cylinders using PLC.
3. Hydraulic motor with timer using PLC.
4. Automate the tank water level control using PLC.
5. Automatic bottle filling process using PLC.
6. Traffic light controller.
7. Programming the material handling system.
8. Programming and control the lamp by timer.
9. Programming the linear actuation of hydraulic cylinder.
10. Programming the automatic car parking system using counter.
11. Stepper motor interface.

TOTAL PERIODS | **30**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	construct the PLC program for cylinder actuation and control.	Applying (K3)
CO2	develop the PLC program for tank water level control and bottle filling process.	Applying (K3)
CO3	implement traffic control using PLC.	Analyzing (K4)
CO4	interface the microcontroller with stepper motor.	Analyzing (K4)

CO-PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	2	2	-	-	-	3	-	-	2	2	3
CO2	3	1	2	2	3	-	-	-	3	-	-	3	2	2
CO3	2	2	3	2	3	-	-	-	3	-	-	2	3	2
CO4	2	2	3	2	3	-	-	-	3	-	-	2	3	3

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Robotics and Automation
13/12/24
AUTONOMOUS

EN20501	CAREER DEVELOPMENT LABORATORY I	0	0	2	1

COURSE OBJECTIVES

To enable students to

1	enhance their writing skills.
2	evaluate their presentation skill to face the corporate world.
3	solve the quantitative aptitude problems and improve their mental ability.
4	improve the critical thinking and reasoning skills.

UNIT I	WRITING SKILLS	6

Writing Skills: The Essentials of Writing – The Importance of Structure – Types of Writing – Common Mistakes in Writing.

Activities: Email Writing – Paragraph writing – Report Writing – Story Writing - Story Telling Session: 2 – JAM Session 1.

UNIT II	PRESENTATION SKILLS AND GROUP DISCUSSION	6

Presentation Skills: Types of Presentation – Methods of Delivering Presentation –Ways to improve the Presentation – Presentation Aids; Group Discussion: Introduction –Types and Importance – Why GD – Types of GD- Evaluation Criteria – Do's and Don'ts of GD.

Activities: Presentation Session I, Group Discussion Session I, Role Play Session (Team): Level II – Personality Profile Session II – Company Profile Analysis Session II.

UNIT III	QUANTITATIVE APTITUDE	6

Simplification – Cubes and Cube Roots – Squares and Square Roots – Boats and Streams – Trains – Profit and Loss – Pipes and Cisterns.

UNIT IV	LOGICAL REASONING - I	6

Series Completion – Letter Series – Symbol Series – Number Series – Arithmetic Reasoning.

UNIT V	LOGICAL REASONING - II	6

Blood Relations – Seating Arrangement - Character Puzzle.

	TOTAL PERIODS	30

COURSE OUTCOMES At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	excel in drafting mails and speaking.	Analyzing (K4)
CO2	demonstrate the participative skills in group discussions.	Applying (K3)
CO3	solve problems based on quantitative aptitude.	Applying (K3)
CO4	enhance their logical and verbal reasoning.	Analyzing (K4)

TEXTBOOKS

1. Agarwal, R.S." A Modern Approach to Verbal and Non Verbal Reasoning", S.Chand & Co Ltd, New Delhi, 2015.
2. Agarwal, R.S. " Objective General English", S.Chand & Co. 2016.

REFERENCES

1. Abhijit Guha, "Quantitative Aptitude ", Tata-Mcgraw Hill, 2015.
2. Word Power Made Easy By Norman Lewis, Wr.Goyal Publications, 2016.
3. Johnson, D.W. Reaching out – Interpersonal Effectiveness and self-actualization. Boston: Allyn and Bacon, 2019.
4. Infosys Campus Connect Program – students' guide for soft skills, 2015.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's)
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes (PO's)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	3	1	-	-	-	-	-	-	3	2
CO2	-	2	3	-	2	-	2	-	-	-	-	-	3	2
CO3	3	2	2	-	-	1	-	-	-	-	2	-	2	3
CO4	2	3	3	2	1	3	3	1	-	1	2	-	2	3

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English
12/8/22
AUTONOMOUS

RA20601	AUTOMATION SYSTEM DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	know fundamentals of various automation process.
2	aware the concepts related to automation components.
3	learn the automated assembly and transfer lines.
4	understand the parts design for automatic assembly.
5	aware of system integration and implementation.

UNIT I	INTRODUCTION TO PROCESS AUTOMATION	9

Process Automation – paper industry, packaging industry, food processing industry, Integrated design issues in automation systems, the Mechatronics design process- benefits, modeling of electromechanical systems, bond graph technique, Automation migration strategy - building blocks of automation systems.

UNIT II	SELECTION OF MOTION COMPONENTS	9

Selection of motor for automation system, Calculation of inertia force for motor, LM Guide ways, Ball screws, Selection, from the manufacturer's catalogue based on the applications.

UNIT III	TRANSFER LINES AND AUTOMATED ASSEMBLY	9

General terminology-takt time, setup time and cycle time, Automated flow lines with storage buffers. Automated assembly-design for automated assembly, types of automated assembly systems, part feeding devices, analysis of multi-station assembly machines - modular fixturing - Flow line balancing.

UNIT IV	DESIGN FOR HIGH SPEED AUTOMATIC ASSEMBLY	9

Introduction, Design of parts for high speed feeding and orienting, high speed automatic insertion, Analysis of an assembly, General rules for product design for automation - Application of high speed automatic assembly.

UNIT V	SYSTEM INTEGRATION	9

Issues and systematic approaches, design and simulation using CIROS software, economics of automation systems design and implementation.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	specify the automation process and requirements.	Remembering (K1)
CO2	select the appropriate precision motion components based on the application.	Understanding (K2)
CO3	describe the considerations automated assembly and transfer lines.	Understanding (K2)
CO4	describe the basic design considerations of high speed automatic assembly.	Applying (K3)
CO5	analyze the integration automation components.	Analyzing (K4)

TEXT BOOKS

1. Mikell P Groove, "Automation Production Systems and Computer Integrated Manufacturing", Pearson education, New Delhi, 2019.
2. Geoffery Boothroyd, "Assembly Automation and Product Design", CRC Press, USA, 2021.

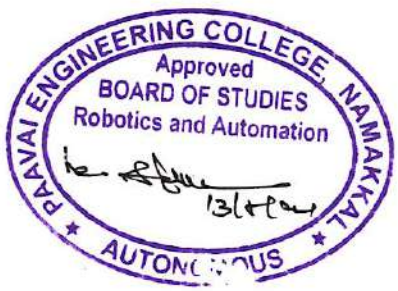
REFERENCES

1. Devadas Shetty, "Mechatronics System Design", PWS Publishing Company, USA, 2018.
2. Wilfried Voss, "A Comprehensible Guide to Servo Motor Sizing", Copperhill Technologies Corporation, Massachusetts, 2017.
3. Conveyor Equipment Manufacturers Association, "Belt Conveyors for Bulk Materials", CBI Publishing Company, Massachusetts, 2020.
4. HIWIN Linear Guideway – Technical Information Index, 2019.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2	2	-	-	-	2	-	-	-	2	2	2
CO2	2	3	2	2	-	-	-	-	-	-	-	2	2	1
CO3	2	3	2	2	-	-	-	-	-	-	-	2	1	2
CO4	2	2	3	1	-	-	-	2	-	-	-	2	3	1
CO5	2	2	2	2	3	-	-	-	-	-	-	2	2	3



RA20602	POWER ELECTRONICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	impart knowledge on different types of power semi-conductor devices and their switching characteristics.
2	know the controlling techniques of switching devices and protection of power semiconductor devices.
3	understand the operation of Phase controlled convel1er and various chopper conversion techniques.
4	study the mode of inverters and different modulation techniques.
5	learn the types of AC voltage controllers and basics of matrix converters.

UNIT I	POWER SEMI-CONDUCTOR DEVICES	9

Study of switching devices- Construction, working operation , I-V Characteristics of Power Diode, SCR, TRIAC, GTO, BJT, MOSFET and IGBT.

UNIT II	GATE DRIVE AND PROTECTION CIRCUIT	9

Gate triggering circuits- Firing circuit for the SCR, R, RC, UJT; Drive circuits for BJT, gate drive circuits for MOSFET and IGBT; Isolation of gate and base drives- Pulse transformer, optocouplers; Protection circuits- Snubber circuits, di/dt protection with the help of inductor.

UNIT III	THYRISTOR RECTIFIERS AND CHOPPER	9

Phase controlled converter- 2-pulse, 6-pulseconverters(R Load); Chopper- Step-down and step-up chopper, switched mode regulators, buck, boost, buck-boost converter; Introduction to resonant converters.

UNIT IV	INVERTERS	9

Single phase and three phase voltage source inverters (180 degree mode)(R Load); PWM techniques- Multiple PWM, sinusoidal PWM, modified sinusoidal PWM; Current source inverter, Introduction to space vector modulation; Current source inverter, Applications- UPS.

UNIT V	AC VOLTAGE REGULATOR	9

Single phase AC Voltage Regulator and Three phase AC Voltage Regulator(R Load) - multistage sequence control; Single phase and three phase cyclo converters; Introduction to matrix converters.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	identify and select the switching devices for different power converter applications.	Remembering (K1)
CO2	apply the different controlling techniques and protection schemes based on the load.	Understanding (K2)

CO3	design a suitable DC power supply for given load specification from AC and DC supply.	Understanding (K2)
CO4	describe and analyze the single and three phase inverters.	Applying (K3)
CO5	explain an AC voltage controller electromagnetic compatibility of power converters.	Analyzing (K4)

TEXT BOOKS

1. M.H.Rashid, Power Electronics: Circuits, Devices Applications, Pearson, 2016.
2. M.D. Singh and Khanchandani K:B., Power Electronics, Tata Mc.Graw Hill., 2016.

REFERENCES

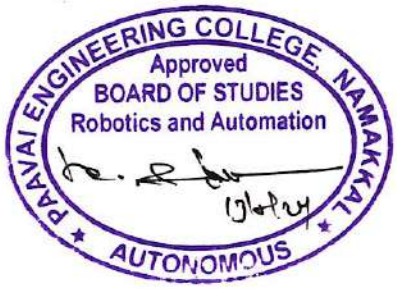
1. L.Umanand, Power Electronics Essentials and Appli cations, Wiley India Pvt Ltd, Reprint, 2015.
2. G.K. Dubey, S.R. Doradla, A. Joshi and R.M.K. Sinha, Thyristorised Power Controllers, NewAge, International Publishers, 2017.
3. Ned Mohan,Tore M. Undeland and Willi am P.Robins, Power Electronics - Converters, Applications and Design Third Edition, John Wiley and Sons, 2018.
4. R.S. Ananda Murthy and V. Nattarasu, Power Electronics: A Simplified Approach, Pearson /Sanguine Technical Publishers, 2017.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	1	-	-	-	-	-	-	-	1	1	3	3
CO2	3	1	2	-	-	-	-	-	-	-	2	1	3	3
CO3	3	1	2	-	-	-	-	-	-	-	2	1	3	3
CO4	3	1	2	-	-	-	-	-	-	-	2	1	3	3
CO5	3	1	2	-	-	-	-	-	-	-	2	1	3	3



RA20603	EMBEDDED SYSTEM DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the building blocks of an embedded system and software tools.
2	emphasize the role of input/output interfacing with bus communication protocol.
3	illustrate the software developmental tools.
4	explain the basics of a real-time operating system.
5	analyze the applications based on embedded design approaches.

UNIT I	INTRODUCTION TO EMBEDDED SYSTEMS	9

Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor and memory devices - DMA - Memory management methods - Software architecture of embedded system.

UNIT II	EMBEDDED NETWORKING	10

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols RS232 standard – RS485 – CAN Bus- Serial Peripheral Interface (SPI) – Inter- Integrated Circuits (I^2C).

UNIT III	EMBEDDED SOFTWARE DEVELOPMENT TOOLS	10

Introduction to embedded software development tools – Host and Target machines – Linking and locating Software – Issues in hardware - software design – Basic concepts of compiler, Linker, Loader, Simulator, Emulator, Logic Analyzer, Watchdog timer and ICE.

UNIT IV	RTOS-BASED EMBEDDED SYSTEM DESIGN	10

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication-shared memory, message passing- Interprocess Communication- Introduction to process synchronization using semaphores.

UNIT V	EMBEDDED SYSTEMS APPLICATION	6

Case Study: Precision Agriculture - Autonomous car - Digital still Camera.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	know the hardware functional and software strategies required to develop the embedded systems.	Remembering (K1)
CO2	basic differences between various bus communication standards.	Understanding (K2)
CO3	incorporation of the different software tools.	Understanding (K2)
CO4	various scheduling algorithms through a real-time operating system.	Applying (K3)
CO5	various embedded concepts for developing automation applications.	Analyzing (K4)

TEXT BOOKS

1. Rajkamal, 'Embedded system-Architecture, Programming, Design, McGraw Hill ,3rd edition, 2017.
2. K.V.K.K.Prasad "Embedded System – Architecture Programming, Design', McGraw Hill, 2013.

REFERENCES

1. Peckol, "Embedded system Design", John Wiley & Sons, 2010.
2. Shibu. K.V, "Introduction to Embedded Systems", Tata Mcgraw Hill, 2nd edition, 2017.
3. Lya B.Das, "Embedded Systems", Pearson Education, 1st edition, 2012.
4. Parag H.Dave, Himanshu B.Dave, "Embedded Systems - Concepts, Design and Programming", Pearson Education, 2015.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2	2	1	-	-	-	-	-	-	1	2	2
CO2	3	2	3	2	1	-	-	-	-	-	-	1	2	1
CO3	3	3	2	3	1	-	-	-	-	-	-	1	2	1
CO4	3	2	2	2	1	-	-	-	-	-	-	1	1	2
CO5	3	2	1	2	1	-	-	-	-	-	-	1	3	1

RA20604	ROBOT DYNAMICS AND CONTROL	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	learn and understand generalized co-ordinates, jacobian matrix mass distribution and other fundamental equations.
2	understand lagrangian and hamiltonian mechanics.
3	understand nonlinearities in control system.
4	understand various force control strategies.
5	understand various concepts in linearizing a no linear signal.

UNIT I	ROBOT FORCE MODELS	9

Generalized co-ordinates - Generalized Forces - Equation of Motions – Static Forces in Manipulators - Jacobian matrix - Jacobians in The Force Domain - Cartesian Transformation of Velocities and Static Forces - Acceleration of A Rigid Body - Mass Distribution – Nonrigid Body Effects - Newton's Equation - Euler's Equation – Langrage Equation.

UNIT II	ROBOT DYNAMICS	9

General Expressions for Kinetic and Potential Energy - Kinetic Energy for an n-Link Robot - Potential Energy for an n-Link Robot - Equations of Motion - Lagrangian Multiplier - Langrage's Equation - Hamilton Equation - Hamilton vector Field- Euler - Langrage Equation – State Vector and Equation Formulation.

UNIT III	ROBOT CONTROL SYSTEM	9

The manipulator control problem, Linear second-order model of manipulator. Functions of controller and power amplifier. Joint actuators- stepper motor, servo motor. Control Schemes: PID control scheme – Position and force control schemes. Robotic sensors and its classification, Internal sensors – Position, velocity, acceleration and force information. External Sensors – Contact sensors - Limit switches, piezoelectric, pressure pads, Non-contact sensors – Range sensors, Vision sensor- robotic vision system, Description of components of vision system.

UNIT IV	CONTROL OF MANIPULATORS	9

Linear Time Varying and Linearization – Input and Output Stability - Background: The Frobenius Theorem - Single-Input Systems. Introduction to nonlinear system – time varying systems - multi-input, multi-output control systems - the control problem for manipulators - practical considerations - current industrial-robot control systems - Lyapunov stability analysis – Cartesian - based control systems - adaptive control - Limit Cycle - Describing Function.

UNIT V	FORCE CONTROL	9

Constrained Dynamics - Static Force/Torque Relationships - Constraint Surfaces - Natural and Artificial Constraints - Network Models and Impedance - Impedance Operators - Classification of Impedance Operators - Force Control Strategies - Impedance Control - Hybrid Impedance Control.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	describe generalized co-ordinates, jacobian matrix mass distribution and equation of motion.	Remembering (K1)
CO2	evaluate dynamics of robot using lagrangian and hamiltonian mechanics.	Understanding (K2)
CO3	describe the sensors in robot control system.	Understanding (K2)
CO4	evaluate the architecture of robot manipulator.	Applying (K3)
CO5	develop the control strategies for robot system.	Analyzing (K4)

TEXT BOOKS

1. Groover,M.P., Weis.M., Nagel,R.N. and Odrey,N.G., "Industrial Robotics Technology, Programming and Applications", McGraw-Hill, Int., 2019.
2. John J. Craig, "Introduction to Robotics - Mechanics and control", 3rd edition, Prentice hall, 2016.

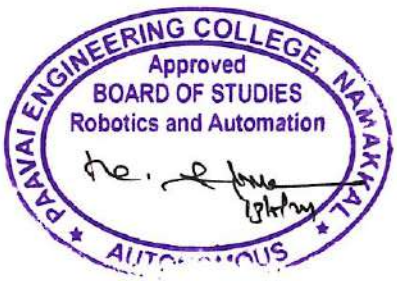
REFERENCES

1. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 2018.
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, John Wiley & sons, Inc., 2019.
3. Klafter,R.D., Chmielewski, T.A. and Negin,M., "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 2016.
4. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robotics", 3rd edition, John & sons, 2020.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	1	1	-	-	-	-	-	-	-	2	1	1
CO2	2	3	2	1	-	-	-	-	-	-	-	2	2	2
CO3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO4	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO5	2	2	1	3	-	-	-	-	-	-	-	2	2	2



RA20605	POWER ELECTRONICS LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	study the VI characteristics of SCR, TRIAC, MOSFET and IGBT.
2	analyze the performance of semi converter, full converter, step up, step down choppers by simulation and experimentation.
3	study the behavior of voltage waveforms of PWM inverter applying various modulation techniques.
4	design and analyze the performance of AC Voltage controller.

LIST OF EXPERIMENTS

1. Characteristics of SCR and TRIAC.
2. Characteristics of MOSFET and IGBT.
3. UJT Triggering Circuits
4. AC to DC half controlled converter.
5. AC to DC fully controlled converter.
6. Step down MOSFET based choppers.
7. Step up MOSFET based choppers.
8. IGBT based single phase PWM inverter.
9. IGBT based three phase PWM inverter.
10. AC Voltage controller.

TOTAL PERIODS 30

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	determine the characteristics of SCR, IGBT, TRIAC, MOSFET and IGBT.	Understanding (K2)
CO2	find the transfer characteristics of full converter, semi converter, step up and step down choppers by simulation experimentation.	Understanding (K2)
CO3	analyze the voltage waveforms for PWM inverter using various modulation techniques.	Applying (K3)
CO4	design and experimentally verify the performance of basic DC/DC converter topologies used for AC Voltage controller.	Analyzing (K4)

CO-PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	3	-	-	-	-	-	3	-	1	1	3	3
CO2	3	2	3	-	-	-	-	-	3	-	2	1	3	3
CO3	3	2	3	-	-	-	-	-	3	-	2	1	3	3
CO4	3	2	3	-	-	-	-	-	3	-	2	1	3	3

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Robotics and Automation
19/4/24
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RA20606	ROBOT KINEMATICS AND DYNAMICS LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	model and simulate a robot and verify its kinematics.
2	model and simulate a robot and generate a trajectory plan.
3	model and simulate a robot and verify its forward dynamics.
4	model and simulate a robot and verify its inverse dynamics.

LIST OF EXPERIMENTS

1. Verification of forward kinematics for 2R, 2P and RP robot.
2. Verification of D-H transformation for 6DOF Serial manipulator
3. Verification of inverse kinematics for 2R, 2P and RP robot.
4. Verification of forward kinematics for 3R spatial robot.
5. Kinematic analysis of 2R planar robot for varying trajectories using Robo analyzer.
6. Workspace analysis of 2R planar robot manipulator for a specified trajectory.
7. Kinematic analysis of 6 DOF robot for varying trajectories using Robo analyzer.
8. Inverse dynamic analysis of 6 DOF robot robot for varying trajectories using Robo analyzer.
9. Forward and inverse dynamics of 2R planar robot using Robo analyzer.
10. Creation of Robot in ROS using Gazebo/V-REP.
11. Motion simulation of robot in ROS using Gazebo/V-REP/Moveit/Industrial.
12. Simulation of trajectory analysis of 2R and 3R manipulators using MATLAB - SIMULINK.

TOTAL PERIODS	**30**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the kinematics and dynamics for various robots.	Analyzing (K4)
CO2	simulate and evaluate the kinematics for various robots.	Applying (K3)
CO3	simulate and evaluate the dynamics for various robots.	Applying (K3)
CO4	create a robot and program a trajectory plan for the robot.	Analyzing (K4)

CO-PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	1	2	-	-	1	3	-	-	2	2	3
CO2	3	2	1	2	3	-	-	1	3	-	-	2	2	3
CO3	3	2	1	2	3	-	-	1	3	-	-	2	2	3
CO4	3	2	1	1	3	-	-	-	3	-	-	2	3	3

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EN20601	CAREER DEVELOPMENT LABORATORY II	0	0	2	1

COURSE OBJECTIVES

To enable students to

1	draft resume and enhance their skills to manage stress to survive in corporate world.
2	excel in interview skills.
3	solve the quantitative aptitude problems and improve their problem-solving skills.
4	improve their reasoning skills to get placed in reputed companies.

UNIT I	RESUME WRITINGS	6

Resume Writing Skills: Curriculum Vitae and Resume – Things to do while writing a Resume – Mistakes and Pitfalls to Avoid- Cover Letter: General Guidelines – The Content - Stress Management – Dressing Etiquette.

Activities: Corporate Resume Building Session I – JAM Session: Level III – Role Play Session (Individual): Level III - Company Profile Analysis Session III – Personality Profile Analysis Session III.

UNIT II	INTERVIEW SKILLS	6

Interview Skills: Introduction – Before the Interview – During the Interview – After the Interview – Types of Interview.

Activities: Presentation Session: Level II- Group Discussion Session: Level III, Mock Interview Practice Session, Corporate Resume Building Session II.

UNIT III	QUANTITATIVE APTITUDE	6

Permutation and Combination – Probability: Dice, Colors, Coin, Cards; Partnership – Ages – Calendars.

UNIT IV	LOGICAL REASONING - I	6

Making Judgments – Matching Definitions – Cause and Effect.

UNIT V	LOGICAL REASONING - II	6

Directions – Syllogism – Analogy – Statements and Arguments.

TOTAL PERIODS	30

COURSE OUTCOMES At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	write resume and enhance their etiquettes.	Analyzing (K4)
CO2	demonstrate the interpersonal skills in group discussions.	Applying (K3)
CO3	compute problems based on quantitative aptitude.	Applying (K3)
CO4	reveal their logical and verbal reasoning by scoring the expected percentage to get placed in reputed companies.	Analyzing (K4)

TEXTBOOKS

1. Agarwal, R.S." A Modern Approach to Verbal and Non Verbal Reasoning", S.Chand & Co Ltd, New Delhi, 2015.
2. Agarwal, R.S. " Objective General English", S.Chand & Co, 2016.

REFERENCES

1. Abhijit Guha, "Quantitative Aptitude ", Tata-Mcgraw Hill, 2015.
2. Word Power Made Easy By Norman Lewis, Wr.Goyal Publications, 2016.
3. Johnson, D.W. Reaching out – Interpersonal Effectiveness and self-actualization. Boston: Allyn and Bacon, 2019.
4. Infosys Campus Connect Program – students' guide for soft skills, 2015.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's)
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes (PO's)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	3	1	-	-	-	-	-	-	3	2
CO2	-	2	3	-	2	-	2	-	-	-	-	-	3	2
CO3	3	2	2	-	-	1	-	-	-	-	2	-	2	3
CO4	2	3	3	2	1	3	3	1	-	1	2	-	2	3

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PROFESSIONAL ELECTIVE COURSES (PE)

PROFESSIONAL ELECTIVE – I

RA20151	MICROROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	expose the fundamental aspects of the emerging field of micro robotics.
2	learn micro scale, technologies for fabricating small devices, bio-inspired design, and applications of the field.
3	understand various Mathematical formalism for flexures, Electrostatic actuators, Piezo-electric actuators, Magneto-strictive actuator and other sensors.
4	know various applications micro robotics.
5	engage in implementation of microrobotics.

UNIT I	INTRODUCTION TO MICROROBOTICS AND APPLICATIONS	9

Introduction to Micro robotics; MST (Micro System Technology); Micromachining - Working principles of Microsystems Applications of Microsystems, Micro-fabrication principles, Design selection criteria for micromachining; Packaging and Integration aspects; Micro-assembly platforms and manipulators.

UNIT II	SCALING LAWS AND MATERIALS FOR MEMS	9

Introduction; Scaling laws - Scaling effect on physical properties scaling effects on Electrical properties, scaling effect on physical forces;Physics of Adhesion – Silicon; compatible material system; Shape memory alloys; Material properties - Piezoresistivity, Piezoelectricity and Thermoelectricity.

UNIT III	FLEXURES, ACTUATORS AND SENSORS	9

Elemental flexures - Flexure systems, Mathematical formalism for flexures; Electrostatic actuators; Piezo-electric actuators; Magneto-strictive actuators; Electromagnetic sensors; Optical-based displacement sensors; Motion tracking with microscopes.

UNIT IV	MICROROBOTICS	9

Introduction; Task specific definition of micro-robots; Size and Fabrication Technology based definition of micro- robots; Mobility and Functional-based definition of micro-robots; Applications for MEMS based micro-robots.

UNIT V	IMPLEMENTATION OF MICROROBOTS	9

Arrayed actuator principles for micro-robotic applications; Micro-robotic actuators; Design of locomotive micro-robot devices based on arrayed actuators; Micro-robotics devices; Micro- grippers and other micro-tools;Micro-conveyors; Walking MEMS Micro-robots; Multi-robot system - Micro-robot powering, Micro-robot communication.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	explain and apply the concepts of mass, energy, and momentum	Understanding (K2)

	balance in microrobotics.	
CO2	apply adapt, and synthesize learned engineering skills to create microrobot.	Applying (K3)
CO3	model micro robots for different robotics applications.	Applying (K3)
CO4	formulate the specifications and design of mechatronic systems.	Analyzing (K4)
CO5	program the micro robot for different robotics applications.	Analyzing (K4)

TEXT BOOKS

1. Mohamed Gad-el-Hak, "The MEMS Handbook", 2nd Edition, CRC Press, New York, 2019.
2. Yves Bellouard, "Microrobotics Methods and Applications", CRC Press, Massachusetts, 2019.

REFERENCES

1. Nadim Maluf and Kirt Williams, "An Introduction to Micro electromechanical systems Engineering", 2nd edition, Artech House, 2004.
2. Julian W Gardner, "Microsensors: Principles and Applications", 2nd edition, Wiley, 2007.
3. MetinSitti, "Mobile Microrobotics", MIT Press, 2017.
4. Nicolas Chaillet, Stephane Rangier "Microrobotics for Micromanipulation", John Wiley & Sons, 2013.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	1	2	-	-	-	-	-	-	2	2	2
CO2	3	2	1	1	2	-	-	-	-	-	-	3	2	2
CO3	3	2	1	1	2	-	-	-	-	-	-	2	2	2
CO4	3	2	1	1	2	-	-	-	-	-	-	3	2	2
CO5	3	2	1	1	2	-	-	-	-	-	-	2	2	2

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RA20152	ADVANCED MANUFACTURING PROCESSES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	know the fundamental concepts in powder metallurgy.
2	learn various non-traditional machining processes and advanced inspection systems.
3	know the advanced machining and finishing processes like CNC, mico and nano machining processes, abrasive finishing processes etc.
4	understanding students an introduction to an advanced process technique.
5	learn about the various advanced inspection techniques and applications.

UNIT I	POWDER METALLURGY	9

Powder Metallurgy (PM) - Stages in powder metallurgy, production of metal powders, characteristics of metal powders, Mixing of metallic powders, compaction, Mechanism of sintering, applications; Impregnation and Infiltration Advantages, disadvantages and specific applications of PM.

UNIT II	NON-CONVENTIONAL MAHINING PROCESS	9

Non-conventional machining processes - Comparison between traditional and non-traditional machining process; Abrasive Jet Machining; Electrical Discharge Machining; Electrochemical Machining; Ultrasonic Machining; Laser Beam Machining; Electron Beam machining; Introduction to Rapid Prototyping & Rapid Tooling.

UNIT III	CNC MACHINES	9

CNC machines - Overview, types, construction, tool and work holding devices, feedback devices, part programming, examples; Data exchange between CAD/CAM - Concepts of native and neutral file formats for data exchange, Interfacing with manufacturing systems; Computer aided process planning.

UNIT IV	ADVANCED FINISHING PROCESSES	9

Abrasive Flow Machining; Magnetic Abrasive Finishing, chemo mechanical polishings; Magneto rheological Abrasive Flow Finishing; Magnetic Float Polishing; Elastic Emission Machining; Material addition process - stereo lithography, selective laser sintering, 3D Printing, fused deposition modelling, laminated object manufacturing, laser engineered net - shaping, laser welding, LIGA process, applications.

UNIT V	ADVANCED INSPECTION TECHNOLOGIES	9

Automated Inspection - Coordinate Measuring Machines, Construction, operation & Programming, Software, Application & Benefits; Flexible Inspection System - Inspection Probes on Machine Tools, Machine Vision, contact and non-contact Optical Inspection Techniques & Non-contact Non-optical Inspection Technologies.

TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	grasp the importance of powder metallurgy and the process steps for manufacturing a powder metallurgy component.	Remembering (K1)
CO2	utilize knowledge of different energy-based non-traditional machining processes to recommend an appropriate method based on specific situations.	Understanding (K2)
CO3	enhance programming abilities for creating or modifying cnc programs, with a focus on understanding g and m codes.	Applying (K3)
CO4	identify and quantify measurement errors, then recommend appropriate techniques to reduce them.	Analyzing (K4)
CO5	choose a particular material addition, micro, nano, or super-finishing process.	Analyzing (K4)

TEXT BOOKS

1. Sharma.P.C, "A textbook of Production Technology", Vol I and II, S. Chand and Company Ltd., New Delhi, 2021.
2. SeropeKalpakjian and Steven Schmid, "Manufacturing Engineering and Technology", Pearson Education, 7th edition, 2020.

REFERENCES

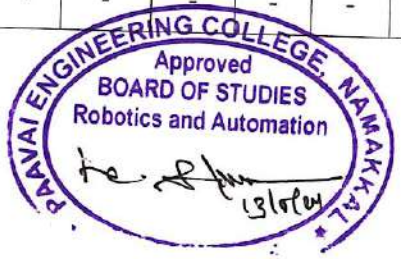
1. Serope Kalpakjian and Steven Schmid, Manufacturing Engineering and Technology, 8th Edition, Pearson, 2020.
2. Ibrahim Zeid and R Sivasubramanian, CAD/CAM Theory and Practice, Tata McGraw Hill, 2022.
3. Benedict. G.F. Nontraditional Manufacturing Processes, Marcel Dekker Inc., New York, 2020.
4. Jagadeesha T, Non-Traditional Machining Processes, I K International Publishing House 2021.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	3	2	-	-	-	-	-	-	2	3	3
CO2	2	1	3	2	1	-	-	-	-	-	-	2	1	2
CO3	2	2	2	3	2	-	-	-	-	-	-	3	2	2
CO4	2	2	3	2	2	-	-	-	-	-	-	2	3	2
CO5	3	1	3	3	1	-	-	-	-	-	-	2	2	2



RA20153	CONDITION MONITORING AND FAULT DIAGNOSTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the various types of maintenance, their procedure and defects analysis commonly adopted in manufacturing industries.
2	know the different types of maintenance.
3	learn the procedures and guidelines on work permit system to carry out jobs of inspection, testing, maintenance, alternation, repair, upkeepment and construction in safest possible manner.
4	know the usage of computers for maintenance management.
5	understand the various condition monitoring techniques

UNIT I	CONDITION MONITORING TECHNIQUES AND MACHINE CONDITION MONITORING	9

Condition Monitoring in manufacturing industries; Noise monitoring, Wear and debris Analysis, Thermography, Cracks monitoring, Ultrasonic techniques - Case studies. Vibration, Acoustic emission and vibro-acoustics signal analysis; intelligent fault detection system, Case studies.

UNIT II	SENSORS FOR FAULT DIAGNOSTICS	9

Introduction - Contaminant monitoring sensors- Corrosion monitoring sensors - Force monitoring sensors - Gas leakage monitoring - sensors Air pollution monitoring sensors - Liquid contamination monitoring sensors - Non-destructive testing techniques - Optical examination -Temperature sensing

UNIT III	SIGNAL PROCESSING AND ANALYSIS	9

Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions. Time domain and Frequency domain and Time-frequency domain analysis.

UNIT IV	FAILURE ANALYSIS, MAINTENANCE AND MACHINE LEARNING	9

Maintenance Principles, Failure mode analysis - Equipment down time analysis – Breakdown analysis - condition based maintenance, Vibration, Acoustic emission and vibrio-acoustics signal analysis; intelligent fault detection system, Case studies.

UNIT V	MONITORING SYSTEMS CASE STUDEIS	9

Introduction - Marine monitoring systems - Marine turbine monitoring systems - Shipboard vibration monitoring - Monitoring integrity verification - Aircraft condition monitoring - Condition monitoring - generating plant - Automotive diagnostic equipment - Systematic fault monitor selection

TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	analyze the defects and failures encountered in manufacturing system.	Analyzing (K4)
CO2	classify the maintenance system and select suitable one based on requirement.	Remembering (K1)

CO3	analyze the documentation and record updating involved in maintenance systems.	Analyzing (K4)
CO4	utilize the computer to assist the maintenance system.	Understanding (K2)
CO5	establish the monitoring strategies according to system characteristics.	Applying (K3)

TEXT BOOKS

1. R. A. Collacott, Chapman and Hall London, "Mechanical Fault Diagnosis and Condition Monitoring" by A Halstead Press Book John Wiley & Sons, New York 2021.
2. W.H. Tang, Q.H. Wu, Springer Verlag London, "Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence" 5th edition, McGraw Hill Education, 2016.

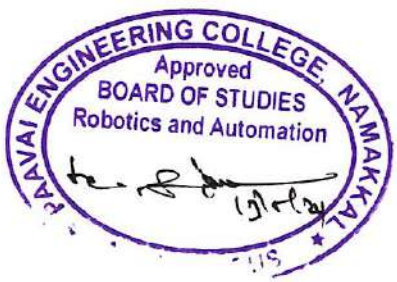
REFERENCES

1. Keith Mobley, Lind ley Higgins and Darrin Wikoff, "Maintenance Engineering Handbook", 8th edition, McGraw Hill Education, 2016.
2. M. P. Paonia and S. C. Sharma, "Industrial Safety and Maintenance Management", 1st edition, Khanna Book Publishing, 2019.
3. Alakesh Manna, "A Textbook of Reliability and Maintenance Engineering", Dreamtech Press, 2020.
4. B. K. N. Rao "A Textbook of Condition Monitoring Business & Economics" Elsevier, 2016.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	-	-	-	-	-	-	2	-	-	1	3	3
CO2	3	2	2	1	-	-	-	-	2	-	-	1	3	3
CO3	3	2	2	1	-	-	-	-	2	-	-	1	3	3
CO4	3	2	2	1	-	-	-	-	2	-	-	2	3	3
CO5	3	1	1	-	-	-	-	-	2	-	-	2	3	3



RA20154	PROCESS PLANNING AND COST ESTIMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	know a process plan for a given product.
2	understand the purpose, functions and procedure for estimating
3	learn cost elements, overheads and depreciation for a given product.
4	know cost for the casting, forging and welding processes.
5	learn the machining times and costs for various machining processes.

UNIT I **INTRODUCTION TO PROCESS PLANNING** **9**

Outlining to process planning - Drawing interpretation –material selection process and methods, Selection of production processes – standardization, simplification, break even analysis, factors to be considered in selecting; Process Sequencing; Operation Sequencing; Process parameters Equipment & Tool Selection; Tool Material evaluation, Selection of jigs and fixtures; Computer Aided Process Planning – Manual, Retrieval CAPP and Generative CAPP, Case Study in Process Planning.

UNIT II **FUNDAMENTAL OF ESTIMATING** **9**

Concept and Purpose of Estimating; Functions of Estimating department; Costing versus Estimating - Types of Estimates, Importance of Estimates, Estimating Procedure, Case Study in Estimating.

UNIT III **FUNDAMENTAL OF COSTING** **9**

Aims, Functions and Importance of costing – methods of costing, elements of cost estimation, Cost Estimators and their Qualifications, Principal Constituents in a Cost Estimate, Allocation of Cost Elements , Material Cost, Labour Cost, Expenses and Cost of Product (Ladder Cost), Distribution of Overhead Cost and Methods to Calculate the Depreciation.

UNIT IV **COST ESTIMATION OF CASTING, FORGING & WELDING COSTS** **9**

Estimation of cost for various production processes - Estimation of Forging Shop, Losses in forging, Forging cost - Estimation of Welding Shop, Electric welding cost, Gas Welding cost, Estimation of Foundry Shop– Pattern cost, Casting cost.

UNIT V **ESTIMATION OF MACHINING TIME AND COSTS** **9**

Estimation of Machining Time - Importance of Machine Time Calculation- Machining Time Calculation for the Conventional Machining Processes; Calculation of Machining Time and Cost for Lathe operations, Drilling, Boring, Milling and Grinding

TOTAL PERIODS **45**

COURSE OUTCOMES

At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	ability to create a clear and comprehensive process plan for a given product.	Remembering (K1)
CO2	capability to distinguish between estimation and costing	Remembering (K1)

CO3	ability to allocate cost elements, distributes overheads, compute depreciation for a given product.	Understanding (K2)
CO4	proficiency in estimating costs for diverse production processes such as casting, forging, and welding for a given product.	Applying (K3)
CO5	capability to compute machining times and costs for different conventional machining processes	Analyzing (K4)

TEXT BOOKS

1. Adithan, M, "Process planning and Cost Estimation", New Age International Publishers, 2019.
2. Peter Scallan, "Process Planning, The Design/Manufacture Interface", Butterworth Heinemann, 2022.

REFERENCES

1. Chitale A. K., and Gupta R. C., "Product Design and manufacturing", Prentice Hall of India, New Delhi, 2021.
2. Gideon Halevi, "Process and operation planning", Kluwer academic publishers (Printed ebook), 2022.
3. Narang G.B.S. & Kumar. V, "Production and Costing", Khanna Publishers, 2020.
4. Phillip F. Ostwald & Jairo Munoz, "Manufacturing Processes and Systems", 9th Edition, Wiley student edition, 2022.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
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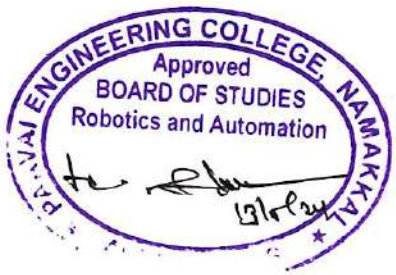
CO3	3	3	2	2	-	-	-	-	2	-	1	2	2	1
CO4	3	3	2	2	-	-	-	-	1	-	2	1	2	2
CO5	3	3	2	2	-	-	-	-	2	-	1	2	2	1



PROFESSIONAL ELECTIVE – II

RA20251	SENSOR NETWORKS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	gain knowledge in units, standards, error analysis and characteristics of measurement systems.
2	know about the different devices available in mechanical measurement.
3	understand the basic laws used in the operation of electrical instruments and measurement techniques.
4	learn a signal conditioning circuit and data acquisition system.
5	understand the construction, working principles and characteristics of biomedical sensors.

UNIT I	OVERVIEW OF WIRELESS SENSOR NETWORKS	9

Introduction: Fundamentals of wireless communication technology, Single Node Architecture, Network Characteristics, characteristics of wireless channels, modulation techniques, Types of wireless sensor networks.

UNIT II	ARCHITECTURES	9

Network Architecture, Sensor Networks Scenarios, Design Principle, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Gateway Concepts, Operating Systems and Execution Environments, Internet to WSN Communication.

UNIT III	NETWORKING SENSORS	9

Routing protocols, MAC Protocols for Wireless Sensor Network, Low Duty Cycle Protocols And Wakeup Concept, SMAC IEEE 802.15.4 standard, Wakeup Radio Concepts, Address and Name Management Assignment of MAC Addresses, Routing Protocols Energy Efficient Routing, Geographic Routing.

UNIT IV	INFRASTRUCTURE ESTABLISHMENT	9

Topology Control, Clustering Time Synchronization Localization and Positioning Sensor Tasking and Control Real-time traffic support and security protocols.

UNIT V	SENSOR NETWORK PLATFORMS AND TOOLS	9

Sensor Node Hardware Berkeley Motes Programming Challenges, Node level software platforms Node level Simulators, StateÃ, Âcentric programming.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	analyzing the units and standards, their conversions, characteristics and error analysis of systems.	Analyzing (K4)
CO2	describe the different devices available in mechanical measurements.	Remembering (K1)
CO3	classify and describe resistive, inductive and capacitive transducers which are used for measuring various.	Understanding (K2)

CO4	parameters like displacement, temperature, humidity etc.	Remembering (K1)
CO5	design a signal conditioning circuit and data acquisition system.	Understanding (K2)

TEXT BOOKS

1. Holger Karl & Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks",John Wiley, 2005.
2. Feng Zhao and Leonidas J.Guibas, Wireless Sensor Networks An Information Processing Approach, Elsevier, 2007.

REFERENCES

1. A.K.Sawhney and P.Sawhney, A Course on Mechanical Me asurement Instrumentation and Control, Dhanpat Rai and Co, New Delhi , 2017.
2. R S Khandpur, "Handbook of Biomedical Instrumentation ", Jrd edition , McGraw Hill Education, 2014
3. Mohammad S. Obaidat andSudip Misra Principles of Wireless Sensor Networks Cambridge University Press Print publication year: 2014
4. Anna Hac, "Wireless Sensor Network Designs," John Wiley & Sons, December 2003

CO-PO MAPPING:

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
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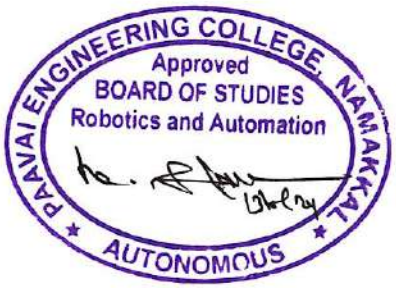
CO2	2	1	-	-	-	3	2	1	3	2	1	-	-	-
CO3	-	3	2	1	2	-	-	3	2	-	2	2	-	1
CO4	2	3	2	-	1	2	2	1	-	3	2	1	-	2
CO5	-	2	2	1	2	-	-	3	2	-	2	2	-	1



RA20252	ADDITIVE MANUFACTURING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the need, hi story, growth and classification of additive manufacturing.
2	learn the design process for additive manufacturing
3	know the principle, process parameters, and applications of SLA, SLS and EBM.
4	learn the principle, process parameters, applications of FDM and LOM.
5	understand the principle, process parameters, and applications of three dimensional printing.

UNIT I	INTRODUCTION TO ADDITIVE MANUFACTURING	9

Introduction to AM- AM evolution, Distinction between AM and CNC machining; Steps in AM, Classification of AM processes, Advantages of AM; Types of materials for AM.

UNIT II	DESIGN FOR ADDITIVE MANUFACTURING	9

Concepts and Objectives -AM Unique Capabilities; Part Consolidation -Topology Optimization, Lightweight Structure, DF AM for Part Quality Improvement; Data Processing - CAD Model Preparation, Part Orientation and Support Structure Generation, Model Slicing, Tool Path Generation; Customized Design and Fabrication for Medical Applications.

UNIT III	PHOTO POLYMERIZATION AND POWDER BED FUSION PROCESSES	9

Photo polymerization- SLA, WAAM, Advantages and Applications; Powder Bed Fusion- SLS, Process description, Powder fusion mechanism, Process Parameters, Typical Materials and Application; Selective Laser Melting (SLM) and Electron Beam Melting (EBM) - Materials, Process, Advantages and Applications

UNIT IV	EXTRUSION BASED AND SHEET LAMINATION PROCESSES	9

Extrusion Based System - FDM, Introduction, Basic Principle, Materials, Applications and Limitations; Bio extrusion; Sheet Lamination Process - LOM, Gluing or Adhesive bonding, Thermal bonding, Materials, Application and Limitation

UNIT V	PRINTING PROCESSES AND BEAM DEPOSITION PROCESSES	9

Droplet formation technologies - Continuous mode, Drop on Demand mode; Three-Dimensional Printing -Advantages, Bio plotter; Beam Deposition Process - LENS, Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition- Process description, Material delivery, Process parameters, Materials, Benefits, Applications.

TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	apply the basics of additive manufacturing techniques in manufacturing.	Applying (K3)
CO2	design a prototype the models of real-world engineering parts.	Remembering (K1)
CO3	understanding a powder-based rapid prototyping system would typically cover both theoretical.	Understanding (K2)

CO4	design FDM and LOM process in suit able applications.	Analyzing (K4)
CO5	develop the various printer models using RP process.	Understanding (K2)

TEXT BOOKS

1. Jain R.K. "Engineering Metrology", Khanna Publishers, 2022.
2. Gupta. I.C., "Engineering Metrology", Dhanpatrai Publications, 2021.

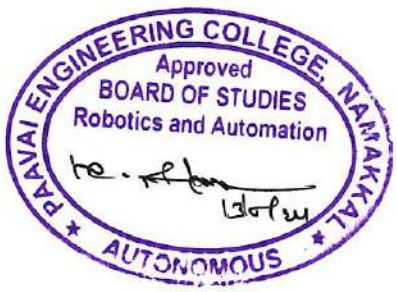
REFERENCES

1. Connie Dotson, et al., "Fundamentals of Dimensional Metrology", Thomas Asia, Singapore, 2021.
2. Doeblin E.O., "Measurement System Applications and Design", Tata McGraw Hill Publishing Company, New Delhi, 2022.
3. Groover M.P., "Automation, Production System and Computer Integrated Manufacturing ", Prentice – Hall, New Delhi, 2023.
4. Dr.R.Venkat Reddy, "Engineering Metrology and Measurements", Invincible Publishers, 2021.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	-	-	-	-	-	-	2	-	-	1	3	3
CO2	3	2	2	1	-	-	-	-	2	-	-	1	3	3
CO3	3	2	2	1	-	-	-	-	2	-	-	1	3	3
CO4	3	2	2	1	-	-	-	-	2	-	-	2	3	3
CO5	3	1	1	-	-	-	-	-	2	-	-	2	3	3



RA20253	ROBOT OPERATING SYSTEM	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	learn with the operating systems in context with the robotic operating systems.
2	understand the linux commands and its processing.
3	comprehend and explain the operating system architectures .
4	focus on methods of computation graph levels .
5	understand and describe the debugging and visualization process.

UNIT I	INTRODUCTION TO ROS	9

Introduction - history - distributions - difference from other meta - operating systems -services - ROS framework - operating system – releases.

UNIT II	INTRODUCTION TO LINUX COMMANDS	9

UNIX commands - file system - redirection of input and output - File system security - Changing access rights - process commands - compiling, building and running commands –handling variables.

UNIT III	ARCHITECTURE OF OPERATING SYSTEM	9

File system - packages - s tacks - messages - services – catkin workspace - working with catkin workspace - working with ROS navigation and listing commands.

UNIT IV	COMPUTATION GRAPH LEVEL	9

Navigation through file system - Understanding of Nodes - topics - services - messages - bags - master - parameter server - interfacing of Sensors and Actuators.

UNIT V	CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY	9

Debugging of Nodes - topics - services - messages - bags - master parameter - visualization using Gazebo - Rviz - URDF modeling - Xacro - launch files. Applications: Navigation stack - tf - sensors - odometer - imu - laser scan - base controller - robot configuration - cost map - base local planner - global planner - localization - sending goals - tele operation of robot using joystick and mapping.

TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	explain the fundamental concepts of robotic operating systems.	Remembering (K1)
CO2	familiarize yourself with linux commands for the robotic operating system.	Understanding (K2)
CO3	differentiate between various operating system architectures.	Applying (K3)
CO4	examine the levels of computation and graph analysis.	Applying (K3)
CO5	comprehend and assess debugging and visualization techniques.	Analyzing (K4)

TEXT BOOKS

1. Aaron Martinez, Enrique Fernández, Packt Publishing Ltd, "Learning ROS for Robotics Programming", 2021.
2. Jason M O Kane Create Space, "A Gentle Introduction to ROS", 2020.

REFERENCES

1. Enrique Fernandez, Luis Sanchez Crespo, Anil Mahtani, "Learning ROS for Robotics Programming", Packt Publishing, 2nd Edition, 2020.
2. Anil Mahtani, Luis Sanchez, Enrique Fernandez, Aaron Martinez, "Effective Robotics programming with ROS", Packt Publishing,3rd Edition,2019.
3. Morgan Quigley, Brian Gerkey, William Smart, "Programming Robots with ROS: A Practical Introduction to the Robot Operating System", 1st Edition, 2020.
4. Springer Nature Switzerland AG, "Robot Operating System", 1st edition 2021.

CO-PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	1	2	-	-	-	-	-	-	1	1	2	1
CO2	2	1	1	2	-	-	-	-	-	-	1	1	2	1
CO3	2	1	1	2	-	-	-	-	-	-	1	1	2	1
CO4	2	1	1	2	-	-	-	-	-	-	1	1	2	1
CO5	2	1	1	2	-	-	-	-	-	-	1	1	2	1

RA20254	PRODUCT DESIGN AND DEVELOPMENT	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the global trends and development methodologies of various types of products and services.
2	conceptualize, prototype and develop product management plan for a new product based on the type of the new product and development.
3	learn methodology integrating the hardware, software, controls, electronics and mechanical systems.
4	understand requirement engineering and know how to collect, analyze and arrive at requirements for new product development and convert them in to design specification.
5	understand system modeling for system, sub-system and their interfaces and arrive at the optimum system specification and characteristics.

UNIT I	DEVELOPMENT PROCESSES AND ORGANIZATIONS	9

Introduction to New Product and Product design- Characteristics of successful product development – The challenges in product development -Product development process – Adapting generic product development process- Product development process flows –product development organizations.

UNIT II	OPPORTUNITY IDENTIFICATION AND PRODUCT PLANNING	9

Types of opportunities- Structure of Opportunity Identification – Opportunity identification process; Product Planning Process - Four types of product development projects – Steps in Product Planning- - Identifying Customer needs.

UNIT III	PRODUCT SPECIFICATIONS AND CONCEPT DEVELOPMENT	9

Product Specifications – Target and final specifications. Concept generation: Five step method- Concept selection- Concept screening – Concept scoring – concept testing.

UNIT IV	PRODUCT ARCHITECTURE AND INDUSTRIAL DESIGN	9

Implications of the architecture – Establishing the architecture – Delayed differentiation – Platform Planning – System level design issues. Industrial Design – Assessing the Need for Industrial Design and its impact - Industrial design process and management – Assessing the quality of Industrial Design

UNIT V	DESIGN CONSIDERATIONS AND PROTOTYPING	9

Design for environment – Design for manufacturing and supply chain; Prototyping – Principles – Technologies – planning for prototypes -Robust design – Process flow.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	define, formulate and analyze a problem.	Understanding (K2)
CO2	solve specific problems independently or as part of a team.	Applying (K3)
CO3	gain knowledge of the innovation & product development process in the business context.	Remembering (K1)

CO4	work independently as well as in teams.	Applying (K3)
CO5	manage a project from start to finish.	Analyzing (K4)

TEXT BOOKS

1. Ulrich, Karl T., Eppinger, Steve D., and Yang, Maria C., "Product Design and Development", 7th Edition, McGraw-Hill Education, 2020.
2. Devdas Shetty, "Product Design for Engineers", Cengage Learning, Boston, 2016.

REFERENCES

1. Hiriyappa B, "Corporate Strategy – Managing the Business", Author House, 2013.
2. Peter F Drucker, "People and Performance", Butterworth – Heinemann [Elsevier], Oxford, 2004.
3. Vinod Kumar Garg and Venkita Krishnan N K, "Enterprise Resource Planning - Concepts", Second Edition, Prentice Hall, 2003.
4. Karl Ulrich "Product Design and Development", McGraw-Hill Education; 5th edition 2011.

CO-PO MAPPING:

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	Programme Outcomes PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	2	-	-	-	-	-	-	-	3	2	2
CO2	3	3	3	-	-	2	-	-	2	-	-	3	2	2
CO3	3	3	3	3	2	2	-	-	-	-	-	3	2	2
CO4	3	3	3	3	2	2	-	-	-	-	-	3	2	2
CO5	3	3	3	-	-	2	-	-	-	-	-	3	2	2

OPEN ELECTIVE COURSES (OE)

OPEN ELECTIVE – I

RA20901	COMPUTER AIDED INSPECTION AND TESTING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	familiar the measurement standards and to know the instruments used and various errors in measurements.
2	understand the use of basic and advanced instruments for measurements.
3	learn the applications of opto-electronics device for measurements.
4	know the various measurement techniques using laser metrology.
5	gain knowledge on computer aided inspection and advances in metrology.

UNIT I	FUNDAMENTALS AND CONCEPTS IN METROLOGY	9

Standards of Measurement; Analog and Digital Measuring Instruments; Comparators - Limits, Fits and Tolerances; Gauge Design; Surface Roughness; Form Errors and Measurements.

UNIT II	INSPECTION AND GENERAL MEASUREMENTS	9

Linear Measuring Instruments – Evolution, Types, Classification; Limit Gauges - Gauge Design,Terminology, Procedure, Concepts of Interchange Ability and Selective Assembly: Angular Measuring Instruments - Types, Bevel Protractor Clinometers Angle Gauges, Spirit Levels Sine Bar; Angle Alignment Telescope – Autocollimator, Applications - Inspection of Gears And Threads, Tool Makers' Microscope, Universal Measuring Machine.

UNIT III	OPTO ELECTRONICS IN ENGINEERING INSPECTION	9

Use of Optoelectronics in Tool Wear Measurements; Microhole Measurement and Surface Roughness; Applications in In-Process Measurement and On-Line Inspection.

UNIT IV	LASER METROLOGY	9

Precision instrument based on Laser - Use of Lasers, Principle; Interferometers - Interference microscope. Optical flats, Laser Interferometer, Application in Linear and Angular measurements, Testing of machine tools using Laser Interferometer; Use of Laser Interferometer in Machine Tool Inspection; Uses of Laser in On-Line Inspection; Laser Micrometer; Laser Alignment Telescope.

UNIT V	COMPUTER AIDED INSPECTION AND ADVANCES IN METROLOGY	9

Application of robot in manufacturing; Exploration of practical application of robots in welding;Co-ordinate Measuring Machines - Constructional features, Types, Applications of CMM, CNC CMM applications - Measurement arms, Laser tracker; Fundamentals of Computer Aided Inspection; Introduction to Nano metrology.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	recall the standards in measurements and to avoid the various forms of errors in measurements.	Remembering (K1)

CO2	relate basic and advanced metrology instruments for measurements.	Understanding (K2)
CO3	build the knowledge on non-contact opto-electronics device for measurements.	Applying (K3)
CO4	describe various measurement techniques using laser metrology.	Remembering (K1)
CO5	recognize the computer aided inspection and advances in metrology.	Analyzing (K4)

TEXT BOOKS

1. Anil. K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India Pvt. Ltd., 2006.
2. Beckwith, Marangoni, Lienhard, "Mechanical Measurements", Pearson Education, 2014.

REFERENCES

1. Charles Reginald Shotbolt, "Metrology for Engineers", Cengage Learning EMEA,5th edition, 1996.
2. Jain R.K., "Engineering Metrology", Khanna Publishers, 2012.
3. Robert G. Seippel, "Opto-Electronics for Technology and Engineering", Prentice Hall, 1989.
4. Robert J. Hocken, Paulo H. "Coordinate Measuring Machines and Systems", CRC Press, 2nd edition, 2016.

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CO4	3	2	1	1	-	-	-	-	-	-	-	3	1	2
CO5	3	2	2	2	-	-	-	-	-	-	-	1	1	2

RA20902	SMART MOBILITY AND INELLIGENT VEHICLES	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles.
2	learn basics of radar technology and systems, ultrasonic sonar systems, lidar sensor technology and systems and other sensors for automobile vision system.
3	learn basic control system theory applied to autonomous automobiles.
4	produce overall impact of automating like various driving functions, connecting the automobile to sources of information that assist with a task.
5	allow the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants through connected car & autonomous vehicle technology.

UNIT I	INTRODUCTION TO AUTOMATED, CONNECTED, AND INTELLIGENT VEHICLES	9

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Power train Electronics, Introduction to Automated, Connected, and Intelligent Vehicles.

UNIT II	SENSOR TECHNOLOGY FOR SMART MOBILITY	9

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems.

UNIT III	CONNECTED AUTONOMOUS VEHICLE	9

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.

UNIT IV	VEHICLE WIRELESS TECHNOLOGY & NETWORKING	9

Wireless System Block Diagram and Overview of Components, Transmission Systems - Modulation/Encoding, Receiver System Concepts– Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks.

UNIT V	CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY	9

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues.

TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, students will be able to		BT Mapped (Highest Level)
CO1	understand the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles	Remembering (K1)
CO2	identify the concept of remote sensing and the types of sensor technology needed to implement remote sensing	Understanding (K2)
CO3	familiar with the concept of fully autonomous vehicles	Applying (K3)
CO4	utilize the basic concepts of wireless communications and wireless data networks	Applying (K3)
CO5	examine the concept of the connected vehicle and its role in automated vehicles	Analyzing (K4)

TEXT BOOKS

1. Radovan Miucic, "Connected Vehicles: Intelligent Transportation Systems (Wireless Networks) Hardcover – Import, 3 November 2018.
2. Margot Deruyck, "Unmanned Aerial Vehicle (UAV): Enabled Wireless Communications and Networking" Hardcover Import, 2022.
3. Jason M O Kane Create Space, "A Gentle Introduction to ROS", 2020.

REFERENCES

1. Tom Denton, "Automobile Electrical and Electronic systems, Roult edge", Taylor & Francis Group, 5th Edition, 2020.
2. Pradip Kumar Sarkar, Amit Kumar Jain "Intelligent Transport Systems" Paperback, 2018.
3. Zhihua Qu, "Cooperative Control of Dynamical Systems: Applications to Autonomous Vehicles" Paperback Import, 2010.
4. Walid Saad, Mehdi Bennis, Mohammad Mozaffari, Xingqin Lin "Wireless Communications and Networking for Unmanned Aerial Vehicles" Hardcover Import, 2020.

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CO4	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO5	3	2	1	1	-	1	-	-	-	-	-	1	2	1

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