

Amrutvahini Sheti and Shikshan Vikas Sanstha's

AMRUTVAHINI COLLEGE OF ENGINEERING, SANGAMNER

At-Amrutnagar, Post. Ghulewadi, Tal. Sangamner, Dist. Ahilyanagar – 422 608



(An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune)

Curriculum Structure and Syllabus of Second Year B. Tech. Automation & Robotics Engineering



(Effective from Academic Year 2026-27)


Chairman
B.Tech. Automation & Robotics Engineering
Amrutvahini College of Engineering, Amrutnagar
Sangamner-422608




Chairman
Academic Council
Amrutvahini College of Engineering, Amrutnagar
Sangamner-422608

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Abbreviation

AEC - Ability Enhancement Course

AICTE - All India Council for Technical Education

CEP - Community Engagement Project

EEM - Entrepreneurship/Economics/Management Courses

MDM - Multidisciplinary Minor

MOOC - Massive Open Online Course

NEP - National Education Policy

NPTEL - National Programme on Technology Enhanced Learning

OE - Open Elective

PCC - Program Core Course

CCC – Cocurricular Course

PEO - Programme Educational Objectives

PSO - Program Specific Outcomes

SWAYAM - Study Webs of Active-learning for Young Aspiring Minds

UGC - University Grants Commission

VEC - Value Education Course

VSE - Vocational and Skill Enhancement Course

WK - Knowledge and Attitude Profile

CCE - Comprehensive and Continuous Evaluation

ISO - International Organization for Standardization

EOMS - Educational Organization Management System

Institute Vision

To create opportunities for rural students to become able engineers and technocrats through continual excellence in engineering education.

Institute Mission

Our mission is to create self-disciplined, physically fit, mentally robust and morally strong engineers and technocrats with high degree of integrity and sense of purpose who are capable to meet challenges of ever advancing technology for the benefit of mankind and nature.

We, the management, the faculty and staff, therefore promise to strive hard and commit ourselves to achieve this objective through a continuous process of learning and appreciation of needs of time.

Department Vision

Create able Automation and Robotics engineers through excellence in academics and industry – institute – interaction.

Department Mission

M1: To produce confident and professionally sound Automation and Robotics Engineers.

M2: To keep pace with recent development in academics/industry by strengthening the skill sets.

M3: To apply Automation and Robotics engineering knowledge for the benefit of society.

ISO 21001:2018 - EOMS Policy

We, at AVCOE Sangamner, are committed to:

- Provide quality technical education to the rural students
- Provide conducive environment for all round development of the students.
- Develop as a premier institute for technical education & research as per the needs and expectations of all stake holders.
- Comply all applicable requirements.
- Develop students into technocrats having social responsibility.
- Keep abreast about the advances in technology and innovation.
- Enhance industry-institute interaction.
- Managing intellectual property.
- Maintain hygiene, health and safety for applicable requirements.
- Achieve continual improvement in academic and administrative processes.
- We shall strive to maintain Educational Organizational Management System.

Knowledge and Attitude Profile

A Knowledge and Attitude Profile (KAP), often represented as WK (Knowledge and Attitude Profile) in some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes related to a specific area, topic, or domain.

WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole- life cost, re-use of resources, net zero carbon, and similar Concepts, that supports engineering design and operations in a practice area.

WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Outcomes (POs)

PO1	Engineering knowledge	Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2	Problem analysis	Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3	Design / Development of Solutions	complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6	The Engineer and The World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	Individual and Collaborative Team work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	Communication	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11	Life-Long Learning	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)
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Program Educational Objectives (PEOs):

PEO1: To blend students with a solid foundation in mathematical, scientific and engineering fundamentals that will enable them to have a successful career in Automation and Robotics and its allied Industries.

PEO2: To have in-depth and recent knowledge of Automation and Robotics to deal with multidisciplinary domain.

PEO3: Possess an innovative mind with better interpersonal skills with ethical values and team spirit leading to responsible & competent professionals.

Program Specific Outcomes (PSOs):

A graduate of the Automation & Robotics Engineering Program will demonstrate-

PSO1: To be able to think critically, creatively and analytically in developing technological solutions to problems in Automation and Robotic system using multidisciplinary approach.

PSO2: To be able to handle collaboration between Automation and Robotics related functions.

PSO3: To be able to understand professional, ethical and social responsibilities and engage in lifelong learning.

Preface

It gives me immense pleasure to present the autonomous curriculum of the Second Year B.Tech. in Automation & Robotics Engineering, introduced by the Department of Automation & Robotics Engineering. This curriculum has been carefully designed to meet the evolving requirements of modern industry, higher education, and emerging technological advancements while establishing a strong foundation in automation, robotics, manufacturing, and intelligent engineering systems.

Automation & Robotics Engineering is a multidisciplinary domain that integrates electrical drives, control systems, industrial automation, manufacturing technologies, robotics, machine design, data analytics, and sustainable engineering practices. The curriculum has been structured to provide students with the essential knowledge and practical skills required to understand, design, operate, and optimize modern automated and robotic systems used across manufacturing, process industries, and smart industrial environments. The syllabus offers a balanced blend of engineering fundamentals and professional competencies through different courses enabling students to translate theoretical concepts into practical applications.

I sincerely appreciate the dedicated efforts and valuable contributions of all faculty members, industry experts, academicians, and members of the Board of Studies who have actively participated in the design and development of this curriculum. Their collective expertise and commitment have ensured that the syllabus remains contemporary, industry-oriented, and academically rigorous.

I am confident that this autonomous curriculum will equip students with strong technical foundations, practical competencies, professional values, and lifelong learning abilities, enabling them to excel in their careers and contribute meaningfully to technological advancement and societal development.

I extend my best wishes to all students and faculty members for the successful implementation of this curriculum and for achieving excellence in teaching, learning, innovation, research, and professional practice.

Dr. V. B. Shinde,

Head, Department of Automation & Robotics Engineering
Amrutvahini College of Engineering, Sangamner
(An Autonomous Institute affiliated to Savitribai Phule Pune University, Pune)

Program codes:

The institute has assigned a unique program code to each branch.

Table 1 – Program codes

Sr. No.	Program code	Code
UG Programs		
1	Automation & Robotics Engineering	AR

Subject code nomenclature:

The following nomenclature demonstrates the subject codes:

- **R-Year** (of designing/revising syllabus) – **Program code** (as given in Table 1) - **Course Type** (as per NEP) – **Course Number** (101 – FY B. Tech Subject 1, 201 - SY B. Tech Subject 1, 301 - TY B. Tech Subject 1, 401 - B. Tech Subject 1 etc.)

Guidelines for Examination Scheme:

The evaluation of students shall be based on continuous academic performance in a course based on Comprehensive Continuous Evaluation (CCE) and End Semester Examination (ESE).
Components of the Examination System:

1. Comprehensive Continuous Evaluation (CCE):

- CCE of 40 marks based on all the Units of course.
- To design a Comprehensive Continuous Evaluation scheme for a theory subject of 40 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Table 3: Allocation of marks & structure

Sr. No.	Examination	Conduction Marks	Marks	Coverage of Units
1	CCE –I (Class test – 1)	32	16	Units 1 & Unit 2 (8 Marks/Unit)
2	CCE –II (Assessment tools: Case Study, presentation, Open book test etc.)	32	16	Units 3 & Unit 4 (8 Marks/Unit)
3	CCE –III (Assessment tools: Assignments, seminar, quiz, course project, field visit etc.)	08	08	Unit 5

The distribution of marks across various assessment tools and their mapping to COs is detailed in the table below.

Table 4: Allocation of marks & structure

EXAM	Assessment tool	CO1	CO2	CO3	CO4	CO5
CCE	CCE1	08	08			
	CCE2			08	08	
	CCE3					8
	Subject teacher should select any assessment tool for conducting CCE1, CCE2 & CCE3 (Class Test, Assignments, seminar, quiz, course project, field visit, Case study, Open book test)					
ESE	Written Examination	12	12	12	12	12
Total	100	20	20	20	20	20

Timeline for conduction of CCE:

- Weeks 1- 4: Completion of Unit 1 and 2

- Week 5: Conduct CCE1 1 (16 marks)
- Weeks 6 - 8: Completion of Unit 3 and 4
 - Week 9: Conduct CCE2 as (16 marks)
- Weeks 10 - 12: Completion of Unit 5
 - Week 13: Conduct Seminar/Course project/Presentation/Quiz/Open Book test (8 marks)

Evaluation and Feedback:

- **Unit Test:** Student answer papers will be evaluated promptly, and constructive feedback will be provided highlighting strengths and areas for improvement.
- **Assignments / Case Study:** Student submissions will be assessed as per the given rubric, and meaningful feedback will be provided to help students understand their performance and scope for enhancement.
- **Seminar Presentation:** Students will be evaluated based on content accuracy, delivery, and responses during the Q&A session. Feedback will be shared on communication skills and conceptual understanding.
- **Open Book Test:** Evaluation will focus on the depth of analysis and the ability to apply concepts. Feedback will emphasize students' critical thinking and problem-solving skills.
- **Mini Project:** Students will be assessed on problem identification, design approach, implementation quality, and documentation. Innovation, teamwork, and practical application of concepts will be strongly considered.
- **Field Visit:** Evaluation will be based on the student's report and reflection, focusing on understanding of real-world practices and their relevance to the course outcomes. Marks will reflect clarity, insight, and active participation.

2. End Semester Examination (ESE):

The ESE is a compulsory examination for all students. The ESE examination will be conducted at the end of the semester by the institute Department of Examination and Evaluation (DEE). The ESE will be based on 100% syllabus (Unit 1 to Unit 5). The ESE shall be of 60 marks (12 Marks / Unit) conducted for all theory courses as mentioned in the programme structure.

Syllabus Structure

Course Code	Course Type	Name of the Subject	Teaching Scheme (Hrs./week)					Examination Scheme and Marks						Credit			
			TH	PR	TUT	SL	Total	CCE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-III																	
R25-AR-PCC-201	Program Core course - 1	Electrical drives and Control	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-PCC-202	Program Core course - 2	Industrial Automation Technology	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-PCC-203	Program Core course - 3	Manufacturing Engineering and Technology	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-MDM-204	Multidisciplinary Course-1	Applied Mathematics	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-OE-205	Open Elective - 1	(To be chosen from OE-1 basket finalized at college level)	2	-	-	30	60	40	60	-	-	-	100	2	-	-	2
R25-AR-HSSM-206	Entrepreneurship/Economics/ Management course	Design Thinking and Entrepreneurship	1	2	-	15	60	25	-	25	-	-	50	1	1	-	2
R25-AR-EVC-207	Value Education Course	Universal Human Values & Ethics	2	-	-	30	60	50	-	-	-	-	50	2	-	-	2
R25-AR-PCC-208	Program Core Course- Lab	Drive and Control Technology Laboratory	-	2	-	-	30	-	-	25	-	25	50	-	1	-	1
R25-AR-PCC-209	Program Core Course Lab / Multidisciplinary Course-Lab	Industrial Automation Laboratory	-	2	-	-	30	-	-	25	25	-	50	-	1	-	1
R25-AR-ECEP-210	Community Engagement Project / Field Project	Community Engagement Project	-	4	-	-	60	-	-	50	-	-	50	-	2	-	2
			17	10	0	255	660	275	300	125	25	25	750	17	5	0	22

Semester-IV

Course Code	Course Type	Name of the Subject	Teaching Scheme (Hrs./week)					Examination Scheme and Marks						Credit			
			TH	PR	TUT	SL	Total	CCE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
R25-AR-PCC-211	Program Core course - 4	Fundamentals of Industrial Robotics	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-PCC-212	Program Core course - 5	Mechanism and Robot Kinematics	3	-	-	45	90	40	60	-	-	-	100	3	-	-	3
R25-AR-PCC-213	Program Core course - 6	Materials and Machine Elements	2	-	-	30	60	40	60	-	-	-	100	2	-	-	2
R25-AR-MDM-214	Multidisciplinary Course - 2	Data Science & Visualization	2	-	-	30	60	40	60	-	-	-	100	2	-	-	2
R25-AR-OE-215	Open Elective - 2	(To be chosen from OE-2 basket finalized at college level)	2	-	-	30	60	40	60	-	-	-	100	2	-	-	2
R25-AR-VSEC-216	Vocational Skill Course	Material Testing and Characterisation	1	2	-	15	60	-	-	25	-	25	50	1	1	-	2
R25-AR-AEC-217	Ability Enhancement Course	Modern Indian Language	1	2	-	15	60	-	-	50	-	-	50	1	1	-	2
R25-AR-HSSM-218	Entrepreneurship/Economics/Management course	Engineering Economics and Financial Management	2	-	-	30	60	50	-	-	-	-	50	2	-	-	2
R25-AR-PCC-219	Program Core Course- Lab	Robots Programming Laboratory - I	-	2	-	-	30	-	-	-	25	-	25	-	1	-	1
R25-AR-PCC-220	Program Core Course Lab	Mechanism and Robot Kinematics Lab	-	2	-	-	30	-	-	25	-	-	25	-	1	-	1
R25-AR-VEC-221	Value Education Course	Environmental Science and Sustainable Development	2	-	-	30	60	50	-	-	-	-	50	2	-	-	2
			18	8	0	270	660	300	300	100	25	25	750	18	4	0	22

Semester – III



Program:		S. Y. B. Tech (A&R Engineering)		Semester:		III	
Course:		Electrical Drives and Control		Course Code:		R25-AR-PCC-201	
Teaching Scheme (Hrs./Week)				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
3	--	--	03	40	60	--	--
Course Description To Provide the fundamental concepts, construction, and working principles of motors and special purpose machines.							
Course Relevance To develop the students with ability to choose the correct motor type for specific application, design automation and robotics system and troubleshoot drive systems.							
Prerequisite: 1. Engineering Physics 2. Basic Electrical Engineering 3. Basic Electronics Engineering 4. Engineering Mathematics – I, II							
Bridge Content: It Bridges theoretical Knowledge with industry application, enhancing employability in Automation and robotics.							
Course Objectives: 1. DEFINE the fundamental concepts, constructional details, characteristics, features and speed control methods of DC motors. 2. UNDERSTAND the concept of power electronics to control electric motors 3. EXPLAIN the principle of operation, types, and speed–torque characteristics of induction motors. 4. ILLUSTRATE different speed control and braking techniques for DC and AC motors in industrial applications. 5. COMPARE and EVALUATE different types of motor drives based on their operating principles, control techniques, and applications.							
Course Outcomes: After learning the course, students will be able to understand the performance of various machines, select suitable drives for robotics application.							
CO	Course Outcome					Bloom’s Level	
CO1	EXPLAIN the construction, classifications, and operating principles of DC motors and its application.					2,3	
CO2	UNDERSTAND the concept of power electronics devices like Converters, Switching Circuits, Diodes, Thyristors, MOSFETs, IGBTs to control electric motors.					2,3	
CO3	EXPLAIN the performance characteristics, losses, and efficiency of Induction motor & different electric drives used in automation					2,4	
CO4	ILLUSTRATE speed control methods for DC and AC motors using converters, choppers, and inverters.					3,4	



CO5	EVALUATE the performance of electric drives under various loading and braking conditions.	4,5
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Course Content			
Unit 1	DC Drives and Controls	08 Hrs.	CO1
Principles of working, Constructional details, Types of DC motors, significance of back E.M.F, torque equation, Types of DC motors (DC series and shunt), significance of back E.M.F, torque equation, Characteristics and Selection of DC Motors, working at no-load and on-load, Starting of DC Motors, Speed Control methods (Descriptive treatment), reversal of rotation, regenerative braking, Losses, power flow diagram and efficiency, BLDC motor, Permanent Magnet DC (PMD) motors, applications in robotics.			
Exemplars / Practical Applications, Usage: - Automotive Systems: DC motors are widely used in vehicles for functions such as power windows, windshield wipers, seat adjustments, and electric power steering, electric vehicles (EVs) and hybrid electric vehicles (HEVs) - Industrial Machinery: DC motors drive conveyor belts, hoists, cranes and machine tools. Their ability to provide precise speed and torque control makes them suitable for these applications - Consumer Electronics: Small DC motors power devices such as electric toothbrushes, shavers, and cooling fans in laptops. Their compact size and low voltage operation make them ideal for portable electronics - Medical Equipment: DC motors are used in medical devices like ventilators, infusion pumps, and surgical tools, where precise and reliable motion control is critical - Renewable Energy Systems: They are employed in solar tracking systems to adjust the position of solar panels for optimal sunlight exposure and in wind turbine pitch control mechanisms			
Assignments: Investigate and write specifications of DC motors used in various automotive and domestic applications. Study type, construction, working of DC motor.			
Unit 2	Power Electronics Utilized for Control of Motors	08 Hrs.	CO2
Parts of Electric Drives: Converters, Switching Circuits, Diodes, Thyristors, MOSFETs, IGBTs. Pulse Width Modulation (PWM) for DC Drives, Frequency control for AC motor (V/F Control method), Motor Protection Type, Fault and Devices.			
Introduction to Digital Control System, PID, adaptive control for motor drives.			
Exemplars / Practical Applications, Usage: - DC Motor Speed Control: Widely used in electric vehicles, robotic arms, and automated assembly lines. - Converters: Converters change electrical power from one form to another. - LED Dimming: PWM controls brightness by adjusting the duty cycle. - Heating Control: PWM adjusts the effective power supplied to resistive heaters. - A robotic arm uses PWM to precisely control the speed of a DC motor for smooth motion.			



- Conveyor Systems: Smooth acceleration/deceleration of motors using V/F control.
- Variable Frequency Drives (VFDs): Control the speed of AC induction motors in pumps, fans, and compressors.

Assignments:

1. Illustrate how proper selection of parts provides control over the motor drives while designing automated system.

Unit 3	Single-Phase and Three Phase Induction Motor	08 Hrs.	CO3
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Single-Phase Induction Motors: Types, construction, working principle of shaded-pole types, applications

Three-Phase Induction Motors: Types of induction motor, flux and MMF waves, development of circuit model, power across air gap, torque and power output, starting methods, speed control, applications, induction generator, induction machine dynamics, high efficiency induction motors.

Exemplars / Practical Applications, Usage:

- Industrial Machinery - Three-phase squirrel-cage motors power heavy-duty machines like conveyor belts, crushers, mixers, presses, lathes, and milling machines due to their self-starting capability, reliability, and cost-efficiency
- Fans, blowers, and pumps in HVAC and industrial ventilation systems rely on these motors for continuous operation
- Pumps & Compressors - Widely used in water pumps, submersible pumps, and air compressors
- Household Appliances - Single-phase induction motors are found in refrigerators, washing machines, fans, garbage disposals, and small power tools.
- Elevators & Hoists - Slip-ring (wound-rotor) induction motors provide variable-speed control and high torque at startup—ideal for cranes, elevators, and mine hoists
- Oil, Gas & Refining - Robust three-phase induction motors drive pumps, compressors, and conveyors in environments that demand durability and resistance to harsh conditions

Assignments:

1. Investigate and write specifications of Induction motors used in various domestic applications. Study type, construction, working of induction motor.

Unit 4	Synchronous Machines Drive and Control	08 Hrs.	CO4
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Construction, types, armature reaction, determination of synchronous reactance, phasor diagram, power angle characteristics, synchronous motor operation. PMSM Drive: Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics.

Special purpose motors: Construction, working principle, characteristic and applications of stepper motors, A.C and D.C servomotors

Exemplars / Practical Applications, Usage:

- High-Precision & Positioning Systems - Used in servo applications, robotics, positioning tables, and printing press drives that need accurate speed synchronization and positioning.
- Clocks, Turntables & Lab Instruments - In devices where unwavering speed precision



means the difference between good and great performance. • Electric Power Generation: Operating as synchronous generators, they convert mechanical energy from turbines into electricity in thermal, hydro, and nuclear power plants. • Constant-Speed Drives - They run at precise, synchronous speed (locked to supply frequency)			
Assignments: 1. Investigate and write specifications of synchronous motors used in various domestic applications. Study construction, working of synchronous motor. Also, comment on various industrial applications.			
Unit 5	Fundamentals of Electric Drives	08 Hrs.	CO5
Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications Motor Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability. Robot Arm Drives and Control, Application of Electric Drives and Control in Automation and Robotics.			
Exemplars / Practical Applications, Usage: • CNC machinery & cutting tools: Use servo drives for high precision in positioning and speed. • Robots & pick-and-place: Stepper and servo drives enable accurate, repeatable motion in manufacturing. • Conveyors & production lines: AC drives with VFDs regulate speed and torque to optimize throughput. • Hoisting drives: Heavy-duty induction or synchronous motors with VFD provide smooth start/stop, accurate positioning, and energy efficiency.			
Assignments: 1. Understand requirements of Electric drives and components of drives with functions in Automation & Robotics.			
Textbooks:			
1. V. K. Mehta and Rohit Mehta, Principles of Electrical Machines, S Chand Publication 2. Ashfaq Husain, Electrical Machines, Dhanpat Rai and Co. 3. B. L Theraja –Electrical Technology, Vol II, S. Chand publication. 4. G. K. Dubey, “Fundamentals of Electrical Drives”, Second edition (sixth reprint), Narosa Publishing house, 2001. 5. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education 6. N. K. De, P. K. Sen, “Electric Drives”, Prentice Hall of India Eastern Economy Edition			
Reference Books:			
1. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electrical Machines”, Tata McGraw Hill Publication Ltd., Fifth Edition. 2. A.S. Langsdorf, “Theory and performance of DC machines”, Tata McGraw Hill.			



3. Smarajit Ghosh, “Electrical Machines”, Pearson Education, New Delhi
4. P. C. Sen, “Principles of Electric Machines and Power Electronics “, John Wiley and Sons Publication, second edition 1997.
5. R. Krishnan, “Electric Motor Drives – Modeling Analysis and Control”, PHI India
6. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education
7. Austin Huges, “Electrical motor and drives: Fundamental, types and applications”, Heinemann Newnes, London
8. Frank D. Petruzella – Programmable Logic Controllers (McGraw-Hill)
9. R.K. Rajput – Industrial Electronics and Control (S. Chand)
10. James A. Rehg & Glenn J. Sartori – Industrial Electronics (Pearson)

MOOCs Links and additional reading material:

1. <https://archive.nptel.ac.in/courses/108/104/108104140/>
2. <https://archive.nptel.ac.in/courses/108/108/108108077/>
3. https://onlinecourses.nptel.ac.in/noc19_ee65/preview
4. https://onlinecourses.swayam2.ac.in/nou24_ee02/preview

Strength of CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	1	-	-	-	-	1	-
CO2	3	2	1	1	1	-	-	-	-	1	-
CO3	3	3	2	2	2	1	1	-	-	1	1
CO4	3	3	3	2	3	-	-	-	-	1	1
CO5	3	3	2	3	2	1	1	-	1	1	2
Avg.	3.0	2.6	1.8	1.6	1.8	0.4	0.4	0	0.2	1.0	0.8

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE						ESE
	CT1	CT2	Assignments	Course Project	Field Activity / Case Study	Quiz / Presentation etc.	
K1	---	---	---	---	---	---	√
K2	√	√	√	---	---	---	√
K3	√	√	√	---	---	---	√
K4	---	---	√	---	---	√	√
K5	---	---	---	---	---	√	√
K6	---	---	---	---	---	---	√

**Assessment Table:**

EXAM	Assessment tool	CO1	CO2	CO3	CO4	CO5
Knowledge and Attitude Profile (WK)		----	----	----	----	----
CCE	CT1	08	08	----	----	----
	Assignments	----	----	08	08	----
	Course Project	----	----	----	----	----
	Seminar/Quiz / Presentation etc.	----	----	----	----	08
ESE	60	12	12	12	12	12
Total	100	20	20	20	20	20

This course serves as a prerequisite for / maps with the following future courses:

1. Advanced Electrical Drives
2. Power Electronics
3. Industrial Automation and Control
4. PLC and SCADA Systems
5. Control Systems Engineering
6. Electric Vehicle Technology
7. Renewable Energy Systems
8. Embedded Systems for Industrial Applications
9. Robotics and Motion Control

Job Mapping:

Job opportunities that one can get after learning this course:

1. Electrical Design Engineer
2. Automation Engineer
3. Testing and Commissioning Engineer
4. Research and Development (R&D) Engineer



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	III		
Course:	Industrial Automation Technology			Course Code:	R25-AR-PCC-202		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
3	--	--	3	40	60	--	--
Course Description: This course provides foundational knowledge in automated systems, focusing on PLC programming, SCADA/HMI systems, and process instrumentation. Students learn to design, maintain, and troubleshoot industrial automation system, preparing them for specialized automation roles.							
Relevance: Industrial automation is essential for modern industries to achieve efficiency, quality, and large-scale production. This course introduces students to the basics of automation, focusing on PLCs, SCADA etc. It emphasizes practical applications, problem-solving, and hands-on skills to prepare students for Industry 4.0 and careers in automation-driven sectors.							
Prerequisite: Basic Electrical Engineering, Basic Electronics Engineering, Digital Electronics, Electronics Measurement and Instruments.							
Bridge Content: This course typically focuses on bridging the gap between theoretical knowledge and practical, industry-relevant skills in automation technologies.							
Course Objectives: 1. EXPLAIN the Industrial automation and terminologies related to automation. 2. IDENTIFY and DESCRIBE basic technologies and modules of PLC. 3. DEVELOP and IMPLIMENT ladder logic programs for timers, counters and industrial applications. 4. FAMILIARIZE with HMI, SCADA and DCS architecture for process control and data acquisition from the field. 5. UNDERSTAND core pillars of Industry 5.0.							
Course Outcomes: After learning the course, students will be able to:							
CO	Course Outcome					Bloom's Level	
CO1	EXPLAIN the need, benefits, and types of industrial automation systems along with their applications.					2	
CO2	IDENTIFY PLC modules and DISCUSS Ladder programming for different logic gates					2	
CO3	APPLY the basics of PLC programming and TEST ladder logic programs for a given application.					1,3	
CO4	ANALYZE and DEMONSTRATE role of HMI, SCADA/DCS in supervisory control, communication and process monitoring.					3,4	
CO5	DISCUSS various concepts of Industry 5.0.					2	
Course Content							



Unit 1	Introduction to Automation	6 Hrs.	CO1
Definition, Mechanization vs Automation, Advantages of Automation, Goals of Automation, Types of Automation, Need of Automation in industries, Steps of Automation, Challenges in Automation, Principles and Strategies of Automation, Factory Automation, Process Automation, Levels of Automation, Main Components of Industrial Automation.			
Exemplars / Practical Applications and usage: In industries manual processes are replaced with automation for increased efficiency and consistent quality.			
Assignments: Visit industry and provides a comprehensive overview of automation, covering its impact on modern industry.			
Unit 2	PLC Fundamentals	6 Hrs.	CO2
Introduction, Need for PLC, PLC evolution, Architecture of PLC, Types of PLC, PLC modules, PLC Configuration, Scan cycle, Capabilities of PLC, Selection criteria for PLC, PLC Programming languages, Components of ladder diagram, Rules to construct Ladder Logic, Ladder programming for different logic gates.			
Exemplars / Practical Applications and usage: Use of PLC in day today appliances like Elevators and Escalators, Automatic Doors, Automatic Car Washes, Water Treatment Plants.			
Assignments: Construct truth tables for different logic gates. PC vs PLC.			
Unit 3	Programming of PLC	6 Hrs.	CO3
Introduction, PLC programming for various functions: Latching, Sequencing, Timers, counters. Ladder Logic for Industrial Applications: DOL starter, water level controller, motor sequencing control, car parking system, 24-hour digital clock, Bottle filling system, Traffic Light Control.			
Exemplars / Practical Applications and usage: PLC used to automate conveyor, control flow, temperature, pressure, and speed in manufacturing/process industry.			
Assignments: Program PLC using ladder logic to perform Temperature control (ON/OFF) function.			
Unit 4	HMI, SCADA and DCS	6 Hrs.	CO4
Introduction, Need for HMI, SCADA and DCS in Industrial Automation. Human Machine Interface (HMI): Importance, role in safety, types. Supervisory Control and Data acquisition (SCADA): Basic function, generalized block diagram, functions of each block, applications of SCADA.			



Distributed Control System (DCS): Basic function, generalized block diagram, function of each block, applications of DCS.

Industrial communication protocols: Modbus, Profibus, Field bus, Process bus, Ethernet/IP, CAN Open.

Exemplars / Practical Applications and usage:

HMI, SCADA, and DCS are fundamental automation technologies used to monitor, control, and optimize industrial processes. HMI provides the visual interface for operators, SCADA manages data acquisition across wide, geographically dispersed areas (e.g., pipelines), and DCS manages centralized, complex, high-speed processes within a single facility (e.g., refineries), improving safety, efficiency, and data-driven decision-making.

Assignments:

Differentiate HMI, SCADA and DCS.

Unit 5	Industry 5.0	6 Hrs.	CO5
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Introduction, Industry 4.0 vs Industry 5.0, Core Principles of Industry 5.0, Foundations of Industry 5.0, Drivers of Industry 5.0, Human-Centric Systems, Impact of Industry 5.0, Challenges in Industry 5.0.

“6S” in Industry 5.0 - Safety, Security, Sustainability, Sensitivity, Service, and Smartness.

Role of Robots in Industry 5.0, Future of Industry 5.0.

Exemplars / Practical Applications and usage:

Industry 5.0 merges human creativity with robotic efficiency, prioritizing sustainability and worker-centric, collaborative technologies.

Assignments:

Briefly discuss COBOTS in manufacturing/process industries.

Course Projects:

Automatic Patient's Health Monitoring System.

Description: Design and build smart health monitoring system which monitor patient's health and capture relevant data in real-time and share with patient's relatives and doctors so they can access the progress in patient's health.

Textbooks:

1. Gary Dunning, "Introduction to Programmable Logic Controllers" Thomson Learning, 2001.
2. W. Bolton, "Programmable Logic Controllers" 5th Edition Newnes, 2009.

Reference Books:



1. Parr, "Programmable Controllers: An Engineers Guide", 3rd Edition, Elsevier, Indian Reprint, 2013.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", Prentice Hall India publication.
3. Frank D. Petruzella, "Programmable logic controller", Tata McGraw-Hill publication.
4. John R Hackworth and Fredrick D Hackworth Jr., "Programmable Logic Controllers: Programming Methods and Applications", Pearson Education, 2015.

MOOCs Links and additional reading material:

1. Industrial Automation and Control, by Prof. Alokanti Deb, IIT Kharagpur.
<https://nptel.ac.in/courses/108105088>
2. Industrial Automation with PLC & SCADA (IAD101), by Prof. Arumugam J., NIEIT Calicut.
<https://www.nielit.gov.in/calicut/calicut/content/online-course-industrial-automation-plc-scada>
3. Program Logic Controllers, by Prof. P. M. Pathak
<https://www.youtube.com/watch?v=MS3qJq2jvu0>

Strength of CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	-	-	-	1	-	2	1	2
CO2	3	2	2	1	2	-	-	-	-	1	-	2	2	2
CO3	3	2	3	2	3	-	-	-	-	2	-	3	2	2
CO4	2	2	2	1	2	1	1	-	-	1	-	2	2	2
CO5	1	-	-	-	-	2	2	3	-	1	-	1	1	3
Avg.	2	2	2	1	2	2	2	3		1		2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE						ESE
	CT1	CT2	Assignments	Course Project	Field Activity / Case Study	Quiz / Presentation / Certificate Course	
K1	---	---	---	---	---	---	√
K2	√	√	√	---	---	---	√
K3	√	√	√	---	---	---	√
K4	---	---	√	---	---	√	√
K5	---	---	---	---	---	√	√
K6	---	---	---	---	---	---	√

**Assessment Table:**

EXAM	Assessment tool	CO1	CO2	CO3	CO4	CO5
Knowledge and Attitude Profile (WK)		----	----	----	----	----
CCE	CT1	08	08	----	----	----
	Assignments	----	----	08	08	----
	Seminar/Quiz / Presentation / Certificate Course etc.	----	----	----	----	08
ESE	60	12	12	12	12	12
Total	100	20	20	20	20	20

This course serves as a prerequisite for / maps with the following future courses:

- Sensors and Actuators for Robotics
- Mechatronics and Control Systems
- Industrial Robotics and Automation
- Sensor and Vision System in Robots

Job Mapping: Job opportunities that one can get after learning this course:

- Automation Engineer
- Automation System Analyst
- Process Simulation Analyst
- Field Analyst in Agricultural/Industrial Automation



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	III		
Course:	Manufacturing Engineering and Technology			Course Code:	R25-AR-PCC-203		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
03	--	--	3	40	60	--	--

Course Description:

Manufacturing Engineering and Technology introduces students to the principles, processes, tools, and systems used in the production of engineering components and products. The course covers conventional and advanced manufacturing processes, machine tools, metrology, process planning, automation in manufacturing, and quality control. It provides fundamental knowledge of how raw materials are transformed into finished products efficiently, economically, and sustainably.

Relevance: This course forms a strong foundation for Automation and Robotics engineers by developing an understanding of manufacturing systems, production technologies, and industrial automation environments. It enables students to comprehend how robots, CNC machines, automated material handling systems, and smart manufacturing technologies are integrated into modern industries, thereby preparing them for advanced studies in robotics, industrial automation, Industry 4.0, and intelligent manufacturing systems.

Prerequisite:

1. Manufacturing Practice Workshop
2. Programming & Problem Solving

Bridge Content:

Introduction to Engineering Materials and their Properties, Basics of Manufacturing Processes and Workshop Practices, Fundamentals of Machine Tools and Machining Operations, Engineering Drawing and Reading of Manufacturing Drawings, Introduction to Industrial Automation, Sensors and PLCs, Basic Welding and Metal Joining Concepts, Fundamentals of Material Removal and Cutting Tool Geometry, Introduction to CAD and Product Design Concepts

Course Objectives:

1. **STUDY** and **EXPLAIN** the principles of subtractive manufacturing processes and machining automation.
2. **UNDERSTAND** various casting and foundry operations and explore the role of automation in modern foundries.
3. **DEVELOP** knowledge of industrial joining processes and the role of automation in advanced welding systems.
4. **UNDERSTAND** sheet metal forming operations and die design procedure.
5. **UNDERSTAND** plastic processing techniques and 3D printing requirements.

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	DEMONSTRATE an understanding of subtractive manufacturing processes and machining automation	2, 3



	used in industrial production.	
CO2	EXPLAIN casting processes and foundry operations with reference to automation systems used in modern foundries.	2, 3
CO3	APPLY knowledge of joining processes and welding automation to improve manufacturing efficiency and quality.	2, 3
CO4	DEMONSTRATE press working operations and APPLY the basic principles to DESIGN dies and tools for forming and shearing operations	3, 4
CO5	DIFFERENTIATE thermoplastics and thermosetting and applications in modern manufacturing in 3D printing	2, 4
Course Content		
Unit 1	Theory of Metal Cutting and Machining Automation	9 Hrs. COs Mapped: CO1
Subtractive Manufacturing, operations on Lathe, Milling & Grinding machines. Automation in lathe and milling such as apron feed mechanism. Modern machining automation - CNC machine tools, Fundamentals of metal cutting and chip formation, types of chips, Orthogonal and oblique cutting, Metal Cutting Theory and Force Analysis- Shear angle and Merchant's theory, Cutting Forces and Power Estimation, Properties of cutting tool materials, Tool signature, Tool wear and tool life, Taylor's tool life equation Real World Assignment – 1. Conduct a real-time case study on apron mechanism. 2. Study the difference between manual and hydraulic chuck and also tail stock in workshop/ lab 3. Understand the different lathe and milling operation and cutting tool in workshop. 4. Understand the difference between conventional machine, CNC and Automates. 5. Conduct a real-time case study on tool life for an industrial component. Exemplars / Practical Applications and usage: Perform and submit the report on turning or milling operation on different materials (like mild steel, aluminum, cast iron), apron mechanism, and hydraulic chuck (in a lab or workshop)		
Unit 2	Casting Processes and Foundry Automation	9 Hrs. COs Mapped: CO2
Introduction to casting processes, Patterns: Pattern materials, types of patterns, allowances pattern design, molding sand, Properties of molding sands, Core making, melting practices and furnaces, Pouring and Gating system design, Numerical estimation to find mold filling time, Riser design and placement, Cleaning and finishing of casting, Defects and remedies, Principle and equipment of Permanent mold casting, Investment casting, Centrifugal casting, Continuous casting. Automation and robot application in casting processes.		

**Real World Assignment:**

1. Case Study on Industrial Casting Applications.
2. Investigate real-world casting defects and propose solutions.
3. Case study on automation of sand / permanent mould casting process.

Exemplars / Practical Applications and usage:

Design a basic gating system and riser for the selected component. Report (4-5 pages) including design calculations, gating system layout.

Unit 3	Welding Processes and Automation	9 Hrs.	COs CO3	Mapped:
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Classification of joining processes: Welding, brazing, soldering, Welding joints. Gas Welding and Cutting, automation and CNC Systems - Process Control (APC), Ignition and Monitoring, Torch Height Control (ATHC)
Arc Welding Processes: Single carbon arc welding, FCAW, TIG, MIG, SAW, Weld inspection, Welding defects and remedies; Atomization of SAW-Tractors/Carriages, Manipulators & Booms, Robotic Integration. Continuous Wire Feeder, Automatic Flux Hopper & Recovery, Sensors & Tracking Atomization in MIG- Hard/Mechanized Automation, Robotic Automation, Collaborative Robots (Cobots), Voltage & Wire Feed, Travel Speed, Shielding Gas Flow
Resistance Welding: Spot, Seam and Projection weld process, resistance welding Automation.

Real World Assignment:

1. Comparative Analysis of Welding, Brazing, and Soldering in Industrial Applications
2. Understand the automation of saw in industrial application - pressure vessels /long run welding
3. Investigate common welding defects and propose quality control measures.

Exemplars / Practical Applications and usage:

Case study report (4-5 pages) with images, defect analysis, and automation involved.

Unit 4	Metal Forming and Sheet Metal Working	9 Hrs.	COs CO4	Mapped:
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Fundamentals of Metal Forming: Classification of forming processes: bulk deformation processes and sheet metal processes, Stress-strain relations in plastic deformation, Hot working vs. cold working,
Rolling and Rolling Mill Automation
Types of rolling mills and rolling operations. Rolling defects, causes, remedies, and industrial applications. Automatic Gauge Control (AGC): purpose, principle, and importance.
Forging and Forging Automation: Open-die, Closed-die, and Impression-die forging, Forging defects and applications. Automation in forging.
Extrusion and Extrusion Line Automation: Direct, Indirect. Extrusion line automation, and its benefits.
Wire and Tube drawing: Principle of wire drawing and tube drawing. Drawing equipment, lubrication, and applications. Automation in wire rod and tube drawing:



Sheet Metal Working and Press Automation: Types of sheet metal operations, Press working equipment and terminology, Types of dies, Clearance analysis, Estimation of cutting forces, Centre of pressure and blank size determination, Design of strip lay-out, Blanking die design, Introduction to Drawing, Bending dies. Press automation

Real World Assignment –

1. Identify at least one industrial applications for each process (e.g., hot rolling for railway tracks, cold rolling for automotive sheets).
2. Compare forging with other manufacturing processes (e.g., casting, machining) in terms of strength and durability.
3. Apply sheet metal operations such as shearing, bending, and deep drawing to create a real-world product.
4. Research the principles, advantages, and limitations of hot working and cold working

Exemplars / Practical Applications and usage:

Suggest an appropriate forming process for a given product (e.g., turbine blades, aluminum cans) and justify the choice.

Unit 5	Plastic Processing Methods	9 Hrs.	COs Mapped: CO5
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Thermoplastics and Thermosetting, Plastic Processing Methods: Compression molding, transfer molding, Blow molding, Rotation moulding, Extrusion: Type of extruder, extrusion of film, pipe, Cable, Automation in plastic extrusion, Injection moulding - Process and equipment, Automation in plastic injection molding integrates robotics, sensors, and auxiliary equipment.

Introduction to Additive Manufacturing, 3D Printing techniques (FDM, SLA, SLS, DMLS)

Real World Assignment –

1. Design a functional part (e.g., gear, bracket, or prototype model) using CAD software.
2. Print the part using different 3D printing techniques.

Exemplars / Practical Applications and usage:

Comparison Report (2-3 Pages): 3D Printing vs. Conventional Machining

Comprehensive Continuous Evaluation (CCE) components for the course:

1. Course Projects (Mini/Micro Project):

CNC Programming and Simulation of Turning/Milling Operations
 Design and Fabrication of Smart Foundry Monitoring System using Sensors
 Development of PLC-Based Welding Automation Demonstrator
 Design of Blanking/Piercing Die using CAD Software
 Design and 3D Printing of Functional Mechanical Component
 Comparative Study of Conventional Manufacturing vs Automated Manufacturing
 Automated Material Handling Prototype for Manufacturing Cell
 Industry 4.0 Enabled Manufacturing Process Monitoring System

Textbooks:

1. Amitabha Ghosh & Ashok Kumar Mallik, 'Manufacturing Science', East-West Press.



2. R.K. Rajput, 'A Textbook of Production Engineering', Laxmi Publications.
3. Serope Kalpakjian & Steven R. Schmid, 'Manufacturing Engineering and Technology', Pearson Education
4. S.K. Hajra Choudhury, A.K. Hajra Choudhury & Nirjhar Roy, 'Workshop Technology (Vol. 1 & 2)', Media Promoters & Publishers Pvt. Ltd.

Reference Books:

1. J.S. Campbell, 'Principles of Manufacturing Materials and Processes', Tata McGraw-Hill.
2. Mikell P. Groover, 'Introduction to Manufacturing Processes', Wiley India
3. Ian Gibson, David Rosen, Brent Stucker, 'Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing', Springer

MOOCs Links and additional reading material:

1. <https://www.youtube.com/watch?v=z-mM8LwQcno/>
2. <https://www.youtube.com/watch?v=DA3r97Icgd0>
3. https://www.youtube.com/watch?v=_AhfOzQDynE
4. <https://www.youtube.com/watch?v=9JTRqfNAqhM&list=PLwdnzlV3og>
5. <https://www.youtube.com/watch?v=ljveGnQw2G0&list=PL9ssGyHa3fnwPH1gSkV8pjX12SrKx8rgq>

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	-	-	-	-	-	-	3	2	1
CO2	3	3	3	2	2	-	-	-	-	-	-	3	2	1
CO3	3	2	2	2	2	-	-	-	-	-	-	3	3	1
CO4	3	3	2	2	2	1	-	-	-	-	-	2	3	2
CO5	2	3	2	2	3	-	1	1	-	-	-	2	3	2
Avg	2.8	2.8	2.2	2.0	2.2	0.2	0.2	0.2	0	0	0	2.6	2.6	1.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Unit wise Weightage:

Exam	Unit1	Unit 2	Unit 3	Unit 4	Unit 5
CT1	CO- 1&2		-	-	-
CCE Assessment by Teacher	8 Unit Test	8 Unit Test	8 Quiz	8 Presentation	8 Industrial Visit Report
ESE	12	12	12	12	12
Total	20	20	20	20	20

Assessment Pattern



BT Level	CCE				ESE				
	CT1	CCE2	CCE3	CCE4					
CO	CO 1&2				CO1	CO2	CO3	CO4	CO5
K1	-	-	-	-	-	-	-	-	-
K2	8	4	-	-	6	6	6	6	6
K3	8	4	-	8	6	6	6	6	6
K4	-	-	8	-	-	-	-	-	-
K5	-	-	-	-	-	-	-	-	-
K6	-	-	-	-	-	-	-	-	-

This course serves as a prerequisite for / maps with the following future courses:

1. Manufacturing Processes–II
2. Advanced Manufacturing Processes
3. Industrial Engineering
4. Production and Operations Management
5. Manufacturing Automation

Job Mapping:

Job opportunities that one can get after learning this course:

1. Manufacturing Engineer
2. Welding Engineer / Welding Inspector
3. Shop Floor Supervisor



Program:		S. Y. B. Tech (A&R Engineering)		Semester:		III	
Course:		Applied Mathematics		Course Code:		R25-AR-MDM-204	
Teaching Scheme (Hrs./Week)				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
3	--	--	03	40	60	--	--
Course Description This course provides applied mathematical tools required for analysis, modeling, and simulation of automation and engineering systems. It covers probability and statistics for uncertainty handling, linear programming for optimization, Laplace and Fourier transforms for system and signal analysis, and numerical methods for computational problem-solving. The course focuses on application-oriented learning to support automation, control, and robotics-based engineering systems.							
Course Relevance This course provides fundamental mathematical tools for analyzing and solving problems in Automation and Robotics. It supports modeling, optimization, signal processing, and simulation of engineering systems, enabling efficient and reliable system design.							
Prerequisite: Basic knowledge of Engineering Mathematics including algebra, calculus, matrices, and differential equations; along with fundamental concepts of probability and statistics.							
Bridge Content Revision of basic concepts of algebra, matrices, and calculus; introduction to probability fundamentals and basic statistics; overview of differential equations and basic programming tools (MATLAB/Python) for solving engineering problems.							
Course Objectives: - To DEVELOP understanding of probability and statistical methods for data analysis in engineering systems. - To DEVELOP the ability to solve higher-order linear differential equations and APPLY partial differential equations to model and ANALYSE engineering problems. - To ANALYSE linear systems using Laplace transform methods and UNDERSTAND signal representation, processing using Fourier transform techniques. - To DEVELOP the ability to APPLY vector calculus concepts and integral theorems for modeling and analyzing motion, force, and field-related problems in automation and robotics. - To APPLY numerical methods for solving complex engineering and robotic system problems.							
Course Outcomes: On completion of the course, learner will be able to :-							
CO	Course Outcome						Bloom's Level
CO1	APPLY probability distributions and statistical techniques to ANALYZE and interpret data in engineering and robotic systems.						3



CO2	SOLVE higher-order linear and simultaneous differential equations and APPLY partial differential equations to engineering applications involving wave and heat flow phenomena.	3
CO3	APPLY Laplace and Fourier transform techniques to ANALYZE control systems, process signals, and SOLVE engineering problems in automation and robotics.	3
CO4	APPLY vector calculus and integral theorems to ANALYZE engineering systems involving robotic motion, force fields, and spatial transformations.	3
CO5	USE numerical methods to SOLVE complex algebraic and differential equations in engineering and robotic simulations.	3

Course Contents			
Unit 1	Probability Theory & Statistics	8 Hrs.	CO1
Statistics -Measures of central tendency; measures of dispersion, correlation coefficient; regression analysis, Fitting of the curve by Least Square method. Probability -Bayes' theorem; probability distributions (Binomial, Poisson, Normal,); Hypothesis Testing – Chi-square test. Exemplars / Practical Applications, Usage: An autonomous vehicle company evaluates the safety and efficiency of its self-driving cars by analyzing sensor accuracy, navigation success rates, and response times to obstacles. Students learn how statistics and probability are applied in real-world autonomous driving performance monitoring and reliability analysis. Assignments: ● Problems based on skewness, kurtosis, correlation. ● Problems based on Binomial, Poisson, and Normal distribution.			
Unit 2	Linear Differential Equations and Applications of Partial Differential Equations	8 Hrs.	CO2
Linear differential equations of higher order; complementary function; particular integral by shortcut method and method of variation of parameters, simultaneous linear Differential equation, Applications in engineering. Applications of partial differential equations: wave equation, one-dimensional and two-dimensional heat flow equations and their solutions with applications in engineering problems Exemplars / Practical Applications, Usage: An engineering team evaluates the behavior of dynamic systems such as heat transfer in materials, vibration of mechanical structures, and fluid flow in pipelines by applying linear differential equations and partial differential equations. Students learn how these			



mathematical tools are used in real-world modeling, simulation, and reliability analysis of engineering systems.

Assignments:

- Problems based on particular integral; method of undetermined coefficients; variation of parameters.
- Problems based on wave equation, one-dimensional and two-dimensional heat flow equations.

Unit 3	Transforms	8 Hrs.	CO3
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Laplace transform, transforms of standard functions and properties; inverse Laplace transform; application to linear systems;
Fourier transform; cosine and sine Fourier transform; system analysis in automation

Exemplars / Practical Applications, Usage: An engineering team evaluates the performance of dynamic systems such as electrical circuits, mechanical vibrations, and signal processing by applying Laplace transforms and Fourier series. Students learn how these mathematical tools are used in real-world system analysis, control design, and reliability testing.

Assignments:

- Problems based on Laplace transform.
- Problems based on Fourier transform.

Unit 4	Vector Calculus	8 Hrs.	CO4
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Vector algebra, Gradient-directional derivative, divergence and curl of vector functions, solenoidal and irrotational vector fields.

Vector Integration –Line Integral, Surface integral, Green's lemma, Gauss's Divergence Theorem, Stoke's Theorem.

Exemplars / Practical Applications, Usage: An engineering team evaluates fluid flow, electromagnetic fields, and mechanical stress in materials by applying vector calculus concepts such as gradient, divergence, and curl.

Assignments:

- Problems based on Operations on vectors dot product, cross product, scalar triple product and vector triple product.
- Problems based on Solenoidal and irrotational vector fields and their physical interpretation.

Unit 5	Numerical Methods	8 Hrs.	CO5
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Solution of algebraic equations using Gauss elimination; Jacobi method; Gauss-Seidel method; Cholesky decomposition; numerical solution of ordinary differential equations using Euler's method, Modified Euler's method, and Runge-Kutta methods; Application in simulation of engineering and robotic systems.



Exemplars / Practical Applications, Usage: An engineering team evaluates the performance of large linear systems arising in structural analysis, circuit simulations, and fluid flow problems by applying Numerical Methods. Students learn how these algorithms are used in real-world system modeling, simulation, and optimization.

Assignments:

- Problems based on Gauss elimination; Jacobi method; Gauss-Seidel method.
- Problems based on using Euler's method, Modified Euler's method, and Runge-Kutta methods.

Textbooks:

- Higher Engineering Mathematics – *B. S. Grewal*
- Advanced Engineering Mathematics – *Erwin Kreyszig*
- Probability and Statistics for Engineers and Scientists – *Ronald E. Walpole et al.*
- Numerical Methods for Engineers – *Steven C. Chapra*

Reference Books:

- Introduction to Probability Models – *Sheldon M. Ross*
- Applied Numerical Methods with MATLAB for Engineers and Scientists – *Steven C. Chapra*
- Operations Research – *Hamdy A. Taha*
- Signals and Systems – *Alan V. Oppenheim & Alan S. Willsky*

MOOCs / NPTEL Links and additional reading material:

1. **Statistics & Probability:** Prof. S. Dharmaraja, IIT Delhi
<https://youtu.be/1NPBMF2T8Iw?si=NFIZByxt-xPgKIcM>
2. **Applications to Linear Differential Equations and Partial Differential Equations:** Prof. A. K. Nandakumaran, P. S. Datti & Raju K. George, IISc Bangalore <https://youtu.be/NBcGLLU90fM?si=6ifrbk6-47PXTaEY>
3. **Transforms :** By Prof. Adrijit Goswami , IIT Kharagpur.
<https://youtu.be/sbDuvBc8m8M?si=UnDx0dD52KrPXlqy>
4. **Vector Calculus :** By Prof. Hari Shankar Mahato , IIT Kharagpur.
<https://youtu.be/MPGPX7UkKsU?si=zzEUCSkLxQVUusr0g>
5. **Numerical Methods for Engineering Systems :** By Prof. Saurabh Basu , IIT Guwahati. <https://youtu.be/pOtnzAXIXvI?si=oHNUDpbvTY8L5RCv>



Strength of CO-PO-PSO Mapping											
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	-	-	-	-	2	2	1	-	2
CO2	3	3	-	-	-	-	2	2	1	-	2
CO3	2	2	-	-	-	-	2	2	1	-	2
CO4	3	3	-	-	-	-	2	2	1	-	2
CO5	3	3	-	-	-	-	2	2	1	-	2
Avg.	2.60	2.60	-	-	-	-	2.00	2.00	1.00	-	2.00

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE						ESE
	CT1	CT2	Assignments	Course Project	Field Activity / Case Study	Quiz / presentation etc.	
K1	✓	✓	✓	---	✓	✓	✓
K2	✓	✓	✓	---	✓	---	✓
K3	✓	✓	✓	---	✓	---	✓
K4	---	---	---	---	---	---	---
K5	---	---	---	---	---	---	---
K6	---	---	---	---	---	---	---

Assessment Table:

EXAM	Assessment tool	CO1	CO2	CO3	CO4	CO5
Knowledge and Attitude Profile (WK)		---	---	---	---	---
CCE	CT1	08	08	---	---	---
	CT2	---	---	08	08	---
	Assignments	---	---	---	---	---
	Course Project	---	---	---	---	---
	Field Activity / Case Study	---	---	---	---	04
	Quiz / Presentation etc.	---	---	---	---	04
ESE	60	12	12	12	12	12
Total	100	20	20	20	20	20

**Unit wise Weightage:**

Exam	Unit1	Unit2	Unit3	Unit4	Unit5
CT1	8	8	---	---	---
CT2	---	---	8	8	---
Assessment by Teacher by using any two tools	---	---	---	---	8
ESE	12	12	12	12	12
Total	20	20	20	20	20

This course serves as a prerequisite for / maps with the following future courses:

- Control Systems Engineering
- Signals and Systems
- Robotics Engineering
- Artificial Intelligence & Machine Learning
- Optimization Techniques / Operations Research
- Embedded Systems and IoT
- Mechatronics Systems
- Simulation and Modeling of Engineering Systems
- GATE Exam/ CAT Exam /Aptitude Tests

Job Mapping:

Job opportunities that one can get after learning this course:

- Automation Engineer
- Robotics Engineer
- Control Systems Engineer
- Data Analyst / Data Scientist (Industrial Applications)
- AI/ML Engineer
- Embedded Systems Engineer
- Mechatronics Engineer
- Simulation & Modelling Engineer



Program:	S. Y. B. Tech (Automation & Robotics)			Semester:	III		
Course:	Design Thinking and Entrepreneurship			Course Code:	R25-AR-HSSM-206		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
01	02	--	2	25	--	25	--
Course Description and Relevance: This course introduces students to the fundamentals of entrepreneurship, innovation, and startup development. It focuses on developing entrepreneurial thinking, creativity, problem-solving skills, and innovation strategies using modern tools such as Design Thinking, Lean Startup Methodology, and Business Model Canvas. Students learn how to identify real-world problems, generate innovative solutions, and transform ideas into viable business opportunities. Entrepreneurship and innovation are essential skills for engineers in the modern technology-driven economy. The course enables students to understand startup ecosystems, innovation practices, financial planning, and emerging business opportunities. It encourages interdisciplinary thinking and equips learners with the ability to create sustainable and socially impactful technological solutions. The course also supports employability, startup culture, self-employment, and innovation-based industrial growth.							
Prerequisite: 1. Basic communication and presentation skills 2. Fundamental understanding of technology and engineering applications 3. Awareness of societal and industrial problems							
Bridge Content: Introduction to startup ecosystem, Basics of innovation and creativity, Introduction to Design Thinking process, Fundamentals of business and entrepreneurship							
Course Objectives: 1. Understand the fundamentals of entrepreneurship, innovation, creativity, and design thinking for solving engineering and societal problems. 2. Apply design thinking tools to identify user needs, generate innovative ideas, and develop feasible engineering solutions. 3. Develop entrepreneurial skills by analysing business opportunities, preparing business models, and evaluating startup feasibility. 4. Build professional competencies in teamwork, communication, ethical decision-making, financial awareness, and entrepreneurial leadership.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome						Bloom's Level
CO1	EXPLAIN entrepreneurship concepts, innovation processes, creativity techniques, and the Design Thinking methodology for engineering applications.						2
CO2	APPLY Design Thinking principles to identify real-world problems, generate innovative solutions, and DEVELOP prototypes.						3
CO3	DEVELOP a Business Model Canvas, prepare a basic business plan, and EVALUATE the technical, financial, and market feasibility of a startup idea.						6
CO4	DEMONSTRATE entrepreneurial, communication, teamwork,						3

Approved By:



	leadership, and ethical skills by presenting innovative business ideas and startup pitches	
Course Content		
Unit 1	Entrepreneurship, Innovation and Entrepreneurial Mindset	4 Hrs. COs: 1
Introduction to Entrepreneurship, Characteristics and competencies of entrepreneurs, Types of Entrepreneurs, Entrepreneurship Ecosystem in India, Innovation and Creativity, Product, Process, Service and Frugal Innovation, Startup India, Make in India, MSME, Case Studies of successful Indian Entrepreneurs. Applications: Analysis of successful startups, Entrepreneur interviews, Innovation case studies Real World Assignments (Any One) 1. Entrepreneur Interaction Report • Interview a local entrepreneur/startup founder/MSME owner. • Identify entrepreneurial qualities, challenges faced, and innovation adopted. • Submit a 2-page report. 2. Innovation Around Us • Identify five innovative products or services used in daily life. • Classify each as Product, Process, Service, or Frugal Innovation. • Justify the classification. 3. Startup Ecosystem Study • Study one Government initiative such as Startup India, Make in India, Atal Innovation Mission, or MSME. • Prepare a presentation on objectives, benefits, and success stories. 4. Entrepreneurial Competency Self-Assessment • Evaluate personal entrepreneurial skills using a standard questionnaire. • Prepare an improvement plan. Exemplars / Practical Applications and Usage • Understanding how startups solve real-life engineering problems. • Innovation in manufacturing and automation industries. • Entrepreneurial opportunities in Robotics and Automation. • Role of innovation in Industry 4.0.		
Unit 2	Design Thinking and Creativity	4 Hrs. COs: 2
Introduction to Design Thinking, Empathize, Define, Ideate, Prototype, Test, Creativity Techniques, Mind Mapping, Brainstorming, SCAMPER, TRIZ, User-Centred Product Development. Applications: Solving campus problems, Engineering product redesign, Community engagement project Real World Assignments (Any One) 1. Campus Problem Solving using Design Thinking • Identify a campus problem (parking, energy waste, attendance, laboratory management, etc.). • Apply all five Design Thinking stages. • Present the proposed solution. 2. Product Redesign Activity • Select an everyday engineering product. • Improve it using SCAMPER and Design Thinking tools. • Prepare sketches and justification. 3. User Observation Study		



- Observe users performing an engineering-related activity. - Identify pain points and propose improvements. 4. Creativity Workshop - Generate at least ten innovative ideas using Brainstorming, Mind Mapping, or TRIZ techniques. - Select the best solution based on feasibility. Exemplars / Practical Applications and Usage - Human-centred design in robotics and automation. - Product development for industrial automation. - Designing user-friendly engineering systems. - Smart campus and community problem solving.			
Unit 3	Opportunity Identification and Business Modelling	4 Hrs.	COs: 3
Opportunity Recognition, Need Analysis, Market Survey, Value Proposition, Business Model Canvas, Lean Startup, Minimum Viable Product (MVP), Business Plan, Revenue Model, Cost Estimation, Break-even Analysis, Unit Economics. Applications: Prepare Business Model Canvas, Develop MVP, Startup feasibility analysis Real World Assignments (Any One) 1. Business Model Canvas - Develop a Business Model Canvas for an innovative product or service. 2. Market Survey - Conduct a survey among at least 20 users regarding a product or service. - Analyse customer needs and identify improvement opportunities. 3. Minimum Viable Product (MVP) - Develop a low-cost prototype, wireframe, or service blueprint. - Collect user feedback. 4. Startup Feasibility Analysis - Evaluate technical, financial, market, and operational feasibility of a startup idea. Exemplars / Practical Applications and Usage - Business planning for robotics startups. - Market validation of engineering products. - Lean Startup methodology. - Product commercialization.			
Unit 4	Startup Management, Funding and Entrepreneurship Skills	3 Hrs.	COs: 4
Startup Funding, Angel Investors, Venture Capital, Crowdfunding, Government Schemes, Financial Literacy, Intellectual Property Rights, Pitching Skills, Team Building, Leadership, Ethics, Communication Skills, Startup Pitch Presentation Applications: Elevator Pitch, Business Pitch Competition, Startup Proposal Presentation Real World Assignments (Any One) 1. Startup Pitch Competition - Prepare and deliver a three-minute elevator pitch for a startup idea. 2. Funding Proposal - Select an appropriate Government funding scheme. - Prepare a funding proposal for the proposed startup. 3. Intellectual Property Case Study - Study one Indian patent related to Robotics, AI, Automation, or Manufacturing. - Explain its commercial importance.			



- Team Startup Challenge
- Work in groups to prepare a startup proposal covering business model, funding, ethics, and sustainability.

Exemplars / Practical Applications and Usage

- Startup incubation and entrepreneurship development.
- Technology commercialization.
- Funding through Startup India, MSME, and Atal Innovation Mission.
- Entrepreneurship opportunities in AI, Robotics, Automation, and Smart Manufacturing.

Textbooks:

1. Entrepreneurship Development – S.S. Khanka
2. Entrepreneurship Development and Small Business Enterprises – Poornima M. Charantimath
3. Entrepreneurship: New Venture Creation– David H. Holt (Indian Edition by Vikas Publishing)
4. Innovation and Entrepreneurship – Dr. R.G. Desai
5. Essentials of Entrepreneurship and Small Business Management – Nandan H.

Reference Books:

1. The Lean Startup – Eric Ries
2. Disciplined Entrepreneurship: 24 Steps to a Successful Startup – Bill Aulet (MIT)
3. Zero to One – Peter Thiel
4. The Startup Owner's Manual – Steve Blank & Bob Dorf
5. Jugaad Innovation – Navi Radjou, Jaideep Prabhu, and Simone Ahuja
6. Stay Hungry Stay Foolish – Rashmi Bansal
7. Connect the Dots – Rashmi Bansal
8. Innovation and Entrepreneurship – Peter F. Drucker
9. Startup Sutra – Rohit Prasad
10. Dream with Your Eyes Open – Ronnie Screwala

MOOCs Links and additional reading material:

1. Entrepreneurship Essentials – Offered by IIT Kharagpur (NPTEL)
Duration: 8 weeks | Level: UG/PG
Covers: Entrepreneurial process, business models, marketing, funding.
2. Entrepreneurship and Innovation – IIT Roorkee
Duration: 12 weeks
Covers: Types of innovation, design thinking, ecosystem, and scaling.
3. Product Management and Entrepreneurship – IIM Bangalore
Duration: 8 weeks
Focus: Customer discovery, MVPs, and product-led growth.
4. Innovation, Business Models and Entrepreneurship – IIT Madras
Explores innovation in products and services, and lean canvas approach.
5. Design Thinking - A Primer – IIT Madras Ideal for teaching creativity and problem-solving using design thinking.
6. Coursera: Design Thinking for Innovation by University of Virginia
7. edX: Entrepreneurship in Emerging Economies by Harvard

YouTube Channels / Playlists:

1. Startup India Official Channel •
2. Regular videos on policies, funding opportunities, and success stories.
 - a. IIT Madras – NPTEL Entrepreneurship Playlist
Covers fundamentals of startup creation and innovation strategy.
 - b. Dr. HYPERLINK "<https://www.youtube.com/user/MrVivekBindra>"Vivek HYPERLINK
"<https://www.youtube.com/user/MrVivekBindra>" HYPERLINK
"<https://www.youtube.com/user/MrVivekBindra>"Bindra HYPERLINK



"https://www.youtube.com/user/MrVivekBindra" – Entrepreneur HYPERLINK
 "https://www.youtube.com/user/MrVivekBindra"& HYPERLINK
 "https://www.youtube.com/user/MrVivekBindra" Motivational Speaker
 c. Popular in India; motivational and strategic content (more business-oriented).
 d. Desh HYPERLINK "https://www.youtube.com/@DeshDeshpandeFoundation" Deshpande Foundation Videos on grassroots entrepreneurship and social innovation.
 3. Stanford HYPERLINK "https://www.youtube.com/user/ecorner"eCorner

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	2	-	1	-	2	1	1
CO2	2	3	3	2	2	-	-	-	2	2	-	3	2	2
CO3	2	3	3	2	1	-	-	2	2	2	3	2	3	2
CO4	-	1	2	-	-	-	-	3	3	3	2	1	2	3
Avg.	1.5	2.25	2	1	0.75	-	-	1.75	1.75	2	1.25	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Unit wise Weightage:

Exam	Unit1	Unit2	Unit3	Unit4
CCE				
Activities	12	13		
CCE2			12	13
CCE3				
ESE				
Total	12	13	12	13

Assessment Pattern

BT Level	CCE				ESE				
	CT1	CCE2	CCE3	CCE4					
CO	CO1				CO1	CO2	CO3	CO4	CO5
K1									
K2	√	√							
K3	√	√							
K4	√	√							
K5									
K6									



This course serves as a prerequisite for / maps with the following future courses:

- Innovation and Product Development
- Startup and Incubation Activities
- Project-Based Learning
- Technology Management

Job Mapping:

Job opportunities that one can get after learning this course:

- Startup Founder
- Innovation Engineer
- Product Development Associate
- Business Development Executive
- Startup Consultant
- Entrepreneurial Research Assistant
- Incubation and Innovation Coordinator
- Technology Analyst



Program:	S. Y. B. Tech (A&R Engineering)				Semester:		III
Course:	Universal Human Values & Ethics				Course Code:		R25-AR-EVC-207
Teaching Scheme (Hrs./Week)				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
2	--	--	02	50	--	--	--

Course Description

This course provides a blueprint for long-term fulfillment by balancing technical skills with life-long ethical values. The syllabus focuses on Self-Exploration, helping you distinguish between material success and lasting mental peace to prevent future burnout. It covers Harmony in the Self, Family, and Society, providing the emotional intelligence needed to navigate high-pressure careers and build trust-based relationships. By exploring Harmony in Nature and Professional Ethics, it prepares you to lead with integrity and social responsibility. Ultimately, it equips you with a clear moral compass to handle adulthood's complexities with stability and purpose.

Course Relevance

This course serves as a life-long compass for adulthood, moving you from simply "earning" to truly "living." It helps you distinguish between material success and mental peace, preventing burnout by teaching you to manage your internal state during high-pressure situations. By fostering Trust and Respect, it ensures your personal and professional relationships are built on harmony rather than ego. In your career, it provides the ethical framework needed to lead with integrity, securing a reputation that lasts longer than any job title. Ultimately, it equips you with the emotional intelligence to navigate life's complexities with clarity and purpose.

Prerequisite:

Student Induction Program (SIP)

Bridge Content:

Basic Human Values.

Course Objectives:

1. To **HELP** the students develop a holistic, humane world-vision, and appreciate the essential complementarity between values and skills to ensure mutual happiness and prosperity
2. To **ELABORATE** on 'Self-exploration' as the process for Value Education
3. To **FACILITATE** the understanding of harmony at various levels starting from self and going towards family and society.
4. To **ELABORATE** on the salient aspects of harmony in nature and the entire existence

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	EXAMINE their own potential to explore and apply this understanding in daily life	4
CO2	DIFFERENTIATE the human being as the coexistence of self and body to identify their real needs and basic aspirations in daily life.	4
CO3	RELATE the relationship between one self and the	4

Approved By:



	other self as an essential part of harmony in the family and apply it in daily life interactions	
CO4	ANALYSE the interconnectedness, harmony, and mutual fulfilment in nature and existence to derive ethical and holistic approaches for responsible living, technology, production systems, management, and societal practices.	4

Course Content			
Unit 1	Introduction to Value Education	07 Hrs.	CO1
(i) Understanding Value Education (ii) Self-exploration as the Process for Value Education (iii) Continuous Happiness and Prosperity - the Basic Human Aspirations and their Fulfilment (iv) Right Understanding, Relationship and Physical Facility (v) Happiness and Prosperity - Current Scenario (vi) Method to Fulfil the Basic Human Aspirations			
Exemplars / Practical Applications, Usage: Discussion on modern lifestyle stress despite material growth			
Assignments: - Is excitement and happiness the same thing or different? Explain with a few examples of both, preferably from your own experience. - Is there any difference between prosperity and accumulation of wealth? Explain with a few examples of both, preferably from your own experience.			
Unit 2	Harmony in the Human Being	07 Hrs.	CO2
(i) Understanding Human being as the Co-existence of the Self and the Body (ii) Distinguishing between the Needs of the Self and the Body (iii) The Body as an Instrument of the Self (iv) Understanding Harmony in the Self (v) Harmony of the Self with the Body (vi) Programme to Ensure self-regulation and Health			
Exemplars / Practical Applications, Usage: Prepare a personal health and self-regulation plan to improve their mental and physical well-being in daily life.			
Assignments: - Self is the 'Seer', 'Doer' and 'Enjoyer' in this way it's central to Human Existence while the body is just an instrument for the 'Self'. Illustrate the statement with the help of an example. - Our Sanskar keeps getting updated as discussed in the course. Sanskar at the next moment is $\text{Sanskar (t+1)} = \text{Sanskar (t)} + \text{Environment (t)} + \text{Self-exploration (t)}$. Explain the meaning of this statement with the help of any two examples from your life			



Unit 3	Harmony in the Family and Society	08 Hrs.	CO3
(i) Harmony in the Family - the Basic Unit of Human Interaction "Trust' - the Foundational Value in Relationship (ii) 'Respect' - as the Right Evaluation (iii) Values in Human-to-Human Relationship (iv) Understanding Harmony in the Society (v) Vision for the Universal Human Order			
Exemplars / Practical Applications, Usage: List the important relationships in their life (family, friends, teachers) and identify values like trust and respect in each relationship			
Assignments: - What is the meaning of family for you? List down the people in your family/extended family. What do you call these people? What are your expectations from each of these people? What are your responsibilities (expected feelings) towards each of them? - Describe the proposal of Trust as given in the course. Critically evaluate the statement - 'I cannot trust any stranger because I don't know his/her intention'.			
Unit 4	Harmony in the Nature (Existence) & Professional Ethics	08 Hrs.	CO4
(i) Understanding Harmony in the Nature (ii) Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature (iii) Realizing Existence as Co-existence at All Levels (iv) The Holistic Perception of Harmony in Existence (v) Professional Ethics in the light of Right Understanding (vi) Strategies for Transition towards Value-based Life and Profession			
Exemplars / Practical Applications and usage: Students should conduct group activities for tree plantation/campus garden maintenance/waste segregation campaigns/water conservation awareness, and submit a brief report with photographs and observations demonstrating their contribution towards harmony with nature.			
Assignments: Critically analyze the statement "Nature is already in harmony (except for human being without right understanding), so there is a potential or provision for harmony in human being." 'There is definitiveness in human conduct just in the same way as there is definitiveness in the characteristics of a mango tree or a horse etc. but this definitiveness becomes evident only through right understanding'. Give your comments on this statement with justification.			
Course Projects:			
Students should work in groups of 4–5 to plan and perform activities that demonstrate the			



concepts learned in all four units of the course. The group must practically apply the values in real-life situations and document their activities with photographs, observations, and reflections.

2. Students design and run a small awareness campaign on topics like plastic reduction, energy saving, or water conservation in the college or community.

Textbooks:

1. A Foundation Course in Human Values and Professional Ethics, RR Gaur, R Asthana, GP Bagaria, 3rd revised edition, UHV Publications, 2023, ISBN: 978-81-957703-7-3 (Printed Copy), 978-81-957703-6-6 (e-book)
2. Teacher's Manual for A Foundation Course in Human Values and Professional Ethics, RR Gaur, R Asthana, GP Bagaria, 3rd revised edition, UHV Publications, 2023, ISBN: 978-81-957703-5-9 (Printed Copy), 978-81-957703-0-4 (e-Book)

Reference Books:

1. P. L. Dhar, R. R. Gaur (1990) Science and Humanism, Commonwealth Publishers.
2. A. Nagaraj (1999) Jeevan Vidya: Ek Parichaya, Jeevan Vidya Prakashan, Amarkantak.
3. B. P. Banerjee (2005) Foundations of Ethics and Management, Excel Books.
4. A. N. Tripathy (2003) Human Values, New Age International Publishers.
5. E. G. Seebauer & Robert L. Berry (2000) Fundamentals of Ethics for Scientists & Engineers, Oxford University Press.
6. B. L. Bajpai (2004) Indian Ethos and Modern Management, New Royal Book Co., Lucknow.
7. M. Govindrajan, S Natrajan & V.S. Senthil Kumar, Engineering Ethics and Human Values, Eastern Economy Edition, Prentice Hall of India Ltd.
8. M. K. Gandhi, "The Story of my Experiments with Truth", Discovery Publisher

MOOCs Links and additional reading material:

1. Swayam Course on "Understanding Human Being Nature and Existence Comprehensively" by
Dr. Kumar Sambhav, Director, UP Institute of Design (UPID), Noida.
https://onlinecourses.swayam2.ac.in/aic22_ge23/preview
2. NPTEL Course on "Exploring Human Values: Visions of Happiness and Perfect Society" by Prof.A. K. Sharma, Department of Humanities and Social Sciences, IIT Kanpur.
<https://nptel.ac.in/courses/109104068>
3. <https://www.youtube.com/@sadhguru>
4. <https://www.youtube.com/@GaurGopalDas>



Strength of CO-PO-PSO Mapping														
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	2	1	1	1	-	2	1	-	-
CO2	-	-	-	-	-	2	1	1	1	-	2	1	-	-
CO3	-	-	-	-	-	2	1	1	1	-	2	1	-	-
CO4	-	-	-	-	-	2	1	1	1	-	2	1	-	-
Avg.	-	-	-	-	-	2	1	1	1	-	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE						ESE				
	CT1	CCE 2	CCE3	CCE 4							
CO	CO1						CO1	CO2	CO3	CO4	CO5
K1											
K2	√	√					√	√	√	√	
K3	√	√					√	√	√	√	
K4	√	√					√	√	√	√	
K5											
K6											

Unit wise Weightage:

Exam	Unit1	Unit2	Unit3	Unit4
CCE				
Activities	12	13		
CCE2			12	13
CCE3				
ESE				
Total	12	13	12	13

This course serves as a prerequisite for / maps with the following future courses:

1. Sustainable Development
2. Humanities and Social Sciences (HSS)

Approved By:

**Job Mapping:**

Job opportunities that one can get after learning this course:

1. Human Resource (HR) Specialist
2. Public Relations (PR) Manager
3. Counselor / Life Coach
4. Sustainability Consultant



Program:		S. Y. B. Tech (A&R Engineering)		Semester:		III		
Course:		Drive and Control Technology Laboratory		Course Code:		R25-AR-PCC-208		
Teaching Scheme				Examination Scheme				
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	OR	
--	2	--	1	--	--	25	25	
Course Description To Provide the fundamental concepts, construction, and working principles of motors and special purpose machines.								
Course Relevance To develop the students with ability to choose the correct motor type for specific application, design automation and robotics system and troubleshoot drive systems.								
Prerequisite: 1. Engineering Physics 2. Basic Electrical Engineering 3. Basic Electronics Engineering 4. Engineering Mathematics – I, II								
Bridge Content: It Bridges theoretical Knowledge with industry application, enhancing employability in Automation and robotics.								
Course Objectives: - To understand the operation and performance of AC and DC motors, the factors influencing the choice of electric drives in Automation and Robotics. - To develop the techniques to understand construction, working of different motors and its applications that would enhance thinking in their respective disciplines.								
Course Outcomes: After learning the course, students will be able to								
CO	Course Outcome						Bloom's Level	
CO1	EXPLAIN the construction, classifications, and operating principles of DC motors and it's application.						2,3	
CO2	UNDERSTAND the concept of power electronics to control electric motors.						2,3	
CO3	EXPLAIN the performance characteristics, losses, and efficiency of Induction motor & different electric drives used in automation						2,4	
CO4	ILLUSTRATE speed control methods for DC and AC motors using converters, choppers, and inverters.						3,4	
CO5	EVALUATE the performance of electric drives under various loading and braking conditions.						4,5	
List of Practical: (Any Eight out of Ten)								
Experiment No.1	Speed control of DC shunt motor						2 Hrs.	CO1,4
Objective:								

Approved By:



To study and perform speed control of a DC Shunt Motor by varying:

1. Field current (Field Control Method)
 2. Armature voltage (Armature Control Method)
- and observe the effect of these methods on motor speed.

Associated Tasks:

1. Identify the main parts of the DC shunt motor setup.
2. Connect the circuit according to the given diagram.
3. Measure: Armature voltage, Field current and Motor speed (RPM)
4. Vary the field rheostat or armature voltage.
5. Record changes in speed.
6. Plot graphs: Speed vs Field Current
Speed vs Armature Voltage
7. Analyze the relationship between speed and control parameters.
8. Follow electrical safety precautions during operation.

Exemplars and Utility:

- 1) Speed control of DC shunt motors is widely used in: Electric traction systems, Cranes and hoists, Conveyors, Rolling mills, Printing machines, Machine tools and Elevators and lifts

Experiment No.2	Brake test on DC shunt motor	2 Hrs.	CO3,4, 5
------------------------	-------------------------------------	---------------	-----------------

Objective:

To perform a brake test on a DC Shunt Motor and determine: Output power, Input power, Efficiency of the motor and Torque developed by the motor

Associated Tasks:

1. Identify the components of the brake test setup: DC shunt motor, Brake drum, Belt and spring balance, Tachometer, Ammeter and voltmeter
2. Connect the circuit according to the laboratory diagram.
3. Apply mechanical load using the brake arrangement.
4. Measure: Supply voltage, Armature current, Speed (RPM) and Spring balance readings
5. Calculate: Torque, Output power and Efficiency
6. Plot performance characteristics if required.
7. Follow safety precautions while applying load.

Exemplars and Utility:

1. Brake test is used to: Determine actual efficiency of DC motors, Measure torque and output power, Study load characteristics of motors, Evaluate motor performance in laboratories and industries
2. Applications include: Motor testing laboratories, Industrial maintenance departments, Electrical machine performance analysis and Educational and

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research institutions			
Experiment No.3	Determination of equivalent circuit parameters of three phase induction motor by no-load and blocked rotor test	2 Hrs.	CO3
Objective: To determine the equivalent circuit parameters of a three-phase induction motor using: 1) No-load test 2) Blocked rotor test Associated Tasks: 1) No-Load Test 1. Connect the three-phase induction motor to rated supply voltage. 2. Run the motor without mechanical load. 3. Measure: Line voltage, Line current and Input power 4. Determine: Core loss, Magnetizing current and No-load power factor 2. Blocked Rotor Test 1. Lock the rotor mechanically. 2. Apply reduced voltage until rated current flows. 3. Measure: Applied voltage, Current and Input power 4. Determine: Equivalent resistance, Leakage reactance and Short-circuit impedance Exemplars and Utility: 1. Helps understand induction motor modeling. 2. Demonstrates practical estimation of equivalent circuit parameters.			
Experiment No.4	Load test on 3 phase induction motor	2 Hrs.	CO3,5
Objective: To perform a load test on a 3-phase induction motor and determine: Efficiency at different load conditions, Output power and input power Associated Tasks: 1. Connect the 3-phase induction motor with the loading arrangement (brake drum/dynamometer). 2. Measure: Line voltage, Line current, Input power using wattmeter and Speed using tachometer 3. Apply load gradually on the motor. 4. Record readings for different load conditions. 5. Calculate: Output power, Efficiency, Slip, Torque and Power factor 6. Plot characteristic curves such as: Efficiency vs Load Current vs Load Speed vs Load			

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7. Analyze motor performance and compare with rated values.

Exemplars and Utility:

1. Assists in identifying overload or inefficient operating conditions
2. Important in power plants, manufacturing units, and automation systems

Experiment No.5	Plotting speed-torque characteristic of three phase induction motor	2 Hrs.	CO3,4
Objective: To plot the speed–torque characteristic of a three-phase induction motor and study the relationship between motor speed and developed torque under varying load conditions. Associated Tasks: 1. Connect the three-phase induction motor with: Three-phase supply, loading arrangement (brake drum/dynamometer) and Measuring instruments 2. Ensure proper electrical and mechanical connections. 3. Plot: Speed vs Torque Exemplars and Utility: 1. In conveyor systems: Motors operate near rated torque and Speed–torque characteristics help to select suitable motors for varying loads.			
Experiment No.6	Study of starters for AC and DC motors	2 Hrs.	CO1,3,4
Objective: To study the construction and working of starters used for AC and DC motors and to understand the necessity of starters in limiting starting current. Associated Tasks: 1. Identify the parts and connections of different motor starters. 2. Study the working principle of: DOL (Direct-On-Line) starter, Star-Delta starter, Auto-transformer starter, Three-point starter for DC motors and Four-point starter for DC motors 3. Connect the starter circuit with the motor under supervision. 4. Observe starting current and motor behavior during starting. 5. Note protection mechanisms provided in the starter. 6. Compare advantages and limitations of various starters. 7. Draw circuit diagrams of each starter and explain operation. Exemplars and Utility: 1. Widely used in industries, workshops, and power systems 2. Essential for motor control and automation applications			
Experiment No.7	Study of BLDC motor drive	2 Hrs.	CO1,4

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**Objective:**

To study the construction and working principle of a Brushless DC (BLDC) motor drive and to understand the electronic commutation process used in BLDC motors.

Associated Tasks:

1. Identify the main parts of the BLDC motor drive setup:
2. Study the block diagram and connection diagram of the BLDC drive.
3. Observe electronic commutation using sensor signals.

Exemplars and Utility:

1. BLDC drives provide high efficiency, high reliability, and low maintenance.
2. Widely used in modern automation and electric transportation systems.

Experiment No.8	Study of operating modes of stepper motor	2 Hrs.	CO3,4
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Objective:

To study the construction and working principle of a stepper motor and to understand different operating modes of a stepper motor

Associated Tasks:

1. Identify the components of the stepper motor setup:
2. Study the connection diagram and excitation sequence.
3. Study operation of motor in different modes:

Exemplars and Utility:

1. Stepper motors provide precise position and speed control and it is suitable for open-loop control systems, Easy interfacing with digital controllers and microprocessors.

Experiment No.9	Study of Servo Motor	2 Hrs.	CO3,5
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Objective:

To study the construction, working principle, speed-torque characteristics, position control, and applications of a servo motor used in automation and control systems.

Associated Tasks:

1. Identify the main parts of a servo motor.
2. Understand the feedback mechanism used in servo control.
3. Study the operation of servo motor for different input signals.
4. Compare servo motors with conventional DC motors.

Exemplars and Utility:

1. Provides precise position and speed control.
2. Widely used in robotics and industrial automation.

Experiment No.10	Study of Power Electronics to control motor drive in Robotics	2 Hrs.	CO2
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**Objective:**

To understand the role of power electronics in controlling motor drives used in robotic systems, and to study how electronic switching devices and control circuits regulate speed, direction, torque, and efficiency of motors.

Associated Tasks:

1. Identify different power electronic devices used in motor control (e.g., MOSFETs, IGBTs, thyristors).
2. Study basic motor drive circuits such as H-bridge and PWM controllers.
3. Study direction control using switching circuits.
4. Study about interface of motor driver circuits with microcontrollers (Arduino/PLC).

Exemplars and Utility:

1. Essential for automation in robotics, manufacturing, and smart systems. Reduces mechanical wear by using electronic switching instead of mechanical control.
2. Forms the backbone of modern electric drives in robotics, EVs, and industrial automation.

Textbooks:

1. V. K. Mehta and Rohit Mehta, Principles of Electrical Machines, S Chand Publication
2. Ashfaq Husain, Electrical Machines, Dhanpat Rai and Co.
3. B. L Theraja –Electrical Technology, Vol II , S. Chand publication.
4. G. K. Dubey, “Fundamentals of Electrical Drives”, Second edition (sixth reprint), Narosa Publishing house,2001.
5. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education
6. N. K. De, P. K. Sen, “Electric Drives”, Prentice Hall of India Eastern Economy Edition

Reference Books:

1. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electrical Machines”, Tata McGraw Hill Publication Ltd., Fifth Edition.
2. A.S. Langsdorf, “Theory and performance of DC machines”, Tata McGraw Hill.
3. Smarajit Ghosh, “Electrical Machines”, Pearson Education, New Delhi
4. P. C. Sen, “Principles of Electric Machines and Power Electronics “, John Wiley and Sons Publication, second edition 1997.
5. R. Krishnan, “Electric Motor Drives – Modeling Analysis and Control”, PHI India
6. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education
7. Austin Huges, “Electrical motor and drives: Fundamental, types and

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- applications”, Heinemann Newnes, London
8. Frank D. Petruzella – Programmable Logic Controllers (McGraw-Hill)
 9. R.K. Rajput – Industrial Electronics and Control (S. Chand)
 10. James A. Rehg & Glenn J. Sartori – Industrial Electronics (Pearson)

MOOCs Links and additional reading material:

1. <https://archive.nptel.ac.in/courses/108/104/108104140/>
2. <https://archive.nptel.ac.in/courses/108/108/108108077/>
3. https://onlinecourses.nptel.ac.in/noc19_ee65/preview
4. https://onlinecourses.swayam2.ac.in/nou24_ee02/preview

Strength of CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	0	0	0	0	0	0	0	3	1	1
CO2	3	3	2	1	3	0	0	0	0	0	1	2	1	3	2
CO3	3	3	0	2	2	0	2	0	0	0	1	0	3	2	2
CO4	3	2	3	0	3	0	0	0	0	0	2	0	2	3	3
CO5	2	3	0	3	3	0	1	0	0	0	2	0	2	2	3
Avg	2.8	2.6	1.4	1.4	2.4	0.0	0.6	0.0	0.0	0.0	1.2	0.4	2.0	2.0	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

This course serves as a prerequisite for / maps with the following future courses:

1. Advanced Electrical Drives
2. Power Electronics
3. Industrial Automation and Control
4. PLC and SCADA Systems
5. Control Systems Engineering
6. Electric Vehicle Technology
7. Renewable Energy Systems
8. Embedded Systems for Industrial Applications
9. Robotics and Motion Control

Job Mapping:

Job opportunities that one can get after learning this course:

1. Electrical Design Engineer
2. Automation Engineer
3. Testing and Commissioning Engineer
4. Research and Development (R&D) Engineer



Program:		S. Y. B. Tech (A&R Engineering)		Semester:		III	
Course:		Industrial Automation Lab		Course Code:		R25-AR-PCC-209	
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
-	2	-	1	-	-	25	25
Course Description This course provides foundational knowledge in automated systems, focusing on PLC programming. Students learn to design, maintain, and troubleshoot industrial automation system, preparing them for specialized automation roles.							
Relevance: Industrial automation is essential for modern industries to achieve efficiency, quality, and large-scale production. This course introduces students to the basics of automation, focusing on basics of PLCs and its programming. It emphasizes practical applications, problem-solving, and hands-on skills to prepare students for Industry 4.0 and careers in automation-driven sectors.							
Prerequisite: • Basic Electrical Engineering • Basic Electronics Engineering • Electronics Measurement and Instruments.							
Bridge Content: This course typically focuses on bridging the gap between theoretical knowledge and practical, industry-relevant skills in automation technologies.							
Course Objectives: 6. EXPLAIN the Industrial automation and terminologies related to automation. 7. IDENTIFY and DESCRIBE basic technologies and modules of PLC. 8. UNDERSTAND basics of PLC programming. 9. DEVELOP ladder logic programs for timers and counters. 10. IMPLIMENT ladder logic programs for industrial applications.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome				Bloom's Level		
CO1	EXPLAIN the need, benefits, and types of industrial automation systems along with their applications.				2		
CO2	IDENTIFY PLC modules and understand PLC configuration.				2		
CO3	DESCRIBE basics of PLC programming.				2		
CO4	DISCUSS Ladder programming for different logic gates and functions.				2		
CO5	APPLY the basics of PLC programming and TEST ladder logic programs for a given application.				3		
Course Content							
List of Practical:							
Experiment		Manufacturing and Process			2 Hrs.		CO1

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No.1	Automation		
Objective: Understand the manufacturing and process automation systems along with their applications. Associated Tasks: 1. Study the basic structure of automation. 2. Learn how to automate the manual process: Case Study Exemplars and Utility: Useful to understand how manual processes are replaced with automation in industries to increase efficiency and get consistent quality.			
Experiment No.2	PLC modules and configuration	2 Hrs.	CO2
Objective: Understand types of PLC, its modules and configuration. Associated Tasks: 1. Learn basics of PLC hardware. 2. Learn PLC configuration. Exemplars and Utility: Useful for students to learn the internal structure and selection criteria of PLC.			
Experiment No.3	Development of ladder logic diagram using Bit Instructions.	4 Hrs.	CO3, CO4
Objective: Develop ladder logic program for various logic gates and functions. Associated Tasks: 1. Construct ladder logic program for logic gates: AND, OR, NOR, NOT, XOR, XNOR 2. Construct ladder logic program for functions: Latching, Timer, Counter Exemplars and Utility: Helps students to understand the logic functions and their applications.			
Experiment No.4	Implement DOL starter using PLC	2 Hrs.	CO3, CO4
Objective: Construct and implement ladder logic program to operate Direct-On-Line (DOL) starter by using PLC. Associated Tasks: 1. Study operating principle of Direct-On-Line (DOL) starter. 2. Start and stop motor by using PLC controlled DOL starter. Exemplars and Utility: Helps to understand the latching (hold) function of DOL starter to keep motor in on state even after releasing start push button.			
Experiment No.5	Implement the digital clock using PLC	2 Hrs.	CO3, CO4, CO5
Objective: Construct and implement ladder logic program for 24 hour digital clock using PLC. Associated Tasks: 1. Develop 24-hour digital clock using timers and counters controlled by PLC. 2. Upload program in PLC and operate it to get output as a clock. Exemplars and Utility:			

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Helps to understand how up counter, timers are work together to design a digital clock.			
Experiment No.6	PLC based automatic tank filling system	2 Hrs.	CO3, CO4, CO5
Objective: Construct and implement ladder logic program to fill the tank when it's empty and stop the filling when it's full. Associated Tasks: 1. Observe current manual tank filling system. 2. Develop ladder logic program to automate tank filling process by using pump and sensors controlled by PLC. 3. Upload program in PLC and operate it to see the output. Exemplars and Utility: Students understand how the tank filling, motor starting and stopping process carried out automatically in water purifiers used at home.			
Experiment No.7	Control the traffic signals using PLC	2 Hrs.	CO3, CO4, CO5
Objective: Construct and implement ladder logic program to Control the traffic signals using PLC. Associated Tasks: 1. Observe the traffic signals and note the sequence of lights and its operating time. 2. Develop ladder logic program to control traffic signals using PLC. 3. Upload program in PLC and operate it to get different outputs by changing the sequence of light and operating time. Exemplars and Utility: Students understand the working principle traffic signals and how they are controlled by PLC.			
Experiment No.8	PLC based parking station using Counter and Bit Instructions.	2 Hrs.	CO3, CO4, CO5
Objective: Construct and implement ladder logic program for PLC based car parking station. Associated Tasks: 1. Observe the car parking system of mall. 2. Develop ladder logic program to open the gate of parking station if vacant slot is available for car parking as well as shows the number of slots available/unavailable for parking. 3. Upload program in PLC and operate it to see the output. Exemplars and Utility: Students understand how car parking system of mall works automatically. They learn how it operates only when there is vacant slot available for car parking and shows' parking is full signal when there isn't any parking slot available.			
Textbooks:			
1. Gary Dunning, 'Introduction to Programmable Logic Controllers' Thomson Learning, 2001. 2. W. Bolton, "Programmable Logic Controllers" 5th Edition Newnes, 2009.			
Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.			
1. Industrial Automation and Control, by Prof. Alokanti Deb, IIT Kharagpur. https://nptel.ac.in/courses/108105088 2. Program Logic Controllers, by Prof. P. M. Pathak, www.youtube.com/watch?v=MS3qJq2jvu0 3. Virtual Labs for PLC programming, https://plc-coep.vlabs.ac.in			



CO-PO-PSO Mapping														
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	-	-	-	-	-	-	-	-	2
CO2	3	3	3	2	2	-	-	-	-	-	-	-	-	3
CO3	3	2	2	2	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	2	2	1	-	-	-	-	-	-	-	2
CO5	3	3	2	2	3	-	1	1	-	-	-	-	-	3
Avg.	3	2.8	2.2	2.0	2.2	0.2	0.2	0.2	0	0	0			2.6

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

This course serves as a prerequisite for / maps with the following future courses:

- Sensors and Actuators for Robotics
- Mechatronics and Control Systems
- Industrial Robotics and Automation
- Sensor and Vision System in Robots

Job Mapping:

Job opportunities that one can get after learning this course:

- Automation Engineer
- Automation System Analyst
- Process Simulation Analyst
- Field Analyst in Agricultural/Industrial Automation



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	III		
Course:	Community Engagement Project/ Field Project			Course Code:	R25-AR-ECEP-210		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
--	4	--	2	--	--	50	--
Course Description and Relevance: Community Engagement Project (CEP) is an experiential learning course that integrates academic knowledge with meaningful community service and social responsibility. The course enables students to work directly with local communities, government bodies, NGOs, and stakeholders to identify real-world societal problems and develop practical, sustainable, and context-specific solutions. Through field activities, surveys, awareness programs, workshops, environmental initiatives, and community-based engineering interventions, students gain first-hand exposure to the social, ethical, environmental, and economic dimensions of engineering practice. The course emphasizes active participation, collaborative learning, documentation, reflection, and continuous evaluation to strengthen students’ practical understanding of societal development and civic engagement. CEP provides students with opportunities to apply engineering principles for solving real-life challenges while developing empathy, teamwork, communication, leadership, and problem-solving skills. The course promotes experiential and service learning, helping students become socially conscious engineers capable of contributing positively to society. It also strengthens students’ ability to evaluate interventions critically and derive actionable insights for sustainable development. Community engagement activities such as renewable energy awareness, hygiene drives, digital literacy, environmental protection, and health awareness programs create a strong foundation for responsible engineering practice and lifelong civic participation.							
Prerequisite: 1. Basic understanding of social and ethical responsibilities 2. Teamwork and communication skills acquired through prior coursework or group activities 3. Familiarity with problem-solving methodologies and project planning 4. Conversational ability in local language							
Bridge Content: 1. Introduction to community engagement and experiential learning concepts. 2. Basics of communication, teamwork, leadership and project planning. 3. Understanding social responsibility, ethics and sustainable development. 4. Methods of community survey, data collection and problem identification. 5. Awareness about local governance systems, NGOs and community participation. 6. Documentation techniques for activity records, reports and presentations.							
Course Objectives: 1. To establish a mutually beneficial relationship between the college and the community. 2. To provide opportunities for students to engage with local communities and develop empathy, teamwork and problem-solving skills.							



3. To understand challenges faced by local communities and the role of engineering in addressing them.
4. To apply technical knowledge and engineering skills for designing interventions with positive social impact.
5. To evaluate and critically analyze engagement activities for sustainable and community-oriented outcomes.

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	IDENTIFY and ANALYZE local community needs and challenges by engaging with stakeholders and evaluating real-world problems.	4
CO2	DESIGN and IMPLEMENT practical, creative, and context-specific solutions using engineering principles to address community issues.	6
CO3	REFLECT and EVALUATE the effectiveness of their interventions and articulate lessons learned through reports and presentations.	5

Course Content

Implementation Guidelines

- A group of 3 to 4 students or an individual student may be assigned to a habitation, village or municipal ward near the college or residence area.
- Each group shall work under the guidance of a faculty mentor.
- Students may collaborate with government officials, village authorities, NGOs or community organizations.
- The CEP should be different from NSS/NCC/club activities.
- Students shall maintain an activity book signed by mentor/HoD.
- Project reports shall be submitted at the end of the semester.
- Evaluation shall be based on participation, implementation, documentation and presentation.

Suggested Topics under Community Engagement Project:

- Use / misuse of mobile phones
- Career orientation for youth
- Water facilities and drinking water availability
- Health and hygiene awareness
- Renewable energy and solar systems
- Air, water and sound pollution
- Plantation and soil protection
- Organic farming
- Food adulteration awareness
- Women education and empowerment
- Digital literacy programs
- Yoga and wellness awareness
- Health intervention programs
- E-waste management initiatives

List of Practicals:

Experiment	Community Survey and Need	COs Mapped: 1	Hrs.
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Approved By:



No.1	Identification		
Objective: - Identify local community issues through surveys, interaction and field visits. - Understand the socio-economic and environmental conditions of the selected area. - Analyze real-world problems affecting local stakeholders. Associated Tasks: Conduct surveys and interviews with local residents. Identify problems related to health, water, environment, education or technology. Prepare community need assessment reports. Interact with local authorities and NGOs for information gathering. Exemplars and Utility: A) Exemplars: Survey on drinking water availability and sanitation facilities. Study of digital literacy among rural students. Identification of waste management issues in villages. B) Utility: - Develops communication and stakeholder interaction skills. - Helps students understand grassroots-level societal challenges. - Builds analytical and observation skills for engineering applications.			
Experiment No.2	Community Awareness and Outreach Activities	COs Mapped: 1, 2	Hrs.
Objectives: - Plan and organize awareness programs for community welfare. - Promote social responsibility and sustainable practices among stakeholders. Associated Tasks: - Organize awareness drives on hygiene, health, renewable energy or pollution control. - Prepare posters, presentations and informational materials. - Conduct interactive sessions with community members. Exemplars and Utility: A) Exemplars: Health and hygiene awareness campaign. Renewable energy and solar system awareness workshop. E-waste management and recycling drive. B) Utility: - Enhances leadership and teamwork abilities. - Improves public communication and presentation skills. - Encourages social and environmental responsibility.			
Experiment No.3	Design and Development of Community Solutions	COs Mapped: 2	Hrs.
Objectives: Apply engineering principles to design practical and low-cost community			

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solutions.

- Encourage innovation and context-specific problem solving.

Associated Tasks:

- Identify engineering interventions suitable for community problems.
- Develop prototypes or conceptual solutions.
- Test feasibility and usability of proposed solutions.

Exemplars and Utility:

A) Exemplars:

Low-cost water-saving devices.
Simple mobile applications for local use.
Solar-powered lighting models for rural areas.

B) Utility:

- Promotes innovation and engineering design thinking.
- Bridges technical knowledge with real-world application.
- Encourages sustainable and affordable solution development.

Experiment No.4	Environmental and Sustainability Initiatives	COs Mapped:2	Hrs.
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Objective:

- Promote environmental sustainability and conservation practices.
- Encourage active participation in ecological and social initiatives.

Associated Tasks:

Organize tree plantation drives and cleanliness campaigns.
Conduct awareness sessions on pollution control and waste management.
Participate in water conservation and energy-saving activities.

Exemplars and Utility:

A) Exemplars:

Plantation and soil protection campaign.
Recycling and clean-up initiatives.
Water conservation awareness activities.

B) Utility:

- Builds environmental awareness and civic responsibility.
- Encourages sustainable engineering practices.
- Develops collaborative and volunteer participation skills.

Experiment No.5	Project Documentation and Presentation	COs Mapped: 3	Hrs.
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Objective:

- Document activities, outcomes and learning experiences systematically.
- Evaluate effectiveness of community interventions and communicate findings.

Associated Tasks:

Prepare project reports and activity documentation.
Maintain activity books and records.
Deliver presentations and poster demonstrations.
Reflect on lessons learned and future improvements.

Exemplars and Utility:

A) Exemplars:

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CEP project report preparation.
Reflection report and feedback analysis.
Group presentation and viva voce.

B) Utility:

- Strengthens technical writing and presentation skills.
- Encourages critical thinking and self-evaluation.
- Develops professional documentation practices.

Textbooks:

1. Waterman, A. Service-Learning: A Guide to Planning, Implementing, and Assessing Student Projects. Routledge, 1997.
2. Beckman, M., and Long, J. F. Community-Based Research: Teaching for Community Impact. Stylus Publishing, 2016.
3. Design Thinking for Social Innovation. IDEO Press, 2015.
4. Dostilio, L. D. et al. The Community Engagement Professional's Guidebook. Stylus Publishing, 2017.

Reference Books:

1. Community Engagement in Higher Education by Barbara Jacoby
2. Engineering for Sustainable Development by John Twidell
3. Introduction to Community Development by Rhonda Phillips and Robert Pittma
4. Social Innovation and Community Development by Frank Moulaert

Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.

1. NPTEL: Ecology and Society

Web Links:

UNESCO: Education for Sustainable Development
EPICS (Engineering Projects in Community Service)
Ashoka: Innovators for the Public
Design for Change

*Add additional rows as per requirement

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	-	3	3	2	3	2	1	2	3	3
CO2	2	3	3	2	1	3	3	2	3	2	2	3	3	3
CO3	1	2	2	2	-	2	2	3	2	3	2	2	2	3
Avg.	1.7	2.7	2.3	2.0	0.3	2.7	2.7	2.3	2.7	2.3	1.7	2.3	2.7	3.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Approved By:

**Assessment Pattern**

BT Level	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5
CO	CO1	CO2	CO3	CO4	CO5
K1					
K2					
K3	3	4	5	5	4
K4	4	4	5	5	5
K5					5
K6			6	6	

This course serves as a prerequisite for / maps with the following future courses:

1. Project Based Learning
2. Innovation and Entrepreneurship
3. Sustainable Engineering Practices
4. Engineering Project Management
5. Rural Technology and Development
6. Social Innovation and Product Design
7. Capstone / Major Project

Job Mapping:

Job opportunities that one can get after learning this course:

1. Social Innovation Engineer
2. CSR Project Coordinator
3. Community Development Officer
4. Sustainability Engineer
5. NGO Technical Consultant
6. Rural Development Engineer
7. Project and Outreach Coordinator



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Fundamentals of Industrial Robotics			Course Code:	R25-AR-PCC-211		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
03	--		3	40	60	--	--
Course Context: The course Fundamentals of Industrial Robotics provides foundational knowledge of robotic systems, including robot kinematics, transformations, end effectors, programming, safety, and industrial applications used in automation and manufacturing.							
Course Relevance: The course is relevant to modern industries as robotics plays a vital role in automation, precision manufacturing, material handling, and smart production systems, supporting the transition toward Industry 4.0.							
Practical Significance: The subject develops practical skills in robot programming, motion analysis, end-effector selection, and safety practices, enabling learners to work with industrial robotic systems in manufacturing and automation environments.							
Prerequisite: 1. Foundation of Automation & Robotics 2. Electric drives & Controls 3. Engineering Physics 4. Manufacturing Technology 5. Applied Mathematics							
Course Objectives: 1. UNDERSTAND and APPLY transformations for representing robot position and orientation. 2. ANALYZE robot kinematics using D-H parameters for forward and inverse solutions. 3. STUDY design and application of various robot end effectors. 4. DEVELOP basic robot programming skills including path planning and sensor use. 5. UNDERSTAND robot safety, maintenance, and emerging trends in robotics.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome						Bloom's Level
CO1	APPLY transformation techniques to model robot position and orientation.						3
CO2	SOLVE forward and inverse kinematics problems using standard methods.						4
CO3	SELECT appropriate end effectors for industrial applications.						5
CO4	DEVELOP basic robot programs with motion and sensor integration.						6
CO5	EXPLAIN safety practices, maintenance, and new trends in robotics.						2
Course Contents							

Approved By:



Unit I	Transformations	8 Hrs.	COs Mapped CO1, CO2
Representation of position and orientation of an object, Homogeneous transformation matrices, Frame Transformations, Combined Transformations, Inverse Transformations. Kinematic equations for positions and orientation: Cartesian, Cylindrical, Spherical and Articulated coordinates. RPY angles and Euler angles.			
Real World Assignment: - Design the coordinate transformation model for a robotic arm used in a warehouse to pick items from a conveyor belt and place them on different shelves. - Model a robotic arm used in an automotive industry for spray painting car bodies with precise orientation control. Exemplars / Practical Applications and usage: - Position and orientation representation is used in robot arms, drones, and mobile robots for locating objects in space. - Homogeneous transformation matrices are used in industrial and surgical robots to combine rotation and translation. - Frame and combined transformations help convert coordinates and compute end-effector position in multi-joint robot systems. - Inverse transformations are used in robot control and CNC machines to determine joint parameters for a target position. - Kinematic models and Euler/RPY angles are used in 3D printers, drones, aircraft, and VR systems for motion and orientation control.			
Unit II	Robot Motion Analysis	8 Hrs.	COs Mapped
Introduction, Denavit -Hartenberg Parameters, Rules for coordinate assignment, Arm matrix, Forward Kinematics, Inverse kinematics problem, Degeneracy and dexterity, Geometric approach to Inverse kinematics.			
Real World Assignment: - Use of Robot simulators for direct and inverse kinematics of simple robot configuration - Demonstration of simple robotic system using available computational facilities Exemplars / Practical Applications: - Forward and inverse kinematics let engineers derive the position/orientation of the end-effector from joint angles (and vice versa), enabling precise tasks like pick-and-place, assembly, welding, and medical robotics. - Trajectory and path planning optimization computes efficient, safe joint-space paths that minimize forces or avoid obstacles			
Unit III	Robot End Effectors	8 Hrs.	COs Mapped
Introduction, Type of End Effectors Grippers, Types of Grippers - Mechanical, Pneumatic and Hydraulic, Magnetic, Vacuum Grippers with applications, Selection and Design Considerations for Grippers; Design of Mechanical Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Advance Grippers- Adaptive grippers, Soft Robotics Grippers, Tactile Sensor Grippers; Various process tools as end effectors; Robot end effectors interface, Active and passive compliance (RCC)			

**Real World Assignment:**

1. Design end effector for handling cylindrical/prismatic objects.
2. Design end effector for handling spherical objects.
3. Compare grippers designed for handling cylindrical/prismatic and spherical objects

Exemplars / Practical Applications:

1. Grippers:
 - 1.1. Mechanical (parallel/claws): Two or more rigid fingers that grasp objects—fast, simple, and ideal for uniform parts, though less suited for fragile items
 - 1.2. Vacuum/Suction cups: Use suction to lift flat/smooth items—great for packaging, glass, and electronics, but less effective on porous surfaces
 - 1.3. Soft/adaptive grippers: Made from flexible materials or air-actuated fingers that conform to varied or delicate shapes (like food items or electronics)
 - 1.4. Magnetic/electrostatic: For handling ferrous materials or ultra-light components using atomic forces.
2. Tools that physically modify objects: welding torches (MIG/TIG/spot), paint sprayers, cutting/drilling/sanding tools, adhesive dispensers, etc.

Unit 4	Fundamentals of Robot Programming and Applications	8 Hrs.	COs Mapped
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Interaction of robot with real world (Mastering, TCP, Payload, Work object, programming), Introduction to Robotic Programming, On-line and off-line programming, programming examples. Various Teaching Methods, Survey of Robot Level Programming Languages Path planning and Interpolation: A Robot Program as a Path in Space, Motion Interpolation, various Textual Robot Languages, Techniques for generating smooth robot motion paths between programmed points. Typical Programming Examples such as Palletizing, Loading a Machine, etc. Sensor Integration: Tactile, position, velocity, and force sensors for robot interaction and feedback.

Real World Assignment:

1. Programming examples for common industrial applications (e.g., welding, painting, material handling, assembly).
2. One program using lead through programming for pick and place applications considering suitable sensor inputs

Exemplars / Practical Applications and usage:

1. Lead through programming for applications like welding, brazing, etc.
2. Robot path planning and programming for pick and place, etc. operations.

Unit 5	Robot Safety, Maintenance and Future Trends	8 Hrs.	COs Mapped
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Safety Programming: Functional Safety in Robotic Application, Emergency stop procedures, safety interlocks, robot programming considerations for safe operation. Troubleshooting and Maintenance: Identifying and resolving common robot programming errors, basic robot maintenance procedures. Future Trends in Industrial Robotics: Advanced programming techniques, collaborative robots (cobots), Humanoid Robots, and the integration of artificial intelligence (AI).

Real World Assignment:

1. Simulation and Offline Programming: Utilizing robot simulation software to create, test, and debug robot programs.

2. Exemplars / Practical Applications:

Approved By:



1. Ethical considerations in ensuring robot safety.
2. ISO 10218 - Robots for Industrial Environments - Safety Requirements

Comprehensive Continuous Evaluation (CCE) components for the course:

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1.	Tests on each unit using LMS (Each test for 15 M and total will be converted out of 05 M)	05
2.	Timely Assignment Submission (total will be converted out of 05 M)	05
3.	Problem solving through Computational Software	05
4.	Value addition course on Robot Programming	05

Textbooks:

1. Groover, M.P. Weiss, M. Nagel, R.N. & Odrey, N.G., Ashish Dutta, Industrial Robotics, Technology, Programming & Applications, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
3. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright
Matthew P. McLaughlin

Reference Books:

1. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
2. Mikell P. Groover, Automation, Production Systems & Computer Integrated Manufacturing, PHI Learning Pvt. Ltd., New Delhi, ISBN:987-81-203-3418-2, 2012
3. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
4. R K Mittal & I. J. Nagrath, Robotics and Control, McGraw Hill Publication, 2015.
5. Mike Wilson, Implementation of Robotic Systems, ISBN: 978-0-124-04733-45. Robotics, Vision & Control: Fundamentals & Advanced Applications by Farid Kendoul
6. Robot Programming: A Guide to Using RUIP with ABB Robots by Rick Young

MOOCs Links and additional reading material:

1. https://onlinecourses.nptel.ac.in/noc20_de11/preview
2. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me166

CO-PO-PSO Mapping														
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	—	—	2	—	—	—	—	—	1			
CO2	3	3	1	1	2	—	—	—	—	—	1			
CO3	2	2	3	1	2	—	—	—	—	—	1			
CO4	2	2	3	2	3	—	—	—	1	1	1			
CO5	1	1	—	—	1	2	1	1	—	—	2			
Avg.														

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Approved By:



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Mechanism and Robot Kinematics			Course Code:	R25-AR-PCC-212		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
03	--	--	03	40	60	--	--
Course Description: The Course provides fundamental knowledge of motion in mechanical systems and robotic structures, focusing on how joints, links, and actuators interact to produce desired movements. It emphasizes the geometry of motion — analyzing positions, velocities, and accelerations of mechanisms such as gears, cams, linkages, and robotic arms. This subject is important because it provides the foundation for designing efficient machines and robots that can perform precise tasks in automation and manufacturing. Its relevance lies in preparing students to understand and model robotic systems mathematically, ensuring accuracy and reliability in real-world applications where precision and efficiency are critical.							
Relevance: The subject is taught because mastering kinematics is essential for designing and controlling robots and automated systems. Engineers must predict and optimize the performance of machines, which requires a deep understanding of how mechanisms move. This knowledge is crucial for developing robots that are safe, efficient, and capable of performing complex tasks. The importance of this subject extends to modern industries where automation and robotics are central — from manufacturing and healthcare to defense and agriculture. Its relevance is seen in the way it equips students with the skills to innovate in areas like robotic surgery, autonomous vehicles, and smart factories, making it a cornerstone of automation and robotics education.							
Prerequisite: 1. Engineering Mathematics - I and II 2. Engineering Physics 3. Engineering Mechanics 4. Product Development Laboratory							
Bridge Content: The course focuses on bridging the gap between the theoretical and practical knowledge in the automation and robotics sector.							
Course Objectives: 1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications. 2. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique. 3. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical approach. 4. To develop the competency to analyze the velocity and acceleration in mechanisms using graphical approach. 5. To apply fundamentals of gear theory as a prerequisite for gear design and construct cam profile for given follower motion.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome						Bloom's Level
CO1	APPLY kinematic analysis to simple mechanisms						3
CO2	SYNTHESIZE a four-bar mechanism with analytical and graphical methods						4



CO3	ANALYZE velocity and acceleration in mechanisms using analytical method	4
CO4	ANALYZE velocity and acceleration in mechanisms using graphical method	4
CO5	APPLY fundamentals of gear theory as a prerequisite for gear design and CONSTRUCT cam profile for given follower motion.	3, 6
Course Content		
Unit 1	Fundamentals of Mechanisms and Mobility	8 Hrs. COs Mapped CO1
Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Gruebler's Criterion and Kutzbach Criterion, Degrees of Freedom and Mobility Analysis, Grashof Criterion, Four-Bar Chain and its Inversions, Slider crank Chain and its Inversions, Double slider crank Chain and its Conversions, Introduction to Robotic Mechanisms and Manipulators		
Exemplars / Practical Applications and usage: Applications: Four-bar chain in bicycle pedals, slider-crank in IC engines, robotic manipulators in assembly lines. Usage: Mobility analysis for designing robotic arms, automation linkages, and industrial machines.		
Unit 2	Synthesis of Mechanism	8 Hrs. COs Mapped CO2
Steps in Synthesis: Type synthesis, Number Synthesis, Dimensional synthesis, Tasks of Kinematic synthesis - Path, function and motion generation (Body guidance), Precision Positions, Chebychev spacing, Mechanical and structural errors Graphical Synthesis: Three position synthesis of Four-Bar and Single Slider Crank Mechanisms by Inversion and relative pole method Analytical Synthesis: Three position synthesis of Four-Bar mechanism using Freudenstein's equation, Blotch synthesis		
Exemplars / Practical Applications and usage: Applications: Path generation in pick-and-place robots, motion generation in packaging machines. Usage: Dimensional synthesis for precision in robotic manipulators and automation equipment.		
Unit 3	Kinematic Analysis of Mechanisms (Analytical Method)	8 Hrs. COs Mapped CO3
Analytical methods for displacement, velocity and acceleration analysis of slider crank Mechanism, Velocity and acceleration analysis of Four-Bar and Slider crank mechanisms using Vector Algebra Methods. Velocity and acceleration analysis of Four-Bar and Slider crank mechanisms using Complex Algebra Methods. Jacobian Cartesian and joint velocity.		
Exemplars / Practical Applications and usage: Applications: CAD-based simulation of slider-crank and four-bar mechanisms, analysis of robotic joints. Usage: Predicting velocity/acceleration for safe robotic operations and machine design.		
Unit 4	Kinematic Analysis of Mechanisms (Graphical Method)	8 Hrs. COs Mapped CO4



Velocity and acceleration analysis mechanisms by Relative Velocity and Relative Acceleration Method (Mechanisms up to 6 Links), Rubbing Velocity at a Pin Joint, Coriolis component of Acceleration (Theoretical treatment only). Instantaneous Centre of Velocity, Kennedy's Theorem, Angular Velocity ratio Theorem, Analysis of mechanism by ICR method (Mechanisms up to 6 Links)

Exemplars / Practical Applications and usage:

Applications: Instantaneous center method in gear trains, Kennedy's theorem in linkage design.

Usage: Quick graphical solutions for mechanism design in automation systems.

Unit 5	Mechanisms in Automation and Robotics	8 Hrs.	COs Mapped CO5
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Rotary Power Transmission: Gears – Classification, terminology, direction, and speed ratios. Gear trains, Belts & Pulleys: Open and cross belt drives, Chains & Sprockets & their applications in automation and robotics Systems,

Linear Power Transmission: Screw, Rack-and-Pinion & Linear Guides.

Classification of Followers and Cams, Terminology of Cam Displacement diagram for the Motion of follower as Uniform velocity, Simple Harmonic Motion (SHM), Cam Profile construction for Knife-edge Follower and Roller Follower,

Indexing Mechanisms: Geneva Indexing Mechanism, Construction, Working & Application.

Introduction to Harmonic drives and cycloidal reducers in Robots

Different types of robot gripper mechanisms

Exemplars / Practical Applications and usage:

Applications: Gears in CNC machines, cams in textile machinery, Geneva indexing in film projectors, harmonic drives in robots.

Usage: Power transmission systems in robotics, automation, and precision engineering.

Comprehensive Continuous Evaluation (CCE) components for the course:

1. Course Projects (Mini/Micro Project):

To make a model of any mechanism by using waste material by the group of 4 to 6 students and to give a presentation using PPTs.

Students are encouraged to undertake a course project that enables them to apply the foundational knowledge gained. The objective of the project is to study mechanism in the automation and robotics system. Through this project, students will develop a basic yet practical understanding of system.

2. Class Tests / Unit Tests: Unit and Unit....(any two units)

The teacher can suggest the most appropriate and relevant components for CCE evaluation from the following (shall cover all the remaining units)

Open ended Assignments, Quiz / MCQ Tests, Case Study Analysis, Seminar / Presentation, Group Discussion / Team Activity, Industry Visit / Field Visit Report, Poster Presentation etc.



Sr. No.	Components for Comprehensive Continuous Evaluation	Marks Allotted (40)
1	Class Test: 24 marks (unit I & Unit II),	10
2	Assignments (unit III & unit IV (12 marks each unit))	10
3	Quiz (Unit V) (MCQ): (20 Marks)	5
4	Mini-Project: (20 Marks)	10
5	Attendance	5

Textbooks:

1. S. S. Rattan, “Theory of Machines”, Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Bevan T, “Theory of Machines”, Third Edition, Longman Publication
3. G. Ambekar, “Mechanism and Machine Theory”, PHI
4. J. J. Uicker, G. R. Pennock, J. E. Shigley, “Theory of Machines and Mechanisms”, Fifth Edition, International Student Edition, Oxford Electronics and AC Drives”, Pearson Education

Reference Books:

1. Paul E. Sandin, “Robot Mechanisms and Mechanical Devices Illustrated”, Tata McGraw Hill Publication
2. M.P. Groover, “Automation, production systems and computer-integrated manufacturing”, Prentice-Hall of India Pvt. Ltd, New Delhi
3. Stephen J. Derby, “Design of Automatic Machinery”, 2005, Marcel Dekker, New York
4. Neil Sclater, “Mechanisms and Mechanical Devices Sourcebook”, Fifth Edition, Tata McGraw Hill Publication
5. Ghosh Malik, “Theory of Mechanism and Machines”, East-West Pvt. Ltd.
6. Hannah and Stephans, “Mechanics of Machines”, Edward Arnold Publication
7. R. L. Norton, “Kinematics and Dynamics of Machinery”, First Edition, McGraw Hill Education (India) P Ltd. New Delhi
8. Sadhu Singh, “Theory of Machines”, Pearson
9. V. P. Singh, “Theory of Machine”, Dhanpat Rai and Sons
10. C. S. Sharma & Kamlesh Purohit, “Theory of Machine and Mechanism”, PHI

MOOCs Links and additional reading material:

1. <https://nptel.ac.in/courses/112104121/> (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur)
2. <https://nptel.ac.in/courses/112/106/112106270/> (NPTEL2, Theory of Mechanism, Prof. Sujatha Srinivasan, IIT Madras)
3. <https://nptel.ac.in/courses/112/105/112105268/> (NPTEL3, Kinematics of Mechanisms)

Approved By:



and Machines, Prof. Anirvan Das Gupta, IIT Kharagpur)

4. <https://nptel.ac.in/courses/112/105/112105236/> (NPTEL4, Mechanism and Robot Kinematics, Prof. Anirvan Das Gupta, IIT Kharagpur)
5. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics/Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay)

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	–	–	–	–	–	–	2	1	–
CO2	2	2	3	2	3	–	–	–	1	1	1	2	3	–
CO3	2	3	2	3	2	–	–	–	–	–	–	3	2	–
CO4	2	2	2	3	2	–	–	–	1	1	–	2	2	–
CO5	1	2	2	2	3	1	1	1	1	1	1	3	2	1
Avg	2.0	2.2	2.0	2.2	2.2	1.0	1.0	1.0	1.0	1.0	1.0	2.4	2.0	1.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE					ESE
	CT1	CT2	Assignment	Course Project	Quiz / presentation etc.	
L1	√	√	√	√	√	√
L2	√	√	√	√	√	√
L3	√	√	√	√	√	√
L4	√	√	√			√
L5						
L6				√		

Unit wise Weightage:

Exam	Unit1	Unit2	Unit3	Unit4	Unit 5
CCE					
CT1	8	7			
CT2			8	7	10
+					
ESE	12	12	12	12	12
Total	20	19	20	19	22

Approved By:



Program:		S. Y. B. Tech (A&R Engineering)		Semester:		IV	
Course:		Materials & Machine Elements		Course Code:		R25-AR-PCC-213	
Teaching Scheme (Hrs./Week)				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
2	--	--	02	40	60	--	--
Course Description To provide foundational knowledge of engineering materials, stress-strain behavior, shear force and bending moment analysis, bending and torsional stresses, and their applications in engineering design.							
Course Relevance To equip students with the fundamental concepts of material behavior and machine element analysis required for design, manufacturing, automation, robotics, and structural applications.							
Prerequisite: 1. Engineering Mechanics 2. Engineering Physics 3. Basic Manufacturing Processes							
Bridge Content: Basic concepts of force systems, stress and strain, simple beam loading, elastic constants, and material properties.							
Course Objectives: To UNDERSTAND engineering materials and their mechanical behavior. To ANALYZE stress, strain, shear force, and bending moment in engineering structures. To APPLY bending and torsion theories in machine elements. To SELECT suitable engineering materials for industrial applications. To DEVELOP analytical ability for solving strength of materials problems.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome					Bloom's Level	
CO1	EXPLAIN crystal structures and APPLY material characterization techniques					2,3	
CO2	ANALYZE stresses and strains in structural members under different loading conditions					4	
CO3	DRAW shear force and bending moment diagrams and DETERMINE bending stress, slope and deflection in beams					3	
CO4	CALCULATE transverse shear stress and torsional stresses in shafts under different loading conditions					3	



Course Content			
Unit 1	Crystal Structures, Material Testing and Characterization Techniques	6 Hrs.	CO1
Crystal Structures: Study of Crystal structures BCC, FCC, HCP and lattice parameters & properties, Miller indices, Crystal imperfections, and Diffusion Mechanisms. Material Properties: Mechanical (Impact, hardness, etc.), Electrical, optical and Magnetic properties Deformation of Materials: Elastic deformation, Plastic deformation: slip, twinning, work hardening, recovery, re-crystallization and grain growth, Fracture: Types of fractures (brittle, ductile), Creep & Fatigue failures. Exemplars / Practical Applications, Usage: 1. Material Analysis: Investigate the crystal structure of a common material (e.g., metals like aluminum or steel) and analyze how its structure influences its mechanical properties, such as ductility or hardness. 2. Deformation Mechanisms: Study the deformation process in real crystal structures, focusing on dislocations and their role in material strength. You can explore strengthening mechanisms like grain size reduction or alloying. 3. Engineering Applications: Examine how crystal structures are utilized in engineering applications, such as turbine blades or semiconductor devices. Discuss how deformation affects their performance. 4. Experimental Study: Conduct experiments to observe deformation in materials under stress. For example, use a tensile test to measure yield strength and correlate it with the material's crystal structure. 5. Case Studies: Research real-world failures in materials (e.g., bridge collapses or aircraft component failures) and analyze how crystal structure and deformation contributed to the failure. Real World Assignment (Assignment 1 compulsory, any one of remaining two): 1. Steps for Specimen Preparation for microscopic examination & Demonstration of Optical Metallurgical microscope 2. Observation and Drawing of Microstructure of Steels, Cast Iron of various compositions 3. Observation and Drawing of Microstructure of Non-Ferrous Metals of various compositions			
Unit 2	Simple Stress & Strain	6 Hrs.	CO2
Introduction to types of loads (Static, Dynamic & Impact Loading) and various types of stresses with applications, Hooke's law, Poisson's ratio, Modulus of Elasticity, Modulus of Rigidity, Bulk Modulus. Interrelation between elastic constants, Stress-strain diagram for ductile and brittle materials, factor of safety, Stresses and strains in determinate and indeterminate beam, homogeneous and composite bars under concentrated loads and self-weight Exemplars / Practical Applications, Usage: • Mechanical properties of materials, Stresses and Design of components with case study. • Tension test for Ductile material using extensometer on Universal Testing Machine • Compression test for Brittle material on Universal Testing Machine.			



• Shear test of ductile material on Universal Testing Machine. • Tension test of Plastic/Composite material on low load capacity Tensile Testing Machine.			
Assignments: 1. Failure Mode Analysis and Stresses with case study. 2. Structural Integrity: Stress analysis ensures that components can withstand applied forces without failure. For example, bridges and buildings are designed to handle stress from loads like vehicles, wind, and earthquakes.			
Unit 3	Shear Force & Bending Moment Diagrams	6 Hrs.	CO3
SFD & BMD: Introduction to SFD, BMD with application, SFD & BMD for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load, couple and combined loading, Concept of zero shear force, Maximum bending moment, point of contra-flexure Bending Stress on a Beam: Introduction to bending stress on a beam with application, Theory of Simple bending, assumptions in pure bending, derivation of flexural formula, Moment of inertia of common cross section (Solid Circular, Rectangular, I-section), Bending stress distribution along the same cross-section			
Exemplars / Practical Applications, Usage: • Experimental verification of flexural formula in bending for cantilever, Simple supported beam. • Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.			
Assignments: 1. Structural Engineering: SFD and BMD are used to analyze beams and frames in buildings, bridges, and other structures to ensure they can withstand applied loads without failure 2. Machine Design: In mechanical engineering, these diagrams help in designing machine components like shafts, levers, and gears to handle forces and moments effectively.			
Unit 4	Shear Stress & Torsion	6 Hrs.	CO4
Shear Stress on a Beam: Introduction to transverse shear stress on a beam with application, shear stress distribution diagram (Solid Circular, Rectangular, I cross-section) Torsion of circular shafts: Introduction to torsion on a shaft with application, Basic torsion formulae and assumption in torsion theory, Torsion in stepped shafts			
Exemplars / Practical Applications, Usage: • Experimental verification of flexural formula in bending for cantilever, Simple supported beam. • Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.			
Assignments: 1. Automotive Engineering: Drive shafts in vehicles are designed to handle torsional stress as they transfer torque from the engine to the wheels. Shear stress analysis ensures the			



durability of components like axles and suspension systems 2. Structural Engineering: Shear stress calculations are critical in designing beams and columns to withstand forces without buckling or breaking.
Course Projects: (Any one)
1. Material selection for robotic arm structure Comparative study of aluminum alloy, composite and mild steel based on strength-to-weight ratio. 2. Heat Treatment Effect on Hardness of Steel Comparative analysis of annealed, normalized and hardened samples. 3. Study of Non-Destructive Testing Techniques Comparative analysis of UT, RT and Eddy Current Testing for industrial components. 4. Microstructure Characterization of Engineering Materials Observation and interpretation of microstructures of ferrous and non-ferrous materials. 5. Material Characterization for Additive Manufacturing Applications Study commonly used AM materials and their applications in robotics and aerospace.
Textbooks:
1. V. D. Kodgire & S. V. Kodgire, “Material Science & Metallurgy for Engineers”, Everest Publication. 2. W. D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc. 3. R. K. Bansal, “Strength of Materials”, Laxmi Publication 4. S. Ramamurtham, “Strength of material”, Dhanpat Rai Publication 5. S. S. Rattan, “Strength of Material”, Tata McGraw Hill Publication Co. Ltd. 6. B. K. Sarkar, “Strength of Material”, McGraw Hill New Delhi 7. Singer and Pytel, “Strength of materials”, Harper and row Publication 8. R. C. Hibbeler, “Mechanics of Materials”, Prentice Hall Publication
Reference Books:
1. Cleghorn, W. L., (2005), “Mechanisms of Machines”, Oxford University Press 2. J. M. Gere, “Mechanics of Materials”, CL Engineering 3. Timoshenko and Young, “Strength of Materials”, CBS Publication, Singapore
MOOCs Links and additional reading material:
Prof. S.K. Bhattacharyya, IIT Kharagpur, “NPTEL Web course material” https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZMrSxe68Ulclei/view?usp=sharing



Strength of CO-PO-PSO Mapping														
CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3
CO1	3	2	-	2	2	-	1	-	-	-	-	3	2	1
CO2	3	3	1	2	1	-	-	-	-	-	-	3	2	1
CO3	3	3	2	2	1	-	-	-	-	-	-	3	2	1
CO4	3	3	2	2	1	-	-	-	-	-	-	3	2	1
Avg .	3.0	2.75	1.25	2.0	1.25	-	0.25	-	-	-	-	3.0	2.0	1.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE						ESE
	CT1	CT2	Assignments	Course Project	Field Activity / Case Study	Quiz / Presentation etc.	
K1	✓	---	✓	---	✓	✓	✓
K2	✓	---	✓	---	✓	---	✓
K3	✓	---	✓	---	✓	---	✓
K4	---	---	---	---	---	---	---
K5	---	---	---	---	---	---	---
K6	---	---	---	---	---	---	---

Assessment Table:

EXAM	Assessment tool	CO1	CO2	CO3	CO4
Knowledge and Attitude Profile (WK)		----	----	----	----
CCE	CT1	10	10	----	----
	CT2	----	----	----	----
	Assignments	----	----	10	10
	Course Project	----	----	----	----
	Field Activity / Case Study	----	----	----	----
	Quiz / Presentation etc.	----	----	----	----
ESE	60	15	15	15	15
Total	100	25	25	25	25

Approved By:

**Unit wise Weightage:**

Exam	Unit1	Unit2	Unit3	Unit4
CT1	10	10	---	---
CT2	---	---	----	---
Assessment by Teacher by using any two tools	---	---	10	10
ESE	15	15	15	15
Total	25	25	25	25

This course serves as a prerequisite for / maps with the following future courses:

1. Design of Machine Elements
Stress analysis, bending, torsion and material selection concepts.
2. Theory of Machines and Mechanisms
Structural loading and machine component behavior.
3. Robotics and Automation Systems
Material selection and structural analysis of robotic components.
4. Finite Element Analysis (FEA)
Stress-strain relations, beam analysis and material properties.
5. CAD/CAM and Product Design
Engineering material selection and machine element design.
6. Mechanical System Design
Strength and rigidity considerations for machine components.
7. Manufacturing Technology
Heat treatment, material processing and material characterization.
8. Additive Manufacturing
Material behavior and properties of AM materials.
9. Industrial Inspection and Quality Control
NDT techniques and material testing methods.
10. Mechatronics System Design
Lightweight structures and machine element applications.

Job Mapping:

Job opportunities that one can get after learning this course:

1. Design Engineer
2. Production Engineer
3. Material Testing Engineer
4. Metallurgical Engineer
5. CAD/CAE Engineer
6. Automation & Robotics Engineer
7. Manufacturing Engineer
8. Industrial Product Development Engineer



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Data Science and Visualization			Course Code:	R25-AR-MDM-214		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
02	--	--	2	50	--	--	--

Course Description and Relevance:

Data Science and Visualization is an interdisciplinary subject that focuses on collecting, processing, analyzing, and visualizing data to extract meaningful insights and support intelligent decision-making. The course introduces students to data analytics, statistical analysis, machine learning fundamentals, and visualization techniques using modern computational tools with applications in automation and robotics systems.

The course is highly relevant for Industry 4.0, Industrial IoT, predictive maintenance, smart factories, robot monitoring, and autonomous systems. It provides students with the skills required to analyze industrial datasets, visualize real-time sensor data, and apply data-driven approaches in automation and robotics engineering.

Prerequisite:

Discrete Mathematics, Engineering Mathematics, Basics of Programming (Python/C)

Bridge Content:

Study of fundamental concepts from Discrete Mathematics, Engineering Mathematics, and basic programming such as sets, matrices, probability, statistics, loops, functions, and file handling, which are essential for data analysis, machine learning, and visualization. Study of introductory knowledge of Python libraries like NumPy, Pandas, and Matplotlib along with handling real-world datasets. The bridge module further connects these mathematical and programming foundations with applications in robotics, industrial automation, sensor data monitoring, and IoT-based systems.

Course Objectives:

1. To **UNDERSTAND** the fundamentals and applications of Data Science and Visualization.
2. To **APPLY** statistical and analytical methods for data interpretation.
3. To **STUDY** data preprocessing, data wrangling, and data analytics lifecycle.
4. To **UNDERSTAND** machine learning techniques and model evaluation methods.
5. To **CREATE** meaningful visualizations and dashboards for industrial and robotic datasets.

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	UNDERSTAND the fundamentals, applications, and challenges of Data Science and Visualization.	2
CO2	APPLY statistical and data preprocessing techniques for real-world datasets.	3
CO3	ANALYZE and IMPLEMENT the Data Analytics lifecycle for engineering applications.	3, 4
CO4	DEVELOP data analysis and machine learning models using Python	6

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	libraries.	
CO5	CREATE effective visualizations and dashboards for industrial and robotic data.	6
Course Content		
Unit 1	Introduction to Data Science and Visualization	6 Hrs. COs Mapped CO1, CO2
Basics and need of Data Science, Data Science vs Business Intelligence, Relationship between Data Science and Information Science, Types of Data and Data Collection Methods, Introduction to Exploratory Data Analysis (EDA), Types of Data Visualization, Principles of Effective Visualization, Essential Python Libraries: NumPy, Pandas, Matplotlib, Seaborn, Introduction to Jupyter Notebook and Python Environment, Applications of Data Science in Automation and Robotics. Exemplars / Practical Applications and usage: Students can analyze simple industrial or robotic sensor datasets using Python libraries such as NumPy and Pandas to understand data patterns and trends. Visualization of robot movement data, production statistics, or IoT sensor readings using charts and graphs helps students understand the importance of data-driven decision-making in automation systems.		
Unit 2	Statistical Inference and Data Preprocessing	6 Hrs. COs Mapped CO1, CO2
Need of Statistics in Data Science, Measures of Central Tendency and Dispersion, Correlation and Regression Basics, Bayes Theorem and Hypothesis Testing, t-test, Chi-Square Test, Data Cleaning and Data Wrangling, Handling Missing Data and Duplicate Data, Data Transformation and Data Integration, Data Reduction and Data Discretization, Data Aggregation and Group Operations, Pivot Tables and Cross Tabulation. Exemplars / Practical Applications and usage: Students can perform statistical analysis on industrial datasets to identify variations, correlations, and performance trends in robotic or manufacturing systems. Practical activities may include cleaning missing sensor data, removing duplicate records, and applying hypothesis testing for quality control and predictive maintenance applications.		
Unit 3	Data Analytics and Visualization	6 Hrs. COs Mapped CO3, CO4
Introduction to Data Analytics Lifecycle, Phases of Data Analytics Lifecycle, Data Analytics Applications in Robotics and Industrial Automation, Visualization using Matplotlib, Seaborn, Plotly, and ggplot2; Time-Series and Advanced Visualizations (Heatmaps, Boxplots, Violin Plots, Bubble Charts, Candlestick Charts, Geospatial Maps, Network Diagrams); Dashboard Design and Power BI Dashboards; Industrial Applications and Case Studies involving Sensor, IoT, and Robotics Data. Exemplars / Practical Applications and usage: Students can study real-world case studies involving industrial automation and IoT-based monitoring systems to understand each phase of the data analytics lifecycle. Applications may include analyzing machine performance data, preparing datasets for predictive analysis, and communicating insights for improving industrial efficiency and robotic operations.		



Students can create interactive dashboards and advanced visualizations for real-time monitoring of industrial, robotic, and IoT systems using tools such as Matplotlib, Plotly, and Power BI. Applications include time-series visualization of sensor data, geospatial mapping of autonomous systems, and dashboard-based monitoring of smart factory operations.

Unit 4	Predictive Analytics and Machine Learning with Python	6 Hrs.	COs Mapped CO4, CO5
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Introduction to Predictive Analytics, Data Preprocessing using Python, Classification Algorithms: Naïve Bayes, Decision Trees, SVM, Regression Techniques: Linear Regression and Logistic Regression, Clustering Techniques: K-Means and Hierarchical Clustering, Association Rule Mining: Apriori Algorithm, FP Growth, Introduction to Scikit-learn, Model Training and Testing, Introduction to PCA and Dimensionality Reduction.

Exemplars / Practical Applications and usage:

Students can develop machine learning models for tasks such as fault prediction, product classification, or robotic behavior analysis using Scikit-learn. Practical applications include clustering industrial process data, performing predictive maintenance, and applying regression models for production forecasting and automation optimization.

Comprehensive Continuous Evaluation (CCE) components for the course:

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted (50)
1	Class Test (Unit-I & II) for 30 Marks	10
2	Test/Quiz on each unit using LMS	10
3	Unit wise Assignment Submission	10
4	Programming Software based assignment	10
5	Value Added Course related as per syllabus requirement	10

Textbooks:

1. David Dietrich, Barry Hiller, “Data Science and Big Data Analytics”, EMC education services, Wiley publication, 2012, ISBN0-07-120413-X.
2. Jiawei Han, Micheline Kamber, and Jian Pie, “Data Mining: Concepts and Techniques” Elsevier Publishers Third Edition, ISBN: 9780123814791, 9780123814807
3. Wes McKinney, Python for Data Analysis, O'Reilly Media.

Reference Books:

1. EMC Education Services, “Data Science and Big Data Analytics- Discovering, analyzing Visualizing and Presenting Data” 1st Edition.
2. DT Editorial Services, “Big Data, Black Book”, DT Editorial Services, ISBN: 9789351197577, 2016 Edition.
3. Chirag Shah, “A Hands-On Introduction to Data Science”, Cambridge University Press, (2020), ISBN: 978-1-108-47244-9.

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4. Wes McKinney, “Python for Data Analysis”, O' Reilly media, ISBN: 978-1-449-31979-3.
5. Trent Hawk, “Scikit-learn Cookbook”, Packt Publishing, ISBN: 9781787286382.

MOOCs Links and additional reading material:

1. An introduction to data Science:
<https://docs.google.com/file/d/0B6iefdnF22XQeVZDSkxjZ0Z5VUE/edit?pli=1>
2. Python for everybody: https://do1.dr-chuck.com/pythonlearn/EN_us/pythonlearn.pdf
3. An Introduction to Statistical Learning by Gareth James
<https://www.ime.unicamp.br/~dias/Intoduction%20to%20Statistical%20Learning.pdf>
4. Python Data Science Handbook by Jake VanderPlas
<https://tanthamhuat.files.wordpress.com/2018/04/pythondatasciencehandbook.pdf>
5. Scikit Learn Tutorial <https://scikit-learn.org/stable/>
6. Matplotlib Documentation <https://matplotlib.org/stable/users/index.html>
7. Pandas Documentation https://pandas.pydata.org/docs/?utm_source=chatgpt.com
8. NPTEL Data Science for Engineers
https://nptel.ac.in/courses/106106212?utm_source=chatgpt.com

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	-	-	-	-	1	-	2	2	1
CO2	3	3	2	2	3	-	-	-	1	1	-	3	2	2
CO3	2	3	3	3	3	1	-	-	2	2	1	3	3	2
CO4	2	3	3	3	3	-	-	-	1	1	-	3	3	3
CO5	2	2	3	2	3	1	1	-	2	3	1	2	3	3
Avg.	2.4	2.6	2.4	2.2	2.8	0.4	0.2	0.0	1.2	1.6	0.4	2.6	2.6	2.2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Unit wise Weightage:

Exam	Unit1	Unit2	Unit3	Unit4	Unit5
CCE					
CT1	15	15	--	--	--
Quiz	--	--	10	10	10
Assignment	05	05	10	10	10
Value Added Course	10	10	10	10	10
Total	30	30	30	30	30

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**Assessment Pattern**

BT Level	CT1	Quiz	Assignment	Value Added Course
CO	CO1, CO2	CO1, CO2, CO3, CO4, CO5		
K1	√	√	√	√
K2	√	√	√	√
K3	√	√	√	√
K4	--	--	--	√
K5	--	--	--	√
K6	--	--	--	--

This course serves as a prerequisite for / maps with the following future courses:

1. Machine Learning and Artificial Intelligence
2. Robotics and Autonomous Systems
3. Computer Vision and Image Processing
4. Predictive Maintenance and Smart Manufacturing
5. Cloud Computing for Automation Systems
6. Human–Robot Interaction and Intelligent Systems

Job Mapping:

Job opportunities that one can get after learning this course:

1. Automation Analytics Engineer
2. Robotics Data Engineer
3. Research Assistant in Data Analytics / Robotics
4. Smart Manufacturing Engineer



Program:	S. Y. B. Tech (Automation & Robotics)			Semester:	IV		
Course:	Material Testing and characterization			Course Code:	R25-AR-VSEC-216		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	OR
1	02	--	2	--	--	25	25
Course Description: This course introduces engineering materials, their properties, processing methods, testing techniques, characterization methods, and industrial applications with special emphasis on Automation & Robotics. The course enables students to understand material selection, performance evaluation, failure analysis, and characterization techniques through theory and laboratory experiments.							
Relevance: Engineering materials play a vital role in the design, manufacturing, operation, and maintenance of automation and robotic systems. Knowledge of material behavior, testing methods, characterization techniques, and material selection helps engineers improve the reliability, safety, durability, and performance of robotic components, automated machines, end-effectors, sensors, and industrial systems.							
Prerequisite: 1. Engineering Physics 2. Engineering Chemistry 3. Basic Manufacturing Processes 4. Engineering Mechanics							
Bridge Content: - Fundamentals of engineering materials - Basic mechanical properties of materials - Stress, strain and deformation concepts - Introduction to manufacturing processes - Fundamentals of laboratory measurements							
Course Objectives: 1. UNDERSTAND various engineering materials and their applications in Automation & Robotics. 2. UNDERSTAND material processing methods and techniques used for improving material properties. 3. EXECUTE material testing and characterization procedures to evaluate engineering materials. 4. SELECT suitable engineering materials based on functional requirements and analyze material failures in engineering applications.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome						Bloom's Level
CO1	EXPLAIN engineering materials and IDENTIFY suitable materials for Automation & Robotics applications.						2
CO2	EXPLAIN material processing techniques and ANALYZE their influence on engineering material properties.						3
CO3	EXECUTE material testing and interpret characterization procedures to evaluate engineering materials.						3
CO4	ANALYZE material failures and recommend suitable engineering materials for industrial Automation & Robotics applications.						4
Course Content							



Unit 1	Engineering Materials for Automation & Robotics	5 Hrs.	CO1
Engineering Materials: Introduction to Engineering Materials, Classification of Engineering Materials, Selection criteria of engineering materials Ferrous Materials: Plain carbon steels, Alloy steels, Stainless steels, cast irons, Engineering applications Non-Ferrous Materials: Aluminium and aluminium alloys, Copper and copper alloys, Titanium alloys, Magnesium alloys, Engineering Polymers: Thermoplastics, Thermosetting plastics, Elastomers Advanced Engineering Materials: Ceramic materials, Composite materials, Smart materials, Shape Memory Alloys, Biomaterials (Introduction), Materials used in Additive Manufacturing (Introduction) Material Selection for Automation & Robotics: Selection of materials for Robot links, Robot frames, End-effectors, Grippers, Bearings, Gears, Shafts, Conveyor systems, Automated guided vehicles (AGVs), Collaborative robots, Drone structures			
Exemplars / Practical Applications / Usage • Study of engineering materials used in industrial robotic manipulators and collaborative robots. • Comparative analysis of metallic, polymeric, and composite materials used for robotic structures. • Material selection for lightweight robotic arm considering strength-to-weight ratio. • Selection of engineering plastics for conveyor rollers and robotic grippers. • Study of composite materials used in drone frames and aerospace robotic systems.			
Real World Assignment Assignment 1 (Any One) 1. Study one industrial robotic system and identify the engineering materials used in its major components. Justify the material selection based on mechanical properties and application. 2. Comparative study of Aluminium Alloy, Mild Steel and Stainless Steel for robotic arm applications. 3. Material selection for an Automated Guided Vehicle (AGV) chassis considering weight, strength and manufacturing cost.			
Unit 2	Material Processing and Property Enhancement	3 Hrs.	CO2
Heat Treatment of Engineering Materials: Objectives of heat treatment, Annealing, Normalizing, Hardening, Tempering Applications of heat treatment in: Gears, Shafts, Bearings, Springs, Cutting tools Surface Engineering: Surface hardening, Carburizing, Nitriding, Flame hardening, Induction hardening Surface Protection Methods: Electroplating, Galvanizing, Powder coating, Anodizing, Painting Material Degradation: Wear, Corrosion, Oxidation, Methods to improve material life.			
Exemplars / Practical Applications / Usage • Study of heat-treated gears used in industrial robotic gearboxes. • Comparison of untreated and hardened steel components.			

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- Industrial applications of nitrided shafts and carburized gears. - Surface coating techniques used for robotic structures operating in corrosive environments. - Applications of anodized aluminium components in lightweight robotic systems.			
Real World Assignment Assignment 1 (Any One) - Study any industrial component and identify the heat treatment process used to improve its mechanical properties. - Comparative study of various surface engineering techniques used in Automation & Robotics industries. - Study different corrosion protection techniques adopted in manufacturing industries for automation equipment.			
Unit 3	Material Testing and Characterization	4 Hrs.	CO3
Engineering materials must satisfy functional requirements such as strength, hardness, toughness, wear resistance, and dimensional stability. Material testing and characterization techniques are employed to evaluate these properties, ensure product quality, verify material specifications, and improve the reliability of engineering components used in Automation & Robotics systems. Destructive Testing: Objectives and significance of destructive testing Tensile testing: Principle, specimen, engineering stress-strain curve, determination of yield strength, ultimate tensile strength, percentage elongation and reduction in area. Compression testing: Principle, applications and engineering significance Hardness testing: Principle and applications of Brinell, Rockwell and Vickers hardness tests Impact testing: Charpy and Izod impact tests, toughness evaluation Torsion testing: Principle, torque-twist relationship and applications Non-Destructive Testing (Overview): Introduction and importance of NDT, Liquid Penetrant Testing (LPT/DPT), Magnetic Particle Testing (MPT), Ultrasonic Testing (UT), Eddy Current Testing (Introduction), Selection of suitable NDT methods for engineering components Material Characterization: Objectives of material characterization, Macrostructure and microstructure of engineering materials, Metallographic specimen preparation (Introduction), Optical metallurgical microscope, Interpretation of microstructures of steels, cast irons and non-ferrous alloys, Material Test Certificate (MTC), Purpose, contents and industrial importance Industrial Applications: Material testing during manufacturing and quality assurance, Inspection of robot frames, gears, shafts, bearings and welded structures, Material testing in automotive, aerospace and automation industries			
Exemplars / Practical Applications / Usage - Evaluation of tensile properties of engineering materials using Universal Testing Machine (UTM). - Comparison of hardness values of heat-treated and untreated steel specimens. - Identification of surface and subsurface defects in welded robotic structures using NDT techniques. - Interpretation of microstructures of engineering materials using optical metallurgical microscope. - Study and interpretation of MTCs supplied with industrial raw materials.			
Real World Assignment Assignment 1 (Any one)			

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1. Perform comparative analysis of DT and NDT methods used for inspection of engineering components in Automation & Robotics industries and prepare a technical report. 2. Study the MTC of any engineering material and identify chemical composition, mechanical properties, applicable standards and suitability for robotic applications. 3. Visit a nearby manufacturing industry/NABL laboratory/NDT laboratory and prepare a report on material testing and characterization techniques employed for quality assurance.			
Unit 4	Failure Analysis and Material Selection	3 Hrs.	CO4
Selection of engineering materials based on functional requirements and understanding failure mechanisms are essential for improving the reliability, durability and safety of engineering components used in Automation & Robotics systems. Material Failure: Introduction to engineering failures, Types of failures, Wear, Corrosion, Fatigue, Creep (applications only), Brittle fracture, Ductile fracture, Failure Analysis, Objectives of failure analysis, Visual inspection, Root Cause Analysis (RCA), Fishbone Diagram (Cause and Effect Analysis), Introduction to Failure Mode and Effects Analysis (FMEA) Material Selection: Selection criteria based on Mechanical properties, Service conditions, Manufacturing process, Weight, Cost, Corrosion resistance, Sustainability, Recyclability Case Studies Selection of engineering materials for Robot manipulator links, Robotic grippers, Industrial gears, Bearings, Conveyor systems, AGV chassis, Collaborative robots, Drone structures, Biomedical robotic components			
Exemplars / Practical Applications / Usage • Material selection for lightweight robotic arm considering strength, stiffness and manufacturing cost. • Failure analysis of fractured shafts and gears used in industrial automation systems. • Comparative study of engineering materials used for robotic end-effectors. • Selection of corrosion-resistant materials for robotic systems operating in harsh industrial environments. • Case study on failure of welded robotic structures and preventive measures.			
Real World Assignment Assignment 1 (Any one) 1. Select suitable engineering materials for any Automation & Robotics application (robot arm, AGV, conveyor system, gripper or drone frame) by considering mechanical properties, manufacturability, cost and service conditions. Prepare a detailed technical report. 2. Study any failed engineering component from industry (shaft, gear, bearing, welded joint, robotic link, etc.) and identify the probable causes of failure with suitable preventive measures. 3. Prepare a comparative report on engineering materials used in industrial robots, collaborative robots and service robots, highlighting their advantages and limitations.			
List of Practical			
Experiment No.1	Tension/Compression Test	COs Mapped: 3	2 Hrs.
Objective: To determine mechanical properties such as yield strength, ultimate tensile strength, Young's modulus, and compressive strength of ductile and brittle materials. Associated Tasks: 1. Validation of experimental results of tension and compression tests using ductile and brittle materials. 2. Comparison of stress-strain plots of tested materials. 3. Comparison and conclusion on failure behavior using experimental graphs.			

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Exemplars and Utility: 1. Aerospace Industry: Validation of aircraft structural components such as wing spars and fuselage frames. 2. Automotive Engineering: Crashworthiness and durability analysis of vehicle body panels and chassis structures.			
Experiment No.2	Torsion / Shear Test	COs Mapped: 3	2 Hrs.
Objective: To determine torsional and shear strength of engineering materials and understand failure behavior under shear loading. Associated Tasks: 1. Conduction of torsional/shear test on ductile material. 2. Case study on part failure under torsion/shear loading. Exemplars and Utility: 1. Design and validation of shafts in mechanical systems such as drive shafts, crankshafts, and axles. 2. Testing of fasteners and threaded components like bolts and screws. 3. Automotive powertrain and steering component analysis.			
Experiment No.3	Impact Testing (Charpy / Izod Test)	COs Mapped: 3	2 Hrs.
Objective: To determine impact strength and toughness of engineering materials under sudden loading conditions. Associated Tasks: 1. Impact testing of steel, aluminum, brass, and copper. 2. Failure case study under impact loading for tested materials. Exemplars and Utility: 1. Quality control in structural steel fabrication for bridges and buildings. 2. Crashworthiness analysis in automotive components such as bumpers and engine mounts.			
Experiment No.4	Hardness Testing and Heat Treatment	COs Mapped: 2,3	2 Hrs.
Objective: To evaluate hardness of materials and study the effect of heat treatment on mechanical properties. Associated Tasks: 1. Hardness measurement using Brinell's, Vicker's, Rockwell, or Poldi hardness testing setup. 2. Comparative study of specimens before and after heat treatment. 3. Visit to heat treatment plant/laboratory. Exemplars and Utility: 1. Quality control in gear manufacturing. 2. Inspection of automotive components such as camshafts and crankshafts. 3. Heat treatment verification in structural steel components.			
Experiment No.5	Non-Destructive Testing (NDT)	COs Mapped: 3	2 Hrs.
Objective: To identify defects in engineering materials and components using non-destructive testing methods. Associated Tasks: 1. Analysis of samples using Dye Penetrant Test (DPT), Magnetic Particle Test (MPT), or Ultrasonic Test (UT). 2. Failure analysis of machine components and household appliances. Exemplars and Utility: 1. Inspection of welded joints in pressure vessels using DPT.			



2. Railway axle and wheel inspection using MPT. 3. Structural steel inspection in bridges using UT.			
Experiment No.6	Microstructure Analysis and Material Characterization	COs Mapped: 3	2 Hrs.
Objective: To study microstructures of ferrous and non-ferrous materials and correlate microstructure with properties. Associated Tasks: 1. Interpretation and drawing of microstructures of steel, cast iron, aluminum, and nickel alloys. 2. Reading and interpretation of standard material test reports. Exemplars and Utility: 1. Microstructure analysis of low, medium, and high carbon steels. 2. Study of graphite morphology in cast irons. 3. Material quality verification in manufacturing industries.			
Experiment No.7	Material Selection and ASTM Standards Study	COs Mapped: 1, 4	2 Hrs.
Objective: To understand material selection criteria considering functional and environmental requirements. Associated Tasks: 1. Case study on material selection for engineering applications. 2. Identification of ASTM standards related to selected materials/components. 3. Preparation of comprehensive technical report. Exemplars and Utility: 1. Bicycle frame design for lightweight applications. 2. Automotive body panel material selection. 3. Wind turbine blade material analysis using composites.			
***All destructive and non-destructive tests shall be performed as per applicable ASTM / BIS standards			
Textbooks: 1. V. D. Kodgire & S. V. Kodgire, “Material Science & Metallurgy for Engineers”, Everest Publication. 2. W. D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc			
Reference Books: 1. A. K. Bhargava, C.P. Sharma, “Mechanical Behaviour & Testing of Materials”, PHI Learning Private Ltd. 2. Raghvan V., “Material Science & Engineering”, Prentice Hall of India, New Delhi. 2003 3. Avner, S.H., “Introduction to Physical Metallurgy”, Tata McGraw-Hill, 1997. 4. Higgins R. A., “Engineering Metallurgy”, Viva books Pvt. Ltd.			
Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.			
Prof. S.K. Bhattacharyya, IIT Kharagpur, “NPTEL Web course material” https://drive.google.com/file/d/1N2Eyy9ofPimIT2OSMZMrSxe68Ulclei/view?usp=sharing			

**CO-PO-PSO Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	1	-	1	-	-	-	-	3	2	1
CO2	3	3	1	2	1	-	1	-	-	-	-	3	2	1
CO3	3	3	2	3	2	-	-	-	-	-	-	3	3	2
CO4	3	3	2	2	2	-	1	-	-	-	-	3	3	2
Avg.	3.0	2.75	1.25	1.75	1.5	—	0.75	—	—	—	—	3.0	2.5	1.5

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

This course serves as a prerequisite for / maps with the following future courses:

1. Machine Design
2. Manufacturing Engineering and Technology
3. Robotics Engineering
4. Industrial Automation Technology
5. Additive Manufacturing
6. Finite Element Analysis (FEA)
7. Mechanical System Design
8. Industrial Inspection and Maintenance
9. Project Phase-I / Project Phase-II

Job Mapping:

Job opportunities that one can get after learning this course:

1. Automation & Robotics Engineer
2. Manufacturing Engineer
3. Production Engineer
4. Quality Assurance Engineer
5. Material Testing Engineer
6. NDT Inspection Engineer
7. Maintenance Engineer
8. Design Engineer
9. CAD/CAE Engineer
10. Product Development Engineer
11. Mechatronics Engineer
12. Industrial Automation Engineer
13. Additive Manufacturing Engineer



Program: S. Y. B. Tech (A&R Engineering)				Semester: IV			
Course: Modern Indian Language		Course Code:		R25-AR-AEC-217			
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
1	2		2	--	--	50	--
Course Description and Relevance: मराठी अभ्यासक्रम उच्च शिक्षण स्तरावर भारताच्या “भाषिक वारसा ” जतन व प्रसार करण्याचे उद्दिष्ट पूर्ण करतो. भारतीय ज्ञान प्रणाली (IKS) या अभ्यासक्रमात अभ्यासल्या जाणाऱ्या वारकरी, भक्ती आणि लोकसाहित्य परंपरा NEP च्या भारतीय ज्ञान वारसा आधुनिक अभ्यासक्रमात एकत्रित करण्याच्या भूमिकेशी थेट सुसंगत आहेत. बहुभाषिकता व सांस्कृतिक बांधीलकी NEP २०२० त्रिभाषिक व बहुभाषिक शिक्षणाचे समर्थन करते. MIL मराठी अभ्यासक्रम मातृभाषा व प्रादेशिक भाषा साक्षरतेला बळ देतो आणि राष्ट्रीय एकात्मतेसोबतच प्रादेशिक अस्मितेचा अभिमान जोपासतो.							
Prerequisite: 1. देवनागरी लिपीची मूलभूत ओळख (वाचन व लेखन) उपयुक्त आहे, परंतु प्रारंभिक स्तरावर ती अनिवार्य नाही. 2. ज्या विद्यार्थ्यांची मातृभाषा किंवा प्रादेशिक भाषा मराठी आहे, त्यांना या अभ्यासक्रमात विशेष सोय होते. 3. भारतीय भाषांमध्ये रुची असणाऱ्या अमराठी भाषिक विद्यार्थ्यांचेही या अभ्यासक्रमात समान स्वागत आहे.							
Bridge Content: 1. देवनागरी लिपीची ओळख 2. मूलभूत मराठी व्याकरण 3. दैनंदिन संभाषण 4. मराठी साहित्य व संस्कृतीची प्राथमिक ओळख.							
Course Objectives: 1. मराठी भाषेतील वाचन, लेखन, श्रवण आणि संभाषण या चारही कौशल्यांचा सर्वांगीण विकास करणे. 2. अभिजात व समकालीन मराठी गद्य, पद्य, नाटक आणि लोकसाहित्य यांचा अभ्यास करून विद्यार्थ्यांमध्ये साहित्यिक जाणीव व समालोचनात्मक विचारशक्ती विकसित करणे. 3. वारकरी, भक्ती, साहित्य आणि सामाजिक सुधारणा लेखन यांच्या माध्यमातून महाराष्ट्राच्या सांस्कृतिक, ऐतिहासिक व सामाजिक वारशाची ओळख करून देणे. 4. विविध विद्याशाखांमधील विद्यार्थ्यांमध्ये भारतीय भाषांबद्दल आदर, बहुभाषिक दृष्टीकोन आणि आंतरसांस्कृतिक संवेदनशीलता निर्माण करणे. 5. राष्ट्रीय शिक्षण धोरण २०२० च्या अनुषंगाने विद्यार्थ्यांमध्ये भारतीय ज्ञान प्रणाली, संविधानिक मूल्ये आणि नैतिक नागरिकत्वाची जाणीव रुजवणे.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome						Bloom's Level
CO1	स्मरण व आकलन (Remember & Understand) मराठी भाषेतील देवनागरी लिपी, मूलभूत व्याकरण नियम आणि साहित्यप्रकारांची माहिती सांगणे व त्यांचा अर्थ स्पष्ट करणे.						1,2
CO2	उपयोजन (Apply) दैनंदिन जीवनातील विविध परिस्थितीमध्ये मराठी भाषेचा वाचन,						3



	लेखन व संभाषणासाठी योग्य प्रकारे उपयोग करणे.	
CO3	विश्लेषण (Analyze) अभिजात व समकालीन मराठी गद्य, पद्य आणि नाटक यांचे साहित्यिक, सामाजिक व सांस्कृतिक संदर्भांच्या आधारे विश्लेषण करणे.	4
CO4	मूल्यमापन (Evaluate) वारकरी, भक्ती, सादित्य आणून सामाजिक सुधारणा लेखन यांच्या सामाजिक प्रासंगिकतेचे व साहित्यिक मूल्याचे समीक्षात्मक मूल्यमापन करणे.	5
CO5	निर्मिती (Create) मराठी भाषेतील सृजनशील लेखन, प्रकल्प अहवाल व तोंडी सादरीकरणाद्वारे स्वतंत्र विचार व्यक्त करण्याची क्षमता निर्माण करणे.	4

Course Content**Syllabus****Unit I & II (07 Hrs & 08 Hrs)**

घटक	तपशील
१	१. भाषा आणि व्यक्तिमत्त्व विकास : सहसंबंध २. लोकशाहीतील जीवनव्यवहार आणि प्रसारमाध्यमे
२	प्रसारमाध्यमांसाठी लेखन १ वृत्तपत्रासाठी बातमीलेखन आणि मुद्रितशोधन २ नभोवाणीसाठी भाषणाची संहितालेखन ३ दूरचित्रवाणीसाठी माहितीपटासाठी संहितालेखन

Unit III & IV (07 Hrs & 08 Hrs)

१	१. भाषा, जीवन व्यवहार आणि नवमाध्यमे, समाजमाध्यमे २. नवमाध्यमे आणि समाजमाध्यमांचे प्रकार : ब्लॉग, फेसबुक, ट्विटर. ३. नवमाध्यमे आणि समाजमाध्यमांविषयक साक्षरता, दक्षता, वापर आणि परिणाम
२	१. वेबसाईट आणि ब्लॉग, ट्विटरसाठी लेखन २. व्यावसायिक पत्रव्यवहार

**Suggested List of Assignments**

1. Read a specific column (Sports, political, finance, editorial, education, international news etc) in the daily Marathi newspapers, summarize and present in the practical. A summary should be added as part of the journal.

दैनिक मराठी वर्तमानपत्रामध्ये विशिष्ट कॉलम (क्रिडा, राजकीय, वित्त, संपादकीय, शिक्षण, आंतरराष्ट्रीय बातम्या इ.) वाचा, सारांश द्या आणि सादरीकरण करा. त्या संदर्भातला सगळा सारांश जर्नलमध्ये जमा करावा.

2. Write blogs and posts on social media up to 200 words on recent development in their field of study.

सोशल मीडियावर त्याच्या अभ्यासाच्या क्षेत्रातील अलीकडील विकासावर 200 शब्दांच्या ब्लॉग लिहावा आणि पोस्ट करावा

3. Professional letter / report writing. (व्यावसायिक पत्र / अहवाल लेखन)

- a. Write a letter to the principal about organizing an NSS camp in a nearby village. Preparation of the budget, permission letters and report submission in the University.

जवळच्या गावात एन एस एस शिबिर आयोजित करण्यासाठी मुख्याध्यापकांना पत्र लिहा. विद्यापीठात बजेट, परवानगी पत्रे आणि अहवाल सादर करणे.

- b. Write a letter for internship sponsorship to any organization.

कोणत्याही संस्थेला इंटर्नशिप प्रायोजकत्वासाठी पत्र लिहा.

4. Book Review – Students are expected to read any novel, fiction or literature book of their choice and write a review on post it on social media of their choice.

पुस्तक पुनरावलोकन- विद्यार्थ्यांनी त्याच्या आवडीचे कोणतेही कादंबरी, काल्पनिक कथा किंवा साहित्य पुस्तक वाचावे आणि त्यावर पुनरावलोकन लिहून ते त्यांच्या आवडीच्या सोशल मीडियावर पोस्ट करावे अशी अपेक्षा आहे

5. Participation in Competitions (in college/outside the college) debate, declamation, elocution – A Report should be submitted

स्पर्धामध्ये (महाविद्यालयात / महाविद्यालयाबाहेर) सहभाग, वादविवाद, भाषणे, वक्तृत्व- अहवाल सादर करावा.

6. Group Activity: Road show, skit play, one-act play

गट, क्रियाकलाप: रोड शो, स्किट प्ले, एकांकिका

7. Participation in Purushottam Karandak, Firodia Karandak, Dajikaka Gadgil Karandak and Shreetej Karandak.

पुरुषोत्तम करंडक, फिरोदिया करंडक, दाजीकाका गाडगीळ करंडक आणि श्रीतेज करंडक या स्पर्धामध्ये सहभाग नोंदवावा.

8. Marathi film Review – Social Marathi movie available and write a review on post it on social media of their choice.

मराठी चित्रपट पुनरावलोकन सामाजिक आशय वर आधारित मराठी चित्रपट उपलब्ध आहे आणि त्या चित्रपटाची समीक्षा करून त्यावर सारांश लिहावा व तो वर्तमानपत्रे किंवा पसंतीच्या सोशल मीडियावर पोस्ट करावा.

**Textbooks:**

सायबर संस्कृती, डॉ. रमेश वरखेडे
 उपयोजित मराठी, संपादक डॉ. केतकी मोडक, संतोष शेणई, सुजाता शेणई
 ओळख माहिती तंत्रज्ञानाची, टिमोथी जे. ओ लिअरी
 संगणक, अच्युत गोडबोले, मौज प्रकाशन, मुंबई.
 इंटरनेट, डॉ. प्रबोध चोबे, मनोरमा प्रकाशन, मुंबई.

Reference Books:

व्यावहारिक मराठी, डॉ. ल. रा. नसिराबादकर, फडके प्रकाशन, कोल्हापूर.
 आधुनिक माहिती तंत्रज्ञानाच्या विश्वात, शिक्रापूरकर दीपक, मराठे उज्ज्वल, उत्कर्ष प्रकाशन, पुणे.

Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.

Not Applicable.

*Add additional rows as per requirement

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	3	2	2	1	3	2	3	3			
CO2	2	1	3	2	2	1	1	1	2	2	2			
CO3	3	3	2	3	2	2	0	2	1	3	2			
CO4	3	2	3	2	2	1	0	2	2	3	2			
CO5	3	3	3	2	2	2	1	3	2	3	3			
Avg.	3	2	3	2	2	2	1	2	2	3	2			

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE based on ARCV					
	Exp. 1	Exp. 2				
CO	CO1					
L1						
L2	XX					
L3		XX				
L4				XX		
L5			XX			
L6						



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Engineering Economics and Financial Management			Course Code:	R25-AR-HSSM-218		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
02	--	--	02	50	--	--	--

Course Description:

This course introduces students to the foundational concepts of Engineering Economics and Financial Management, providing a broad understanding of key domains, including micro- and macroeconomics, market forces, cost-volume-profit analysis, and fundamental financial management for engineers. Through conceptual learning, real-life case studies, and quantitative decision-making, students will explore how economic principles and financial constraints influence engineering design and project viability.

Relevance:

In the modern industrial landscape, Engineering Economics and Financial Management serve as the vital bridge between technical innovation and commercial viability. Since every engineering project operates within financial constraints, a mastery of cost analysis, market equilibrium, and the time value of money is essential for students across all disciplines to ensure their designs are both feasible and sustainable. This foundational knowledge enhances an engineer's ability to navigate the complexities of business economics, from conducting break-even analyses to making informed capital investment decisions.

Prerequisite:

- Knowledge of company operations, design, and Manufacturing,
- Basic principles and practices of Accounting and Budgeting,
- Analytical and Logical Thinking.

Bridge Content: This course typically focuses on bridging the gap between engineering production concepts and the product's actual market value.

Course Objectives:

1. To **INTRODUCE** the fundamental principles of economics and finance relevant to core engineering industries.
2. To **DEVELOP** an understanding of basic financial management concepts and enhance analytical skills for interpreting financial statements.
3. To **FAMILIARIZE** students with key financial terminologies and enable them to prepare and analyze various financial statements.
4. To **PROVIDE** insights into the budgeting process, including formulation, implementation, and control mechanisms.

Course Outcomes: After learning the course, students will be able to



CO	Course Outcome	Bloom's Level	
CO1	EXPLAIN the term related to the business environment, fundamental business economics concepts, and the demand-supply framework.	1,2	
CO2	ANALYZE financial statements effectively through ratio analysis.	3	
CO3	DESCRIBE various types of financial statements.	1,3	
CO4	UNDERSTAND the influence of government policies, taxation, and inflation on financial decision-making.	3	
Course Content			
Unit 1	Introduction to Business Economics and Finance	7 Hrs.	CO1
Business Economics Basics: Definition, scope, and role in engineering, Microeconomics vs. Macroeconomics, Laws of demand & supply, elasticity, market equilibrium.			
Basics of Finance: Role of Financial Management in engineering and resource allocation.			
Exemplars / Practical Applications: Market Structure Analysis for Business Decision Making, Budgeting, and Financial Planning.			
Assignments:			
Case study on the microeconomics in the automation business environment.			
Unit 2	Cost Accounting	7 Hrs.	CO2
Introduction: Importance and difference between cost and financial accounting.			
Cost Accounting: Types of costs: Fixed, variable, direct, indirect. Costing methods: job costing and process costing. Break-even analysis & budgeting for cost control. Engineering Applications: Cost estimation, project budgeting, and financial decision-making.			
Exemplars / Practical Applications and usage:			
Calculating Bill of Materials (BOM) for an industrial robot. Break-Even Analysis for automated assembly lines vs manual labor			
Assignments:			



List and classify the different types of costs involved in manufacturing an industrial robot.

Unit 3	Financial Accounting	8 Hrs.	CO3
Introduction: Financial statements basics (Balance Sheet, Income Statement, Cash Flow), Financial planning & decision-making for engineers. Key Financial Terms: Revenue, Cost of Goods Sold (COGS), Operating Expenses like rent, utilities, salaries. Depreciation in asset value over time, Capital Expenditure. Financial ratios: Profitability, liquidity, efficiency			
Exemplars / Practical Applications and usage: Creating a project budget for an automated warehouse setup under inflationary constraints.			
Assignments: Choose a company or firm (ABB, Fanuc, KuKa, etc.) and analyze its latest financial statements.			
Unit 4	Budget and Budgetary Control	8 Hrs.	CO4
Introduction to Budgeting & Budgetary Control: Definition, purpose, and importance of Budgeting & Budgetary Control. Types of budgets: Fixed, flexible, zero-based, capital, and operational budgets. Impact of inflation and GST/Taxes on hardware engineering.			
Engineering Applications: Budgeting in manufacturing and project management. Taxes and Financial Planning, Impact of government policies, Taxation and Inflation on Financial Management.			
Exemplars/ Practical Applications and usage: To prepare Flexible Budgeting in all Automation and Robotics Engineering Industries, Zero budgeting in Government sectors, Sales and Operating Budgets for the automation Sector.			
Assignments: Design a flexible operational budget for deploying a robotic cell.			

**Textbooks:**

1. Hay, Donald A. and Derek J. Morris. Industrial Economics and Organization: Theory and Evidence, 2nd Edition (Oxford: Oxford University Press), 1991.
2. Lall, Sanjaya. Competitiveness, Technology and Skills (Cheltenham: Edward Elgar), 2001.
3. Scherer, F. M. and D. Ross. Industrial Market Structure and Economic Performance, 3rd Edition (Houghton: Mifflin), 1990.
4. Financial Accounting”, Dr. Kaustubh Sontakke [Himalaya Publishing House].
5. Chandra, Prasanna (2004). Financial Management: Theory and Practice. New Delhi: TATA McGraw Hill

Reference Books:

1. Accounting Theory & Practice Prof Jawahar Lal [Himalaya Publishing House] 79 | Page
2. Engineering Economics, Tara Chand, Nem Chand and Brothers, Roorkee
3. Mechanical Estimating and Costing, T. R. Banga and S. C. Sharma, Khanna Publishers, Delhi
4. Industrial Organization and Engineering Economics, T. R. Banga and S. C. Sharma, Khanna Publishers, New Delhi
5. A Text Book of Mechanical Estimating and Costing, O. P. Khanna, Dhanpat Rai Publications Pvt. Ltd., New Delhi
6. Industrial Engineering and Management, O. P. Khanna, Dhanpat Rai and Sons, New Delhi
7. Financial Management, I. M. Pandey, Vikas Publishing House Pvt. Ltd., New Delhi

MOOCs Links and additional reading material:

1. https://onlinecourses.nptel.ac.in/noc22_ma44/
2. https://onlinecourses.nptel.ac.in/noc22_hs72/
3. https://onlinecourses.nptel.ac.in/noc22_mg63/

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	--	--	--	1	--	--	--	--	2	1	1	2
CO2	3	3	2	2	2	1	--	--	--	--	3	2	2	3
CO3	3	3	2	2	1	--	--	--	--	1	3	1	3	1
CO4	3	3	2	2	1	--	1	1	--	1	3	3	2	2
Avg.	3	3	2	2	1	1	--	--	--	--	3	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Unit-wise Weightage:**

Exam.	Unit 1	Unit 2	Unit 3	Unit 4
CCE				
Class Test	15	15	–	–
Test/Quiz	–	–	6	6
Assignments	–	–	4	4
Total	15	15	10	10

Assessment Pattern

BT Level	CT1	Test/Quiz	Assignments
CO	CO1, CO2	CO1, CO2, CO3, CO4	CO1, CO2, CO3, CO4
K1	√	√	√
K2	√	√	√
K3	√	√	√
K4			
K5			
K6			

Assessment Pattern

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted (50)
1	Class test (Unit I & II) for 20 marks	30
2	Test/Quiz on each unit using LMS	12
3	Timely Assignment Submission	08

This course serves as a prerequisite for / maps with the following future courses:

- Financial Management
- Project Management
- Financial Accounting

Job Mapping:

Job opportunities that one can get after learning this course:

- Finance Manager
- Finance Advisor
- Project Manager
- Budget Control Officer

Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Robot Programming Laboratory-I			Course Code:	R25-AR-PCC-219		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
--	2	--	1	--	--	--	50

Course Description and Relevance:

The Robot Programming Laboratory course is designed to provide hands-on knowledge of robotic manipulator modeling, robot programming, simulation, and industrial robotic applications using modern software and hardware platforms.

The course is highly relevant to the Automation and Robotics industry as it develops practical skills required for robotic system design, simulation, programming, and industrial automation integration.

Prerequisite:

1. Foundations of Automation and Robotics Engineering
2. Applied Mathematics
3. Manufacturing Engineering & Technology

Bridge Content:

Fundamentals of Automation and Robotics, Basic Kinematics Concepts, Computer-Aided Modeling and Simulation, Programming Fundamentals

Course Objectives:

1. To understand the fundamentals of robotic manipulators, coordinate transformations, and kinematic modelling using Denavit–Hartenberg (DH) parameters.
2. To develop analytical and simulation skills for forward and inverse kinematics of robotic manipulators using RoboAnalyzer software.
3. To study the design, selection, and application of robotic grippers/end effectors for industrial automation tasks.
4. To acquire practical knowledge of industrial robot programming and simulation using ABB RobotStudio, RAPID language, RoboDK, and VAL programming environments.
5. To provide hands-on exposure to industrial robotic systems, virtual simulation environments, and real-world automation applications through laboratory practice and industrial visits.

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	IDENTIFY robotic manipulator configurations, coordinate frames, DH parameters, and industrial robot components	1



	used in automation systems.	
CO2	DEVELOP and ANALYZE forward and inverse kinematic models of robotic manipulators using Coordinate Transformation Matrix (CTM) and RoboAnalyzer software.	2
CO3	DESIGN and SELECT suitable robotic grippers/end effectors and PERFORM robot motion programming using RAPID and VAL programming languages.	3
CO4	CREATE and SIMULATE robotic workcells and industrial automation tasks using RobotStudio and RoboDK software environments.	3
CO5	IMPLEMENT and EVALUATE robotic applications in virtual and real laboratory environments while UNDERSTANDING industrial safety practices and real-world automation systems.	4

Guidelines for Laboratory Conduction

- The student shall complete the following activity as a Term Work of Total 8 experiments from the following list must be performed.
 - Term Work of the student is evaluated based on the completion of Practical, Assignments using Drawing Aids, Assignments using Software & Programming Languages, Assignments using Virtual Laboratory and Detailed Industrial Visit Report.
 - Use simulation tools such as RoboAnalyser, RoboDK, Python, ROS, and Gazebo before hardware implementation.
 - Encourage students to work on mini-projects related to real-world applications.
 - Promote teamwork and interdisciplinary collaboration in labs.
 - Focus on debugging techniques and best practices in programming robotic systems.
- There should be continuous assessment and timely submission of journal.

Course Content

List of Practical:

Experiment No.1	Study and Implementation of Coordinate Transformation Matrix (CTM) for Denavit–Hartenberg (DH) Parameter Modelling of Robotic Manipulator	COs Mapped CO1, CO2	2 Hrs.
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Objective: To study the concept of Coordinate Transformation Matrix (CTM) and develop the Denavit–Hartenberg (DH) parameter model for robotic manipulator kinematics.

Associated Tasks:

1. Identification of Coordinate Frames
2. Determination of DH Parameters



3. Formation of CTM
4. Forward Kinematic Analysis
5. Verification Using RoboAnalyzer

Exemplars and Utility:

1. Model a 2R planar robot using DH parameters.
2. Simulate a robotic arm performing pick-and-place operation.
3. Compute end-effector coordinates for different joint angles.
4. Compare manual calculations with RoboAnalyzer outputs.

Experiment No.2	Study and Simulation of Forward Kinematics of a 2-DOF Robotic Manipulator using RoboAnalyzer	COs Mapped CO1, CO2	2 Hrs.
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Objective: To study and perform forward kinematic analysis of a 2-DOF robotic manipulator using RoboAnalyzer software.

Associated Tasks:

1. Study of 2-DOF Robot Structure
2. Assignment of DH Parameters
3. Derivation of Transformation Matrix
4. End-Effector Position Calculation
5. Simulation using RoboAnalyzer

Exemplars and Utility:

1. Model a planar 2R robot using RoboAnalyzer.
2. Compute end-effector coordinates for different joint angles.
3. Compare analytical and simulation results.
4. Visualize robot workspace.
5. Analyze effect of varying link lengths.

Experiment No.3	Study and Simulation of Inverse Kinematics of a 2-DOF Robotic Manipulator using RoboAnalyzer	COs Mapped CO2	2 Hrs.
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Objective: To study and perform inverse kinematic analysis of a 2-DOF robotic manipulator using RoboAnalyzer software.

Associated Tasks:

1. Study of 2-DOF Manipulator
2. Define Desired End-Effector Position
3. Derivation of Inverse Kinematic Equations



4. Manual Calculation of Joint Angles
5. Verification using RoboAnalyzer

Exemplars and Utility:

1. Determine joint angles for multiple target points.
2. Compare elbow-up and elbow-down configurations.
3. Analyze unreachable target positions.
4. Simulate trajectory movement between points.
5. Study singular configurations of the manipulator.

Experiment No.4	Study, Design and Selection of Robotic Gripper / End Effector for Industrial Applications	COs Mapped CO3	2 Hrs.
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Objective: To study various types of robotic grippers/end effectors and design/select a suitable gripper for a given industrial application.

Associated Tasks:

1. Study of Different Grippers
2. Workpiece Analysis
3. Selection of Suitable Gripper
4. Gripping Force Calculation
5. Design of Gripper

Exemplars and Utility:

1. Design a two-finger mechanical gripper for cylindrical objects.
2. Select vacuum gripper for sheet handling application.
3. Design soft gripper for fragile object handling.
4. Compare pneumatic and hydraulic grippers.

Analyze gripper requirements for assembly robot.

Experiment No.5	Robot Programming and Simulation using ABB IRB 1410 in RobotStudio	COs Mapped CO3, CO4	2 Hrs.
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Objective: To study the operation, offline programming, and simulation of the ABB IRB 1410 industrial robot using ABB RobotStudio software.

Associated Tasks:

1. Study of ABB IRB 1410 Robot



2. Learn RobotStudio Interface
3. Creation of Virtual Workcell
4. Teaching Target Points
5. RAPID Program Development
6. Simulation and Collision Analysis

Exemplars and Utility:

1. Simulate pick-and-place operation.
2. Create welding trajectory using MoveL commands.
3. Perform palletizing simulation.
4. Analyze robot workspace and singularities.
5. Develop collision-free robot motion.

Experiment No.6	Robot Programming using RAPID Language with ABB IRB 1410	COs Mapped CO3, CO4	2 Hrs.
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Objective: To understand and execute the fundamentals of RAPID programming language used in ABB robots.

Associated Tasks:

1. Tool and Work Object Configuration
2. Teaching Robot Positions
3. Motion Programming
4. Gripper Control using I/O
5. Pick-and-Place Operation

Exemplars and Utility:

1. Basic Motion Control
2. Gripper Operation
3. Pick-and-Place Program

Experiment No.7	Study of Simulation Environment using RoboDK	COs Mapped CO4	2 Hrs.
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Objective: To create a robotic simulation environment using RoboDK software and perform basic robot motion simulation.

Associated Tasks:

1. Study of RoboDK Interface



2. Importing Robot Model
3. Creation of Work cell
4. Robot Programming and Motion Simulation
5. Collision and Workspace Analysis

Exemplars and Utility:

1. Simulate pick-and-place operation using DexArm.
2. Create conveyor sorting setup using Delta SCARA robot.
3. Simulate palletizing using Cartesian robot.
4. Generate robotic welding trajectory.
5. Analyze robot workspace limitations.

Experiment No.8	Application of RoboDK Simulation environment for DexArm / Delta SCARA / Cartesian Robot	COs Mapped CO4, CO5	2 Hrs.
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Objective: To implement and validate the simulated robotic application developed in RoboDK on an actual DexArm, Delta SCARA, or Cartesian robot in laboratory environment.

Associated Tasks:

1. Robot Hardware Study
2. Robot Calibration and Setup
3. Program Transfer from RoboDK
4. Execution of Robotic Task

Exemplars and Utility:

1. Pick-and-place operation using DexArm.
2. Sorting objects using Delta SCARA robot.
3. Cartesian robot path following.
4. Marker drawing application.
5. Mini assembly operation.

Experiment No.9	Learning VAL Programming for PUMA Robot	COs Mapped CO3, CO4	2 Hrs.
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Objective: To study and implement basic VAL programming commands for controlling a PUMA robot in a virtual laboratory environment.

Associated Tasks:



1. Study of PUMA Robot Configuration
2. Familiarization with VAL Environment
3. Teaching Robot Positions
4. Motion Programming using VAL
5. Gripper Control Programming
6. Pick-and-Place Simulation

Exemplars and Utility:

- i. Simulate pick-and-place operation.
- ii. Develop palletizing sequence.
- iii. Program straight-line and joint motions.
- iv. Study robot speed variations.
- v. Analyze robot workspace and trajectories.

Experiment No.10	Industrial Visit to Robotics Industry	COs Mapped CO5	2 Hrs.
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Objective: To provide practical exposure to industrial robotic systems and automation technologies. To understand the real-time applications of robots in manufacturing and industrial environments.

Associated Tasks:

Observation of Industrial Robotic Systems

Study of Industrial Safety Practices

Interaction with Industry Experts

Documentation and Report Preparation

Exemplars and Utility:

Exemplars (Sample Industries for Visit)

1. Automotive manufacturing industries using robotic welding and assembly.
2. Packaging and material handling automation industries.
3. Smart manufacturing and Industry 4.0 facilities.

Utility of the Practical

1. Provides real-world exposure to industrial robotics and automation systems.
2. Enhances knowledge of industrial workflow and automation integration.
3. Develops awareness about industrial safety standards and operational practices.
4. Helps students relate academic concepts to real industrial applications.



5. Motivates students toward careers in robotics, automation, and smart manufacturing.

Learning Resources

Textbooks:

1. Groover, M.P. Weiss, M. Nagel, R.N. & Odrey, N.G., Ashish Dutta, Industrial Robotics, Technology, Programming & Applications, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
3. Staple Danny, “Learn Robotics Programming”, Packt Publishing Limited, Feb 2021

Reference Books:

1. Industrial Robotics by Yoram Koren (5th Edition)
2. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright and Matthew P. McLaughlin
3. Robotics, Vision & Control: Fundamentals & Advanced Applications by Farid Kendoul
4. Robot Programming: A Guide to Using RUIP with ABB Robots by Rick Young
5. Hughes Cameron, “Robot Programming”, Pearson Publishers, 2016
6. J. Srinivas, “Robotics: Control and Programming”, Narosa Publication, 2009
7. Kailashi Chandra Mahajan, Prashant Kumar Patnaik, Raghvendra Kumar, “Robotics for Engineers”, Vikas Publishing House, 2016

Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.

1. https://onlinecourses.nptel.ac.in/noc19_me74/preview
2. https://onlinecourses.nptel.ac.in/noc20_de11/preview
3. https://www.youtube.com/watch?v=gLQQtWKNmyE&list=PLdG9DWheQeVKS_Rt_1fnptHCbHIEUP0-0t
4. <https://library.abb.com/r?cid=9AAC129676>

**CO-PO-PSO Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	–	2	1	–	1	–	1	–	3	2	1
CO2	3	3	2	2	3	–	–	–	–	1	–	3	2	1
CO3	2	2	3	1	3	1	–	1	1	2	–	3	3	1
CO4	2	2	3	2	3	–	–	–	1	2	1	3	3	1
CO5	2	2	2	2	2	3	2	3	2	2	1	2	2	3
Avg.	2.4	2.2	2.2	1.4	2.6	1.0	0.4	1.0	0.8	1.6	0.4	2.8	2.4	1.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern

BT Level	CCE based on ARCV									
CO	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Exp. 8	Exp. 9	Exp. 10
L1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
L2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
L3	-	✓	-	-	✓	-	-	✓	✓	✓
L4	✓	-	✓	✓	-	✓	✓	✓	-	-
L5	✓	-	✓	✓	-	✓	✓	✓	-	-
L6	-	✓	-	-	✓	-	-	✓	✓	✓

This course serves as a prerequisite for / maps with the following future courses:

Industrial Robotics and Automation

Robot Kinematics and Dynamics

Advanced Robot Programming

Job Mapping:

Job opportunities that one can get after learning this course:

Robotics Engineer

Robot Programmer

Robotics Simulation Engineer

Robotics Application Engineer



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Mechanism and Robot Kinematics Lab.			Course Code:	R25-AR-PCC-220		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
--	2	--	2	--	--	25	--

Course Description:

The Course provides fundamental knowledge of motion in mechanical systems and robotic structures, focusing on how joints, links, and actuators interact to produce desired movements. It emphasizes the geometry of motion — analyzing positions, velocities, and accelerations of mechanisms such as gears, cams, linkages, and robotic arms. This subject is important because it provides the foundation for designing efficient machines and robots that can perform precise tasks in automation and manufacturing. Its relevance lies in preparing students to understand and model robotic systems mathematically, ensuring accuracy and reliability in real-world applications where precision and efficiency are critical.

Relevance:

The subject is taught because mastering kinematics is essential for designing and controlling robots and automated systems. Engineers must predict and optimize the performance of machines, which requires a deep understanding of how mechanisms move. This knowledge is crucial for developing robots that are safe, efficient, and capable of performing complex tasks. The importance of this subject extends to modern industries where automation and robotics are central — from manufacturing and healthcare to defense and agriculture. Its relevance is seen in the way it equips students with the skills to innovate in areas like robotic surgery, autonomous vehicles, and smart factories, making it a cornerstone of automation and robotics education.

Prerequisite:

1. Engineering Mathematics - I and II
2. Engineering Physics
3. Engineering Mechanics
4. Product Development Laboratory

Bridge Content:

The course focuses on bridging the gap between the theoretical and practical knowledge in the automation and robotics sector.

Course Objectives:



1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique.
3. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical approach.
4. To develop the competency to analyze the velocity and acceleration in mechanisms using graphical approach.
5. To apply fundamentals of gear theory as a prerequisite for gear design and construct cam profile for given follower motion.

Course Outcomes: After learning the course, students will be able to

CO	Course Outcome	Bloom's Level
CO1	APPLY kinematic analysis to simple mechanisms	3
CO2	SYNTHESIZE a four-bar mechanism with analytical and graphical methods	4
CO3	ANALYZE velocity and acceleration in mechanisms using analytical method	4
CO4	ANALYZE velocity and acceleration in mechanisms using graphical method	4
CO5	APPLY fundamentals of gear theory as a prerequisite for gear design and CONSTRUCT cam profile for given follower motion.	3, 6

Course Content

List of Practical:

Experiment No.1	Mechanism Model Development using Waste Material	COs Mapped CO1	2 Hrs.
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Objective:

To understand the working principles of mechanisms through design and fabrication of a functional model using low-cost and waste materials while improving teamwork, creativity, and presentation skills.

Associated Tasks:

1. Select a suitable mechanism such as Gripper mechanism, Robot mechanism, Geneva wheel, Scotch yoke, etc.
2. Collect and utilize waste materials for fabrication.



3. Design and assemble the working model.
4. Demonstrate the mechanism operation.
5. Prepare and deliver a PPT presentation.

Exemplars:

- Four-bar linkage made from cardboard and wooden sticks.
- Slider-crank mechanism using syringes and waste plastic.
- Geneva mechanism using acrylic scrap.

Utility:

- Enhances practical understanding of kinematic mechanisms.
- Promotes sustainable engineering practices.
- Develops teamwork and communication skills.

Experiment No.2	Real-Life Mechanism Identification and DOF Analysis	COs Mapped CO1	2 Hrs.
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Objective:

To identify mechanisms in real-life systems and analyze their kinematic structure and degrees of freedom.

Associated Tasks:

1. Identify mechanisms from machines or daily-life applications.
2. Determine links and kinematic pairs.
3. Calculate degree of freedom using Gruebler's equation.
4. Record working video and observations.

Exemplars:

- Bicycle chain mechanism.
- Windshield wiper mechanism.
- Door closer mechanism.
- Robots

Utility:

- Connects theoretical concepts with real engineering systems.
- Improves analytical and observation skills.
- Useful in machine design and robotics.

Experiment No.3	Design and Simulation of Planar Mechanism	COs Mapped CO1	2 Hrs.
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Objective:

To model and simulate planar mechanisms using computer-aided design and



simulation software.

Associated Tasks:

1. Select mechanism configuration.
2. Model links and joints in software (Geogebra, SAM, Working Model, any 3D Modelling Software, etc.).
3. Simulate motion and analyze output.
4. Verify mechanism behavior.

Exemplars:

- Four-bar linkage simulation.
- Slider-crank mechanism simulation.

Utility:

- Develops CAD and simulation skills.
- Reduces design errors before fabrication.
- Important in modern machine design.

Experiment No.4	Programming for Mechanism Synthesis	COs Mapped CO 2	2 Hrs.
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Objective:

To develop programs for mechanism synthesis using analytical methods such as Chebyshev spacing and Freudenstein's equation.

Associated Tasks:

1. Study synthesis techniques.
2. Formulate design equations.
3. Develop computational programs.
4. Analyze generated mechanism dimensions.

Exemplars:

- Function generation using Freudenstein's equation.
- Path generation using Chebyshev spacing.

Utility:

- Important for precision mechanism design.
- Useful in robotics and automation systems.
- Enhances optimization and synthesis capabilities.

Experiment	Programming for Kinematic Analysis	COs Mapped	2
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No.5	of Slider-Crank Mechanism	CO3	Hrs.
Objective: To develop computer programs for analytical kinematic analysis of slider-crank mechanisms. Associated Tasks: 1. Derive displacement, velocity, and acceleration equations. 2. Write program using Python/MATLAB/C/Scilab. 3. Plot kinematic graphs. 4. Validate analytical results. Exemplars: • MATLAB or Python program for slider displacement, velocity and acceleration analysis. Utility: • Improves programming and analytical skills. • Useful in automation and simulation studies. • Helps in engine mechanism analysis.			
Experiment No.6	Velocity and Acceleration Analysis using Relative Velocity and Acceleration Method.	COs Mapped CO4	2 Hrs.
Objective: To determine velocities and accelerations of mechanism components using Relative Velocity and Acceleration Method. Associated Tasks: 1. Draw space and velocity diagrams. 2. Determine relative velocities of links. 3. Construct acceleration polygons. 4. Solve numerical problems. Exemplars: • Four-bar mechanism analysis. • Slider-crank mechanism analysis. Utility:			



- Essential for dynamic analysis of machines.
- Helps predict mechanism performance.
- Important for vibration and force analysis.

Experiment No.7	Velocity Analysis using ICR Method	COs Mapped CO4	2 Hrs.
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Objective:

To analyze velocities in mechanisms using Instantaneous Centre of Rotation (ICR) method.

Associated Tasks:

1. Locate instantaneous centers.
2. Apply Kennedy's theorem.
3. Determine angular and linear velocities.
4. Solve numerical problems.

Exemplars:

- Four-bar mechanism velocity analysis.
- Crank and slotted lever mechanism.

Utility:

- Simplifies velocity analysis.
- Useful for quick graphical solutions.
- Widely used in mechanism design.

Experiment No.8	Cam Profile Design	COs Mapped CO5	2 Hrs.
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Objective:

To design and draw cam profiles for various follower motions with radial and offset configurations.

Associated Tasks:

1. Study follower motion types.
2. Draw displacement diagrams.
3. Construct cam profiles.
4. Analyze follower motion characteristics.

Exemplars:



- Radial cam with SHM follower motion.
- Offset cam with SHM follower motion.

Utility:

- Important in automation and engine valve mechanisms.
- Helps understand motion generation.
- Useful in packaging and textile machinery.

Experiment No.9	Gear Nomenclature and Involute Profile Construction	COs Mapped CO5	2 Hrs.
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Objective:

To study gear terminology and construct involute gear tooth profiles using rack cutter geometry for understanding gear manufacturing principles.

Associated Tasks:

1. Study gear terminology such as pitch circle, addendum, dedendum, pressure angle, module, etc.
2. Draw involute profile using rack cutter method.
3. Analyze gear meshing conditions.
4. Study gear manufacturing techniques.

Exemplars:

- Construction of involute profile for spur gear.
- Rack cutter generation method for standard gears.

Utility:

- Provides foundation for gear design and manufacturing.
- Helps understand power transmission systems.
- Useful in robotics, automotive and industrial machinery applications.

Experiment No.10	To generate a Cam Profile using any Modelling Software (MechAnalyser, any 3D Modelling Software)	COs Mapped CO5	2 Hrs.
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Objective:

To generate and analyze a cam profile using MechAnalyzer or any 3D modelling software for understanding the motion characteristics of cam and follower mechanisms.

Associated Tasks:



1. Select a suitable type of cam and follower mechanism.
2. Define motion parameters such as lift, dwell angle, and follower motion type.
3. Generate the displacement diagram.
4. Create the cam profile using MechAnalyzer or any 3D modelling software.
5. Simulate the cam-follower motion and observe displacement, velocity, and acceleration characteristics.

Exemplars:

- Design and simulate a radial cam with a roller follower for an IC engine valve mechanism using SolidWorks or MechAnalyzer.

Utility:

- Helps in understanding practical applications of cam and follower mechanisms.
- Develops CAD modelling and motion simulation skills.
- Provides knowledge useful in automation machinery, robotics, and machine design applications.

Textbooks:

1. S. S. Rattan, “Theory of Machines”, Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Bevan T, “Theory of Machines”, Third Edition, Longman Publication
3. G. Ambekar, “Mechanism and Machine Theory”, PHI
4. J. J. Uicker, G. R. Pennock, J. E. Shigley, “Theory of Machines and Mechanisms”, Fifth Edition, International Student Edition, Oxford Electronics and AC Drives”, Pearson Education.

Reference Books:

1. Paul E. Sandin, “Robot Mechanisms and Mechanical Devices Illustrated”, Tata McGraw Hill Publication
2. M.P. Groover, “Automation, production systems and computer-integrated manufacturing”, Prentice-Hall of India Pvt. Ltd, New Delhi
3. Stephen J. Derby, “Design of Automatic Machinery”, 2005, Marcel Dekker, New York
4. Neil Sclater, “Mechanisms and Mechanical Devices Sourcebook”, Fifth Edition, Tata McGraw Hill Publication
5. Ghosh Malik, “Theory of Mechanism and Machines”, East-West Pvt. Ltd.
6. Hannah and Stephans, “Mechanics of Machines”, Edward Arnolde Publication
7. R. L. Norton, “Kinematics and Dynamics of Machinery”, First Edition, McGraw Hill Education (India) P Ltd. New Delhi



8. Sadhu Singh, “Theory of Machines”, Pearson
9. Dr. V. P. Singh, “Theory of Machine”, Dhanpatrai and Sons
10. C. S. Sharma & Kamlesh Purohit, “Theory of Machine and Mechanism”, PHI

Virtual Lab, related open source/ subscription-based software, Links or websites for lab conduction, animation, simulation etc., e-learning.

1. <https://mm-nitk.vlabs.ac.in/List%20of%20experiments.html> (All Experiments)
2. <https://mr-iitkgp.vlabs.ac.in/exp/cam-follower-mechanism/>
3. <https://mr-iitkgp.vlabs.ac.in/exp/quick-return-mechanism/>
4. <https://nptel.ac.in/courses/112104121/> (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur)
5. <https://nptel.ac.in/courses/112/106/112106270/> (NPTEL2, Theory of Mechanism, Prof. Sujatha Srinivasan, IIT Madras)
6. <https://nptel.ac.in/courses/112/105/112105268/> (NPTEL3, Kinematics of Mechanisms and Machines, Prof. Anirvan Das Gupta, IIT Kharagpur)
7. <https://nptel.ac.in/courses/112/105/112105236/> (NPTEL4, Mechanism and Robot Kinematics, Prof. Anirvan Das Gupta, IIT Kharagpur)
8. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay).

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	–	–	–	–	–	–	–	2	1	–
CO2	2	2	3	2	3	–	–	–	1	1	1	1	2	3	–
CO3	2	3	2	3	2	–	–	–	–	–	–	1	3	2	–
CO4	2	2	2	3	2	–	–	–	1	1	–	1	2	2	–
CO5	1	2	2	2	3	1	1	1	1	1	1	1	3	2	1
Avg.	2.0	2.2	2.0	2.2	2.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.4	2.0	1.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

BT Level	CCE based on ARCV									
	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Exp. 8	Exp. 9	Exp. 10
L1	√								√	√
L2	√	√	√	√	√	√	√	√	√	√
L3	√	√	√	√	√	√	√	√	√	√
L4	√				√	√	√	√	√	
L5										
L6	√									

This course serves as a prerequisite for / maps with the following future courses:

Dynamics of Machinery, Machine Design, Industrial Automation, Robotics and Control Systems

Job Mapping:

Job opportunities that one can get after learning this course:

Design Engineer, Automation and Robotics Engineer, Product Development Engineer, R&D Engineer, Manufacturing Engineer



Program:	S. Y. B. Tech (A&R Engineering)			Semester:	IV		
Course:	Environmental Science and Sustainable Development			Course Code:	R25-AR-VEC-221		
Teaching Scheme				Examination Scheme			
Lecture	Practical	Tutorial	Credit	CCE	ESE	TW	PR
02	--		2	40	60	--	--
Course Description: Environmental Science and Sustainable Development is an interdisciplinary course that introduces students to the principles of environmental systems, ecological balance, natural resource management, pollution control, sustainability practices, and sustainable energy solutions. The course emphasizes understanding the interactions between human activities and the environment while promoting sustainable approaches to resource utilization, environmental conservation, climate change mitigation, and sustainable development. Through real-world case studies and practical applications, students develop the knowledge required to address contemporary environmental challenges.							
Relevance: The course equips Automation & Robotics Engineering students with awareness of environmental responsibilities and sustainable engineering practices. It enables learners to understand environmental impacts associated with technological developments and prepares them to design, develop, and implement environmentally sustainable solutions in industrial, agricultural, transportation, and smart-city applications.							
Prerequisite: 4. Knowledge of Chemistry, Biology and Earth Sciences							
Bridge Content: - Fundamentals of ecosystem and ecology - Natural resources and environmental components - Basic concepts of pollution and climate change - Introduction to sustainable development goals (SDGs) - Environmental challenges and conservation practices							
Course Objectives: - To INTRODUCE students to the fundamental concepts of environmental science, including the relationship between natural systems and human activities, concept of sustainable development and its significance in the day today life. - To FOSTER critical thinking skills regarding environmental issues such as climate change, pollution, resource depletion, deforestation, and habitat destruction. - To STUDY sustainable practices in energy use, agriculture, waste management, and urban planning, emphasizing the importance of balancing development with environmental preservation. - To EVALUATE the role of renewable energy, green technologies, and conservation efforts in promoting sustainability. - To ENCOURAGE students to apply their knowledge to real-world environmental challenges and sustainable development problems, through case studies, projects, and fieldwork.							
Course Outcomes: After learning the course, students will be able to							
CO	Course Outcome					Bloom's Level	
CO1	To UNDERSTAND and EVALUATE the interdependence between environment, ecology, and natural resources, assess the impact of air pollution and ecological footprints, and ANALYZE the dynamic interactions between socio-economic					2, 4, 5	



	systems.	
CO2	To EVALUATE the causes of soil degradation and apply effective soil conservation and management practices to maintain soil health, enhance agricultural productivity, and promote sustainable land use.	3, 4, 5
CO3	To IDENTIFY various water sources, ANALYZE issues related to water availability and quality, and APPLY sustainable water management practices to support environmental conservation and meet societal needs.	3, 4
CO4	To UNDERSTAND the principles of sustainability, EVALUATE environmental, social, and economic challenges, and APPLY practical sustainability practices to promote responsible resource use.	2, 5
CO5	To ANALYZE the principles of sustainable habitat design and sustainable energy systems, and APPLY environmentally responsible solutions such as green buildings, energy-efficient technologies, and renewable energy sources to promote sustainable living and reduce ecological impact.	3, 4
Course Content		
Unit 1	Introduction to Environmental Science	6 Hrs. COs Mapped: 1
Definition, scope, and importance of Environmental Science, Ecosystem and Ecology, natural resources, Air pollution, Ecological footprint, Interactions between socio-economic systems and eco-systems, Human health and the environment		
Real World Assignment 1. Weather survey of your region of last 10 years 2. Air pollution and its effect on human health.		
Exemplars / Practical Applications 1. Air purifiers 2. Air quality index indicators		
Unit 2	Soil Conservation and Management	6 Hrs. COs Mapped: 2
Introduction to soil resources, Soil degradation and erosion- Types and causes of soil degradation, Effects on agriculture and the environment, Soil pollution and its impact on soil fertility, Soil Conservation Techniques, Soil Fertility and Nutrient Management - impact of soil degradation on agriculture and food production. Recycling of soil nutrients. Inorganic and organic components of soils. Biogeochemical cycles – nitrogen, carbon, phosphorus and Sulphur. Sustainable Soil Management		
Real World Assignment: 1. Analysis of soil texture, Ph and organic matter content 2. Effect of chemical fertilizers on soil biogeochemical cycles and on human health Composting of organic waste		
Exemplars / Practical Applications and usage: 1. Contour farming 2. Strip forming 3. Natural fertilizers		
Unit 3	Water Sources and Management	6 Hrs. COs Mapped: 3

Approved By:



Importance of water resources, Global and national water availability, Hydrological cycle and water balance, Water Sources - Surface water sources, Groundwater sources, Rainwater, Desalination and reclaimed. Water Demand and Distribution - Domestic, agricultural, industrial, and environmental water requirements, Water supply and distribution systems. Water Resource Management, Water Conservation and Sustainable Practices

Real World Assignment:

1. Development of greywater recycling system

Exemplars / Practical Applications and usage:

1. Water source management in desert area
2. Recycling and reuse of waste water
3. Rainwater harvesting

Unit 4	Sustainability and Sustainability Practices	6 Hrs.	COs Mapped: 4
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Sustainability- concept, needs and challenges-economic, social, Aspects of sustainability- from unsustainability to sustainability, Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Zero waste concept, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment.

Real World Assignment –

1. Effect of global warming on human health
2. Indian government policies for sustainable development.

Exemplars / Practical Applications and usage:

Green roofs and Vertical Gardens

Unit 5	Sustainable Habitat and Sustainable Energy	6 Hrs.	COs Mapped: 5
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Sustainable habitat: green buildings, green materials, Energy efficiency, Sustainable transports, Sustainable energy: Non-conventional Sources, Energy Cycles- carbon cycle, emission and sequestration

Real World Assignment –

1. Calculation of carbon foot print.

Exemplars / Practical Applications and usage:

Energy efficient buildings

Comprehensive Continuous Evaluation (CCE) components for the course:

Textbooks:

1. P. D. Sharma; Ecology and Environment; Volume 22 of Popular Biology Text Books Rastogi Publications, 2007
2. D.D. Mishra-Fundamental of Environmental Studies, S Chand & Co Ltd (1 December 2010).
3. M. Dayal- Renewable Energy; Environment and Development, Konark Pub. Pvt. Ltd.
4. Fulekar; Fundamental of Air pollution. 4th Edition, Daniel Vallero, Academic Press, Elsevier .
5. Ambasht R.S.; Environment and Pollution: An Ecological Approach, CBS Publishers & Distributors; 1st Ed. edition 2014

Reference Books:

1. Stanley E. Manahan; Fundamentals of Environmental Chemistry; Publisher: CRC Press 1993
2. E.D. Enger, B. E. Smith; Environmental Sciences-A study of Inter relationships, WCB Publication.
3. Kathy Wilson Peacock; Natural Resources and Sustainable Development.
4. Elizabeth Berner, Robert Berner; Global Environment - Water, Air, and Geochemical Cycles, Princeton University Press; 2nd Revised edition 2012.



5. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
6. Andrew Dessler, Introduction to Modern Climate Change, 2nd Edition, Cambridge University Press, 2015.
7. Bruce Glavovic, Mick Kelly, Robert Kay, Ailbhe Travers, Climate Change and the Coast: Building Resilient Communities, CRC Press, 2015.

MOOCs Links and additional reading material:

1. Environmental and Sustainability Studies - Raquel Friedmann - YouTube
2. Lecture 1 - Sustainable Development Concepts - YouTube
3. Climate Change - A Short Film [4K]

CO-PO-PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	1	-	3	3	2	-	-	-	1	1	-
CO2	2	3	-	2	-	3	3	2	-	-	-	1	1	-
CO3	2	3	1	2	1	3	3	2	-	-	-	1	2	-
CO4	1	2	2	2	-	3	3	2	1	1	-	1	1	-
CO5	2	3	2	2	1	3	3	2	-	-	-	2	2	1
Avg.	1.8	2.6	1	1.8	1	3	3	2	1	1	-	1.2	1.4	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Unit wise Weightage:

Exam	Unit1	Unit 2	Unit 3	Unit 4	Unit 5
CT1	CO- 1&2		-	-	-
CCE Assessment by Teacher	8 Unit Test	8 Unit Test	8 Quiz	8 Presentation	8 Industrial Visit Report
ESE	12	12	12	12	12
Total	20	20	20	20	20

Assessment Pattern

BT Level	CCE				ESE				
	CT1	CCE2	CCE3	CCE4	CO1	CO2	CO3	CO4	CO5
CO	CO 1&2								
K1	-	-	-	-	-	-	-	-	-
K2	8	4	-	-	6	6	6	6	6
K3	8	4	-	8	6	6	6	6	6
K4	-	-	8	-	-	-	-	-	-
K5	-	-	-	-	-	-	-	-	-
K6	-	-	-	-	-	-	-	-	-

Approved By:



This course serves as a prerequisite for / maps with the following future courses:

1. Green Manufacturing and Sustainable Engineering
2. Industrial Safety and Environmental Management
3. Smart Cities and Sustainable Infrastructure
4. Renewable Energy Systems
5. Automation for Environmental Monitoring
6. Energy Management and Conservation
7. Environmental Impact Assessment
8. Sustainable Product Design
9. Robotics Applications in Agriculture and Environmental Monitoring
10. Industrial Automation and Resource Optimization

Job Mapping:

1. Job opportunities that one can get after learning this course:
2. Environmental Management: Environmental Engineer, Environmental Analyst
3. Sustainability: Sustainability Officer, Sustainability Consultant
4. Energy Sector: Energy Auditor, Renewable Energy Executive
5. Manufacturing Industries: EHS Engineer (Environment, Health & Safety), Compliance Officer
6. Water Management: Water Resource Engineer, Water Quality Analyst
7. Agriculture & Rural Development: Soil Conservation Officer, Agricultural Sustainability Specialist
8. Government & NGOs: Environmental Officer, Climate Change Project Associate
9. Smart Cities Smart City Sustainability Coordinator
10. Research & Development: Environmental Research Assistant
11. Automation & Robotics: Environmental Monitoring System Developer, IoT-based Sustainability Analyst