CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

BACHELOR OF TECHNOLOGY (B.Tech.)

(4 Year Undergraduate Degree Programme)

In

ROBOTICS AND AUTOMATION

(In alignment with National Education Policy, 2020)

[w. e. f. 2025-26]

FACULTY OF ENGINEERING AND TECHNOLOGY

SRM UNIVERSITY DELHI-NCR, SONEPAT

39, Rajiv Gandhi Education City, Sonepat

Haryana-131029

PROGRAM STRUCTURE FOR BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMOTION)

DEGREE COURSE

Category of courses	Category	No. of Courses
Basic Applied Sciences	BAS	5
Engineering Sciences	ES	7
Professional Core Courses	PC	17
Professional Electives-Program Specific Specialization Electives	PE	11
Ability Enhancement Courses	AEC	2
Value added Courses	VAC	3
Skill Enhancement Courses (Technical &Soft Skills)	SEC	10
Practical /Workshops	P/W	9
Live Project & Industry Visit	LP	5
Multidisciplinary (Humanities and Social Sciences Courses) Courses	MDC	3
TOTAL		**72**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAMME CREDIT STRUCTURE SEMESTERWISE

Table 4

Sl. No.	Course Category	Course Code	Credits Per Semester								Total Credits	Percentage
			I	II	III	IV	V	VI	VII	VIII		
1	Basic Applied Sciences	BAS	9	9	4	-	-	-	-	-	22	12
2	Engineering Sciences	ES	8/9	8/9	-	-	-	-	-	-	17	10
3	Professional Core	PC	-	-	12	12	9	12	6	-	51	28
4	Professional Electives -Program SpecificSpecialized Elective Courses	PE	-	-	3	3	9	6	12	-	33	18
5	Ability Enhancement Courses	AEC	2/5	5/2	-	-	-	-	-	-	7	3
6	Skill Enhancement courses (Technical andSoft skills)	SEC	-	-	2	2	2	2	2	-	10	5
7	Value Added Courses	VAC	2	2	2	-	-	-	-	-	6	3
8	Practical / Workshop	P/W	-	-	2	3	2	1	1	-	9	6
9	Live Project & Industrial Visit andSummer Internship	LP/SI	-	-	-	1	1	1	5	12	20	10
10	Multidisciplinary (Humanities and Social Sciences Courses) Courses	MDC	-	-	-	3	3	3	-	-	9	5
TOTAL			**22/24**	**22/24**	**25**	**24**	**26**	**25**	**26**	**12**	**184**	**100**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – III

Course Code	Course	Category	Hours Per Week				Credits
			L	T	P	Total Hours	
Theory							
25VAC301	Sports, Yoga & Fitness	VAC	1	0	2	3	2
25AS301	Transforms and Partial differential Equations	BAS	3	1	0	4	4
25RA302	Engineering Mechanics	PC	3	0	0	3	3
25RA303	Material Science and Smart Materials	PC	3	0	0	3	3
25RA304	Sensors in Robotics	PC	3	0	0	3	3
25RA305	Kinematics and Dynamics of Robotics	PC	3	0	0	3	3
25RAXXXX	Professional Elective – I	PE	3	0	0	3	3
Practical							
25RA351	Sensors and Instrumentation Lab	P	0	0	2	2	1
25RA352	Kinematics and Dynamics of Robotics Lab	P	0	0	2	2	1
24CS0201A /24CS0201B /24CS0201C /24CS0201 D	Data Structure and Algorithms using C or C++/Industry Automation Level-I/ Digital Marketing/Fundamentals of CAD for Engineers	**SEC**	**0**	**0**	**2**	**2**	**1**
23SS351	Effective Communication Skills	SEC	0	0	2	2	1
			19	**1**	**10**	**30**	**25**

L : Lecture **T : Tutorials** **P: Practical**	**BAS : Basic Applied Sciences** **AEC : Ability Enhancement Course** **PC : Professional Core** **PE: Professional Elective** **P : Practical** **SEC : Skills Enhancement Course** **LP : Live Project**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – IV

Course Code	Course	Category	Hours Per Week				Credits
			L	T	P	Total Hours	
Theory							
23MDC401	Multidisciplinary Elective-I	MDC	3	0	0	3	3
25RA401	Digital Electronics and Microprocessor	PC	3	0	0	3	3
25RA402	Design of Robot Elements	PC	3	0	0	3	3
25RA403	Programming using Python	PC	3	0	0	3	3
25RA404	Computer Aided Design & Manufacturing (CAD & CAM)	PC	3	0	0	3	3
25RAXXXX	Professional Elective – II	PE	3	0	0	3	3
Practical							
25RA451	Microprocessor Lab	P	0	0	2	2	1
25RA452	Programming with Phyton Lab	P	0	0	2	2	1
25RA452	Modelling and Simulation Lab	P	0	0	2	2	1
24CS0202A/ 24CS0202B/ 24CS0202C	Introduction to SPSS Tool/Design Thinking and Augmented Virtual Reality/Programming Using Python for Engineers	SEC	0	0	2	2	1
23SS452	Teamwork & Interpersonal Skills	SEC	0	0	2	2	1
23LP451	Live Project-I / Internship	LP/SI	0	0	1	1	1
TOTAL			**18**	**0**	**11**	**29**	**24**

L : Lecture **T : Tutorials** **P: Practical**	**MDC- Multi Disciplinary Courses** **PC : Professional Core** **PE: Professional Elective** **P : Practical** **SEC : Skills Enhancement Course** **LP : Live Project**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – V

Course Code	Course	Category	Hours PerWeek				Credits
			L	T	P	Total Hours	
Theory							
25MDC501	Multidisciplinary Elective-II	MDC	3	0	0	3	3
25RA501	Microcontroller and Applications	PC	3	0	0	3	3
25RA502	Introduction to Drones	PC	3	0	0	3	3
25RA503	Robot Operating System	PC	3	0	0	3	3
25RAXXXX	Professional Elective – III	PE	3	0	0	3	3
25RAXXXX	Professional Elective – IV	PE	3	0	0	3	3
25RAXXXX	Professional Elective – V	PE	3	0	0	3	3
Practical							
25RA551	Microcontroller Lab	P	0	0	2	2	1
25RA552	Robot Path Planning and Programming Lab	P	0	0	2	2	1
24CS0301A/ 24CS0301B/ 24CS0301C/ 24CS0301D/ 24CS0301E	Wearable Technology/Big Data Analytics, Tools and Techniques/Machine Learning using Python/Industry Automation Level-II/RCC Structure Drawing Training	**SEC**	**0**	**0**	**2**	**2**	**1**
23SS553	Presentation Skills	SEC	0	0	2	2	1
23LP551	Live Project-II/Internship	LP/SI	0	0	1	1	1
TOTAL			**21**	**0**	**9**	**30**	**26**

L : Lecture **T : Tutorials** **P: Practical**	**PC : Professional Core** **PE : Professional Electives** **MDC- Multi Disciplinary Courses** **P : Practical** **SEC : Skills Enhancement Course** **LP/SI- Live Project-II/Internship**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – VI

Course Code	Course	Category	Hours per Week				Credits
			L	T	P	Total Hours	
Theory							
23MDC601	Multidisciplinary Elective-III	MDC	3	0	0	3	3
25RA601	Robot Vision and Intelligence	PC	3	0	0	3	3
25RA602	Computer Integrated Manufacturing	PC	3	0	0	3	3
25RA603	Humanoid Robotics	PC	3	0	0	3	3
25RA604	Industry 4.0	PC	3	0	0	3	3
25RAXXXX	Professional Elective – VI	PE	3	0	0	3	3
25RAXXXX	Professional Elective – VII	PE	3	0	0	3	3
Practical							
25RA651	Computer Aided Manufacturing Lab	P	0	0	2	2	1
24CS0302A/ 24CS0302B/ 24CS0302C/ 24CS0302D	Artificial Intelligence and Machine Learning/MATLAB for Engineers/ Structural Analysis using FEM-based Tools/Data Analytics Tools	SEC	0	0	2	2	1
23SS654	Professional Skills	SEC	0	0	2	2	1
23LP651	Live Project-II* & Industrial Visits	LP/SI	0	0	1	1	1
TOTAL			**21**	**0**	**7**	**28**	**25**

L : Lecture **T : Tutorials** **P: Practical**	**PC : Professional Core** **PE : Professional Electives** **MDC- Multi Disciplinary Courses** **P : Practical** **SEC : Skills Enhancement Course** **LP/ SI : Live Project-II/Internship**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – VII

Course Code	Course	Category	Hours Per Week				Credits
			L	T	P	Total Hours	
Theory							
25RA701	Engineering Metrology and Instrumentation	PC	3	0	0	3	3
25RA701	Mobile Robotics	PC	3	0	0	3	3
25RAXXXX	Professional Elective – VIII	PE	3	0	0	3	3
25RAXXXX	Professional Elective – IX	PE	3	0	0	3	3
25RAXXXX	Professional Elective – X	PE	3	0	0	3	3
25RAXXXX	Professional Elective – XI	PE	3	0	0	3	3
Practical							
25RA751	Mobile Robotics Lab	P	0	0	2	2	1
24CS0401A/24CS0401B/24CS0401C/24CS0401D	Building information modeling/PLC Programming/ FPGA for Embedded Systems/Essentials of Blockchain and IoT	**SEC**	**0**	**0**	**2**	**2**	**1**
23SS755	Aptitude & Reasoning	SEC	0	0	2	2	1
23LP751	Live Project-IV and Internship	LP/SI	0	0	2	2	1
23ME752	Minor Project	LP	0	0	4	4	4
TOTAL			**18**	**0**	**12**	**30**	**26**

L : Lecture **T : Tutorials** **P: Practical**	**PC : Professional Core** **PE : Professional Elective** **P : Practical** **SEC : Skills Enhancement Course** **LP/ SI : Live Project-II/Internship**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

SEMESTER – VIII

Course code	Course	Category	Hours per week				Credits
			L	T	P	Total Hours	
25RA851	Major Project	LP/SI	0	0	24	24	12
TOTAL			**0**	**0**	**24**	**24**	**12**

* *To be monitored at the Department Level*

L : Lecture **T : Tutorials** **P: Practical**	**LP/SI : Live Project**

BACHELOR OF TECHNOLOGY (ROBOTICS AND AUTOMATION) DEGREE COURSE

PROGRAM COURSE'S STRUCTURE SEMESTER WISE

PROFESSIONAL ELECTIVE (PE)

	Course Code	Course	L	T	P	C
Elective I	25RAPE01	Actuators and Drives	3	0	0	3
	25RAPE02	Manufacturing Processes	3	0	0	3
	25RAPE03	Electrical and Instrumentation Control System	3	0	0	3
Elective II	23RAPE04	Strength of Materials	3	0	0	3
	25RAPE05	Fluid Power Systems and Industrial Automation	3	0	0	3
	25RAPE06	Industrial Automation and control	3	0	0	3
Elective III	25RAPE07	Additive Manufacturing	3	0	0	3
	25RAPE08	IoT and Automation	3	0	0	3
	25RAPE09	Pneumatic and Hydraulic systems	3	0	0	3
Elective IV	25RAPE10	Deep Learning	3	0	0	3
	25RAPE11	AI for Robotics	3	0	0	3
	25RAPE12	Design of Machine Elements	3	0	0	3
Elective V	25RAPE13	Advanced Materials for Robotics	3	0	0	3
	25RAPE14	Simulation Modelling of Manufacturing Systems	3	0	0	3
	25RAPE15	Machine Learning for Robotics	3	0	0	3
Elective VI	25RAPE16	Robotics and automation Problem Solving using AI, ML and DL	3	0	0	3
	25RAPE17	Automation in Manufacturing	3	0	0	3
	25RAPE18	Design of Transmission Systems	3	0	0	3
Elective VII	25RAPE19	Robot Dynamics and Control	3	0	0	3
	25RAPE20	Machine Learning Based Condition Monitoring	3	0	0	3
	25RAPE21	Human computer Interaction	3	0	0	3
	25RAPE22	PLC and SCADA	3	0	0	3

Elective VIII	25RAPE22	AI in NLP	3	0	0	3
	25RAPE23	Automotive Control Systems	3	0	0	3
	25RAPE24	Human Values and Ethics	3	0	0	3
Elective IX	25RAPE25	Virtual and Augmented Reality	3	0	0	3
	25RAPE26	Sustainable Manufacturing	3	0	0	3
	25RAPE27	Data Science for Engineers	3	0	0	3
Elective X	25RAPE28	Project Management and Operation Research	3	0	0	3
	25RAPE29	Computational Fluid Dynamics	3	0	0	3
	25RAPE30	Maintenance and Safety in Robotics	3	0	0	3
Elective XI	25RAPE31	Intelligent Manufacturing Systems	3	0	0	3
	25RAPE32	Optimization for Robot Modelling	3	0	0	3
	25RAPE33	Entrepreneurship	3	0	0	3

SEMESTER - III

Sports, Yoga & Fitness	
Course Code: 25VAC301	Continuous Evaluation: Marks
Credits: 2	End Semester Examination: Marks
L T P: 1 0 2	
Prerequisite: Nil	

Yoga Practices & Physical Education

1. Teaching of different asanas – demonstration practice and correction.
2. Teaching of weight training – demonstration practice and correction.
3. Teaching of circuit training – demonstration practice and correction.
4. Teaching of calisthenics – demonstration practice and correction.
5. Teaching of skills of Football – demonstration, practice of the skills, correction,involvement in game situation (For girls teaching of Tennikoit)
6. Teaching of different skills of Football – demonstration, practice of the skills, correction, involvement in game situation (For girls teaching of Tennikoit)
7. Teaching of advance skills of Football – involvement of all the skills in game situationwith teaching of rules of the game
8. Teaching of skills of Basketball – demonstration, practice of the skills, correction ofskills, involvement in game situation
9. Teaching of skills of Basketball – demonstration, practice of the skills, involvement ingame situation
10. Teaching of skills of Basketball – involvement of all the skills in game situation with teaching of rule of the game
11. Teaching of skills of Kabaddi – demonstration, practice of the skills, correction of skills, involvement in game situation
12. Teaching of skills of Kabaddi – demonstration, practice of the skills, correction of skills, involvement in game situation
13. Teaching of advance skills of Kabaddi – involvement of all the skills in game situationwith teaching of rule of the game
14. Teaching of skills of Ball Badminton – demonstration, practice of the skills, correctionof skills, involvement in game situation
15. Teaching of skills of Ball Badminton – involvement of all the skills in game situationwith teaching of rule of the game
16. Teaching of some of Asanas – demonstration, practice, correction and practice
17. Teaching of some more of Asanas – demonstration, practice, correction and practice
18. Teaching of skills of Table Tennis – demonstration, practice of skills, correction and practice and involvement in game situation
19. Teaching of skills of Table Tennis – demonstration, practice of skills, correction and practice and involvement in game situation
20. Teaching of skills of Table Tennis – involvement of all the skills in game situation with teaching of rule of the game
21. Teaching – Meaning, Scope and importance of Physical Education

22. Teaching – Definition, Type of Tournaments

23. Teaching – Physical Fitness and Health Education
24. Construction and laying out of the track and field (*The girls will have Tennikoit andThrow Ball).

Youth and yoga

History, philosophy, concept, myths and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Notes:

1) Compulsory Uniform: Half pants, Tee Shirts, Shoes and socks all white (Girls will have white Tee Shirt and Track pants)

2) The games mentioned in the practical may be interchanged depending on the season and facilities.

Transforms and Partial differential Equations	
Course Code:25AS301	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination: 60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To familiarize the students with partial differential equations and their solution, Boundary value problem, Fourier transforms, z- transforms and basic concepts of Linear algebra.
- To solve boundary value problems, Heat and Wave equations.
- To gain good knowledge in the application of Fourier transform.
- To demonstrate understanding Z-transform and analyzing Discrete signals by using Z-transform.
- To understand Vector spaces, and Linear Transformation with it's properties.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Solve different types of partial differential equations.
- Find solutions of boundary value problems including heat and wave equations.
- Apply and analyze Fourier transforms with different applications.
- Evaluate the problems using z-transforms.
- Understand linear algebra and its application to Engineering.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02	✓			
03		✓		
04			✓	
05				✓

COURSE CONTENTS

Unit-I: Partial differential equation – I

Formation of partial differential equation by eliminating arbitrary constants and arbitrary functions. Formation of partial differential equation by eliminating arbitrary functions of the form $\varphi(u, v) = 0$. Solution of standard types of first order equations. Solution of standard types of first order equations. Lagrange's linear equation of first order. Linear Homogeneous partial differential equations of second and higher order with constant coefficients. Formation - Solution of standard types of first order equations - Lagrange's equation - Linear homogeneous partial differential and second and higher order with constant coefficients.

Unit-II: Partial differential equation – II

Classification of partial differential equations. Method of separation of variables. One dimensional Wave Equation and its possible solutions. Initial and Boundary value Problems with zero velocity – related problems and Non-zero velocity- related problems. One dimensional heat equation and its possible solutions. Steady state conditions and zero boundary conditions related problems. Introduction to two dimensional heat equation and its possible solutions in steady state. Two dimensional heat equation - Steady state heat flow equation

Unit- III: Fourier Transforms

Fourier Transforms- Elementary properties of Fourier transforms. Fourier Transforms and related problems- Fast Fourier Transform. Fourier Sine Transforms and their properties-problems. Fourier Cosine Transforms and their properties-problems. Convolution Theorem (without proof)-applications. Parseval's Identity (without proof)-applications.

Unit-IV: Z – Transforms

Z Transforms: Definition and properties of Z- Transforms, Inverse Z- Transforms, and Application of Z-Transforms to difference equations.

Unit-V: Vector Spaces

Vectors in two dimensional space and n-dimensional space, Vectors addition and scalar multiplication of Vectors, Vector Spaces: Definition and Examples General properties of vector spaces, Linear combination of Vectors, Linear independence and Linear dependence of Vectors. Linear transformations, linear operators, Properties of Linear Transformation, Algebra of Linear transformation, Matrix Representation of linear transformation, Linear map Associated with Linear Transformation.

TEXT BOOKS

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley-India, 10th Edition, 2017.
2. Grewal B.S., Higher Engineering Mathematics, 44th edition, Khanna Publishers, 2019
3. Gilbert Strang, Introduction to Linear Algebra, Fifth Edition (2016)

REFERENCE BOOKS

1. R.V. Churchill and J. Brown.: "Fourier Series and Boundary Value Problems" McGraw-Hill Book Company 8th edition-2017.
2. M.D. Raisinghania: "Advanced Differential Equations"S. Chand Publishing2018
3. LoknathDebnath, Integral Transforms and their applications, Chapman and Hall/CRC; 2 edition, 2014

Engineering Mechanics	
Course Code:25RA302	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To familiarize students with basic concepts of force and moments in equilibrium.
- To impart students with the knowledge of mechanics for structural analysis.
- To familiarize students with the centroids and MOI.
- To make students aware of rigid body kinetics and kinematics.
- To acquaint students with mechanics of deformable bodies.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in alignment with National Education Policy (NEP). After completion
of course, students would be able to:

- Understand the concepts of force and moments in equilibrium.
- Apply principles of mechanics to real engineering problems
- Understand the basics of Centroids and MOI.
- Grasp the elements of rigid body kinematics and kinetics.
- Understand the mechanics of deformable bodies.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02	✓			
03		✓		
04			✓	
05				✓

COURSE CONTENTS

UNIT-I FORCE SYSTEMS:

Basic concepts: Definitions, Basic assumptions, Scalar & Vector quantities, Free, Forced and fixed vectors. Force System: Force, Classification & Representation, Force as a Vector, Composition of forces, Parallelogram Law, Resolution, Principle of Transmissibility of forces, Moment of a force, Vector representation, Moment for coplanar force system, Varignon's theorem Couple, Vector representation, Resolution of a force into a force and a couple.

Force Systems: Coplanar Concurrent Force system and Coplanar Non-Concurrent force systems, Resultant of coplanar force system., Equilibrium of coplanar force system, Free body diagrams, Determination of reactions, Equilibrium of a body under three forces, Lami's theorem.

UNIT –II:

FRICTION:

Introduction, Wet and Dry friction, Theory of Dry friction, Angle of friction, Angle of Repose, Cone of friction, Coulomb's laws of friction.

BASIC STRUCTURAL ANALYSIS

Plane Truss, Difference between truss and frame, Perfect and imperfect truss, Assumptions and Analysis of Plane Truss, Method of joints, Method of section, Zero force members.

UNIT –III- CENTROID AND MOMENT OF INERTIA:

Center of Gravity, Center of Mass and Centroid of curves, areas, volumes, Determination of centroid by integration, Centroid of composite bodies.

Definition of Moment of inertia of area, Perpendicular axis theorem and Polar moment of Inertia, Parallel axis theorem, Moment of inertia of simple areas by integration, Moment of Inertia of Composite Areas.

Moment of Inertia of masses, Parallel axis theorem for mass moment of inertia, Mass moment of inertia of simple bodies by integration, Mass moment of inertia of composite bodies.

UNIT –IV- KINEMATICS OF RIGID BODY:

Introduction, Absolute motion, Plane rectilinear motion of rigid body, Plane curvilinear Motion of rigid body, x-y and n-t components, Rotation of rigid bodies, Relative Motion, Plane Motion of rigid bodies, Instantaneous center of zero velocity

UNIT- V - KINETICS OF RIGID BODY:

Introduction, Force, Mass and Acceleration, Newton's law of motion, D'Alembert's Principles and Dynamic Equilibrium, Laws of motion applied to planar translation, rotation and plane motion. Work and Energy, Kinetic energy, Principle of work and energy, Conservative forces, Law of conservation of energy, Linear Impulse and Momentum, Conservation of linear momentum.

TEXT BOOKS

1. Engineering Mechanics : Statics and Dynamics", R. C. Hibbler, Pearson
2. Engineering Mechanics " , Thimoshenko & Young , 4ed, Tata McGraw Hill
3. Engineering Mechanics : Statics and Dynamics", Shames and Rao, Pearson
4. Engineering Mechanics " , Bhavikatti , New Age

Material Science and Smart Materials

Course Code:25RA303	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To analyze the properties of smart materials and structures under diverse external conditions for their effective utilization in advanced technologies.
- To understand the fundamental properties that characterize material behavior and to classify materials based on types of loading and environmental conditions they must withstand.
- To acquire knowledge of various smart materials, their fabrication methods, and their multidisciplinary applications.
- To develop an in-depth understanding of the concept of "smart" materials and systems, including their design principles and functional advantages.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Analyze the properties of smart materials and structures in the broader external conditions for the utilization in selected technologies.
- Understand the basic properties that characterize the behavior of materials and classify the materials with their types of loadings/environment that materials should withstand.
- Acquire the knowledge of various smart materials, their fabrication and their multidisciplinary applications.
- Know the concept of "Smart" materials and systems.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02	✓			
03		✓		
04			✓	

COURSE CONTENTS

UNIT 1 : Introduction to engineering materials & their properties:

Crystalline versus non crystalline solids, Unit cell, Crystal systems, Bravais lattice, Fundamental reasons behind classification of lattice, Miller indices for directions & planes, Close-packed planes & directions, packing efficiency, Interstitial voids, Role of X-ray diffraction in determining crystal structures. Deformation of metals, understanding of some material-properties independent of interatomic bonding forces/energies, Stiffness versus modulus, Theoretical/ideal strength versus actual strength of metals, Crystal defects, Role of dislocations in deformation, Strengthening Mechanisms, Role of Cottrell atmosphere.

UNIT 2 : Phase Diagrams:
Objectives & classification, System, Phases & structural constituent of phase diagram. Temperature–Pressure phase diagram of iron & Clausius –Clapeyron equation for boundary between phase regions of temperature-versus-pressure phase diagrams, Gibbs phase rule, Lever rule, Solid solutions, Hume-Rothery rules, Isomorphous, Eutectic, Peritectic & Eutectoid system, Equilibrium diagrams for non-ferrous alloys.
Heat Treatment: Definition, Purpose & classification of heat treatment processes for various types of steels, Bainite & Martensite formation, Introduction & applications of various case hardening & surface hardening treatments, Precipitation Hardening, Heat treatment defects.
Smart materials:

UNIT 3 : Concept of Smart Materials:

Retrospective review, main notion, energy aspects of external influence, systematization and methods of smart materials description: methods of materials taxonomy, smart material model, classification of smart materials and engineering systems, Materials for electrical engineering and electronics: conductors, semiconductors, dielectrics, magnetic materials, optically active materials, materials for thermoelectric devices, smart battery materials, radio wave absorbing materials, sealing materials, heat-insulating and sound absorbing materials.

UNIT 4 :Structural material:

self-healing materials, heat and cold resistant materials, radiation resistant materials, corrosion-resistant materials and anti-corrosive coatings, lubricants, frictional materials,
materials for operation at abnormal temperatures. Materials for biological and biomedical systems materials for implants, targeted drug delivery and tissue growth, antimicrobial materials, filters for water cleaning.

UNIT 5 : Mechanics of smart materials:

Object and subject of smart materials mechanics, structural and functional analysis smart materials in terms of mechanics, the materials with negative characteristics as source of smart effects in structures: Auxetics, statements and solutions of some smart materials based mechanics problems – e.g. self-healing of cracks, self-reinforcing of multimodular materials, porous materials-auxetic materials reversible transformations, self- assembling porous materials etc. Smart materials and energy problem: Global energy problem, energy consumption for production of materials, technical and economical efficiency of smart materials and technical systems.

Text Books:

(i) Raghvan, Materials Science and Engineering, Prentice Hall of India Publishing 5th Edition, 2006.
(ii) W.D. Callister, Materials Science and Engineering 8th Edition, 2006.
Reference Books:
(i) Encyclopedia of Smart Materials (Volume 1 and 2) by Mel Schwartz, John Wiley and Sons, 1st Edition, 2002.
(ii) Design, Fabrication Properties and Applications of Smart and Advanced Materials, Edited by Xu Hou, CRC Press, 1st Edition, 2016.
(iii) Smart Materials: Integrated Design, Engineering Approaches and Potential Applications, Edited by Anca Filimon, Apple Academic Press and CRC Press, 1st Edition, 2019.
(iv) Smart Materials Taxonomy by Victor Goldade, Serge Shil'ko, Alexander Neverov, CRC Press, 1st Edition, 2016.

Sensors in Robotics	
Course Code:25RA304	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To analyze various sensory systems used in robotics and understand their roles in perception and control.
- To select appropriate sensors for specific robotic applications and design effective sensing systems.
- To analyze different types of actuators and configure their parameters for optimal performance in robotic systems.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the systems.
- Analyze actuators and configuring the parameters of Actuators.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03
01	✓		
02	✓		
03		✓	

COURSE CONTENTS

UNIT 1 : Anatomy of Robotic system:
links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations.

UNIT 2: Sensors:
Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors, Ultrasonic sensors, Touch and Slip sensors. sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices.

UNIT 3: Vision Sensors:
Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation.

UNIT 4: Advanced Sensor Technology:
Smart sensors, MEMS based sensors, Innovations in sensor technology Actuators and its selection while designing a robot system. Types of transmission systems.

UNIT 5: Electric Actuators:

Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators.

Text Books:

(i) D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.
(ii) Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.

Reference Books:

(i) Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.
(ii) Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd edition Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.
(iii) Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
(iv) Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008.

Kinematics and Dynamics of Robotics	
Course Code:25RA305	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To introduce Robots history, terminologies, classification and configurations.
- To get knowledge about basic Geometrical and Algebraic approach to solve forward kinematics of serial manipulator.
- To get knowledge about advanced forward kinematics of serial manipulator.
- To get knowledge about inverse kinematics of various serial manipulator.
- To get knowledge about Jacobian aspects and infinitesimal motion of robot

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the history, classifications, and basic terminologies of robotics and various configuration of robots.
- Evaluate forward kinematic model for planar and spatial robot manipulator.
- Evaluate forward kinematic model for multi-DOF robot manipulators.
- Evaluate inverse kinematic model for multi-DOF robot manipulators.
- Evaluate forward kinematic model for differential drive mobile robot.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02	✓				
03		✓			
04			✓	✓	
05					✓

COURSE CONTENTS

UNIT I: OVERVIEW OF ROBOTICS

Introduction to Robotics, History, Definitions, Law of Robotics, Terminologies , Classifications Overview, Links & Joints , Degrees of Freedoms , Coordinate Systems , Work Volume, Precision, Repeatability & Accuracy, Position and Orientation of Objects , Roll, Pitch and Yaw Angles , Joint Configuration of Five Types of Serial Manipulators ,Wrist Configuration- Overview of end effector, Selection and Application of Serial Manipulators.

UNIT II: FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH

Need for forward and Inverse Kinematics Equation – Parameters in Design and Control – Methods of forward and inverse kinematics- Geometrical and Algebraic Approach in Forward Kinematics Solution, 1 DOF - 2 DOF Planar Robot (2P and 2R); 3DOF 2RP Spatial Robot.

UNIT III: FORWARD KINEMATIC MODELING – DENAVIT-HARTEBERG (DH) APPROACH

Unit Circle Trigonometry - Translation Matrix - Rotation matrix, Euler Angles - Quaternion Fundamental - Dot and Cross Products - Frames and Joint Coordinates - Homogeneous Transformation - D-H and Modified D-H Convention and Procedures – Forward kinematics Solution using D-H Convention: 3 DOF wrist , RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical , SCARA and Articulated 3 DOF robots - 3 DOF robot with wrist.

UNIT IV: INVERSE KINEMATICSMODELING

Introduction to inverse kinematics -Issues in inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3DOF planar and Spatial robot - Tool configuration - Inverse kinematics of 3 axis robot and 6 axis Robot - Inverse kinematics Computation- Closed loop solution

UNIT V: KINEMATIC MODELING OF DIFFERENTIAL DRIVE ROBOT

Degree of Mobility, Steerability and Maneuverability- Mobile Robot kinematics - Kinematic model and constraints, Mobile robot workspace – Representation of robot position – Kinematic models of differential wheel drive

TEXT BOOKS:

1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
2. John J. Craig, “Introduction to Robotics”, 3rd Edition, Addison Wesley, ISE 2008.
3. Lynch, Kevin M., and Frank C. Park. Modern Robotics: Mechanics, Planning, and Control 1st ed. Cambridge University Press, 2017.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, Second Edition, 2017
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2017
3. Arthor Critchlow, “Introduction to Robotics”, 1st edition, Macmillan, 2009.
4. Mohsen Shahinpoor, “A Robot Engineering Text Book”, 1st edition, Harper and Row, 2004.
5. Deb S.R., “Robotics Technology and Flexible Automation”, 2nd edition, Tata McGraw – Hill Publis Robotics: Control and Programming.
6. J. Srinivas, R. V. Dukkipati, K., “Robotics: Control and Programming”, Narosa Publishing House, 2009.
7. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001
8. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor - Based integration, Academic Press, 1999.

Actuators and Drives	
Course Code:25RAXXXX	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To analyze various sensory systems used in robotics and understand their roles in perception and control.
- To select appropriate sensors for specific robotic applications and design effective sensing systems.
- To analyze different types of actuators and configure their parameters for optimal performance in robotic systems.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the systems.
- Analyze actuators and configuring the parameters of Actuators.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03
01	✓		
02	✓		
03		✓	

UNIT I: Electric Actuators:
Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

UNIT II : Pneumatic & Hydraulic actuators:
Hydraulic and pneumatic power actuation devices: Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand.

UNIT III Actuator for IoT:
Actuator types, working principle of actuators, integration of sensors and actuators with arduino, formation of actuators, selection criteria for right actuator, maintenance of actuators, smart material actuators.

UNIT IV: Smart Actuators:
Displacement Actuators; Force Actuators; Power Actuators; Vibration Dampers; Shakers; micro fluidic Pumps; micro motors Smart Transducers: Ultrasonic Transducers; Sonic Transducers.

UNIT V Drive Characteristics
Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, torque, and Direction starting & stopping – Selection of motor.

Text Books:

1. D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.
2. Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.
3. Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosal Publishing House, New Delhi, 2001.

Reference Books:

1. Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.
2. Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd edition Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.
3. Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
4. Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008.

Manufacturing Processes	
Course Code:25RAXXXX	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CO)

- To familiarize students with basic concepts of casting and the various types of casting and its design
- To familiarize students with the working principle and application of metal forming operations
- To impart students with the knowledge of machining operation, types of machining operations and its selection
- To make students aware of different gear manufacturing operation and the finishing operations
- To acquaint students with basic machine tools used in mechanical engineering.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy

(NEP). After completion of course, students would be able to:

- Understand various ways of working of metals
- Understand the concepts of Casting and Welding Technology
- Understand the working of Machining with lathes and automats
- Grasp the concept of Milling machine and Gear manufacturing process
- Understand the various Machine tools used in manufacturing

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03		✓		✓	
04			✓		
05					✓

COURSE CONTENTS

UNIT-I CASTING AND WELDING

Introduction to casting, Patterns, Types, Pattern materials, Allowances – Moulding – types– Moulding sand, Gating and Risering, Cores &Core making Special Casting Process - Shell, Investment, Die casting, Centrifugal Casting. Special welding– Laser, Electron Beam, Ultrasonic, Electro slag, Friction welding, Electrical resistance welding

UNIT-II MECHANICAL WORKING OF METALS

Hot and Cold Working: Rolling, Forging, Wire Drawing, Extrusion – types – Forward, backward and tube extrusion. Sheet Metal Operations: Blanking– blank size calculation, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch forming, Shearing, Bending– simple problems– Bending force calculation, Tube forming – Embossing and coining, Types of dies: Progressive, compound and combination dies

UNIT-III THEORY OF METAL CUTTING

Orthogonal and oblique cutting– Classification of cutting tools: single, multipoint – Tool signature for single point cutting tool – Mechanics of orthogonal cutting – Shear angle and its significance – Chip formation– Cutting tool materials– Tool wear and tool life – Machinability – Cutting Fluids– Simple problems.

UNIT-IV GEAR MANUFACTURING AND SURFACE FINISHING PROCESS

Gear manufacturing processes: Extrusion, Stamping, and Powder Metallurgy. Gear Machining: Forming. Gear generating process – Gear shaping, Gear hobbing. Grinding process, various types of grinding machine, Grinding Wheel – types – Selection of Cutting speed and work speed, dressing and truing. Fine Finishing – Lapping, Buffing, Honing, and Super finishing.

UNIT-V MACHINE TOOLS

Milling Machine – specification, Types, Types of cutters, operations, Indexing methods– simple problems. Shaping, Planning and Slotting Machine – description, Operations, Work and tool holding Devices, Jigs & fixtures. Boring machine – Specification, operations, Jig boring machine. Broaching machine – operations, Specification, Types, Tool nomenclature

Text Books

1. Sharma, P.C., A textbook of Production Technology–Vol I and II, S. Chand & Company Ltd., New Delhi, 1996.
2. Rao, P.N., Manufacturing Technology, Vol I & II, Tata McGraw Hill Publishing Co., New Delhi, 1998.

Reference Books

1. Chapman W. A. J., Workshop Technology Vol. I and II, Arnold Publisher, New Delhi, 1998.
2. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., Elements of Manufacturing Technology, Vol II, Media Publishers, Bombay, 1988.
3. Jain. R. K., Production Technology, Khanna Publishers, New Delhi, 1988.
4. Kalpakjian, Manufacturing Engineering and Technology, Addision Wesley Congmen Pvt. Ltd., Singapore, 2000

Electrical and Instrumentation Control System	
Course Code:25RAXXXX	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To acquire fair knowledge on construction, working of measuring instruments, bridges and display devices
- To understand the working of analog meters for power and energy measurements.
- To learn the operation of different measuring and display devices.
- To Comprehend the measurement of non- electrical quantities.
- To understand the working of biomedical instruments and data acquisition system.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to

- Understand the working of analog meters for power and energy measurements.
- Learn the operation of different measuring and display devices.
- Comprehend the measurement of non- electrical quantities.
- Understand the working of biomedical instruments and data acquisition system.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02		✓		
03		✓		
04			✓	
05				✓

COURSE CONTENTS

UNIT I

General Principles of measurements, units, dimensions, standards and calibration of meters.
Characteristics of Instruments - qualities and errors of Measurements and its analysis. Analog Measuring Instruments: Classification of analog instruments, operating forces in indicating instruments, T/W ratio, pointers and scales. Working principle, theory, construction and salient features of electromechanical indicating / registering instrument viz. PMMC, Electrodynamometer, Moving iron, Rectifier type, Induction type for the measurement of dc and ac voltage, current, power, energy (1-phase induction type wattmeter), power factor (single phase Electrodynamometer), Volt ohmmeter or multimeter.

UNIT II : MEASUREMENT OF RESISTANCES

Classification of resistances, measurement of medium resistance, Measurement of low resistance (Kelvin double bridge, Ammeter -Voltmeter) and Measurement of high resistance including loss of charge method and Mega ohm bridge method. AC Bridges: General theory of ac bridge, Measurement of self-inductance, Measurement of capacitance, Measurement of mutual inductance, Measurement of frequency, Sources of error in ac bridges and their minimization.

UNIT III :CATHODE RAY OSCILLOSCOPE

Principle and working of CRO, Block diagram presentation of CRO and brief description of various elements of CRO – CRT, horizontal Deflecting system, Vertical deflecting system, CRO screen, Measurement of voltage, frequency and phase angle using CRO, CRO probes.

UNIT IV : WATTMETER ENERGYMETERS

Principle of measuring power by using Dynamometer and Induction type wattmeters; Errors and compensation; Low power factor polyphase wattmeters; Energymeter – difference between wattmeter & energymeter; Principle of construction of Induction type energymeter; Error compensation and adjustments in energymeter. Special Type Meters : Construction and working principle of Frequency meter, Synchroscope, Power factor meter, Flux meter, Maximum demand meter.

UNIT V: INSTRUMENT TRANSFORMERS

Uses of instrument transformers; Theory of CT & PT; Ratio &; phase angle errors; Errors compensations; Testing of CT & PT. Recorders: Different types of recorders; Construction, working principle and circuit diagrams of Strip-chart & X-Y recorders.

TEXT BOOKS

1. Ernest O Doebelin and Dhanesh N Manik,"Measurements systems Application and design", McGraw Hill publication, 5th edition, 2015.
2. Sawhney A.K, "A course in Electrical and electronic Measurement and Instrumentation", Dhanpat Rai & Sons, New Delhi, 2008

REFERENCE BOOKS

1. Stout MB, "Basic Electrical Measurements", Prentice Hall of India Pvt Ltd., 2007.
2. Rajendra Prasad, "Electrical Measurements & Measuring instruments", Khanna Publishers, 4th Edition, 2010.
3. Albert D Halfride & William D Cooper, "Modern Electronic instrumentation and measurement techniques", Prentice Hall of India Pvt Ltd., 2007

Sensors and Instrumentation Lab	
Course Code:25RA351	**Continuous Evaluation: 60 Marks**
Credits: 3	**End Semester Examination: 40 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Design grippers for various applications considering appropriate design parameters and constraints.
- Understand the working principles of touch sensors and learn their interfacing and feedback mechanisms.
- Perform kinematic analysis of robotic systems.
- Plan and analyze trajectories for robotic motion.
- Detect objects and perform path tracing using vision sensors.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to

- Design a gripper for different applications using design considerations.
- Learn working of touch sensors and their interfacing and feedback.
- Perform kinematic analysis.
- Perform trajectory planning.
- Detect the object and path tracing using vision sensor.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03		✓	✓		
04				✓	
05					✓

LIST OF EXPERIMENTS

1. Robot Gripper design and considerations.
2. Touch Sensors interfacing and feedback system.
3. Manipulator kinematics analysis.
4. Use of object detection and Image processing using Vision sensors in Robot system.
5. Trajectory planning and analysis.
6. Pick and place / path tracking using robot.
7. Virtual lab experiments on Robot kinematics for Movemaster, PUMA 560 and KGP 50: http://vlabs.iitkgp.ernet.in/mr/#

Text Books:

(i) D. Patranabis, Sensors and Transducers, PHI, 2nd Edition, 2013.
(ii) Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.

Reference Books:

(i) Mc Comb, G. Robot builder's bonanza. 5th edition New York: McGraw-Hill, 2019. ISBN 9781260135015.
(ii) Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd ed. Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.
(iii) Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
(iv) Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008.
(v) Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007.
(vi) S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013.

Kinematics and Dynamics of Robotics Lab	
Course Code:25RA352	**Continuous Evaluation: 60 Marks**
Credits: 3	**End Semester Examination: 40 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To model and simulate a robot and verify its kinematics
- To model and simulate a robot and generate a trajectory plan.
- To model and simulate a robot and verify its dynamics

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to

- Analyze the kinematics and dynamics for various robots
- Simulate and evaluate the kinematics and dynamics for various robots
- Create a robot and program a trajectory plan for the robot.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03
01	✓		
02		✓	
03		✓	✓

LIST OF EXPERIMENTS

1. Simulation of four bar mechanism and analyze motion of the mechanism
2. Simulation of slider crank mechanism and analyze motion of the mechanism
3. Simulation of toggle mechanism and analyze motion of the mechanism
4. Verification of Forward Kinematics for 2R, 2P and RP Robot.
5. Verification of D-H transformation for 6DOF Serial manipulator
6. Verification of Inverse Kinematics for 2R, 2P and RP Robot.
7. Verification of Forward Kinematics for 3R spatial Robot.
8. Kinematic Analysis of 2R planar robot for varying trajectories using Robo analyzer
9. Workspace Analysis of 2R planar robot manipulator for a specified trajectory
10. Kinematic Analysis of 6 DOF robot for varying trajectories using Robo analyzer

TEXT BOOKS:

1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
2. John J. Craig, “Introduction to Robotics”, 3rd Edition, Addison Wesley, ISE 2008.
3. Lynch, Kevin M., and Frank C. Park. Modern Robotics: Mechanics, Planning, and Control 1st ed. Cambridge University Press, 2017.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, Second Edition, 2017
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2017
3. Arthor Critchlow, “Introduction to Robotics”, 1st edition, Macmillan, 2009.
4. Mohsen Shahinpoor, “A Robot Engineering Text Book”, 1st edition, Harper and Row, 2004.

SEMESTER – IV

Digital Electronics and Microprocessor	
Course Code: 25RA401	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To present the Digital fundamentals, Boolean algebra and its applications in digital systems.
- To familiarize with the design of various combinational digital circuits using logic gates.
- To introduce the analysis and design procedures for synchronous and asynchronous sequential circuits.
- To explain the various semiconductor memories and related technology.
- To introduce the electronic circuits involved in the making of logic gate.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- State the fundamental operating concepts behind digital logic circuits and microprocessors.
- Recognize the use of various digital logic circuits and sub units in microprocessors.
- Interpret the information flow in digital logic circuits and the architectures of microprocessors.
- Design the DLC and Microprocessor for the standard applications.
- Create the circuits using DLC and Microprocessor for given applications.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01			✓		
02					✓
03	✓				
04				✓	
05		✓			

COURSE CONTENTS

UNIT-I: DIGITAL FUNDAMENTALS

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‘s and 2‘s complements, Codes – Binary, BCD, Excess 3, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of

products and product of sums, Minterms and Maxterms, Karnaugh map Minimization and Quine-McCluskey method of minimization.

UNIT-II: COMBINATIONAL & SYNCHRONOUS SEQUENTIAL CIRCUITS

Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder -Multiplexer, Demultiplexer, Decoder, Priority Encoder. Flip flops – SR, JK, T, D, design of clocked sequential circuits – Design of Counters- Shift registers, Universal Shift Register

UNIT-III: ASYNCHRONOUS SEQUENTIAL CIRCUITS AND MEMORY DEVICES

Stable and Unstable states, output specifications, cycles and races, state reduction, race free assignments, Hazards, Essential Hazards, Pulse mode sequential circuits, Design of Hazard free circuits. Basic memory structure – ROM -PROM – EPROM – EEPROM –EAPROM, RAM – Static and dynamic RAM - Programmable Logic Devices – Programmable Logic Array (PLA) - Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA).

UNIT-IV: 8085 PROCESSOR

Hardware Architecture, pin diagram – Functional Building Blocks of Processor – Memory organization – I/O ports and data transfer concepts– Timing Diagram – Interrupts.

UNIT-V: PROGRAMMING PROCESSOR

Instruction - format and addressing modes – Assembly language format – Data transfer, data manipulation& control instructions – Programming: Loop structure with counting & Indexing – Look up table - Subroutine instructions – stack -8255 architecture and operating modes.

TEXT BOOKS

1. M. Morris Mano and Michael D. Ciletti, “Digital Design”, 5th Edition, Pearson, 2014.
2. Krishna Kant, “Microprocessor and Microcontrollers”, Eastern Company Edition, Prentice Hall of India, New Delhi, 2007.

REFERENCE BOOKS

1. Charles H.Roth. “Fundamentals of Logic Design”, 6th Edition, Thomson Learning, 2013.
2. Thomas L. Floyd, “Digital Fundamentals”, 10th Edition, Pearson Education Inc, 2011
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely ‘The 8051 Micro Controller and Embedded Systems’, PHI Pearson Education, 5th Indian reprint, 2003.
4. R.S. Gaonkar, ‘Microprocessor Architecture Programming and Application’, with 8085, Wiley Eastern Ltd., New Delhi, 2013.

Design of Robot Elements	
Course Code: 25RA402	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To introduce the students to the fundamentals of machine design, material selection and to solve the basic design problems.
- To learn to derive various parameters for modelling links and joints in a robot.
- To learn about Fundamentals of Computer Graphics.
- To learn and understand curves and surfaces in robot modelling.
- To learn to derive various parameters for modelling end-effectors of a robot.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- State the design parameters for designing the components of a robot.
- Apply the CAD modelling techniques in designing a robot.
- Analyse the design parameters for designing the components of a robot.
- Formulate the methods for designing the entire robot assembly.
- Create a Robot CAD Model.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03				✓	
04			✓		
05					✓

COURSE CONTENTS

UNIT-I: FUNDAMENTALS OF MECHANICAL DESIGN

Fundamentals of Machine Design-Engineering Design, Phases of Design, Design Consideration - Standards and Codes - Design against Static and Dynamic Load –Modes of Failure, Factor of Safety, Principal Stresses, Theories of Failure-Stress Concentration, Stress Concentration Factors, Variable

Stress, Fatigue Failure, Endurance Limit, Design for Finite and Infinite Life, Soderberg and Goodman Criteria.

UNIT-II: DESIGN OF LINKS AND JOINTS

Loads and Forces on Links and Joints - Design of solid and hollow shafts - Rigid and flexible couplings - Threaded fasteners - rolling contact bearings-– Links Design: Path and Motion Synthesis – Cognate Linkages – Design of Spherical Joints.

UNIT-III: FUNDAMENTALS OF COMPUTER GRAPHICS

Product cycle- Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation.

UNIT-IV: CURVES AND MODELLING

Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Fundamentals of solid modelling, Different solid representation schemes, Half -spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytic solid modelling, Perspective, Parallel projection, Hidden line removal algorithms.

UNIT-V: DESIGN OF GRIPPERS

Grippers – Types of Grippers Mechanisms – Gripping Methods – Gripping Force analysis – Gripper Design – Two Finger gripper – Three Finger Gripper – Magnetic Gripper Design – Vacuum Gripper Design – Hooks – Scoops – Spools – Miscellaneous Grippers.

TEXT BOOKS

1. Joseph Edward Shigley, Charles R. Mischke “Mechanical Engineering Design”, McGraw Hill, International Edition, 1992.
2. Sharma. C.S. and Kamlesh Purohit, “Design of Machine Elements”, Prentice Hall of India Private Limited, 2003.
3. Ibrahim Zeid, “CAD/CAM theory and Practice”, Tata McGraw Hill, 2nd edition, 2008.
4. Ashby. M.F., “Materials Selection in Mechanical Design”, Third edition, Butterworth- Heineman, New York, 16th edition, 2012.

REFERENCE BOOKS

1. Bhandari. V.B., “Design of Machine Elements”, Tata McGraw-Hill Publishing Company Limited, 2003.
2. Robert L. Norton, “Machine Design – An Integrated Approach”, Prentice Hall International Edition, 2000.
3. Charles. J. A. and Crane. F. A. A, “Selection and Use of Engineering Materials”, second edition, Butterworth-Heinemann Ltd., 3rd edition 2005.
4. Kevin Otto, Kristin Wood, “Product Design”, Pearson Education, 7th Reprint, 2011.
5. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
6. Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018
7. Zeid, I., CAD/CAM, McGraw Hill, 2008.

Computer Aided Design and Manufacturing (CAD&CAM)	
Course Code: 25RA404	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE OBJECTIVES (CO)

- To introduce the student to the basic tools of computer-aided design (CAD) and computer aided manufacturing (CAM).
- To impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids.
- To understand the importance of solid modelling.
- To introduce how computer can be applied in mechanical engineering design.
- To perform part programming for CNC operation.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be able to:

- Explain lifecycle of a product and the role of computer-aided design (CAD) in product development.
- Create the different wireframe primitives, surface primitives and solid primitives using parametric representations.
- Apply geometric transformations on the created wireframe, surface and solid models.
- Understand concepts of modelling in 2D and 3D.
- Understand different CAD Packages and apply the CNC machine tools and programming manufacturing processes

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

COURSE CONTENTS

Unit-I: Fundamentals of computer graphics

Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3Dtransformations- homogeneous coordinates - graphic primitives (point, line, circle drawing

algorithms)-Clipping- viewing transformation.

Unit-II: Geometric modeling

Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Surface Modeling – Surface Entities, representation of Surface, Bezier Surface, B-Spline Surface and Coons Surface. Solid Modeling - Solid Entities, Solid Representation, Boundary Representation (B-Rep), Sweeps Representation, Constructive Solid Geometry (CSG).

Unit- III: Visual realism

Need for hidden surface removal, The Depth - Buffer Algorithm, Properties that help in reducing efforts, Scan Line coherence algorithm, Span - Coherence algorithm, Area-Coherence Algorithms, Warnock's Algorithm, Priority Algorithms– shading – coloring – computer animation.

Unit-IV: Cad standards

Standards for computer graphics- Graphical Kernel System (GKS) - Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, ACIS and DXF - communication standards.

Unit-V: Computer numerical control machine tools

Numerical control (NC) machine tools – CNC: types, constructional details, special features. -Part programming fundamentals – manual programming – computer assisted part programming – Turning, Drilling and Milling. Introduction to Distributed Numerical control (DNC) Machines. Introduction to computer aided process planning.

TEXT BOOKS

1. Ibrahim Zeid, CAD / CAM–Theory and Practice, Tata Mcgraw-Hill, New Delhi, 2010.
2. Radhakrishnan. P., CAD / CAM / CIM - New age international, 2012.
3. Chairs Mcmahon and Jimmie Browne, CAD/CAM, Addision Wesly, New York, 2000.

REFERENCE BOOKS

1. Chandupatla and Belagundu, Introduction to Finite Element Methods in Engineering, Prentice Hall of India Private Limited, New Delhi, 1997.
2. Newman and Sproull R. F., Principles of interactive computer graphics, Tata Mcgraw-Hill, New Delhi,1997.
3. Mikell P. Groover, CAD/CAM, Prentice Hall of India Private Limited, New Delhi, 1997.

Fluid Power Systems and Industrial Automation	
Course Code: 25RAPE05	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To recognize the standard symbols and to understand the functions of basic fluid power generation and actuation elements.
- To realize the functions of fluid regulation and control elements and its typical uses in fluid power circuit and to acquire the practice on assembling the various types of pneumatic circuits.
- To familiar and exercise the design procedure of various types of pneumatic and hydraulic fluid power circuits and to provide a training to create the various types of hydraulic circuits.
- To learn about the fundamentals of Programmable Logic Controller.
- To familiarize the Data Communication and Supervisory Control Systems.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Recognize the various concepts of fluid power and PLC systems.
- Comprehend functions of fluid power and PLC systems.
- Explain the various standard fluid power circuits, functions, communication and IO details of PLC.
- Demonstrate the standard fluid power circuits and PLC based interfaces.
- Construct the fluid power circuits and PLC based automation system.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01				✓	
02		✓			
03	✓				
04			✓		
05					✓

COURSE CONTENTS

UNIT – I: FLUID POWER SYSTEM GENERATION AND ACTUATORS

Need For Automation, Classification of Drives - Hydraulic, Pneumatic and Electric –Comparison – ISO Symbols for their Elements, Selection Criteria. Generating Elements- Hydraulic Pumps and Motor Gears,

Vane, Piston Pumps – Motors - Selection and Specification - Drive Characteristics – Utilizing Elements - Linear Actuator – Types, Mounting Details, Cushioning – Power Packs – Accumulators.

UNIT – II: CONTROL AND REGULATIING ELEMENTS

Control and Regulating Elements — Direction, Flow and Pressure Control Valves -Methods of Actuation, Types, Sizing of Ports. Spool Valves - Operating Characteristics -Electro Hydraulic Servo Valves - Types - Characteristics and Performance.

UNIT – III: CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS

Typical Design Methods – Sequencing Circuits Design - Combinational Logic Circuit Design - Cascade Method – KV Mapping - Electrical Control of Pneumatic and Hydraulic Circuits - Use of Relays, Timers, Counters and PLC in pneumatics and hydraulics.

UNIT – IV: PROGRAMMABLE LOGIC CONTROLLER

Industrial Automation - Programmable Logic Controller - Functions of PLCs - Features of PLC - Selection of PLC - Architecture – IEC61131-3 programming standard and types - Basics of PLC Programming – Ladder Logic Diagrams – Communication in PLC – Programming Timers and Counters – Data Handling - PLC modules – Advanced motion controlled Multi Axis PLC.

UNIT – V: DATA COMMUNICATION AND SUPERVISORY CONTROL SYSTEMS

Industrial Data Communications -– Modbus – HART – DeviceNet – Profibus – Fieldbus – RS232- RS485- Modbus/ Modbus TCP/IP - mechatrolink – CAN – EtherCAT - Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – human machine interfaces - Total Integrated Automation (TIA) – Industry 4.0.

TEXT BOOKS

1. Antony Esposito, “Fluid Power Systems and Control”, Prentice-Hall, 2006.
2. Peter Rohner, “Fluid Power Logic Circuit Design”, the Macmillan Press Ltd., London, 1979.
3. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, Fourth Edition, 2016.

REFERENCE BOOKS

1. Lucas, M.P., “Distributed Control System”, Van Nastrand Reinhold Company, New York, 1986.
2. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, First Edition, 2004.
3. Patranabis. D, “Principles of Industrial Instrumentation”, Tata McGraw-Hill Publishing Ltd., New Delhi, 1999.

Industrial Automation and Control	
Course Code: 25RAPE06	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To introduce the elements of control system and their modelling using various Techniques.
- To perform frequency domain analysis of control systems required for stability analysis.
- To design the compensation technique that can be used to stabilize control systems.
- To study about the hardware and software involved in a PLC.
- To provide the control functions involved in DCS and SCADA.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Write mathematical equations for model mechanical, electrical systems and compute transfer function using block diagram and signal flow graph methods.
- Perform time domain and frequency domain analysis of control systems required for stability analysis in Robot Control.
- Design the compensation technique that can be used to stabilize Robot control systems.
- Program PLC based on applications.
- Summarize the working of various elements of DCS and SCADA.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01		✓			
02	✓				
03					✓
04			✓		
05				✓	

COURSE CONTENTS

UNIT-I: INTRODUCTION TO CONTROL SYSTEM

Basic Elements of Control System – Open loop and Closed loop systems - Differential equation - Transfer function, Modelling of Electric systems, Translational and rotational mechanical systems - Block diagram Signal flow graph – P, PI, PD and PID Compensation, Analysis of Compensation in Mechatronics systems.

UNIT-II: ANALYSIS OF TIME AND FREQUENCY RESPONSE

Time response analysis - First Order Systems - Impulse and Step Response - Analysis of second order systems-Frequency Response - Bode Plot, Polar Plot, Nyquist Plot - Frequency Domain specifications from the plots. Compensators - Lead, Lag, and Lead-Lag Compensators.

UNIT-III: STABILITY ANALYSIS

Stability, Routh-Hurwitz Criterion, Root Locus Technique, Construction of Root Locus, Stability, Dominant Poles, Application of Root Locus Diagram. – Transfer function from State Variable Representation – Solutions of the state equations - Concepts of Controllability and Observability.

UNIT-IV: PROGRAMMABLE LOGIC CONTROLLERS

Introduction to Programmable Logic Controllers, Architecture of PLC, PLC programming languages, Relay Logic, Ladder logic, Timers and Counters, selection of PLC based on input and output. Application of PLC in automation.

UNIT-V: SCADA

Introduction, Application areas of SCADA, Major elements of SCADA systems, Comparison of SCADA, DCS and PLC, Considerations and benefits of SCADA system. Introduction to field- programmable gate array (FPGA).

TEXT BOOKS

1. Nagrath J and M.Gopal, “Control System Engineering”, New Age International Publishers, 6th Edition, 2017.
2. Levent Güvenç, Bilin Aksun Güvenç, Burak Demirel, Mümin Tolga Emirler, “Control of Mechatronic Systems”, Institution of Engineering and Technology, 2017.

REFERENCE BOOKS

1. Benjamin.C.Kuo, “Automatic control systems”, Prentice Hall of India, 9th Edition,2014.
2. Gopal M, “Control System – Principles and Design”, Tata McGraw Hill, 4nd Edition, 2012.
3. Stuart A Boyer, “SCADA-supervisory control and data acquisition”, International Society of automation, 3rd edition,2011.
4. Georg Pelz, “Mechatronic Systems Modeling and Simulation with HDLs”, wiley Publication, 2003.
5. Richard Zurawski, “Industrial Communication Technology Handbook” 2nd Edition, CRC Press, 2015.

Microprocessor Lab	
Course Code: 25RA451	**Continuous Evaluation:60 Marks**
Credit: 1	**End Semester Examination:40 Marks**
L T P : 0 0 2	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- To provide hands-on experience with microprocessor architecture and interfacing techniques.
- To develop skills in assembly language programming.
- to understand and implement interfacing of memory and I/O devices with microprocessors.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Write and execute assembly language programs for 8085/8251/8253 microprocessors.
- Analyse the timing and control signals of microprocessors and interfacing modules.
- Develop and simulate microprocessor-based systems for real-world applications.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03
01			✓
02		✓	
03	✓		

LIST OF EXPERIMENTS

1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.
3. To perform multiplication and division of two 8-bit numbers using 8085.
4. To find the largest and smallest number in an array of data using 8085 instructions set.
5. To write a program to arrange an array of data in ascending and descending order.
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8085 instructions set.
7. To write a program to initiate 8251 and to check the transmission and reception of character.
8. To interface 8253 programmable interval timers to 8085 and verify the operation of 8253 in six different modes.
9. To interface DAC with 8085 to demonstrate the generation of square, saw tooth and triangular wave.
10. Serial communication between two 8085 through RS-232 C port.

REFERENCE BOOKS

1. "Microprocessor Architecture, Programming and Applications with the 8085" by *Ramesh S. Gaonkar*: Penram International / Prentice Hall.
2. "Advanced Microprocessors and Peripherals" *by A. K. Ray and K. M. Bhurchandi*: McGraw Hill Education.

Modelling and Simulation Lab	
Course Code: 25RA452	**Continuous Evaluation:60 Marks**
Credit: 1	**End Semester Examination:40 Marks**
L T P : 0 0 2	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Make the students knowledgeable in modelling the basic components of a robot
- Make the students knowledgeable in modelling some common joints, links and transmission assembly for a robot.
- Make the students knowledgeable in modelling a robot and its end effector.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Identify components and physical features of various parts for a robot system and sub systems.
- Model components and physical features of various parts for a robot system and sub systems.
- Create a CAD and simulation model for a robot system and sub systems.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03
01			✓
02	✓		
03		✓	

LIST OF EXPERIMENTS

1. 3D Modelling Mounting clamp for motor.
2. 3D Modelling of GT2 pulley and belt drive system
3. 3D Modelling Ball Screw and Nut assembly.
4. 3D Modelling and motion simulation of Rotational Joint assembly.
5. 3D Modelling and motion simulation of Prismatic Joint assembly.
6. 3D modelling and simulation of Cartesian Robot
7. 3D modelling and simulation of Articulated / Spherical / Cylindrical Robot.
8. 3D modelling and motion simulation of 2 fingered gripper assembly.
9. 3D modelling of 2 Wheeled skid steering Mobile Robot.
10. 3D modelling of 4 Wheeled 4 steering Mobile Robot.

REFERENCE BOOKS

1. "Robotics: Modelling, Planning and Control" by *Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo:* Springer.
2. "Introduction to Robotics: Mechanics and Control" by *John J. Craig*: Pearson.
3. "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by *Peter Corke*: Springer.

SEMESTER - V

Microcontroller and Applications	
Course Code: 25RA501	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE EDUCATIONAL OBJECTIVES:

1.To introduce the students about architectural features of microcontrollers and its registers
2. To introduce about the instruction set of 8051
3. To know about the I/O Ports and Interrupts of 8051
4. To know about Timers/Counters of 8051
5. To introduce Arduino programming and interfacing of sensors

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Understand the architectural features of MCS-51 and select a suitable microcontroller to suit the application.
2. Develop programs for control applications using assembly language and embedded C
3. Use timers and counters for delay generation and event counting and Illustrate the use of interrupts and service routines
4. Write algorithms and develop programs for serial data communication applications.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02	✓			
03		✓		
04			✓	
05				✓

COURSE CONTENTS

Unit - I: Microcontroller Overview And 8051 Architecture

Features and selection factors for Microcontroller, Block diagram of 8051 Microcontroller: CPU, input device, output device, memory, and buses, Comparison of Microcontroller and Microprocessor on basis of: Memory, Complexity, Type of Architecture, Cost, Applications, Typical examples of Microcontrollers and Microprocessors, Architectures of Microcontroller: Harvard, Von Neumann, Concept of pipelining, 8051 Microcontroller: Architecture, Pin Configuration, Memory Organisation, Power saving options, Derivatives of 8051 (8951, 8031, 8751). Comparison between derivatives

Unit - II: 8051 Programming

Software Development Cycle: Editor, Assembler, Compiler, Cross-Compiler, Linker, Locator, Addressing Modes: Immediate, Register, Direct, Indirect, Indexed, Instruction set: Data Transfer, Arithmetic, Logical, Branching, Machine control, and Boolean, Assembler Directives: ORG, DB, EQU, END, CODE, DATA, Assembly Language Programming (ALP): Data manipulation, Masking, Stack operation, Branch related programming

Unit - III: 8051 Timers, Interrupts, Serial and Parallel Communication

Configuration and Programming of Timer/Counter using Special Function Registers: TMOD, TCON, THx, TLx, Simple programs to generate time delays, Configuration and Programming of interrupts using SFRs: IE, IP, Serial Communication SFRs: SCON, SBUF, PCON, Modes of serial communication, Simple Programs on serial communication, Serial Communication using MAX 232, Configuration and Programming of I/O Port: P0, P1, P2, P3

Unit - IV: 8051 Interfacing

I/O Interfacing: Keyboard, Relays, LED, LCD, Seven Segment display, Interfacing ADC 0808/09 with 8051, Simple programs for ADC interfacing, Interfacing DAC 0808/09 with 8051, Simple programs for DAC interfacing, Memory Interfacing: Program and Data Memory

Unit - V: 8051 Applications

Square and Triangular waveform generation using DAC, Temperature sensor (LM35) interfacing using ADC to 8051, Water Level controller design using Ascending, Stepper Motor Interfacing to 8051 to rotate in clockwise and anticlockwise direction

REFERENCES:

1. The 8051 Microcontroller(3rd edition) - Kenneth J Ayala
2. The 8051 Microcontroller & Embedded systems using assembly and C (2ndEdition) –M.A.Mazidi , J.C. Mazidi & R.D.McKinlay ISBN: 81-317-1026-2
3. The 8051 Microcontroller(4th Edition)- MacKenzie , ISBN:81-317-2018-7
4. The 8051 Microcontroller(1st Edition) – Dr.Uma Rao & Andhe Paallavi, ISBN: 81-317- 3252-5
5. Microcontrollers & applications, Ramani Kalpathi, & Ganesh Raja , ISBN: 81-888-4918-9
6. Programming Arduino: Getting Started with Sketches, Second Edition (Tab) 2nd Edition – Simon Monk

Robot Operating System	
Course Code: 25RA503	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination: 60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OBJECTIVES:

- Understand the basics of robotics, simulation tools, and the setup of ROS environments.
- Develop and implement applications using ROS nodes, services, actions, and URDF.
- Apply mapping and localization techniques for robot navigation using SLAM in ROS.
- Implement robotic manipulation techniques using ROS-based planning tools.
- Apply vision-based algorithms for object detection, pose estimation, and integration with ROS.

COURSE LEARNING OUTCOMES:

- Describe industrial applications of robots, simulation environments, and install/configure ROS tools like Gazebo, MoveIt, and Ubuntu.
- Develop ROS applications using publishers, subscribers, services, and create robot models using URDF.
- Implement SLAM algorithms (e.g., Occupancy Grid Mapping, FastSLAM) for navigation using ROS2 and C++.
- Apply planning algorithms and execute object manipulation tasks using ROS manipulation tools.
- Use ROS vision tools for object detection and pose estimation using camera inputs.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES:

CLO	CEO 01	CEO 02	CEO 03	CEO 04	CEO 05
CLO1.1	✓				
CLO2.1		✓			
CLO3.1			✓		
CLO4.1				✓	
CLO5.1					✓

COURSE CONTENT

Unit I: Introduction
Industrial Applications of Robots, Industrial Environments and Constraints, Free Open Source Software for Robot Simulation, Robotic Operating System (ROS), Gazebo, MoveIt, Ubuntu, Python, Installing and Configuring Simulation Softwares.

Unit II: Robotic Operating System
Robotic Operating System (ROS) Fundamentals, Building a ROS Application, ROS Services, ROS Actions, Unified Robot Description Format (URDF).

Unit III: Robot Navigation
Slam: Simultaneous Localization and Mapping (SLAM) implementation with ROS2 packages and C++. Combining mapping algorithms with the localization concepts, Introduction to the Mapping and SLAM concepts and algorithms. Occupancy Grid Mapping, Mapping an environment with the Occupancy Grid Mapping algorithm, Grid-based FastSLAM: Simultaneous mapping an environment and localize a robot relative to the map with the Grid-based FastSLAM algorithm, Self-Localisation, Path Planning and Obstacle Avoidance, Map-Building and Map Interpretation, Simultaneous Localization and Mapping, Navigation using Software Tools.

Unit IV: Manipulation
Object Manipulation, Manipulation Planning Algorithms, Prehension, Manipulation using Software Tools.

Unit V: Robot Vision
Object Detection, Pose Estimation, Logical Camera, ROS Tools for Vision.

Text Books:

1. Morgan Quigley, "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" , O'Reilly Media, 2015.

2. Carol Fairchild, Dr. Thomas L. Harman, "ROS Robotics by Example", Packt, 2016. Anis Koubaa, "Robot Operating System", Springer link, 2016.

3. Anil Mahtani, "Effective Robotics Programming with ROS", Packt Publishing, 2016.

4. Ramkumar Gandhinathan , Lentin Joseph , " ROS Robotics Projects: Build and control robots powered by the Robot Operating System, machine learning, and virtual reality", Packt Publishing Limited, December 2019.

5. SLAM for dummies: https://dspace.mit.edu/bitstream/handle/1721.1/119149/16-412j-spring-2005/contents/projects/1aslam_blas_repo.pdf

6. ROS Robot Programming; YoonSeok Pyo I HanCheol Cho I RyuWoon Jung I TaeHoon Lim; https://community.robotsource.org/t/download-the-ros-robot-programming-book-for-free/51

Robot Path Planning	
Course Code: 25RA502	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OUTCOMES (COS)

- Understand the fundamentals of task planning and trajectory planning in robotic systems.
- Apply joint space and Cartesian space trajectory planning techniques for robot manipulators.
- Analyze and implement various path planning strategies for mobile robots in known and dynamic environments.
- Evaluate and apply classical and sensor-based motion planning algorithms for navigation and control.
- Develop and test robotic applications using Robot Operating System (ROS) programming.

COURSE-LEVEL OBJECTIVES (CLOS)

- Describe the concepts of task and trajectory planning, and represent robot end-effector motion in Cartesian and joint space.
- Apply joint and Cartesian space trajectory planning techniques such as cubic polynomial, parabolic blends, and straight-line motion.
- Analyze mobile robot environments and implement path planning using visibility graphs, Voronoi diagrams, and potential fields.
- Implement classical and sensor-based motion planning algorithms including A*, D*, and Bug algorithms.
- Develop and execute robotic applications using ROS, including point-to-point and continuous operations with safety features.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES:

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

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

Unit II: Trajectory Planning Of Manipulator: Joint space techniques – Motion profiles – Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion – Cartesian space technique – Straight line and circular trajectories.

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

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

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

Text Books:

1. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.
3. Planning Algorithms by Steve LaValle (Cambridge Univ. Press, New York, 2006).
4. Principles of Robot Motion: Theory, Algorithms, and Implementations (by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun.
5. Robot Motion Planning by J.C. Latombe.
6. Patnaik, Srikanta, "Robot Cognition and Navigation An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
7. Reza N Jazar, "Theory of Applied Robotics", Springer, 2010.
8. Morgan Quigley, Brian Gerkey, William D. Smart, Programming Robots with Ros: A Practical Introduction to the Robot Operating System, First Edition, 2016, ISBN 9352132793; 978-9352132799

Additive Manufacturing	
Course Code: 25RAPE07	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE OBJECTIVES:

- To introduce the development of Additive Manufacturing (AM), various business opportunities and applications
- To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
- To be acquainted with vat polymerization and direct energy deposition processes
- To be familiar with powder bed fusion and material extrusion processes.
- To gain knowledge on applications of binder jetting, material jetting and sheet lamination processes

COURSE OUTCOMES:

At the end of this course students shall be able to:

- Recognize the development of AM technology and how AM technology propagated into various businesses and developing opportunities.
- Acquire knowledge on process of transforming a concept into the final product in AM technology.
- Elaborate the vat polymerization and direct energy deposition processes and its applications.
- Acquire knowledge on process and applications of powder bed fusion and material extrusion.
- Evaluate the advantages, limitations, applications of binder jetting, material jetting and sheet lamination processes.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT I INTRODUCTION

Overview - Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling - Rapid Manufacturing - Additive Manufacturing. AM Process Chain- ASTM/ISO 52900 Classification - Benefits. Applications: Building Printing - Bio Printing - Food Printing-Electronics Printing. Business Opportunities and Future Directions – Case studies: Automobile, Aerospace, Healthcare.

UNIT II :DESIGN FOR ADDITIVE MANUFACTURING (DfAM)

Concepts and Objectives - AM Unique Capabilities - Part Consolidation – Topology Optimization- Generative design - Lattice Structures - Multi-Material Parts and Graded Materials - Data Processing: CAD Model Preparation - AM File formats: STL-Problems with STL- AMF Design for Part Quality Improvement: Part Orientation - Support Structure - Slicing - Tool Path Generation – Design rules for Extrusion based AM.

UNIT III : VAT POLYMERIZATION AND DIRECTED ENERGY DEPOSITION

Photo polymerization: Stereolithography Apparatus (SLA)- Materials -Process – top down and bottom up approach - Advantages - Limitations - Applications. Digital Light Processing (DLP) - Process - Advantages - Applications. Continuous Liquid Interface Production (CLIP)Technology.

Directed Energy Deposition: Laser Engineered Net Shaping (LENS)- Process - Material Delivery - Materials -Benefits -Applications.

UNIT IV :POWDER BED FUSION AND MATERIAL EXTRUSION

Powder Bed Fusion: Selective Laser Sintering (SLS): Process - Powder Fusion Mechanism - Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM): Materials - Process - Advantages and Applications.

Material Extrusion: Fused Deposition Modeling (FDM)- Process-Materials -Applications and Limitations.

UNIT V :OTHER ADDITIVE MANUFACTURING PROCESSES

Binder Jetting: Three-Dimensional Printing - Materials - Process - Benefits- Limitations - Applications.

Material Jetting: Multijet Modeling- Materials - Process - Benefits - Applications.

Sheet Lamination: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding - Thermal Bonding- Materials-Application and Limitation.

Reference Books

1. Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani "Additive manufacturing technologies". 3rd edition Springer Cham, Switzerland. (2021). ISBN: 978-3-030-56126-0
2. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1-56990-582-1.
3. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
4. Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies, and Applications", Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333.
5. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.
6. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer., United States ,2006, ISBN: 978-1-4614-9842-1.

IoT and Automation	
Course Code: 25RAPE08	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination: 60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OBJECTIVES:

- To apprise students with basic knowledge of IoT that paves a platform to understand physical and logical design of IOT
- To teach a student how to analyse requirements of various communication models and protocols for cost-effective design of IoT applications on different IoT platforms.
- To introduce the technologies behind Internet of Things(IoT).
- To explain the students how to code for an IoT application using Arduino/Raspberry Pi open platform.
- To apply the concept of Internet of Things in real world scenario.

COURSE OUTCOMES:

- Explain the concept of IoT.
- Understand the communication models and various protocols for IoT.
- Design portable IoT using Arduino/Raspberry Pi /open platform
- Apply data analytics and use cloud offerings related to IoT.
- Analyze applications of IoT in real time scenario

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT I INTRODUCTION TO INTERNET OF THINGS

Evolution of Internet of Things – Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT Models – Simplified IoT Architecture and Core IoT Functional Stack – Fog, Edge and Cloud in IoT

UNIT II COMPONENTS IN INTERNET OF THINGS

Functional Blocks of an IoT Ecosystem – Sensors, Actuators, and Smart Objects – Control Units - Communication modules (Bluetooth, Zigbee,Wifi, GPS, GSM Modules)

UNIT III PROTOCOLS AND TECHNOLOGIES BEHIND IOT

IOT Protocols - IPv6, 6LoWPAN, MQTT, CoAP - RFID, Wireless Sensor Networks, BigData-Analytics,

Cloud Computing, Embedded Systems.

UNIT IV OPEN PLATFORMS AND PROGRAMMING

IOT deployment for Raspberry Pi /Arduino platform-Architecture –Programming – Interfacing – Accessing GPIO Pins – Sending and Receiving Signals Using GPIO Pins – Connecting to the Cloud.

UNIT V IOT APPLICATIONS

Business models for the internet of things, Smart city, Smart mobility and transport, Industrial IoT,

Smart health, Environment monitoring and surveillance – Home Automation – Smart Agriculture

REFERENCES

1. Robert Barton, Patrick Grossetete, David Hanes, Jerome Henry, Gonzalo Salgueiro, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017
2. Samuel Greengard, The Internet of Things, The MIT Press, 2015
3. Perry Lea, "Internet of things for architects", Packt, 2018
4. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012
5. IOT (Internet of Things) Programming: A Simple and Fast Way of Learning, IOT Kindle Edition.
6. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.
7. ArshdeepBahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015
8. https://www.arduino.cc/
9. https://www.ibm.com/smarterplanet/us/en/?ca=v_smarterplanet

Pneumatic and Hydraulic systems	
Course Code: 25RAPE09	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination: 60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OBJECTIVES

- To understand the basics of fluid properties and flow characteristics.
- To learn about losses in fluid flow through pipes.
- To develop hydraulic circuits and systems.
- To know the working principles of pneumatic power system and its components.
- To learn the trouble shooting methods in fluid power systems.

COURSE LEARNING OUTCOMES

- Understand the behavior of fluids.
- Calculate losses in fluid flow and design the effective fluid flow system.
- Design hydraulic circuits and systems for various applications.
- Design and develop pneumatic and electro pneumatic systems.
- Select, Install and Maintain fluid power systems

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT-I FLUID PROPERTIES AND FLOW CHARACTERISTICS: Properties of fluids-Pressure Measurements-U-tube manometer-Single column manometer- Differential manometer - Buoyancy and floatation-Flow characteristics-Eulerian and Lagrangian Principle of fluid flow– concept of control volume and system –Reynolds transportation theorem-continuity equation, energy equation and momentum equation-Applications.

UNIT-II FLOW THROUGH PIPES : Reynold‟s Experiment-Laminar flow through circular conduits-Darcy Welsbach equation –friction factor- - minor losses-Hydraulic and energy gradient –Pipes in series and parallel. Pumping Theory – Pump.
Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps

UNIT-III HYDRAULIC ACTUATORS AND CIRCUIT DESIGN: Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning ,Hydraulic motors, Direction Control, Flow control and pressure control valves –Types, Construction and Operation – Accessories ,Fluid Power ANSI Symbols –Problems, Accumulators, Intensifiers, Industrial hydraulic Circuit Design and Analysis, Hydrostatic transmission, Sensors used in Electro hydraulic systems, Electro hydraulic circuits,–Servo and Proportional valves –Applications-Mechanical , hydraulic servo systems.

UNIT-IV PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS: Properties of air –Air preparation and distribution –Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit –classification-single cylinder and multi cylinder circuits-Cascade method –Integration of fringe circuits, PLC-Architecture and types, Electro Pneumatic System – Elements –Ladder diagram –timer circuits-Problems.

UNIT-V TROUBLE SHOOTING AND APPLICATIONS: Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Conditioning of hydraulic fluids Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. –Low- c o s t Automation –Hydraulic and Pneumatic power packs- Case studies of innovative applications of fluid power systems in automation

Reference Books:

1. Anthony Esposito, “Fluid Power with Applications”, Pearson New International Edition, England, 2014.
2. Modi P.N. and Seth, S.M. Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 2017.
3. Jagadeesha. T., “Pneumatics Concepts, Design and Applications “, Universities Press, 2015.
4. Joshi.P., Pneumatic Control”, Wiley India, 2008.
5. Majumdar, S.R., “Oil Hydraulics Systems –Principles and Maintenance”,TataMcGraw Hill, 2001
6. Shanmugasundaram.K., “Hydraulic and Pneumatic Controls”. Chand & Co, 2006.
7. Srinivasan.R., “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008

Deep Learning	
Course Code: 25RAPE10	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OUTCOMES (COS)

- Understand the basic concepts of artificial neurons and the Perceptron Learning Algorithm.
- Apply multilayer perceptron (MLP) and backpropagation techniques for building neural networks.
- Implement and compare optimization algorithms for training neural networks effectively.
- Analyze and apply regularization and unsupervised learning techniques such as autoencoders.
- Develop and evaluate deep learning models using CNNs and RNNs for vision and sequence tasks.

COURSE-LEVEL OBJECTIVES (CLOS)

- Describe biological neuron models, perceptrons, threshold logic, linear separability, and convergence of the Perceptron Learning Algorithm.
- Implement MLPs with sigmoid neurons and apply backpropagation using gradient descent for supervised learning.
- Use optimization techniques such as Adam, RMSProp, and SGD with regularization methods like dropout and batch normalization.
- Explain the functioning of autoencoders and their variants, and apply regularization and pre-training strategies.
- Build deep learning models using CNNs and RNNs, apply attention mechanisms, and understand architectural variations (e.g., ResNet, LSTM).

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT 1 Introduction: Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear Separability. Convergence theorem for Perceptron Learning Algorithm.
Introduction to neural network and multilayer perceptrons (MLPs), representation power of MLPs, sigmoid neurons, gradient descent, feedforward neural networks representation, Backpropagation.

UNIT II Gradient Descent: Gradient Descent, Batch Optimization, Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).

UNIT III Autoencoders: Autoencoders, Regularization in autoencoders, De noising autoencoders, Sparse autoencoders, Contractive autoencoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layer Wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

UNIT IV Convolutional Neural Network: Introduction to CNN, Building Blocks of CNN, Transfer Learning, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing CNNs, Guided Backpropagation, Fooling Convolutional Neural Network.

UNIT V Recurrent Neural Network: Introduction to RCNN, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs, Encoder Decoder Models, Attention Mechanism.

REFERENCES

1. Yoshua Benjio, Aaron Courville, “Deep Learning- Ian Goodfellow”, The MIT Press, 2016.
2. A.C. Faul, “A Concise Introduction to Machine Learning”, CRC Press, 2019.
3. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996.
4. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

AI for Robotics	
Course Code: 25RAPE11	**Continuous Evaluation: 40. Marks**
Credits: 3	**End Semester Examination 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE OBJECTIVE

- To study the concepts of Artificial Intelligence
- To learn the methods of solving problems using Artificial Intelligence.
- To introduce the concepts of Probabilistic reasoning and Speech recognition.
- To understand about learning methods
- To understand the role of Artificial intelligence in Robotics

COURSE LEARNING OUTCOMES

On completion of the course students will be able to :

- Identify problems that are amenable to solution by AI methods.
- Identify appropriate AI planning methods to solve a given problem.
- Implement basic AI algorithms for Speech recognition and making decisions.
- Develop learning algorithms for autonomous driving tasks.
- Apply appropriate AI methods to solve assembly problem.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT-I Introduction to AI and Search Techniques : Historical background of Artificial Intelligence, state space search-simple search, Depth First Search (DFS), Breadth First Search (BFS), Comparison of BFS and DFS, Depth Bounded DFS, Depth First Iterative Deepening (DFID), Heuristic Search- Best First Search, Hill Climbing, local maxima, Solution Space Search, Variable Neighborhood Descent, Beam Search.

UNIT-II Finding Optimal Paths : Brute force, Branch &Bound, Refinement Search, Dijkstra's Algorithm, Algorithm A*, Admissibility of A*, Iterative Deepening A*(IDA*), Simulated Annealing, Genetic Algorithm.

UNIT-III Planning and Reasoning: Introduction to AI Planning-STRIPS Domain, Forward and Backward State Space Planning, Goal Stack Planning, Plan Space Planning, Uncertainty and Probabilistic Reasoning-Filtering and Prediction, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Applications in AI-Speech Recognition, Decision-Making Processes.

UNIT-IV Machine Learning in Robotics : Supervised Learning: Introduction to classification and regression, Decision Trees, k-Nearest Neighbors (k-NN), Support Vector Machines (SVM). Unsupervised Learning: Clustering methods like k-means and hierarchical clustering, Dimensionality Reduction - Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). Reinforcement Learning: Basics of Markov Decision Processes, Q-learning, and applications in robot navigation and control.

UNIT-V Neural Networks and Deep Learning for Robotics: Introduction to Neural Networks - Basic concepts, feedforward networks, and backpropagation. Convolutional Neural Networks (CNNs) - Architecture, applications in image recognition, and object detection. Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) - Concepts and applications in sequence prediction and natural language processing for robotic control. Applications in Robotics - Using deep learning for object detection, scene understanding, and human-robot interaction.

REFERENCES:

1. Stuart Russell, Peter Norvig, “Artificial Intelligence: A modern approach”, Pearson Education, India, 2019.
2. Negnevitsky, M, “Artificial Intelligence: A guide to Intelligent Systems”, Harlow: Addison-Wesley, 2022.
3. David L. Poole and Alan K. Mackworth, “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press, 2010
4. Raju Bahubalendruni and Bibhuthi Bhushan Biswal, “Computer aided Optimal Robotic Assembly Sequence Generation”, Lap Lambert Academic Publishing; 1st edition, 2017.
5. Tim Jones M, “Artificial Intelligence: A Systems Approach”, Jones & Bartlett Learning; 1st edition, 2008
6. Ian Good Fellow, Yoshua Bengio & Aaron Courville, “Deep Learning”, MIT Press, USA, 2016.
7. Deepak Khemani, “A first course in Artificial Intelligence”, McGraw Hill, India,2018.

Design of Robot Elements	
Course Code: 25RAPE12	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination 60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OBJECTIVES

- The main learning objective of this course is to prepare the students for:
- To introduce the students to the fundamentals of machine design, material selection and to solve the basic design problems.
- To learn to derive various parameters for modelling links and joints in a robot.
- To learn about Fundamentals of Computer Graphics
- To learn and understand curves and surfaces in robot modelling.
- To learn to derive various parameters for modelling end-effectors of a robot

COURSE OUTCOMES

- Upon completion of this course, the students will be able to:
- State the design parameters for designing the components of a robot.
- Apply the CAD modelling techniques in designing a Robot
- Analyse the design parameters for designing the components of a robot.
- Formulate the methods for designing the entire robot assembly
- Create a Robot CAD Model.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

COURSE CONTENT

UNIT 1 FUNDAMENTALS OF MECHANICAL DESIGN: Fundamentals of Machine Design- Engineering Design, Phases of Design, Design Consideration - Standards and Codes - Design against Static and Dynamic Load –Modes of Failure, Factor of Safety, Principal Stresses, Theories of Failure- Stress Concentration, Stress Concentration Factors, Variable Stress, Fatigue Failure, Endurance Limit, Design for Finite and Infinite Life, Soderberg and Goodman Criteria.

UNIT II DESIGN OF LINKS AND JOINTS: Loads and Forces on Links and Joints - Design of solid and hollow shafts - Rigid and flexible couplings -Threaded fasteners - rolling contact bearings-– Links Design: Path and Motion Synthesis – Cognate Linkages – Design of Spherical Joints.

UNIT III FUNDAMENTALS OF COMPUTER GRAPHICS: Product cycle- Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation.

UNIT IV CURVES AND MODELLING: Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Fundamentals of solid modeling, Different solid representation schemes, Half - spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytic solid modeling, Perspective, Parallel projection, Hidden line removal algorithms.

UNIT V DESIGN OF GRIPPERS: Grippers – Types of Grippers Mechanisms – Gripping Methods – Gripping Force analysis – Gripper Design – Two Finger gripper – Three Finger Gripper – Magnetic Gripper Design – Vacuum Gripper Design – Hooks – Scoops – Spools – Miscellaneous Grippers

REFERENCES:

1. Joseph Edward Shigley, Charles R. Mischke “Mechanical Engineering Design”, McGraw Hill, International Edition, 1992
2. Sharma. C.S. and Kamlesh Purohit, “Design of Machine Elements”, Prentice Hall of India Private Limited, 2003
3. Ibrahim Zeid, “CAD/CAM theory and Practice”, Tata McGraw Hill, 2nd edition, 2008
4. Ashby. M.F., “Materials Selection in Mechanical Design”, Third edition, Butterworth-Heineman, New York, 16th edition, 2012
5. Bhandari. V.B., “Design of Machine Elements”, Tata McGraw-Hill Publishing Company Limited, 2003.
6. Robert L. Norton, “Machine Design – An Integrated Approach”, Prentice Hall International Edition, 2000.
7. Charles. J. A. and Crane. F. A. A, “Selection and Use of Engineering Materials”, second edition, Butterworth-Heinemann Ltd., 3rd edition 2005.
8. Kevin Otto, Kristin Wood, “Product Design”, Pearson Education, 7th Reprint, 2011.
9. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
10. Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018
11. Zeid, I., CAD/CAM, McGraw Hil , 2008.

Microcontroller Lab	
Course Code: 25RA551	**Continuous Evaluation: 60 Marks**
Credits: 1	**End Semester Examination:40 Marks**
L T P : 0 0 1	
Prerequisite: Nil	

COURSE OUTCOMES (COS)

- Interpret architecture of 8-bit microcontrollers.
- Develop program in 8051 in assembly language for the given operation.
- Develop program using timers and interrupts.
- Interface the memory and I/O peripherals to 8051 microcontrollers.
- Maintain microcontroller-based applications.

COURSE-LEVEL OBJECTIVES (CLOS)

- Describe the architecture and functional blocks of the 8051 microcontrollers.
- Write assembly language programs for arithmetic and logical operations using 8051.
- Develop programs using 8051 timers, interrupts, and serial communication.
- Interface input/output devices and peripherals (LCD, ADC, DAC) with 8051.
- Implement microcontroller-based applications such as stepper motor control and water level monitoring.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES:

CLO	CO1	CO2	CO3	CO4	CO5
CLO1	✓				
CLO2		✓			
CLO3			✓		
CLO4				✓	
CLO5					✓

Course Content:

Identification of 8051 development board

1. ALP for arithmetic operations on 8-bit data
2. ALP using various addressing modes
3. ALP to perform addition of BCD data
4. Generate delay using timer register
5. Serial 8-bit data transfer on serial port
6. LED interfacing to 8051 using interrupts
7. LCD interfacing to 8051 to display characters and numbers
8. ADC interfacing to 8051
9. DAC interfacing to generate square waveform
10. Stepper motor interfacing to rotate clockwise

11. Water level controller using 8051 (simulation-based)
12. Temperature sensor (LM35) interfacing to 8051
13. Keyboard interfacing to 8051

REFERENCE BOOKS :

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, Pearson Education, ISBN: 9788131710265
2. Kenneth J. Ayala, Thomson Delmar Learning, ISBN: 9781401861582
3. Ajay V. Deshmukh, McGraw-Hill Education, ISBN: 9780070585959
4. Ajit Pal, PHI Learning, ISBN: 9788120343947
5. Santanu Chattopadhyay, AICTE (2023), ISBN: 9788196057602

SEMESTER VI

Robot Vision and Intelligence	
Course Code:25RA601	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

1. To understand the basics concepts of optics and vision systems.
2. To learn and understand the fundamentals of image processing
3. To impart knowledge on object recognition and feature extraction.
4. To understand algorithms in image processing.
5. To demonstrate the various applications of machine vision system.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Know the various types of sensors, lightings, hardware and concept of machine vision.
2. Acquire the image by the appropriate use of sensors, lightings and hardware.
3. Apply the various techniques of image processing in real time applications.
4. Select the suitable sensors, lightings and hardware.
5. Apply the vision techniques in Robot vision system.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

COURSE CONTENTS

UNIT-I: Image Acquisition:

The Nature of Vision- Robot vision – Need, Applications - image acquisition – Physics of Light – Interactions of light – Refraction at a spherical surface – Thin Lens Equation – Illumination techniques - linear scan sensor, planar sensor, camera transfer characteristic, Raster scan, Image capture time, volume sensors, Image representation, picture coding techniques.

UNIT II: Image Processing Fundamentals

Introduction to Digital Image Processing - Image sampling and quantization – Image enhancement: Gray Value Transformations, Radiometric Calibration, Image Smoothing– Geometric transformation– Image segmentation– Object Recognition and Image Understanding - Feature extraction: Region Features, Gray Value Features, Contour Features–Morphology– Edge extraction– Fitting and Template matching. Unit-III: Fourier Transforms

UNIT III: Object Recognition and Feature Extraction

Image segmentation- Edge Linking-Boundary detection-Region growing-Region splitting and merging-Boundary Descriptors-Freeman chain code-Regional Descriptors recognition structural methods-Recognition procedure, mahalanobic procedure

UNIT IV: Collison Fronts Algorithm

Introduction, skeleton of objects. Gradients, propagation, Definitions, propagation algorithm, Thinning Algorithm, Skeleton lengths of Top most objects.

UNIT V: Vector Spaces

Case study-Automated Navigation guidance by vision system – vision based de palletizing- line tracking-. Automatic part Recognition. Image processing techniques implementation through Image Processing software

TEXT BOOKS:

1. Yi Ma, Jana Kosecka, Stefano Soatto, Shankar Sastry, "An Invitation to 3-D Vision From Images to Models", First Edition, 2004

2. 2. Rafael C. Gonzales, Richard. E. Woods, "Digital Image Processing Publishers", Fourth Edition, 1992.

3. 3. Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision",First Edition,2015

REFERENCE BOOKS:

1. Fu .K.S, Gonzalez .R.S, Lee .C.S.G, "Robotics – Control Sensing, Vision and Intelligence",Tata McGraw-Hill Education, 2008.

2. RafelC.Gonzalez, Richard E.Woods,StevenL.Eddins, "Digital Image Processing using MATLAB", 2nd edition, Tata McGraw Hill, 2010.

Computer Integrated Manufacturing	
Course Code: 25RA602	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P: 3 0 0	
Prerequisite: Nil	

COURSE OBJECTIVES (CO)

The students will be able to

1. To understand the operations and programming of NC, CNC and DNC machines.
2. To understand the concepts of reverse engineering, computer-aided process planning and unmanned manufacturing.
3. To understand the reverse engineering.
4. To familiar with computer aided process planning for fabrication process.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be able to:

1. Describe scope of C.I.M. in manufacturing technology.
2. Describe scope of group technology in manufacturing industry.
3. Write program for manufacturing component.
4. Prepare CAPP (Computer Aided Process Planning) for fabrication process equipment.
5. Describe concept of reverse engineering.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

CLO / CEO	01	02	03	04	05
01	✓				✓
02			✓		
03		✓			
04				✓	

UNIT-I

NC/CNC/DNC terminology, Operations of NC/CNC machine tools. Control cycles in CNC machine tools and how do these reduce operator's activities, Central Processing Unit (CPU) , Input Devices, Storage Devices , System Configuration, Feasible report to introduce CAM technology for the first time in the industry , advantages &limitations of using CNC technology**.**

UNIT-II

Parameters for adaptation of CAM technology, Advantages and disadvantages of CAM, Part programming, Manual & CAP, APT& its statements/programming with suitable examples to machine the components on CNC lathe, CNC milling machine, CNC jig boring machine, etc, Parallel programming& its advantages, Post etc.
Reverse engineering, Reasons for reverse engineering, importance of reverse engineering, Process of reverse engineering, Applications of reverse engineering

UNIT-III

Canned cycles, linear/circular, parabolic interpolation, online/offline programming, unidirectional, bidirectional approach, point to point and continuous control, Buffer storage, adaptive control, Nesting, opti part, opti-route, precision sheet metal processing, CNC turret punch press, CNC press brake & its programming to machine the sheet metal components, Auto indexing, safety aspects in CNC machine tools. Tool length/ cutter compensation, Computer optimized manufacturing, etc

UNIT-IV

CAPP, Types of CAPP, Group technology, Merit/ Demerits, Database management in the development of CAPP, CAD-CAM integration, Essential elements of CAPP, Future trends in CAPP, Importance of CAPP in CAM/CIM, etc. Introduction to Robots, its types, Laws of robotics, Symbolic modelling of robots, Robotic sensors, Configurations of robot, Applications of Robots in engineering industries

UNIT-V

Basic concepts of CIM, Evolution of CIM, Unmanned manufacturing, Elements of CIM, CIM implementation, CIM hardware and CIM software. Product development through CIM, Sequential engineering, Concurrent engineering, Comparison of sequential and concurrent engineering, implementation of concurrent engineering, concurrent engineering and information technology, Characteristics of concurrent engineering. Soft computing in CIM: Artificial neural networks/Artificial intelligence, Fuzzy, Fuzzy AHP Benefits of CIM, Lean manufacturing, comparison of lean manufacturing with conventional manufacturing, applications of lean manufacturing, etc.

Text Book

1. M. Thomas Crandell, CNC Machining and Programming an Introduction, Industrial Press Inc., New York, 2002.
2. P. Groover Mikell, Automation, Production Systems, and computer Integrated manufacturing,
3. Prentice Hall of India, New Delhi, 2003.

Reference Book

1. K. Yoram, Ben and U. Joseph, Numerical Control of Machine Tools, Khanna Publishers, New Delhi, 2005.
2. Mikell P. Groover, and Emory W. Zimmers, Computer aided design and manufacturing, Prentice Hall of India, New Delhi, 2003.

Humanoid Robotics	
Course Code: 25RA603	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

1. To know the basic knowledge about Humanoid robots.
2. To impart knowledge in kinematics of humanoids.
3. To learn about the dynamics in humanoid robots.
4. To understand the basic in biped walking.
5. To know about the different walking patterns

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Describe about the evolution of Humanoid robots
2. Expose the basic knowledge in kinematics of humanoids.
3. Calculate the Humanoid Robot Motion and Ground Reaction Force.
4. Identify Two-Dimensional Walking pattern on different terrain.
5. Create the Walking Pattern models

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

COURSE CONTENTS

UNIT-I: Introduction

Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots.

UNIT II: KINEMATICS

Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis

UNIT III: ZMP AND DYNAMICS

ZMP Overview,2D Analysis,3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force , Momentum, Angular Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum

UNIT IV: BIPED WALKING

Two-Dimensional Walking Pattern Generation, Two Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain.

UNIT V: WALKING PATTERN GENERATION

ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation,Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers.

TEXT BOOKS:

1. Dragomir N. Nenchev, Atsushi Konno, "Humanoid Robots Modeling and Control", Butterworth Heinemann, 2019
2. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH "Introduction to Humanoid Robotics", Springer, London, 2014.
3. Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.

REFERNCE BOOKS:

1. J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022
2. J K. Harada, E. Yoshida, K. Yokoi (Eds.), "Motion Planning for Humanoid Robots",Springer, London, 2010.
3. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", second edition, Springer, 2000.
4. Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.

INDUSTRY 4.0	
Course Code: 25RA604	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE OBJECTIVES (CO)

1. Introduce students to the fundamentals of smart manufacturing and Industry 4.0
2. Introduce concepts of smart manufacturing and Industry 4.0 in manufacturing industries
3. To expose students to advanced concepts like Robotic automation, mobile computing and cyber security, Industry 4.0

COURSE LEARNING OUTCOMES (CLO)

At the end of the course students will be able to,

1. The scope of Industry 4.0 and its applicability in Indian Industry.
2. The conceptual framework and road map of Industry 4.0
3. Requirement of Robotic technology and Augmented reality for Industry 4.0
4. The obstacles and framework conditions for Industry 4.0
5. Advantages of machine integration for Industry 4.0

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	COL 1	COL 2	COL 3	COL 4	COL 5
CO 1	✓				
CO 2		✓		✓	
CO 3			✓		✓

COURSE CONTENTS

UNIT-I: Introduction to Industry 4.0

Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies.

UNIT-II: Concept and framework for industry 4.0

Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

UNIT- III: Technology roadmap for industry 4.0

Introduction, Proposed Framework for Technology Roadmap, Strategy Phase, Strategy Phase, New Product and Process Development Phase.

UNIT-IV: Related disciplines for enabling industry 4.0

Robotic Automation and Collaborative Robots-Support System for Industry 4.0-Mobile Computing-Related Disciplines- Cyber physical Systems -Cyber Security.

UNIT-V: Other applications and case studies

Opportunities and Challenges- Works and Workers for Industry 4.0-Strategies for competing in an Industry 4.0 -Industrial Applications-Case studies from HKPolyU students.

TEXT BOOKS

1. Anand Nayyar; Akshi Kumar, A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development, Springer Nature, ISBN: 978-3-030-14543-9, Switzerland, 2020.
2. G. R. Kanagachidambaresan, R. Anand, E. Balasubramanian, V. Mahima, Internet of Things for Industry 4.0: Design, Challenges and Solutions, Springer Nature, ISSN-2522-8609, Switzerland, 2020

REFERENCE BOOKS

1. Bartodziej, Christoph Jan,"The Concept Industry 4.0".
2. Alp Ustundag and Emre Cevikcan,"Industry 4.0: Managing the Digital Transformation".
3. Klaus Schwab,"The Fourth Industrial Revolution".
4. Christian Schröder, "The Challenges of Industry 4.0 for Small and Medium-sized Enterprises"

Robotics And Automation Problem Solving Using AI, Ml And Dl	
Course Code: 25RAPE16	**Continuous Evaluation:40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

1. To understand the basics of automation process and RPA
2. To impart basic principle automation, different variables used in automation
3. To know the advanced automation techniques
4. To focus on how to handle user events and exceptions in robotic automation process.
5. To acquaint deploying and maintenance of BOTs.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

On successful completion of this course, the student will be able to

1. Describe RPA, where it can be applied and how it's implemented.
2. Describe the different types of variables, Control Flow and data manipulation techniques.
3. Identify and understand Image, Text and Data Tables Automation.
4. Describe how to handle the User Events and various types of Exceptions and strategies.
5. Understand the Deployment of the Robot and to maintain the connection.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

COURSE CONTENTS

Unit-I: RPA BASICS

Scope and techniques of automation, Robotic process automation - What can RPA do? Benefits of RPA, Components of RPA, RPA platforms, The future of automation. History of Automation - What is RPA - RPA vs Automation - Processes & Flowcharts – Programming Constructs in RPA - What Processes can be Automated - Types of Bots - Workloads which can

UNIT II: RPA TOOL INTRODUCTION AND BASICS

Introduction to RPA Tool - The User Interface - Variables - Managing Variables - Naming Best Practices - The Variables Panel - Generic Value Variables - Text Variables - True or False Variables - Number Variables - Array Variables - Date and Time Variables - Data Table Variables - Managing Arguments -

Naming Best Practices - The Arguments Panel - Using Arguments - About Imported Namespaces - Importing New Namespaces- Control Flow - Control Flow Introduction - If ElseStatements - Loops - Advanced Control Flow - Sequences - Flowcharts - About Control Flow - Control Flow Activities

UNIT III: ADVANCED AUTOMATION CONCEPTS & TECHNIQUES

Recording Introduction - Basic and Desktop Recording - Web Recording - Input/Output Methods - Screen Scraping - Data Scraping - Scraping advanced techniques - Selectors - Defining and Assessing Selectors - Customization - Debugging - Dynamic Selectors - Partial Selectors - RPA Challenge - Image, Text & Advanced Citrix Automation - Introduction to Image & Text Automation - Image based automation

UNIT IV: HANDLING USER EVENTS & ASSISTANT BOTS, EXCEPTION HANDLING

What are assistant bots? - Monitoring system event triggers - Hotkey trigger - Mouse trigger - System trigger - Monitoring image and element triggers - An example of monitoring email - Example of monitoring a copying event andblocking it - Launching an assistant bot on a keyboard event.

UNIT V: DEPLOYING AND MAINTAINING THE BOT

Publishing using publish utility - Creation of Server - Using Server to control the bots - Creating a provision Robot from the Server - Connecting a Robot to Server - Deploy the Robot to Server - Publishing and managing updates - Managing packages - Uploading packages - Deleting packages.

TEXT BOOKS:

1. Alok Mani Tripathi, “Learning Robotic Process Automation”, Packt Publishing, 2018.
2. The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems Paperback – 29 February 2020, by Tom Taulli.
3. Frank Casale, Rebecca Dilla, Heidi Jaynes, Lauren Livingston, “Introduction to Robotic Process Automation: a Primer”, Institute of Robotic Process Automation,1st Edition 2015.

REFERENCE BOOKS:

1. Richard Murdoch, Robotic Process Automation: Guide to Building Software Robots, Automate RepetitiveTasks & Become an RPA Consultant”, Independently Published, 1 st Edition 2018.
2. Srikanth Merianda, Robotic Process Automation Tools,Process Automation and their benefits: Understanding RPA and Intelligent Automation”, Consulting Opportunity Holdings LLC, 1 st Edition 2018.

AUTOMATION IN MANUFACTURING	
Course Code: 25RAPE17	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P : 3 1 0	
Prerequisite: Nil	

COURSE OBJECTIVES (CO)

1. To understand the basics of hydraulic systems.
2. To impart knowledge about pneumatic systems.
3. To explain the concepts of robot kinematics.
4. To acquire the basic knowledge of robot dynamics.
5. To study grippers, gripping style and sensors.

COURSE LEARNING OUTCOMES (CLO)

After completion of this course, the students will be able to:

1. Demonstrate the technique and procedures associated with hydraulic power system.
2. Analyse the pneumatic controls and techniques.
3. Deliver knowledge of robot kinematics
4. To analyse robot dynamics.
5. Model basic grippers with sensors.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	CLO 1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

Unit I Hydraulic System

Introduction to fluid power system - Hydraulic fluids - functions, types, properties, selection and application. Construction, operation, characteristics and graphical symbols of hydraulic components – pumps, different types of pump, Description of positive displacement pump, Gear pump, vane pump, piston pump, actuators/motors, valves, switches, filters, seals, fittings and other accessories.

Unit II Pneumatic System

Introduction, comparison with hydraulic systems and pneumatic system. Construction, operation, Characteristics and symbols of pneumatic components. Different type of compressor, Air treatment – principles and components. Sensors –types, characteristics and applications.

Unit III Robot Kinematics

Robotics in Automation: Robot classification and anatomy, forward and inverse kinematics, DH matrix transformation

Unit IV Robot Dynamics

Jacobian and differential motion, Trajectory planning, Static and dynamic analysis, applications in manufacturing.

Unit V End Effectors and Robot Controls

Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, Magnetic Grippers, Vacuum grippers- Gripper force analysis, Robot Controls-Point to point control, Continuous path control, Feedback Devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.

TEXT BOOKS

1. Deb S.R., "Robotics technology and flexible automation", 2nd Edition, Mc Graw Hill, 2009.
2. Majumdar S.R., Oil Hydraulics, Tata McGRaw Hill, 2002.
3. Majumdar S.R., Pneumatic systems – principles and maintenance, Tata McGraw-Hill, New Delhi, 1995.
4. K. ShanmugaSundaram,. Hydraulics and Pneumatic Controls,S.Chand,2006

REFERENCE BOOKS

1. K. S. Fu, "Robotics: control, sensing, vision and intelligence", Mcgraw-Hill,1987.
2. Bolton, W., "Mechatronics: electronic control systems in mechanical and electrical engineering", McGraw Hill,2009.
3. Deb S.R., "Robotics technology and flexible automation", 2nd Edition, Mc Graw Hill, 2009.
4. Boucher, T. O., "Computer automation in manufacturing - an Introduction", Chapman and Hall, 1996.
5. Morris A. Cohen and Uday M. Apte, "Manufacturing Automation", McGraw Hill, 1997.

Robot Dynamics and Control	
Course Code: 25RAPE19	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P: 3 1 0	
Prerequisite: NA	

COURSE OBJECTIVES (CO)

The students will be able to

1. Understand the velocity kinematics and its importance in analysis
2. Understand the concept of static forces and trajectory planning
3. Understand and solve dynamics problem for the manipulator
4. Introduce the concept of position control methods and its importance
5. Introduce the concept of force control methods and its importance

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be able to:

1. Compute the Jacobian for serial manipulator and compute the singular configuration
2. Compute the joint torque at statics and design a trajectory planning algorithm
3. Compute the dynamic model of a serial manipulator
4. Understand the concept of position control and its application
5. Understand the concept of force control and its application

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

UNIT-I: Velocity Kinematics and analysis

Velocity Kinematics introduction – Jacobian, Understanding the Jacobian matrix elements, Introduction and properties of skew symmetric matrix, Derivation of rotation matrix –using skew symmetric matrix property , Representing angular velocity, General angular velocity Jacobian formulation, Representing linear velocity, General linear velocity Jacobian formulation, Concept of Pseudo inverse, Application, Concept of Singularity-its consequences,

Computing singularity condition, Derivation of Jacobian matrix for RR planar manipulator, Concept of Singularity for manipulator , Computing Jacobian for RRR spatial manipulator, Computing Singularity condition for a RRR spatial manipulator, Computing Jacobian for RPY wrist, Concept of wrist singularity

UNIT-II: Statics and Trajectory Planning

Static Forces in Manipulator, Static Forces in Manipulator – Example, Jacobian in Force Domain,Derivation using Principle of Virtual Work ,Static Force Computation of a Planar RR Manipulator ,Understand the Torque Force Relation ,Jacobian in Robot Motion, Concept of Resolved Rate Control – 2D,Understanding Robot Work Space ,Work Space Analysis, Introduction to Trajectory Planning, Joint Space and Cartesian Space Difference and Applications, Joint Space Trajectory Joint Space Trajectory Planning via Points, Cubic Polynomial via Points, Cartesian Space Trajectory Planning, Case Study

UNIT-III: Dynamic Modelling

Introduction to Dynamics, Elemental Terms in Dynamics – Inertia, Coriolis Forces, Centrifugal Forces etc., Inertia Tensor Computation and Its Effect on Dynamics, General Dynamic Description for Manipulator, Understanding Dynamics of a Simple System – Mass Spring Damper System, Inverse and Forward Dynamics, Lagrangian Formulation, Computing Generalized Torque/Force through Lagrangian Euler Method, Dynamic Model of a 2R Planar Manipulator Using LE Method, Newton Euler Formulation, Computing Generalized Torque/Force through Newton Euler Method, Dynamic Model of a 2R Planar Manipulator Using LE Method, Dynamic model of a inverted pendulum, Dynamic model of a inverted pendulum, Dynamic model of a spatial serial manipulator, Dynamic model of a spatial serial manipulator.

UNIT-IV: Introduction to Position Control

Review of Position Control, Mass–Spring Damper System, Various Linear Control Schemes, Characteristics of Linear Control, ,Position Control of Second Order System,PI Implementation, Position Control of Second Order System,PD Implementation, Position Control of Second Order System,PID Implementation, Modelling of 1 DOF manipulator Joint, Deriving the mathematical model, Partitioned PD (PPD) Control Scheme, Architecture and Difference from PD Control,Application of Partitioned PD Control Scheme to 1 DOF Manipulator Joint,Analysis, Modelling the PPD with External Disturbance,Architecture with External Disturbance, Partitioned PID control scheme, Architecture.

UNIT-V: Introduction to Force Control

Introduction to Force Control – Framework, Application of Force Control. ,Define – Artificial and Natural Constraints, Case Study – Artificial and Natural Constraint, Description of Force

Control Task, Example – Peg in Hole Assembly, Force Control of Mass Spring System, Force Control of Mass Spring System, Computed torque control Architecture. ,Example, Impedance Force/Torque Control, Example -,Introduction to Hybrid Force Position Control Problem, ,Example-,Hybrid Force Position Control Architecture, ,Example – Case Study

Text Book

1. John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.
2. Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008.
3. J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.
4. Saeed B.Niku, "Introduction to Robotics Analysis, Systems and Applications", 2nd edition, Prentice Hall of India, 2009.

Reference Book and other materials

1. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India Learning, 2009.
2. Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.
3. Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition McGraw Hill, 2008.
4. Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003.

Machine Learning Based Condition Monitoring	
Course Code: 25RAPE20	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P: 3 1 0	
Prerequisite: NA	

Course Objectives

This course is expected to enable the student to:

1. Familiarize with the concept of condition-based maintenance for effective utilization of machines
2. Impart knowledge of artificial intelligence for machinery fault diagnosis

Course Outcomes

1. Select the proper maintenance strategies and condition monitoring techniques for identification of failure in a machine.
2. Acquire and Process sound and vibration signals in a dynamic mechanical system
3. Predict the faulty component in a machine by analyzing the acquired vibration signals
4. Build a classifier model for machine learning based fault diagnosis of rotating machines

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

COURSE LEARNING OUTCOME / COURSE OBJECTIVES	CLO 01	CLO 02	CLO 03	CLO 04
CO 01	✓		✓	
CO 02		✓		✓

Unit 1: Fundamentals of Maintenance and Condition Monitoring

Machinery failures and their causes, Overview of basic maintenance strategies, Factors influencing maintenance strategies, Introduction to machine condition monitoring, Transducer selection and location, PC interfacing and basics of virtual instrumentation

Unit 2: Fault Detection and Diagnosis in Rotating Machinery

Vibration signatures of faults in rotating machines, Techniques for fault detection, Diagnosis of common machinery faults, Case studies in early-stage fault recognition

Unit 3: Sensors and Signal Processing in Condition Monitoring

Types of sensors: Vibration, sound, acoustic emission, Temperature, ultrasonic, and infra-red sensors Basics of signal processing: Time-domain analysis, Frequency-domain analysis, Time-frequency analysis and introduction to wavelets

Unit 4: Feature Engineering and Pattern Recognition

Feature extraction and selection techniques, Feature reduction using PCA, Discriminant functions and decision boundaries, Decision trees, maximum likelihood, and nearest neighbour classification, Introduction to Bayesian theory in condition monitoring

Unit 5: Machine Learning and Applications in Condition Monitoring

Use of neural networks and SVMs for classification, Application case studies: Bearings, Gearboxes, Centrifugal pumps, Turbines, Tool wear monitoring Trends in AI-based predictive maintenance

Textbooks

1. Clarence W.de Silva "Vibration Monitoring, Testing and Instrumentation (Mechanical and Aerospace Engineering Series)", CRC Press, Taylor & Francis, 2007.
2. A. R. Mohanty, "Machinery Condition Monitoring: Principles and Practices" , CRC Press, Taylor & Francis, 2015

Reference(s)

1. Colla cot, "Mechanical Fault Diagnosis and Condition Monitoring", Chapman- Hall, 1987.
2. Davies, "Handbook of Condition Monitoring – Techniques and Methodology", Springer, 1998.
3. Cornelius Scheffer and Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", Elsevier, 2004.
4. K.P.Soman, Shyam Diwakar and V.Ajay, "Data Mining: Theory and Practice" PHI Learning Pvt. Ltd., 2006.
5. Duda, R.O., Peter, Hart, E., and Stork, D.E., "Pattern Classification", 2e, Wiley India, 2007.

Human computer Interaction	
Course Code: 25RAPE21	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P: 3 1 0	
Prerequisite: NA	

Course Objectives (COs):

- Understand the fundamentals of Human-Computer Interaction and user interface design beyond traditional input methods.
- Learn key concepts of human sensory and cognitive systems as they relate to task performance.
- Apply cognitive psychology models to predict and analyze user interaction performance.
- Emphasize user-centered design and evaluation throughout the development process.
- Explore emerging interface technologies such as AR/VR, wearable, mobile, and ubiquitous computing, along with their social and ethical implications.

Course Outcomes (CLOs):

- Apply HCI concepts and design principles to real-world interaction design problems.
- Design and evaluate user-friendly tools, including assistive technologies for the differently-abled.
- Integrate cognitive models to optimize user interface performance and usability.
- Employ user-centered methods in designing and testing interactive systems.
- Work collaboratively on a complete product design project, enhancing teamwork and communication skills.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

UNIT - I

Introduction: Importance of user Interface – definition, importance of good design. Benefits of good design. A brief history of Screen design. The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics, Web user – Interface popularity, characteristics- Principles of user interface.

UNIT - II

Design process – Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds, understanding business junctions. Screen Designing: Design goals – Screen planning and purpose, organizing screen elements, ordering of screen data and content – screen navigation and flow – Visually pleasing composition – amount of information – focus and emphasis – presentation information simply and meaningfully – information retrieval on web – statistical graphics – Technological consideration in interface design.

UNIT- III

Windows – New and Navigation schemes selection of window, selection of devices based and screen- based controls. Components – text and messages, Icons and increases – Multimedia, colors, uses problems, choosing colors.

UNIT- IV

HCI in the software process, The software life cycle Usability engineering Iterative design and prototyping Design Focus: Prototyping in practice Design rationale Design rules Principles to support usability Standards Golden rules and heuristics HCI patterns Evaluation techniques, Goals of evaluation, Evaluation through expert analysis, Evaluation through user participation, Choosing an evaluation method. Universal design, Universal design principles Multi-modal interaction

UNIT- V

Cognitive models Goal and task hierarchies Design Focus: GOMS saves money Linguistic models The challenge of display-based systems Physical and device models Cognitive architectures Ubiquitous computing and augmented realities Ubiquitous computing applications research Design Focus: Ambient Wood – augmenting the physical Virtual and augmented reality Design Focus: Shared experience Design Focus: Applications of augmented reality Information and data visualization Design Focus: Getting the size right.

Textbook(s)

1. Clarence W.de Silva “Vibration Monitoring, Testing and Instrumentation (Mechanical and Aeropace Engineering Series)”, CRC Press, Taylor & Francis, 2007.
2. A. R. Mohanty, “Machinery Condition Monitoring: Principles and Practices” , CRC Press, Taylor & Francis, 2015

Reference(s)

1. Collacot, “Mechanical Fault Diagnosis and Condition Monitoring”, Chapman- Hall, 1987.
2. Davies, “Handbook of Condition Monitoring – Techniques and Methodology”, Springer, 1998.
3. Cornelius Scheffer and Paresh Girdhar, “Practical Machinery Vibration Analysis and Predictive Maintenance”, Elsevier, 2004.

PLC and SCADA	
Course Code: 25RAPE22	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P: 3 1 0	
Prerequisite: NA	

Course Objectives (COs):

1. To introduce students to the fundamental architecture, components, and working principles of PLC and SCADA systems.
2. To familiarize students with PLC programming using ladder logic and the application of timers, counters, and logic gates.
3. To provide insight into advanced PLC instructions including comparison and arithmetic functions.
4. To equip students with the skills required for real-time system interfacing, troubleshooting, and industrial automation applications.

Course Outcomes (COs):

After completing this course, students will be able to:

1. Understand the structure and components of PLCs and SCADA systems, including power supply, memory, I/O modules, and numbering systems.
2. Design and implement ladder diagrams for Boolean logic expressions, as well as timer and counter-based control problems.
3. Apply and analyze various PLC instructions including timers, counters, and logic gates in practical automation tasks.
4. Perform comparative analysis using advanced instructions such as EQU, NEQ, GRT, LEQ, and LIM in ladder logic programming.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

COURSE LEARNING OUTCOME / COURSE OBJECTIVES	CLO 01	CLO 02	CLO 03	CLO 04
CO 01	✓			
CO 02		✓		
CO 03			✓	
CO 04				✓

UNIT-1: PLC Introduction

Technical Definition, advantages, characteristics, Chronological Evolution, Types of PLC: Unitary, Modular, Small, Medium and Large. Block Diagram of PLC: Input/output (I/O) section, Processor Section, Power supply, Memory central Processing Unit: Processor Software / Executive Software, Multi-tasking, Languages, Ladder Language.

Bit Logic Instructions: I/O Symbols, Numbering system of inputs and outputs, Program format, introduction to logic: Equivalent Ladder diagram of various logic gates, De Morgan theorem validation.

UNIT-2: Timers and Counters

Timer-on Delay, Timer off delay, Retentive and non-retentive timers. Format of a timer instruction. Operation of PLC Counter, Counter Parameters, Counters Instructions Overview Count up (CTU) Count down (CTD).

UNIT-3: Advanced instructions

Introduction: Comparison instructions, discussions on comparison instructions, "EQUAL" or "EQU" instruction, "NOT EQUAL" or "NEQ" instruction, "LESS THAN" or "LESS" instruction, "LESS THANOR EQUAL' or "LEQ" instruction, GREATER THAN" OR "GRT" instruction, "GREATER THAN OR EQUAL TO" or "GRO" instruction, "MASKED COMPARISON FOR EQUAL" or "MEQ" instruction, "LIMIT TEST" or "LIM" instruction.

UNIT-4: PLC input output (I/O) modules and power supply

Classification of I/O, I/O system overview, practical I/O system and its mapping addressing local and expansion I/O, input-output systems, direct I/O, parallel I/O systems serial I/O systems. Sinking and sourcing. Discrete input module. Rectifier with filter, threshold detection, Isolation, logic section, specifications of discrete input module, types of analog input module, special input modules, analog output module,

UNIT-5: SCADA

Definition and history of Supervisory Control and Data Acquisition, typical Architecture, Communication Requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA. SCADA Architecture (First generation-Monolithic, Second Generation-Distributed, Third generation Networked Architecture), SCADA systems in operation and control of interconnected power system,

Text Book:

1. "PLC and Industrial application", Madhu chhanda Mitra and Samarjit Sengupta, Pernram international pub. (Indian) Pvt. Ltd., 2011.
2. Ronald L Krutz, "Securing SCADA System", Wiley Publication.

Reference Books:

1. Gary Dunning, “Introduction to Programmable Logic Controllers”, Thomson, 3rd Edition.
2. John W Webb, Ronald A Reis, “Programmable Logic Controllers: Principles and Application”, PHI Learning, New Delhi, 5th Edition.
3. Stuart A Boyer, “SCADA Supervisory Control and Data Acquisition”, ISA, 4th Revised edition.

AI in NLP	
Course Code: 25RAPE22	**Continuous Evaluation: 40 Marks**
Credits: 4	**End Semester Examination:60 Marks**
L T P: 3 1 0	
Prerequisite: NA	

COURSE OBJECTIVES:

1. Introduce to some of the problems and solutions of NLP and their relation to linguistics and statistics.
2. To understand linguistic phenomena and learn to model them with formal grammars.
3. To understand and carry out proper experimental methodology for training and evaluating empirical NLP systems.
4. To learn how to manipulate probabilities, construct statistical models over string sand trees
5. To estimate parameters using supervised and unsupervised training methods.

Course Outcomes (COs):

After completing this course, students will be able to:

1. Show sensitivity to linguistic phenomena and an ability to model them with formal grammars.
2. Understand and carry out proper experimental methodology for training and evaluating empirical NLP systems.
3. Able to manipulate probabilities, construct statistical models over strings and trees.
4. Will be able to estimate parameters using supervised and unsupervised training methods.
5. Able to design, implement, and analyze NLP algorithms. Able to design different language modeling Techniques.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

CLO / CEO	01	02	03	04	05
01	✓				
02		✓			
03			✓		
04				✓	
05					✓

UNIT –I:

Natural Language processing (NLP) : Introduction, Applications or Use cases of NLP, Components of NLP, Steps in NLP, Finding the Structure of Words: Words and Their Components, Lexemes, Morphemes, Morphology, Problems in morphological processing,

Typology, Morphological Typology, Natural Language Processing with python NLTK package (Text Preprocessing Tasks): Word Tokenization, Sentence Tokenization, Filtering Stop words, Stemming, Tagging Parts of Speech, Lemmatization, Chunking, Chinking, Named Entity Recognition, Term Frequency and Inverse Document Frequency (TF-IDF).

UNIT–II:

Syntax Analysis: Parsing Natural Language, Tree banks: A Data-Driven Approach to Syntax, Representation of Syntactic Structure: Syntax Analysis using Dependency Graph, Syntax Analysis using Phrase Structure Trees, Parsing Algorithms: Shift Reduce Parsing, Hyper Graphs and Chart Parsing (CYK Parsing), Models for ambiguity Resolution in Parsing: Probabilistic Context Free Grammar, Generative Models, Discriminative models for Parsing.

UNIT-III:

Language Modeling: Introduction, N-Gram Models, Language Model Evaluation, Parameter Estimation, Language Model Adaptation, Types of Language Models, Language-Specific Modeling Problems.

UNIT–IV:

Semantic Parsing: Introduction, Semantic Interpretation, System Paradigms, Word Sense Systems, Software.

UNIT–V:

Predicate-Argument Structure, Meaning Representation Systems, Software. Discourse Processing: Cohesion, Reference Resolution, Discourse Cohesion and Structure.

Text Book:

1. Multilingual natural Language Processing Applications: From Theory to Practice–Daniel M.Bikel and Imed Zitouni, Pearson Publication.
2. 2. Speech and Natural Language Processing-Daniel Jurafsky & James H Martin, Pearson Publications.

Reference Books:

Natural Language Processing and Information Retrieval: Tanvier Siddiqui, U.S.Tiwary.

COMPUTER AIDED MANUFACTURING (CNC) LABORATORY-I	
Course Code: 25RA651	**Continuous Evaluation: 60 Marks**
Credits: 1	**End Semester Examination:40 Marks**
L T P : 0 0 2	
Prerequisite: NIL	

COURSE OBJECTIVES (CO)

- To familiarize students with manual CNC part programming for milling and turning machines.
- To generate part programs using CNC programming and simulation s/w for CNC Lathe, CNC Milling.
- To get hands on experience by machining the parts on actual machines like CNC Lathe, and CNC milling machine.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course students will be able to,

- Display competency in manual CNC part programming for milling and turning machines
- Exhibit generation of part programs using CNC programming and simulation s/w for CNC Lathe, CNC Milling
- Demonstrate machining the parts on actual machines CNC Lathe and CNC Milling Machine.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES(CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES		
	COL 1	COL 2	COL 3
CO 1	✓		
CO 2		✓	
CO 3			✓

LIST OF EXPERIMENTS

Exp. No. 1: Study of different CNC control systems and CNC codes.

Exp. No. 2: Programming and simulation for turning, taper turning, circular interpolation operations.

Exp. No. 3: Programming and simulation for thread cutting, facing and parting operations.

Exp. No. 4: Programming and simulation using Canned cycles for CNC Lathe.

Exp. No. 5: Programming and simulation for machining of internal surfaces in CNC Lathe.

Exp. No. 6: Programming and simulation for 3D profile milling, drilling, operation.

Exp. No. 7: Programming and simulation for 3D profile, rigid tapping, boring operation.

Exp. No. 8: Programming and simulation for circular and rectangular pocket milling.

Exp. No. 9: Programming using canned cycles for CNC Milling machine.

Exp. No. 10: Generate CL Data and Post process data using CAM packages for Machining and Turning Centre.

TEXT BOOKS

1. Laboratory Manual.

REFERENCE BOOKS

1. Harshal dhawas "cnc programming for lathe & milling: siemens sinumerik control" Kindle Edition 2019.
2. Ali Ahmadi Soleh "CNC Lathe programming and operation Kindle Edition".

SEMESTER - VII

Engineering Metrology and Instrumentation	
Course Code: 25RA701	**Continuous Evaluation: 40 Marks**
Credits : 3	**End Semester Examination:60 Marks**
L T P : 3 0 0	
Prerequisite : NIL	

COURSE OBJECTIVES

To make the student to understand

- Various comparative measurements.
- Fundamentals of gears, thread measurements and measurements of surface finish.
- Principle of light wave interference and applications of light wave interference for measurements.
- To know about Control chart techniques in quality control.
- Purpose and use of sampling and its benefits.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course the students will be able to

- Analyse the principle of different metrology instruments
- Reduce various components on machine tools and carry out dimensional measurement.
- Demonstrate the terminology and its application of interference of light wave.
- Perform the available different precision instruments in the field of measurement.
- Quantify the measurement uncertainty along with Quality.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

Unit I: INTRODUCTION TO METROLOGY

Basic Concepts - Legal Metrology - Precision - Accuracy - Types of errors - Linear and Angular Measurements - Standards of Measurements - Slip gauges - Calibration - Interchangeability and selective assembly. Introduction to Comparators - Types of Comparators - Mechanical, Mechanical – Optical, Electrical and Electronic, pneumatic, Fluid Displacement - Automatic

gauging machines. Co ordinate Measuring Machine.

Unit- II: SCREW THREAD – GEAR MEASUREMENTS – SURFACE FINISH

Internal and External screw threads: Measurements of various elements of thread - Best size wire - Two and three wire method. Gear: Measurements of various elements - Constant chord method - Base tangent method. Surface Finish: Surface topography definitions - Measurement of Surface Texture - Methods - Evaluation of Surface finish.

Unit-III: INTERFEROMETRY

Principle of light wave interference - Light sources - Types of Interferometers - Michelson, Twyman Green Specialisation of Michelson, NPL flatness Interferometers, The Pitter NPL gauge - laser interferometer. Measurement of straightness - Flatness - squareness - parallelism - circularity - and Rotation.

Unit-IV: STATISTICAL QUALITY CONTROL

Introduction - Definition of Quality - Chance Causes and assignable Causes - SQC Benefits and Limitations. Fundamental concepts in probability - Normal curve - Measures of Dispersion - Distributions - Binomial, Poisson, Geometric, Hyper geometric, Poisson as an approximation to Binomial, Normal as an approximation to Binomial.

Unit-V: ACCEPTANCE SAMPLING

Basic Concepts and OC curve - AQL - LTPD - AOQL - Sampling Plans - Simple - Double - Multiple and sequential sampling plans - stratified sampling plans for variables. Related problems using BIS code books.

TEXT BOOK:

1. K. Duraivelu & S. Karthikeyan, Engineering Metrology and measurement, University Press, New Delhi, 2018.
2. Jain. R. K., Engineering Metrology, Khanna Publishers, New Delhi, 1987.
3. Gupta. R. C., Statistical Quality Control, Khanna Publishers, New Delhi, 1994.

REFERENCE BOOK AND OTHER MATERIALS

1. Doeblin, E. O., Measurement System Applications and Design,1st Edition McGraw Hill, London, 1990.
2. Grant E. L., Statistical Quality Control, McGraw Hill, New York, 1984.
3. Gaylor, Shotbolt and Sharp, “Metrology for Engineers ", O.R.Cassel, London, 1993.

Mobile Robotics	
Course Code: 25RA701	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: Fundamentals of Robotics	

COURSE OBJECTIVES (CO)

- **Understand** the fundamental principles of mobile robotics, including locomotion, sensing, and navigation.
- **Analyze** various robotic architectures (wheeled, legged, UAVs) and their kinematic/dynamic models.
- **Implement** sensor fusion techniques (LiDAR, IMU, vision) for perception and localization.
- **Design** path planning and obstacle avoidance algorithms (A*, RRT, SLAM).
- **Develop** autonomous navigation systems using ROS (Robot Operating System).

COURSE LEARNING OUTCOMES (CLO)

After completing the course, the student should be able to:

- Explain the working principles of mobile robots and their applications in industry and research. *(Knowledge)*
- Model and simulate wheeled/legged robots using kinematic and dynamic equations. *(Analysis)*
- Integrate sensors (LiDAR, cameras, IMUs) for environment mapping and localization. *(Application)*
- Implement path planning algorithms (A*, D*, Potential Fields) in simulated and real robots. *(Synthesis)*
- Develop a basic SLAM (Simultaneous Localization and Mapping) system using ROS. *(Practical Skills)*

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	√				
CO2					√
CO3		√			
CO4				√	
CO5			√		

COURSE CONTENTS

UNIT I: Introduction to Mobile Robotics

- Definition, History, and Applications (Industry 4.0, AGVs, Drones)
- Locomotion Mechanisms: Wheeled, Tracked, Legged, Flying Robots
- Challenges in Autonomous Navigation

UNIT II: Kinematics & Dynamics of Mobile Robots

- Holonomic vs. Non-Holonomic Systems
- Differential Drive Kinematics
- Dynamic Modeling and Control

UNIT III: Sensors for Mobile Robotics

- LiDAR, Ultrasonic, and Infrared Sensors
- Vision Systems (RGB-D, Stereo Cameras)
- IMU, GPS, and Odometry

UNIT IV: Perception & Localization

- Sensor Fusion (Kalman Filter, Particle Filter)
- Feature Extraction and Matching
- Monte Carlo Localization (MCL)

UNIT V: Path Planning & Obstacle Avoidance

- Grid-Based (A*, D*) and Sampling-Based (RRT, PRM) Methods
- Potential Fields and Dynamic Window Approach
- Multi-Robot Coordination

TEXT BOOKS

1. Mobile Robotics- Mathematics, Models, and Methods by Alonzo Kelly, Cambridge University Press- 2013

REFERENCE BOOKS

1. Springer Handbook of Robotics
2. Robotics, Vision, and Control: Fundamental Algorithms in MATLAB by Peter Corke
3. Probabilistic Robotics by Sebastian Thrun, Wolfram Burgard and Dieter Fox
4. Introduction to Robotics: Mechanics and Control (3rd Edition) by J.J. Craig
5. Introduction to autonomous mobile robots by Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza
6. Planning Algorithms by Steven M. LaValle, Cambridge Press.

Automotive Control Systems	
Course Code: 25RAPE23	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 3 0 0	
Prerequisite: Circuit, Sensor/ Transducer and Control systems	

COURSE OBJECTIVES (CO)

- To know the layout and arrangement of principal parts of an automobile.
- To understand the working of transmission and brake systems.
- To comprehend the operation and working of steering and suspension systems.
- To know the Injection system and its advancements.
- To know the automobile emissions and its effects on the environment.

COURSE LEARNING OUTCOMES (CLO)

After learning the course, the students should be able to:

- Identify the different parts of an automobile and its working.
- Understand the working of transmission and braking systems.
- Understand the working of steering and suspension systems and their applications.
- Selection and applications of various types of fuels and injection systems.
- Analyze the cause of automobile emissions, their effects on the environment, and methods to reduce the emissions.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

Course Objectives (CO)	**Course Learning Outcomes (CLO)**				
	CLO 1	**CLO 2**	**CLO3**	**CLO4**	**CLO5**
CO 1	√				
CO 2		√			
CO 3			√		
CO4				√	
CO5					√

Course Content

Unit I: Introduction to Automotive Systems

- Overview of automotive systems
- Electronic Engine Management
- Transmission Control
- Brake and Suspension Control

- Emission and Fuel Economy Regulations

Unit II: Sensors and Actuators

- Types of Sensors: Manifold Absolute Pressure Sensor (MAP), Mass Air Flow Sensor (MAF), Oxygen, Throttle Position, Knock Sensors
- Actuators: Stepper Motors, Solenoids, Injectors
- Signal Conditioning and Interface with ECUs

Unit III: Electronic Control Units (ECU)

- Architecture of ECU
- Microcontroller-based control
- Communication Protocols: Controller Area Network (CAN), Local Interconnect Network (LIN), FlexRay
- Diagnostic Systems: On-Board Diagnostics (OBD, OBD-II)

Unit IV: Automotive Control Strategies

- Engine Control (Air-Fuel Ratio, Ignition Timing)
- Transmission Control
- Cruise Control
- ABS and Electronic Stability Program (ESP)

Unit V: Advanced Automotive Control

- Drive-by-wire systems
- Hybrid and Electric Vehicle Control Systems
- Autonomous Driving Fundamentals
- Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Communication

Text Books

1. William B. Ribbens, Understanding Automotive Electronics, 7th Edition, Butterworth-Heinemann, 2012.
2. Robert Bosch GmbH, Bosch Automotive Handbook, 10th Edition, Wiley, 2018.

Reference Books

1. Automotive Mechanics William H Crouse & Donald L Anglin Tata McGraw Hill Publishing Company Ltd 10th Edition 2007
2. Automotive Mechanics: Principles and Practices, Joseph Heitner D Van Nostrand Company, Inc.
3. Automobile Engineering R. B. Gupta Satya Prakashan 4thedition 1984.
4. Fundamentals of Automobile Engineering K.K.Ramalingam Scitech Publications (India) Pvt. Ltd.

Human Values and Ethics	
Course Code: 25RAPE24	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: NIL	

COURSE OBJECTIVES

To make the student to understand

- To create awareness about values and ethics enshrined in the Constitution of India
- To sensitize students about the democratic values to be upheld in the modern society.
- To inculcate respect for all people irrespective of their religion or other affiliations.
- To instill the scientific temper in the students' minds and develop their critical thinking.
- To promote sense of responsibility and understanding of the duties of citizen.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course the students will be able to

- Identify the importance of democratic, secular and scientific values in harmonious functioning of social life
- Practice democratic and scientific values in both their personal and professional life.
- Find rational solutions to social problems.
- Behave in an ethical manner in society
- Practice critical thinking and the pursuit of truth.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT I DEMOCRATIC VALUES

Understanding Democratic values: Equality, Liberty, Fraternity, Freedom, Justice, Pluralism, Tolerance Respect for All, Freedom of Expression, Citizen Participation in Governance – World Democracies, French Revolution, American Independence, Indian Freedom Movement. Reading Text: Excerpts from John Stuart Mills' On Liberty.

UNIT II SECULAR VALUES

Understanding Secular values – Interpretation of secularism in Indian context - Disassociation of state from religion – Acceptance of all faiths – Encouraging non-discriminatory practices. Reading Text: Excerpt from Secularism in India: Concept and Practice by Ram Puniyani

UNIT III SCIENTIFIC VALUES

Scientific thinking and method: Inductive and Deductive thinking, Proposing and testing Hypothesis, Validating facts using evidence based approach – Skepticism and Empiricism – Rationalism and ScientificTemper. Reading Text: Excerpt from The Scientific Temper by Antony Michaelis R

UNIT IV SOCIAL ETHICS

Application of ethical reasoning to social problems – Gender bias and issues – Gender violence – Social discrimination – Constitutional protection and policies – Inclusive practices. Reading Text: Excerpt from 21 Lessons for the 21st Century by Yuval Noah Harari

UNIT V SCIENTIFIC ETHICS

Transparency and Fairness in scientific pursuits – Scientific inventions for the betterment of society -Unfair application of scientific inventions – Role and Responsibility of Scientist in the modern society.

REFERENCES:

1. The Nonreligious: Understanding Secular People and Societies, Luke W. Galen Oxford University Press, 2016.

2. Secularism: A Dictionary of Atheism, Bullivant, Stephen; Lee, Lois, Oxford University Press, 2016.

3. The Oxford Handbook of Secularism, John R. Shook, Oxford University Press, 2017.

4. The Civic Culture: Political Attitudes and Democracy in Five Nations by Gabriel A. Almond and Sidney Verba, Princeton University Press,

5. Research Methodology for Natural Sciences by Soumitro Banerjee, IISc Press, January 2022.

Data Science for Engineers	
Course Code: 25RAPE27	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: NIL	

COURSE OBJECTIVES

To make the student to understand

- To introduce the fundamental concepts and workflow of data science and its role in solving engineering problems.
- To enable students to apply data preprocessing, data wrangling, and data visualization techniques.
- To provide knowledge of statistical inference, probability, and hypothesis testing relevant to engineering analysis.
- To introduce machine learning algorithms and their applications in robotics and automation.
- To expose students to data science tools and programming platforms like Python/R for real-time data analytics.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course the students will be able to

- Explain the data science lifecycle and its applications in robotics and automation.
- Perform data cleaning, transformation, and visualization on real-world datasets.
- Apply statistical techniques such as correlation, regression, and hypothesis testing.
- Implement basic machine learning models for predictive and classification tasks.
- Design a mini-project integrating machine learning and data analytics in robotics.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	**COURSE LEARNING OUTCOMES**				
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT I Introduction to Data Science

Understanding the data science lifecycle: data collection, preprocessing, analysis, visualization, and interpretation. Applications of data science in engineering contexts. Techniques for handling missing data, outliers, and inconsistencies. Data transformation and normalization methods.

UNIT II Descriptive Statistics and Data Visualization

Measures of central tendency and variability. Visual tools: histograms, scatter plots, box plots, and heatmaps. Probability distributions and their applications. Hypothesis testing and confidence intervals.

UNIT III Machine Learning Fundamentals

Supervised learning: linear regression, decision trees. Unsupervised learning: clustering techniques. Evaluation metrics for model performance.

UNIT IV Big Data Technologies

Introduction to big data frameworks like Hadoop and Spark. Understanding NoSQL databases and their use cases.Programming languages: Python or R for data analysis. Libraries and tools: Pandas, NumPy, Matplotlib, Scikit-learn.

UNIT V Applications in Robotics and Automation

Utilizing data science for predictive maintenance. Sensor data analysis and real-time decision-making in robotic systems.

Text Books

1. **Data Science from Scratch: First Principles with Python,** Joel Grus, *Publisher:* O'Reilly Media.
2. **Doing Data Science,** Cathy O'Neil and Rachel Schutt *Publisher:* O'Reilly Media.
3. **Introduction to Data Science,** Laura Igual, Santi Seguí, *Publisher:* Springer.

Reference Books

1. **Python for Data Analysis,** Wes McKinney, *Publisher:* O'Reilly Media.
2. **Machine Learning: A Probabilistic Perspective,** Kevin P. Murphy, *Publisher:* MIT Press.
3. **Practical Statistics for Data Scientists,** Peter Bruce, Andrew Bruce, Peter Gedeck *Publisher:* O'Reilly Media.

Sustainable Manufacturing	
Course Code: 25RAPE26	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: NIL	

COURSE OBJECTIVES (COs):

By the end of this course, students should be able to:

- **Understand** the fundamental concepts of sustainable manufacturing and its significance in modern industries.
- **Analyze** the environmental, economic, and social impacts of manufacturing processes.
- **Learn** sustainable design principles, lean manufacturing, and waste reduction techniques.
- **Evaluate** energy-efficient and resource-efficient manufacturing systems.
- **Explore** Industry 4.0 technologies (IoT, AI, Robotics) for sustainable production.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course the students will be able to

- Explain the principles of sustainable manufacturing and its role in reducing environmental impact. (Knowledge)
- Assess the sustainability of different manufacturing processes using metrics like energy consumption, waste generation, and emissions. (Analysis)
- Apply lean and green manufacturing techniques to optimize production efficiency. (Application)
- Evaluate renewable energy integration and circular economy approaches in manufacturing. (Evaluation)
- Propose Industry 4.0-based solutions (smart factories, predictive maintenance) for sustainable automation. (Synthesis)

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	**COURSE LEARNING OUTCOMES**				
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

Unit I: Introduction to Sustainable Manufacturing

- Definition, Need, and Drivers
- Triple Bottom Line (TBL): Environmental, Economic, Social Sustainability
- Global Standards & Regulations (ISO 14000, ISO 50001)

UNIT II: Sustainable Materials & Processes

- Eco-friendly Materials (Biodegradable, Recyclable)
- Energy-efficient Machining (Dry Machining, MQL)
- Additive Manufacturing (3D Printing) for Sustainability

UNIT III: Lean & Green Manufacturing

- Waste Reduction (Toyota Production System, Six Sigma)
- Circular Economy & Closed-loop Manufacturing
- Remanufacturing & Recycling Strategies

UNIT IV: Energy & Resource Efficiency

- Renewable Energy in Manufacturing (Solar, Wind)
- Smart Grids & Energy Management Systems
- Water Conservation & Zero Liquid Discharge (ZLD)

UNIT V: Industry 4.0 for Sustainability

- IoT-enabled Smart Factories
- AI & Robotics for Waste Minimization
- Digital Twins & Predictive Maintenance

TEXTBOOKS:

1. **"Sustainable Manufacturing: Shaping Global Value Creation"** by Günther Seliger
2. **"Green Manufacturing: Fundamentals and Applications"** by David A. Dornfeld
3. **"Life Cycle Assessment: Principles and Practice"** by Scientific Applications International Corporation (SAIC)

REFERENCE BOOKS:

1. **"Sustainable Engineering: Concepts, Design, and Case Studies"** by David T. Allen & David R. Shonnard
2. **"The Lean Sustainable Supply Chain"** by Robert Palevich
3. **"Industry 4.0: The Industrial Internet of Things"** by Alasdair Gilchrist
4. **"Circular Economy for Dummies"** by Ritchie, H. & Ali, S.

ADDITIONAL RESOURCES:

1. **Journals:** *Journal of Cleaner Production, Sustainable Production and Consumption*

2. **Online Courses:** Coursera's *"Sustainable Manufacturing"* (University of Illinois)
3. **Tools:** OpenLCA, SimaPro (for LCA analysis)

Virtual and Augmented Reality	
Course Code: 25RAPE25	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: NIL	

COURSE OBJECTIVES (COs):

By the end of this course, students should be able to:

- Understand the fundamental concepts of VR, AR, and Mixed Reality (MR) and their applications in robotics and automation.
- Analyze the hardware and software components of VR/AR systems, including sensors, displays, and tracking technologies.
- Develop basic VR/AR applications using industry-standard tools (Unity3D, Unreal Engine, ROS integration).
- Explore the role of VR/AR in robotics, including teleoperation, simulation, and human-robot interaction (HRI).
- Evaluate the challenges and future trends of immersive technologies in industrial automation.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course, the students will be able to

- Differentiate between VR, AR, and MR and their applications in robotics and automation. *(Knowledge)*
- Explain the working principles of VR/AR hardware (HMDs, haptic devices, motion trackers). *(Comprehension)*
- Design and implement a basic VR/AR application for robotic simulation or control. *(Application)*
- Integrate VR/AR with robotic systems (e.g., ROS, Gazebo) for teleoperation or training. *(Analysis)*
- Assess the benefits and limitations of VR/AR in industrial automation and smart manufacturing. *(Evaluation)*

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	**COURSE LEARNING OUTCOMES**				
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT I: Introduction to VR/AR/MR

- Definitions, Evolution, and Differences
- Applications in Robotics & Automation (Simulation, Training, Teleoperation)
- Industry Use Cases (Manufacturing, Healthcare, Automotive)

UNIT II: VR/AR Hardware & Sensors

- Head-Mounted Displays (HMDs: Oculus, HoloLens, Varjo)
- Tracking Systems (Optical, Inertial, Magnetic)
- Haptic Feedback & Controllers

UNIT III: Software & Development Tools

- Game Engines (Unity3D, Unreal Engine)
- Augmented Reality Software Development Kits (AR SDKs: ARKit, ARCore, Vuforia)
- Robot Operating System (ROS) Integration for Robotics Simulation

UNIT IV: VR/AR in Robotics & Automation

- Virtual Prototyping & Digital Twins
- Teleoperation of Robots using Virtual Reality (VR)
- Augmented Reality (AR) for Maintenance & Assembly Guidance

UNIT V: Human-Robot Interaction (HRI) in VR/AR

- Gesture & Voice Recognition
- Collaborative Robotics (Cobots) with AR Overlays
- Safety & Ergonomics in VR/AR Environments

TEXTBOOKS:

1. **"Augmented Reality: Principles and Practice"** – Dieter Schmalstieg & Tobias Hollerer
2. **"Virtual Reality Technology"** – Grigore C. Burdea & Philippe Coiffet
3. **"ROS Robotics By Example 2nd Edition"** (for VR/AR + ROS Integration) – Carol Fairchild, Dr. Thomas L. Harman

REFERENCE BOOKS:

1. **"Understanding Virtual Reality: Interface, Application, and Design"** – William R. Sherman, Alan B. Craig
2. **"Augmented Reality for Developers"** – Jonathan Linowes, Krystian Babilinski
3. **"Robotics, Vision and Control: Fundamental Algorithms in MATLAB"** – Peter Corke (for robotics integration)

ADDITIONAL RESOURCES:

1. **Tools/Platforms:** Unity3D, Unreal Engine, Gazebo (ROS), Microsoft HoloLens SDK
2. **Journals:** *IEEE Transactions on Visualization and Computer Graphics, Virtual Reality*
3. **Online Courses:** Coursera's *"Introduction to Augmented Reality and ARCore"* (Google)

AI in Natural Language Processing (NLP)	
Course Code: 25RAPE22	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination:60 Marks**
L T P : 0 0 3	
Prerequisite: NIL	

COURSE OBJECTIVES (COs):

By the end of this course, students should be able to:

- Understand the fundamentals of NLP and its role in human-robot interaction (HRI).
- Analyze key NLP techniques such as tokenization, parsing, sentiment analysis, and machine translation.
- Implement NLP models (rule-based, statistical, and neural networks) for robotics applications.
- Explore speech recognition, text-to-speech (TTS), and dialogue systems for robotic control.
- Evaluate ethical challenges and biases in NLP systems.

COURSE LEARNING OUTCOMES (CLOs)

Upon successful completion of the course the students will be able to

- Explain core NLP concepts (syntax, semantics, pragmatics) and their relevance in robotics. *(Knowledge)*
- Apply preprocessing techniques (tokenization, stemming, lemmatization) to text data. *(Application)*
- Develop rule-based and machine learning-based NLP models for robotic command interpretation. *(Synthesis)*
- Integrate speech recognition (ASR) and text-to-speech (TTS) systems with robotic platforms. *(Analysis)*
- Assess the limitations of NLP in robotics (ambiguity, context-awareness, multilingual support). *(Evaluation)*

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	**COURSE LEARNING OUTCOMES**				
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT I: Introduction to NLP & Linguistics Basics

- What is NLP? Applications in Robotics (HRI, Voice Commands)
- Syntax, Semantics, Pragmatics
- Corpus and Dataset Collection

UNIT II: Text Preprocessing & Feature Extraction

- Tokenization, Stemming, Lemmatization
- Bag-of-Words (BoW), TF-IDF, Word Embeddings (Word2Vec, GloVe)
- Named Entity Recognition (NER) for Robotics

UNIT III: Rule-Based & Statistical NLP

- Regular Expressions, Finite State Automata
- Hidden Markov Models (HMMs), Conditional Random Fields (CRFs)
- POS Tagging & Dependency Parsing

UNIT IV: Neural NLP & Deep Learning

- Recurrent Neural Networks (RNNs), LSTMs, GRUs
- Transformer Models (BERT, GPT)
- Fine-tuning Pre-trained Models for Robotics

UNIT V: Speech Processing for Robotics

- Automatic Speech Recognition (ASR) – CMU Sphinx, Whisper
- Text-to-Speech (TTS) – Google TTS, Festival
- Voice-Controlled Robots

TEXTBOOKS:

1. "Speech and Language Processing" – Daniel Jurafsky & James H. Martin
2. "Natural Language Processing with Python" – Steven Bird, Ewan Klein, Edward Loper (NLTK-based)
3. "Deep Learning for NLP and Speech Recognition" – Uday Kamath, John Liu

REFERENCE BOOKS:

1. "Neural Network Methods for Natural Language Processing" – Yoav Goldberg
2. "Transformers for Natural Language Processing" – Denis Rothman (BERT, GPT-3)
3. "Artificial Intelligence for Robotics" – Francis X. Govers (NLP + Robotics integration)

ADDITIONAL RESOURCES:

1. **Tools:** NLTK, spaCy, Hugging Face Transformers, ROS + NLP integration
2. **Datasets:** COCO, LibriSpeech, Cornell Movie Dialog Corpus
3. **Online Courses:** Coursera's "Natural Language Processing Specialization" (DeepLearning.AI).

Design Thinking and Engineering Practices	
Course Code: 25ME152/253	**Continuous Evaluation: 40 Marks**
Credit: 1	**End Semester Examination:60 Marks**
L T P : 0 0 2	
Prerequisite: NIL	

COURSE OBJECTIVES (COs):

- To introduce students to the fundamentals of design thinking and its application in engineering problem-solving.
- To provide hands-on experience in basic engineering practices such as welding, carpentry, machining, and sheet metal work.
- To foster creativity, teamwork, and practical skills through physical prototyping.
- To understand safety, tools, and standard practices involved in common engineering operations.

COURSE LEARNING OUTCOMES (CLOs):

Upon successful completion of the course the students will be able to

- Apply design thinking principles to simple engineering problems.
- Operate basic workshop tools used in carpentry, welding, sheet metal, and machining.
- Demonstrate hands-on skills through the fabrication of simple mechanical components.
- Work effectively as a team member in engineering practice sessions.
- Follow workshop safety protocols and proper tool handling procedures.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	COURSE LEARNING OUTCOMES				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	

COURSE CONTENTS/LIST OF EXPERIMENTS

1. **Introduction to Design Thinking:** Empathize, Define, Ideate, Prototype, Test – with engineering case examples.
2. **Safety and Workshop Orientation:** Personal Protective Equipment (PPE), safety signs, hazard zones, and tool use policies.

3. **Carpentry Practice:** Sawing, chiseling, planning, drilling – make a dovetail or T-joint.
4. **Welding Practice:** Arc welding (butt & lap joints), electrode selection, safety protocols.
5. **Sheet Metal Work:** Cutting, bending, rivet joining, tray/box making.
6. **Machining Practice:** Lathe operation (facing, turning), drilling, tapping
7. **Mini Project (Design + Fabrication):** Students form teams to design and fabricate a small product using at least 2 workshop processes
8. **Presentation & Evaluation:** Final demonstration of project, reflection on design thinking, peer review

TEXT BOOK/REFERENCES:

1. **K.C. John** *"Mechanical Workshop Practice"*, PHI Learning Pvt. Ltd., Latest Edition.
2. **Sanjay Moizuddi***"Introduction to Design Thinking"*, Pearson Education, 1st Edition.
3. **Raghavendra, K. and Krishnamurthy, L.** *"Engineering Workshop Practice"*, PHI Learning Pvt.Ltd.
4. **P. Kannaiah & K.L. Narayana** *"Workshop Manual"*, Scitech Publications.
5. **IDEO.org** *"The Field Guide to Human-Centered Design"*, IDEO Press (Free PDF available online).
6. **Tapan P. Bagchi** *"Engineering Design"*, Wiley India Pvt. Ltd.

SEMESTER – VIII

Course code	Course	Category	Hours per week				Credits
			L	T	P	Total Hours	
25RA851	Major Project	LP/SI	0	0	24	24	12
TOTAL			**0**	**0**	**24**	**24**	**12**

* *To be monitored at the Department Level*

L : Lecture **T : Tutorials** **P: Practical**	**LP/SI : Live Project**

Specialization in Robotics and Automation

Professional Elective Courses

Project Management and Operation Research	
Course Code: 25RAPE28	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the fundamentals of production management and analyse and design efficient production systems.
- Apply techniques for inventory control, quality management, and supply chain coordination and develop problem-solving skills to address real-world production challenges.
- Understand the principles and methodologies of operations research (OR).
- Communicate effectively the solutions and insights obtained from OR models.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the core concepts and functions of production management.
- Develop production plans and schedules.
- Formulate real-world problems as mathematical models.
- Apply optimization techniques such as transportation, assignment, and network models to practical scenarios.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02				✓
03		✓		
04			✓	

COURSE CONTENTS

Unit-I: Project Management

Introduction to PERT and CPM, critical Path calculation, float calculation and its importance. Inventory Control- Introduction to inventory control and its role in resource management, Types of inventory systems - deterministic and probabilistic models, Economic Order Quantity (EOQ) model, Economic Production Quantity (EPQ) model, Inventory control with price breaks, safety stock, and reorder point, ABC analysis, Just-In-Time (JIT) inventory, and other inventory management techniques.

Unit-II: Linear Programming

Introduction to linear programming formulation of different models, Graphical method, Linear programming (LP)in standard form, Solution of LP by simplex and Big-M method, Duality theory.

Unit- III: Transportation and Assignment Problems

Concepts, Formulations of models, Solution procedures, Optimality checks, Balanced/Unbalanced, Maximum/Minimum problems, Prohibited case-degeneracy.

Unit-IV: Sequencing and Queuing Models

Sequencing problems and its assumptions, Processing n Jobs through one machine, Processing n Jobs through two machines, Processing n Jobs through three machines, Applications of queuing models, Kendall's notation for representing queuing models, Single-channel queuing theory.

TEXT BOOKS

1. "Production and Operations Management" by K. Aswathappa & K. Shridhara Bha.t
2. "Production and Operations Management" by R. Panneerselvam.

REFERENCE BOOKS

1. "Operations Management" by Jay Heizer and Barry Render.
2. "Production and Operations Management" by S. Anil Kumar and N. Suresh.

Computational Fluid Dynamics	
Course Code: 25RAPE29	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the fundamental principles of fluid mechanics and numerical methods.
- Develop mathematical models for fluid flow problems.
- Use CFD software tools effectively.
- Solve real-world engineering problems using CFD techniques.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the governing equations of fluid flow.
- Apply numerical methods such as finite difference, finite volume, and finite element methods.
- Develop and implement simple CFD algorithms.
- Use commercial or open-source CFD software and interpret and critically analyse CFD simulation results.

MAPPING COURSE EDUCTIONALOBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01				✓
02	✓			
03		✓		
04			✓	

COURSE CONTENTS

Unit 1: Introduction

Finite Difference Method, Finite Volume Method, Finite Element Method, Governing

Equations and Boundary Conditions.

Unit II: Hyperbolic equations

Explicit Schemes and Von Neumann Stability Analysis, Implicit Schemes, Multi Step Methods, Nonlinear Problems, Second Order One-Dimensional Wave Equations, Burgers Equations, Explicit and Implicit Schemes, Runge-Kutta Method.

Unit III: Formulations of Incompressible Viscous Flows

Formulations of Incompressible Viscous Flows by Finite Difference Methods, Pressure Correction Methods, Vortex Methods. manufacturer& assembly. Process selection, Waiting line management & models.

Unit IV: Treatment of Compressible Flows

Potential Equation, Euler Equations, Navier-Stokes System of Equations, Flow Field Dependent Variation Methods, Boundary Conditions, Example Problems.

TEXT BOOKS

1. Computational Fluid Dynamics, John Anderson, McGraw Hill Education.
2. Computational Fluid Mechanics and Heat Transfer, Richard H. Pletcher and John C. Tannehill, CRC Press.

REFERENCE BOOKS

1. Computational Fluid Dynamics and Heat Transfer, Pradip Majumdar, Taylor & Francis.
2. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method" by H. Versteeg and W. Malalasekera.

Maintenance and Safety in Robotics	
Course Code: 25RAPE30	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the fundamental principles of robotic systems maintenance.
- Identify common faults and failures in robotic components and systems.
- Develop maintenance schedules and procedures.
- Understand the safety standards, regulations, and best practices.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the different types of maintenance strategies used in robotic systems, including preventive, predictive, and corrective maintenance.
- Identify and diagnose common faults and failures in robotic components and subsystems.
- Develop and implement effective maintenance plans to ensure optimal performance and longevity of robotic equipment.
- Conduct risk assessments and hazard analyses specific to robotic environments.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01	✓			
02			✓	
03				✓
04		✓		

COURSE CONTENTS

Unit 1: Robot Maintenance

Introduction, General Maintenance Functions and Types of Maintenance, Robot Maintenance Needs and Types, Robot Parts and Special Tools for Maintenance and Repair, Robot Warranty Coverage and Preventive Maintenance Kits, Robot Inspection, Some Guidelines for

Safeguarding Robot Maintenance Personnel.

Unit II: Safety Standards for Robotic Technology

BIS and ISO safety standards for Robots, Safety management system, Hazard identification, Risk analysis and Evaluation, Audit Programme, Preventive Maintenance of Robots, Accident Prevention Techniques, Ergonomics of robots handling, Safety management and management principles.

Unit III: Introduction to Robot Safety

Introduction, Safety-Related Terms and Definitions, Organizations Concerned with Safety, Introduction, Robotic Safety Problems and Hazards, Use of Robots to Promote Safety, Weak Points in Planning and Design, Operations Causing Safety Problems, The Manufacturer's and User's Role in Robot Safety, Safety Considerations in Robot Design, Installation, Programming, and Operation and Maintenance, Robot Safeguard Methods**.**

Unit IV: Robot Safety and Safety devices

Introduction, Robot Safety Education, Safety Considerations in Robot Testing and Start-Up, Commissioning, and Acceptance, Safety Considerations in Robot Welding Operations, Robot Safety in the Automobile Industry, Stopping Grippers of Industrial Robots Not Dropping Throwing Work Items When Experiencing Energy Loss or Not Gripping on the Return of Energy, Robot Standardization and Safety Standards, Safety Devices, STOP type of a Robot, Emergency Stop.

TEXT BOOKS

1. B.S. Dhillon, “Robot Reliability and Safety”, CRC Press, 2015.
2. Paolo Barattini et. al., “Human Robot Interaction: Safety, Standardization and Benchmarking”, CRC Press, 2019.

REFERENCE BOOKS

1. Nicholas Odrey, “Industrial Robotics -Technology, Programming and Applications”, 2017.
2. Mikell Groover, “Industrial Robotics, Tata McGraw Hill, 2008.
3. Tom Taulli, “The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems”, Springer India, 31 December 2021.

Intelligent Manufacturing Systems	
Course Code: 25RAPE31	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the principles and architecture of intelligent manufacturing systems (IMS).
- Explore the integration of advanced technologies such as AI, IoT, robotics, and data analytics into manufacturing systems.
- Analyse the design and implementation of smart factories.
- Develop an understanding of intelligent process control, automation, and human-machine collaboration.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the components, structure, and functions of intelligent manufacturing systems (IMS).
- Explain the integration and application of advanced technologies.
- Analyse the architecture and operation of cyber-physical systems (CPS) and digital twins in manufacturing environments.
- Design intelligent manufacturing solutions that improve productivity, adaptability, and decision-making.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01			✓	
02				✓
03		✓		
04	✓			

COURSE CONTENTS

Unit 1: Introduction

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

Unit II: Knowledge Based System

Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

Unit III: Group Technology

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

Unit-IV: Advanced Manufacturing Technologies

Additive Manufacturing (3D Printing) and IMS, Digital Twins for Manufacturing Systems, Augmented Reality (AR) and Virtual Reality (VR) in Manufacturing, Smart Sensors and Real-Time Monitoring, Intelligent Scheduling and Resource Allocation, Adaptive Production Systems, Supply Chain Integration and Optimization, Real-Time Decision Making in Manufacturing.

TEXT BOOKS

1. Andrew Kusiak, “Intelligent Manufacturing Systems”, Prentice Hall, 1990.
2. Pat Langley, “Computational Intelligence and Intelligent Systems”, 2006.

REFERENCE BOOKS

1. Mohammad Jamshidi, “Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic”, 1st Edition, 1995.
2. Lucia Knapčíková, Michal Balog, “Industry 4.0: Trends in Management of Intelligent Manufacturing Systems”, Springer, 2019.

Optimization for Robot Modelling	
Course Code: 25RAPE32	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the fundamentals of optimization techniques and their relevance in robotic system modelling and control.
- Explore various optimization methods such as linear, nonlinear, convex, and evolutionary algorithms applied to robotic tasks.
- Apply optimization to key robotic problems.
- Develop mathematical models of robotic systems and formulate them as optimization problems for performance enhancement.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain fundamental optimization concepts and techniques used in robotic modelling and control
- Formulate robotic problems such as inverse kinematics, trajectory planning, and system identification as optimization problems.
- Develop and simulate robotic models using optimization techniques in tools like MATLAB, Python, etc.
- Analyse the results of optimization processes and interpret their impact on robotic system behaviour and performance.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01		✓		
02	✓			
03				✓
04			✓	

COURSE CONTENTS

Unit 1: Introduction and Robot Modelling

Overview of optimization in robotics, Review of linear algebra and multivariable calculus, Optimization problem formulation, Kinematic modelling (DH parameters, forward/inverse kinematics), Dynamic modelling (Lagrangian and Newton-Euler methods), Model parameter identification.

Unit II: Mathematical optimization and Inverse Kinematics

Linear and nonlinear programming, Constrained vs. unconstrained optimization, Convexity, duality, and KKT conditions, Analytical vs. numerical approaches, Redundant manipulators, Jacobian-based methods and null-space optimization.

Unit III: Structural and Mechanical Design Optimization

Topology Optimization of Robotic Components, Optimization of Link Dimensions and Joint Placement, Weight Reduction vs. Structural Strength Trade-off, Stiffness and Flexibility Optimization in Soft Robotics.

Unit IV: Optimal control and Estimation in Robot Models

Linear Quadratic Regulator (LQR), Model Predictive Control (MPC), Applications to mobile and manipulator robots, System identification, Parameter estimation via optimization, Optimization in machine learning for robotics (e.g., policy gradient methods), Software and Tools: Practical implementation in Python/MATLAB.

TEXT BOOKS

1. Optimization for Machine Learning by Suvrit Sra, Sebastian Nowozin, and Stephen J. Wright.
2. Numerical Optimization by Jorge Nocedal and Stephen Wright.

REFERENCE BOOKS

1. Modern Robotics by Kevin M. Lynch and Frank C. Park (freely available online).
2. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar.

Entrepreneurship	
Course Code: 25RAPE33	**Continuous Evaluation: 40 Marks**
Credits: 3	**End Semester Examination: 60 Marks**
L T P : 3 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEO)

- Understand the foundational principles of entrepreneurship, including the role of entrepreneurs in economic and social development.
- Explore the process of starting and growing a business, from idea generation to business model development, funding, and scaling.
- Develop the ability to identify market opportunities and assess the feasibility of innovative ideas.
- Apply business planning techniques including financial forecasting, marketing strategy, and operational planning.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define key concepts and theories of entrepreneurship and explain the role of entrepreneurs in the economy.
- Identify and evaluate business opportunities based on market needs, customer segments, and competitive analysis.
- **Analyse risks and challenges** faced by entrepreneurs and apply risk management strategies.
- **Work effectively in teams** to plan and present entrepreneurial projects.

MAPPING COURSE EDUCTIONAL OBJECTIVES & COURSE LEARNING OUTCOMES

CLO / CEO	01	02	03	04
01		✓		
02				✓
03	✓			
04			✓	

COURSE CONTENTS

Unit-I: Introduction to Entrepreneurship

concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, Myths about entrepreneurs, agencies in entrepreneurship management and future of entrepreneurship types of entrepreneurs, The Entrepreneur Why to become entrepreneur, the skills/ traits required to be an entrepreneur, Creative and Design Thinking, the entrepreneurial decision process, skill gap analysis, and role models, mentors and support system, entrepreneurial success stories.

Unit-II: E-Cell and Communication

E-Cell Meaning and concept of E-cells, advantages to join E-cell, significance of E-cell, various activities conducted by E-cell, Communication Importance of communication, barriers and gateways to communication, listening to people, the power of talk, personal selling, risk taking & resilience, negotiation.

Unit-III: Business Organization

Introduction to various form of business organization (sole proprietorship, partnership, corporations, Limited Liability company), mission, vision and strategy formulation.

Unit-IV: Financial Planning and Budgeting for Startups

Concept of Revenue Forecasting, Expense planning, Cash flow projections, Profit and Loss Statement (P&L), Balance Sheet, Burn Rate & Runway, Break-Even Analysis, Capital Requirements and Funding Plan, Key Performance Indicators (KPIs).

TEXT BOOKS

1. “Entrepreneurship" by Robert D. Hisrich, Michael P. Peters, and Dean A. Shepherd.
2. “Essentials of Entrepreneurship and Small Business Management" by Norman M. Scarborough.

REFERENCE BOOKS

1. "Entrepreneurship: Theory, Process, Practice" by Donald F. Kuratko.
2. “Entrepreneurship and Small Business" by Paul Burns.