D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

D Y Patil College of Engineering, Akurdi, Pune													
Second Year Engineering SY B Tech Semester III (2024 Course)													
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**							
							Theory % Marks			**Practical % Marks**			
		L	**T**	**P**	**Cr**	**Exam**	**Max**	**Min for Pass**		**Max**	**Min for Pass**		
RA124PC301	Metrology and Quality Control	3	0	0	3	CCA	50	20	40				
						ESE	50	20					
RA124PC301	Metrology and Quality Control Lab	0	0	2	1	CCA				50	20	40	
						ESE				50	20		
RA124PC302	Engineering Mathematics-III	3	0	0	3	CCA	50	20	40				
						ESE	50	40					
RA124PC303	Strength of Materials	3	0	0	3	CCA	50	20	40				
						ESE	50	20					
RA124MDM301	Robotics Engineering	2	0	0	2	CCA	50	40	40				
						ESE	50	40					
RA124OE301	3D Printing	3	1	0	4	CCA	50	20	40				
						ESE	50	20					
RA124EEM301	Entrepreneurship/ Economics and Management 1	2	0	0	2	CCA	50	20	40				
						ESE	50	20					
VEC1	Sustainable Development - 1	2	0	0	2	CCA	50	20					
RA124FEP301	Basic Robotics Workshop (FAB Lab)	0	0	4	2	CCA	100	40					
NCMC1	Design Thinking	1	0	2	0	CCA	50	20					
NCMC2	Professional and Technical Communication	0	0	2	0	CCA	50	20					
	Total	**19**	**01**	**10**	**22**								
				Hrs									
L	Lecture	**Theory**		**20**									
T	Tutorial	**Pract/Lab**		**10**									
P	Practical	**Total**		**30**									
Cr	Credits												
NC	Non Credit Course (Pass/Fail)												
CCA	Continuous and Comprehensive Assessment												
ESE	End Semester Examination												

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

D Y Patil College of Engineering, Akurdi, Pune

Second Year Engineering SY B Tech Semester IV(2024 Course)

Course Code	Course	Teaching Scheme				Evaluation Scheme						
							Theory % Marks			Practical % Marks		
		L	T	P	Cr	Exam	Max	Min for Pass		Max	Min for Pass	
RA124PC401	Industrial Electronics and Electrical Technology	3	0	0	3	CCA	50	20	40			
						ESE	50	20				
RA124PC401	Industrial Electronics and Electrical Technology Lab	0	0	2	1	CCA				50	20	40
						ESE				50	20	
RA124PC402	Computer Graphics for Robotics	3	0	0	3	CCA	50	20	40			
						ESE	50	20				
RA124PC402	Computer Graphics for Robotics Lab	0	0	2	1	CCA				50	20	40
						ESE				50	20	
RA124PC402	Design of Machine Elements	2	0	0	2	CCA	50	20	40			
						ESE	50	20				
RA124MDM402	Mechatronics and Microcontroller	2	0	0	2	CCA	50	20	40			
						ESE	50	20				
RA124OE402	Financial Management and Costing	2	0	0	2	CCA	50	20	40			
						ESE	50	20				
RA124CSEC403	Robot Operating System	1	0	2	2	CCA	100	40				
HSM2401P01	Soft Skills: Workplace and Life Readiness Category: Ability Enhancement Course	1	0	2	2	CCA	100	40				
RA124EEM402	Entrepreneurship/Economics and Management 2	2	0	0	2	CCA	50	20	40			
						ESE	50	20				
VEC2	Sustainable Development - 2	2	0	0	2	CCA	50	20				
NCMC3	Robot Software Simulation	0	0	2	0	CCA	50	20				
NCMC4	Professional and Technical Communication	0	0	2	0	CCA	50	20				
	Total	**18**	**0**	**12**	**22**							
				Hrs								
L	Lecture	**Theory**		**18**								
T	Tutorial	**Pract/Lab**		**12**								
P	Practical	**Total**		**30**								
Cr	Credits											
NC	Non Credit Course (Pass/Fail)											
CCA	Continuous and Comprehensive Assessment											
ESE	End Semester Examination											

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An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category					**Course Code**	RA124PC301			
Course Title	**Metrology & Quality Control**								
Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**Cr**	**Exam**	**Theory Marks**			**Practical Marks**	
					Max	**Min Marks for Pass**		**Max**	**Min for Pass**
3	0	0	3	CCA	50	20			
Total Hours				ESE	50	20	40	-	-
39	0	0	Total hrs: 39		100				

Prerequisites:		

Course Objectives:

1. To impart students knowledge of theoretical and practical aspects of measurement standards, measuring instruments and their construction, working and applications.
2. To explain the concepts of limits, fits, tolerances& their importance in manufacturing & interchangeability.
3. To impart students knowledge of special measuring devices for surface finish measurements& advanced metrology
4. To impart knowledge of different quality control tools & techniques.
5. To provide knowledge of quality & SQC principles for maintaining and improving quality.

Course Outcomes: After successful completion of the course the student will be able to		Bloom's Cognitive Level	Descriptor
CO1	**Analyze** the working principles, advantages, and limitations of various linear and angular measuring devices to ensure precision in measurements.	**4**	**Analyse**
CO2	**Design** limit gauges	**6**	**Design**
CO3	Measure and **evaluate** surface texture and roughness, Gear parameters, Screw thread parameters using different methods and tools	**5**	**Evaluate**
CO4	**Evaluate** the impact of TQM and TPM strategies on organizational productivity and customer satisfaction.	**5**	**Evaluate**
CO5	**Analyze** different types of control charts to identify process variations and assess their effectiveness in quality control.	**4**	**Analyse**

Syllabus

Unit I	**Introduction to Metrology**	**8 hrs**
	Meaning of Metrology, Precision, Accuracy, Errors in Measurement, Calibration,	

	Linear Measurement: Standards, Classification of Standards, Precision and Non Precision Measuring instrument, Slip Gauges. Manufacturing of slip gauges Angular Measurement: Sine bar, Sine Center, Uses of sine bars, angle gauges, Auto Collimator, Angle Dekkor. Inspection of Geometric parameters: Straightness, flatness, Parallelism, Concentricity, Squareness and Circularity. Alignment testing-lathe/milling/ drilling m/c Comparators: Uses, Types, Advantages and Disadvantages of various Comparators.	
Unit II	**Limits, Fits and Tolerances**	**7 hrs**
	Meaning of Limit, Fits and Tolerance, Cost -Tolerance relationship, concept of Interchangeability, selective assembly, Indian Standard System. Design of limits Gauges: Types, Uses, Taylor's Principle, Design of Limit Gauges, Introduction to auto gauging systems. Interferometry: Introduction, Flatness testing by interferometry, NPL Interferometer, laser interferometer	
Unit III	**Form Measurement & Advances in Metrology**	**8 hrs**
	Surface Texture, methods of evaluation of surface roughness, Grades of Roughness, Specifications, Tomlinson's Surface Recorder, Taylor-Hobson Surface Meter and Talysurf for measuring all characteristics of surface texture. Screw Thread Metrology: External Screw Thread terminology, effective diameter measurement methods, Application of Tool Maker's Microscope, Use of Profile Projector. Gear Metrology: Spur Gear Parameters, Gear tooth thickness measurement: Gear tooth Vernier caliper, Constant chord method, Span Micrometer, Base tangent method. Advanced Metrology-Universal measuring machine, Basic concept of CMM – Types of CMM– Constructional features – Probes – Accessories – Software – Applications – Basic concepts of Machine Vision System – Element – Applications.	
Unit IV	**Introduction to Quality**	**8 hrs**
	Meaning of Quality, Quality of Product, Quality of Service, Cost of Quality, Value of Quality, Role of Quality in Present day environment. Total quality management (T.Q.M):- Approaches-Deming's Approach, Juran's Approach, Seven quality tools and new seven quality tools, Q.F.D., Quality Circles, Kaizen, six sigma, T.P.M.	
Unit V	**Statistical Quality Control**	**8 hrs**
	Introduction to Statistical Quality Control: Control Charts, X, R, P and C Charts, Sampling inspection, OC Curves and Sampling Plans, Process Capability Index (PCI), Concept, Methods of determining PCI and uses of PCI.	

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

References

Text Books:
1. K.J.Hume, "Engineering Metrology", Kalyani publication ISBN8170290015
2. K.W.B.Sharp, "Practical Engineering Metrology", Pitman Publication
3. F. M. Gryna, R. Chua & J. Defco, "Jurans Quality Planning and Analysis for Enterprise Quality", McGraw Hill series. ISBN0070618488

References Books:
1. R.K. Jain, "Engineering Metrology", Khanna Publication.
2. I.C.Gupta, "A Text book of Engineering Metrology", Dhanpat Rai and Sons.
3. Kaoru Ishikawa, "Guide to Quality Control", Asian Productivity Organisation, Series,
4. Juran's Quality Handbook

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0: No Mapping

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Metrology and Quality Control Lab	L	T	P	Credit
Course Code: RA124PC301	0	0	2	1

Course Pre-Requisite: Engineering Graphics, Machine Drawing, and Manufacturing Technology

Course Description:

The Metrology & Quality Control Lab is a hands-on laboratory course designed to complement the theoretical knowledge gained in metrology and quality control lectures. This lab emphasizes practical applications, enabling students to gain essential skills in measurement techniques, inspection processes, and quality control methodologies.

Course Objectives:

1. To provide students with hands-on experience using various metrology instruments and measuring devices.
2. To develop practical skills in performing measurements and inspections of components.
3. To enable students to understand the design and application of limit gauges.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Analyze** the precision measurement techniques to accurately assess the linear & Angular dimensions of composite parts using appropriate instruments.	4	**Analyze**
CO2	**Analyze** interference fringes obtained from optical flatness tests to evaluate the flatness and smoothness of surfaces.	4	**Analyze**
CO3	**Evaluate** component profiles of given composite object using profile projector	5	**Evaluate**
CO4	**Evaluate** surface roughness parameters like Ra and Rz.	5	**Evaluate**
CO5	**Evaluate** the major, minor, and pitch diameters of threads accurately using Floating Carriage Micrometer.	5	**Evaluate**
CO6	**Measure** and **analyze** gear tooth geometry.	4	**Analyze**
CO7	**Analyze** and **evaluate** the performance of a Coordinate Measuring Machine (CMM) in measuring complex, irregularly shaped components.	5	**Evaluate**
CO8	**Analyze** and **interpret** control charts for different manufacturing processes and evaluate the process capability using statistical techniques to ensure product quality and process stability.	4	**Analyze**

CO-PO Mapping:

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

CO4	3	3	2	3	3	3	1	1	2	3	3	3	2	2
CO5	3	3	3	3	3	2	1	1	3	3	3	3	2	2
CO6	3	3	3	3	3	3	1	1	2	3	3	2	3	2
CO7	3	3	3	3	3	3	3	1	3	3	3	2	3	2
CO8	3	3	2	3	3	3	2	2	3	2	3	2	3	2

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (CCA) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
CCA	50
ESE	50

CCA are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- **2 Hrs**

Aim and Objectives:

Aim: To measure linear dimensions & angle of given composite part using precision measuring instruments.

Objectives:

1. To familiarize students with the use of precision measuring instruments such as calipers, micrometers, and gauges for accurate linear measurements and Sine bar for angular measurements.
2. Students will learn to interpret measurement data, emphasize the significance of proper handling of instruments, and understand error sources in measurement.

Outcomes:

1.Students will be able to accurately measure linear dimensions.
2.Proficiency in handling precision instruments.

Theoretical Background:

1. Overview of measurement concepts, units, and precision instruments.
2. Discussion of measuring techniques.

Experimentation:

1. Use precision instruments (e.g.Vernier calipers, micrometers, height gauge, sine bar) to measure dimensions of specified objects.
2. Record measurements and perform repeated trials to assess precision.

Results and Discussions:

1. Present the measurements and calculate averages and deviations.
2. Discuss factors affecting measurement accuracy (instrument calibration, user technique).

Conclusion: Precision instruments provide reliable measurements when used correctly, and errors can be minimized through proper handling.	
Experiment No. 2:--- **Aim and Objectives:** **Aim:** To study and demonstrate the identification and characterization of surfaces using an optical flat. **Objectives:** **1.** Learn the principles of light interference in surface identification. 2.Understand how fringe patterns are formed and interpreted. **Outcomes:** Students will be able to interpret interference fringes to assess flatness and smoothness. **Theoretical Background:** A discussion of the concept of optical flats, including their definition, how they work, and their role in optical testing. Explain the phenomenon of interference and how it allows for the assessment of surface flatness through the observation of fringe patterns. **Experimentation:** 1. Place the optical flat over the specimen in a controlled lighting environment. 2. Observe the interference fringes formed between the optical flat and the specimen surface. 3. Interpret the fringe patterns to identify surface irregularities or deviations from flatness. **Results and Discussion:** Discuss the observed fringe patterns and their correlation with the surface characteristics. **Conclusion**: Optical flats provide a highly accurate method for identifying surface characteristics. Interpreting interference fringes is a reliable technique for assessing surface flatness and smoothness in precision components.	2 **Hrs.**
Experiment No. 3:--- **Aim and Objectives:** **Aim:** To study Determination of geometry & dimensions of given composite object using profile projector . **Objectives:** 1.To set up and operate a profile projector. 2.To measure dimensions and geometry of various components. **Outcomes:** 1.Students will gain skills in using profile projectors for dimensional analysis. 2.Students will be able to inspect component profiles. **Theoretical Background:** Projection principles and magnification. **Experimentation:** Measure dimensions of a complex profile. **Results and Discussions:**	2 **Hrs.**

1. Present analysis and dimensions derived from profile projection. 2. Discuss accuracy and potential applications of the technology. **Conclusion**: Profile projectors offer accurate inspection of component shapes.	
Experiment No. 4:--- **Aim and Objectives:** **Aim:** To measure the surface roughness of the given specimens using surface roughness Tester. **Objectives:** 1.Understand the concept of surface texture. 2.Evaluate surface roughness parameters like Ra and Rz. **Outcomes:** Students will be able to derive Ra and Rz values and assess surface quality. **Theoretical Background:** 1**.** Overview of different roughness parameters. 2. Types of surfaces and roughness measurement techniques. **Experimentation:** 1. Use a surface roughness tester to measure surface finish on different specimens. 2. Record and analyze data. **Results and Discussions:** Analyze surface quality based on measured parameters. **Conclusion**: Surface finish parameters were measured using surface roughness tester.	2 **Hrs.**
Experiment No. 5:--- **Aim and Objectives:** **Aim:** To measure screw thread parameters using Floating Carriage Micrometer **Objectives:** To use a floating carriage micrometer for measuring screw thread parameters. **Outcomes:** Students will measure major, minor, and pitch diameters of threads accurately. **Theoretical Background:** 1**.** Overview of thread geometry, floating carriage micrometer. **Experimentation:** 1. Use a floating carriage micrometer to perform measurements on sample threads. 2. Record measurements and calculate thread parameters. **Results and Discussions:** Screw thread parameters were measured using floating carriage micrometer. **Conclusion**: Floating carriage micrometer enables precise thread measurement.	2 **Hrs.**
Experiment No. 6:--- **Aim and Objectives:** **Aim:** To Measure Gear tooth thickness using Gear tooth Vernier caliper **Objectives:** 1.Learn gear geometry. 2.Measure thickness using Gear tooth Vernier caliper. **Outcomes:**	2 **Hrs.**

Students will be able to measure and analyze gear tooth geometry. **Theoretical Background:** 1**.** Overview of gear tooth terminology, Gear tooth Vernier caliper. **Experimentation:** 1. Measure gear tooth thickness using a gear tooth Vernier caliper. 2.Record multiple measurements for accuracy. **Results and Discussion:** Present the measurements & calculate average. **Conclusion**: Gear tooth Vernier caliper enables precise gear tooth thickness measurement.	
Experiment No. 7:--- **Aim and Objectives:** **Aim:** To measure dimensions of given composite object using Coordinate Measuring Machine (CMM). **Objectives:** 1. To familiarize oneself with the functioning and components of a CMM. 2.To measure the physical dimensions (length, width, height, and other geometrical features) of test specimens using the CMM. **Outcomes:** Students will be able to 1. Understand the concept and working of CMM. 2. Measure components using CMM. **Theoretical Background:** 1. Overview of CMM, construction & working of CMM. **Experimentation:** 1. Measure dimensions of given composite object using Coordinate Measuring Machine (CMM). 2. Record multiple measurements for accuracy. **Results and Discussion:** Present the measurements & calculate average. calculated angles with **Conclusion:** Coordinate Measuring Machine (CMM) provided precise measurements of the test part's dimensions, including length, width, height, and other geometric features.	2 **Hrs.**
Experiment No. 8: --- **Aim and Objectives:** **Aim:** To plot control charts for various manufacturing processes & thereby conducting the process capability analysis. **Objectives:** 1. To learn about control charts (X-bar, R, P, NP) and their importance in quality control. 2. To plot control charts to monitor the process over time. 3. To evaluate the process capability using Cp and Cpk indices.	

4. To identify process variations and take corrective actions based on control chart results and capability analysis.

Outcomes:

Students will be able to

1 Calculate and interpret control charts (X-bar, R, P, NP) and process capability indices

Theoretical Background:

1. Overview of Control charts & process capability analysis

Experimentation:

1.Plot the control chart and compare the observed data points with the control limits.

2.Identify any points that fall outside the control limits or exhibit non-random patterns. Investigate the causes of these variations.

Results and Discussion:

1. Analyze the plotted control charts.
2. Calculate Cp and Cpk to assess the process capability.

Conclusion: Using control charts and process capability analysis together allows for proactive identification of process issues, leading to improvements in process stability, product quality, and operational efficiency.

Report based on Industrial Visit

Textbooks:

1. K.J.Hume, “Engineering Metrology”, Kalyani publication ISBN8170290015
2.K.W.B.Sharp, “Practical Engineering Metrology”, Pitman Publication
3. F. M. Gryna, R. Chua & J. Defco, “Jurans Quality Planning and Analysis for Enterprise Quality”, McGraw Hill series. ISBN0070618488

References:

1. R.K. Jain, “Engineering Metrology”, Khanna Publication.
2. I.C.Gupta, “A Text book of Engineering Metrology”, Dhanpat Rai and Sons.
3. Kaoru Ishikawa, “Guide to Quality Control”, Asian Productivity Organisation, Series, Juran’s Quality Handbook

Experiment wise Measurable Students Learning Outcomes:

1. Students will accurately measure linear dimensions and angles using precision instruments.
2. Students will interpret interference fringes to assess surface flatness and smoothness.
3. Students will analyze and measure component geometry using a profile projector.
4. Students will evaluate surface roughness parameters (Ra, Rz) to assess surface quality.
5. Students will measure major, minor, and pitch diameters of screw threads using a floating carriage micrometer.
6. Students will determine gear tooth thickness using a gear tooth Vernier caliper.
7. Students will measure complex object dimensions using a Coordinate Measuring Machine (CMM).
8. Students will analyze control charts and process capability indices (Cp, Cpk) for quality control.

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Code: RA124PC302 **Course Title: Engineering Mathematics III**

Category: Programme Specific

		Teaching Scheme			Evaluation Scheme		
					Theory % Marks		
L	T	P	Cr	Exam	Max	Min for Pass	
3	1	0	3	CCA	50	20	40
39	0	0		ESE	50	20	

Prerequisites:

Differential & Integral calculus, Differential equations of first order & first degree, Fourier series, Collection, classification and representation of data and Vector algebra.

Course Objective

1. To make the students familiarize with concepts and techniques in Ordinary & Partial Differential equations, Laplace-Transform, Statistical methods and Probability.
2. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes: After successful completion of the course the student will be able to

CO1	**SOLVE** higher order linear differential equations using appropriate techniques for modelling and analysis of mass spring systems, free and forced damped and undamped systems	BT-3
CO2	**APPLY** Integral transform techniques such as Laplace transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.	BT-3
CO3	**SOLVE** Partial differential equations such as wave equation, one and two dimensional heat flow equations.	BT-3
CO4	**APPLY** Statistical methods like correlation, regression as applicable to analyse and interpret experimental data related to energy management, power systems, testing and quality control	BT-3
CO5	Apply Probability theory as applicable to **ANALYZE** and interpret experimental data related to energy management, power systems, testing and quality control.	BT-4

Syllabus

Unit I	Differential Equation & Its Application	8 hrs

LDE of nth order with constant coefficients, Complementary Function, Particular Integral, Short methods, Method of variation of parameters, Cauchy's and Legendre's DE. Modelling of mass-spring systems, free and forced damped and undamped systems.

Unit II	Integral Transforms	8 hrs

Laplace Transform (LT): Definition of LT, Inverse LT, Properties & theorems, LT of standard functions, LT of some special function. Applications of LT for solving Linear differential equationsz

Unit III	**Applications of Partial Differential Equations**	**8 hrs**
Basic concepts, modelling of Vibrating String, Solution of Wave equation, One and two dimensional Heat flow equations, method of Separation of variables, use of Fourier series.		
Unit IV	**Statistics**	**8 hrs**
Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates..		
Unit V	**Probability**	**7 hrs**
Probability, Theorems on Probability, Bayes Theorem, Random variables, Mathematical Expectation, Probability distributions: Binomial, Poisson, Normal, Test of Hypothesis: Chi-Square test, t-distribution..		
Text Books		
1. Higher Engineering Mathematics by B. V. Ramana (Tata McGraw Hill) 2. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi		
Reference Books		
3. Advanced Engineering Mathematics by Erwin Kreyszig (Wiley Eastern Ltd.) 4. Advanced Engineering Mathematics by M. D. Greenberg (Pearson Education) 5. Advanced Engineering Mathematics by Peter V. O'Neil (Thomson Learning) 6. Thomas' Calculus by George B. Thomas, (Addison-Wesley, Pearson) 7. Applied Mathematics (Vol. I and II) by P.N. Wartikar and J.N.Wartikar Vidyarthi Griha Prakashan, Pune. 8. Differential Equations by S. L. Ross (John Wiley and Sons)		

CO-PO Mapping

3: High, 2: Moderate, 1: Low, 0: No Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	-	-	-	-	-	1	-	-	1
CO2	3	3	-	-	-	-	-	1	-	-	1
CO3	3	3	-	-	-	-	-	1	-	-	1
CO4	3	3	-	-	-	-	-	1	-	-	1
CO5	3	3	-	-	-	-	-	1	-	-	1

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	Program Specific	Course Code	RA124PC303
Course Title	Strength of Materials		

Prerequisites:

Course Objectives: (Min 3)

1 Understand the basic concepts and principles of strength of materials, including key definitions and theorems

2. Analyse how different materials behave under various types of loads, such as axial, torsional, and bending forces.

3.. Apply knowledge of stress-strain relationships and material properties to determine how materials will respond under different loading conditions.

4. Evaluate the mechanical properties of materials and their failure mechanisms to understand the limits and performance of different materials.

5. Create solutions for problems involving axial, torsional, and bending loads using principles of strength of materials

Course Outcomes: After successful completion of the course the student will be able to

CO1	Demonstrate an understanding of the fundamental concepts and principles of strength of materials.
CO2	Analyze the behavior of materials subjected to various types of loads, including axial, torsional, and bending loads
CO3	Analyze the load transfer mechanisms in beams under various loading conditions
CO4	Apply basic equation of simple torsion in designing of shafts and helical spring
CO5	To analyse the type of materials and its suitability as per applications.

Syllabus

Unit I	Simple Stresses & Strains: Elasticity and plasticity – Types of stresses & strains– Hooke's law– stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Elastic moduli & the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain energy – Resilience – Gradual, sudden, impact and shock loadings**.**	**7 hrs**
Unit II	Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads	**8 hrs**
Unit III	Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I,T, sections. Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T sections	**8 hrs**

Unit IV	Torsion formulation stresses and deformation in circular and hollows shafts – Stepped shafts– Deflection in shafts fixed at the both ends – Stresses in helical springs – Deflection of helical springs, carriage springs.	**8 hrs**
Unit V	An overview of robotics and design fundamentals, with a focus on the selection and use of building materials such as metals, synthetic materials, and composites. This includes a detailed study of the properties of steel used in construction, the characteristics of wrought aluminium alloys, and the mechanical properties of stainless steel. Additionally, the designation and structural examination of titanium alloys, along with techniques like case hardening of titanium and its alloys.	**8 hrs**

References

Text Books:

1.Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2016

2. Jindal U.C., "Strength of Materials", Asian Books Pvt. Ltd., New Delhi, 2009

3. Engineering mechanics, 5th edn by S. Timoshenko , D.H. Young, et al. | 1 July 2017

4. S. Ramamurtham, “Strength of material”, Dhanpat Rai Publication

References Books:

1.Egor. P.Popov “Engineering Mechanics of Solids” Prentice Hall of India, New Delhi, 2002.
2. Ferdinand P. Been, Russell Johnson, J.r. and John J. Dewole,"Mechanics of Materials", Tata McGraw Hill Publishing ‘co. Ltd., New Delhi, 2005.
3.subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2010.
4. Mikell Grover ., ― Industrial Robotics‖ , McGraw Hill , 2016.
5. Beer and Johnston, “Strength of materials”, CBS Publication

Journal Papers:

Authors, *Title of Paper*, Name of Journal, Vol (issue), pp, Year, DOI

You Tube: https://www.youtube.com/watch?v=E2gGF1rburw

Website:

1. **Strength of Materials web course by IIT Roorkee**
   https://nptel.ac.in/courses/112107146/
2. **Strength of Materials video course by IIT Kharagpur**
   https://nptel.ac.in/courses/105105108/

3. .Strength of Materials video course by IIT Roorkee
   https://nptel.ac.in/courses/112107147/18
4. http://www.nptelvideos.in/2012/11/strengthof-materials-prof.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Quiz (To assist in GATE Preparations)**
2. **Demonstrations in Lab**
3. **Virtual Lab Experiments**

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0: No Mapping

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Course Category	Program Specific	Course Code	RA124MDM301
Course Title	Robotics Engineering		

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Prerequisites:

Knowledge of basic physics (mechanics and dynamics)
Fundamentals of mathematics (linear algebra, calculus, differential equations)
Basics of programming (Python, C++, or MATLAB)
Understanding of control systems and mechatronics

Course Objectives: (Min 3)

1. To provide an introduction to the fundamental concepts of robotics.
2. To understand kinematics, dynamics, and control strategies of robotic systems.
3. To develop the ability to design, simulate, and analyze robotic systems.
4. To introduce students to robot programming, sensing, and perception.

Course Outcomes: After successful completion of the course the student will be able to

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain the basic principles, components, and applications of robots.	3	Apply
CO2	Analyze the kinematics and dynamics of robotic systems.	3	Apply
CO3	Design control strategies for various robotic systems.	3	Apply
CO4	Develop algorithms for robot motion planning and navigation.	3	Apply
CO5	Implement robotic systems using sensors, actuators, and programming frameworks.	3	Apply

Syllabus

Unit I	Introduction to Robotics	**5 hrs**
	Definition, History, and Evolution of Robotics, Robot configurations, Robot components, Robot Degrees of freedom, Robot joints and symbols, Robot coordinates, Robot reference frames, Resolution, Accuracy and precision of robot, Work cell control, Applications: Industrial, Medical, Military, and Service Robotics	
Unit II	Kinematics and Dynamics of Robots	**6 hrs**
	Forward and Inverse Kinematics, Homogeneous Transformation Matrices, Workspace Analysis and Trajectory Planning, Joint Space and Cartesian Space Representation, Lagrangian and Newton-Euler Formulations, Dynamic Simulation and Model Development	
Unit III	**Robot sensors**	**5 hrs**

	Transducers and sensors, Sensors in robotics, Principles and applications of following type of sensors, proximity sensors and photo electric sensors, Laser scanners, position sensors – Piezo electric sensors, LVDT and Resolvers Encoders: Absolute and Incremental – Optical Magnetic, Capacitive, Pneumatic Position sensors. Range sensors: Range Finders, Laser Range Maters, Touch sensors, force and torque sensors.	
Unit IV	Robot Control Systems	**5 hrs**
	Fundamentals of Control Systems in Robotics, PID Controllers and Trajectory Tracking, Adaptive and Non-Linear Control, Motion Control Architectures	
Unit V	Mobile and Autonomous Robots	**5 hrs**
	Localization and Mapping (SLAM), Path Planning Algorithms: A*, Dijkstra, RRT, Obstacle Avoidance Techniques, Case Studies on Autonomous Robots	

References

- **"Introduction to Robotics: Mechanics and Control" by John J. Craig**
- **"Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch and Frank C. Park**

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

"Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch and Frank C. Park**CO-PO Mapping**

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

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

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: 3D Printing	**L**	**T**	**P**	**Credit**
Course Code: Open Elective 1 (RA124OE301)	**3**	**1**	**-**	**4**

		Teaching Scheme			**Evaluation Scheme**		
L	**T**	**P**	**Cr**	**Exam**	**Theory % Marks**		
					Max	**Min for Pass**	
3	1	0	3	CCA	50	20	40
39	0	0		ESE	50	20	

Course Pre-Requisite: Basic knowledge of Manufacturing Processes and Material Science.

Course Description:

This course provides a comprehensive introduction to Additive Manufacturing (AM), covering its principles, processes, materials, applications, and future trends. Students will learn about the design considerations, process parameters, and quality control techniques associated with various AM technologies.

Course Objectives:

1. Understand the fundamental concepts and processes in additive manufacturing.
2. Explore the materials and design considerations specific to additive manufacturing technologies.
3. Analyze various AM techniques and their applications across industries.
4. Examine quality control, testing, and standards in additive manufacturing.
5. Investigate the future trends and emerging applications of additive manufacturing.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Elaborate the basic principles and processes of additive manufacturing.	4	Elaborate
CO2	Classify and compare different AM techniques and materials.	3	Classification
CO3	Apply AM design principles to develop optimized part geometries.	3	Apply
CO4	Evaluate the role of quality control and standards in AM processes.	4	Evaluate
CO5	Analyze the potential applications and advancements in additive manufacturing.	4	Analyze

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO 01**	**PSO 02**	**PSO 03**
CO1	3	-	2	-	-	-	-	-	-	-	-	1	3	1
CO2	-	2	-	2	-	-	3	2		3	-	-	2	
CO3	3	2	-	-	-	-	-	-	-	-	2	-	-	2
CO4	-	-	-	-	-	-	-	-	-	-	-	2	2	-
CO4	-	-	3	2	-	-	-	2	2	-	2	2		3
CO5	3	2	-	-	2	2	-	3		-	-	-	-	-

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Assessments:

Teacher Assessment:

Two components of Continuous Comprehensive Assessment (CCA) and one End Semester Examination (ESE) having 50% and 50% weights respectively.

Assessment	Marks
CCA	10
CCA	30
CCA	10
ESE	50

CCA 1 and CCA 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Introduction to Additive Manufacturing Overview of Additive Manufacturing, historical development, and applications. Key differences between traditional manufacturing and AM. Basic principles and classifications of AM processes (e.g., SLA, FDM, SLS).	**08 Hrs.**
Unit 2: AM Processes and Technologies Detailed study of various AM techniques: Stereolithography (SLA), Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Electron Beam Melting (EBM), Direct Metal Laser Sintering (DMLS). Process parameters, advantages, limitations, and applications of each technique. Comparisons among AM processes.	**09 Hrs.**
Unit 3: Materials for Additive Manufacturing Types of materials used in AM: polymers, metals, ceramics, and composites. Material properties, selection criteria, and process compatibility. Challenges in material processing and developments in multi-material AM.	**08 Hrs.**
Unit 4: Design for Additive Manufacturing (DfAM) Design principles specific to AM: part consolidation, topology optimization, and support structures. Guidelines for effective design. Case studies on optimized designs using AM.	**08 Hrs.**
Unit 5: Quality Control, Standards, and Future Trends Quality control and testing methods in AM: dimensional accuracy, surface finish, and mechanical properties. Standards and certifications (ISO, ASTM) relevant to AM. Emerging applications, environmental impact, and future developments in additive manufacturing.	**08 Hrs.**

Textbooks:

1. G. K. Lal and Amitabha Ghosh “Additive Manufacturing and 3D Printing Technology”
2. Rupinder Singh “3D Printing and Additive Manufacturing: Technologies and Applications”
3.Ian Gibson, David W. Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing," Springer.
4. Andreas Gebhardt, "Understanding Additive Manufacturing," Hanser Publications..

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

References:
1. Ramesh Kumar and Vinod Kumar Jain "Advances in Additive Manufacturing and Tooling"
2. K. V. Sudhakar and Shubham Sharma, "3D Printing and Additive Manufacturing of Electronics: Principles and Applications"
3.Frank B. Prinz, "Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography," CRC Press.
2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles and Applications," World Scientific Publishing Company.

Unit wise Measurable Students Learning Outcomes:

1. Explain the fundamentals and applications of additive manufacturing.
2. Differentiate between various AM technologies and their process parameters.
3. Select appropriate materials for specific AM processes.
4. Utilize DfAM principles for creating optimized geometries.
5. Assess AM quality control standards and explore advancements in the field.

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D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: 3D Printing (Tutorial)	**L**	**T**	**P**	**Credit**
Course Code: Open Elective 1 (RA124OE301)	**3**	**1**	**-**	**4**

Course Pre-Requisite: Basic knowledge of Engineering Drawing, CAD software.

Course Description: Students will gain practical experience in 3D modeling, STL file processing, component preparation utilizing slicing software, and 3D printing processes in this lab course that focuses on the practical aspects of Additive Manufacturing (AM). Advanced subjects including quality control, process optimization, and material selection will be covered by the students.

Course Objectives:

1. To introduce students to AM procedures and 3D modeling tools.
2. To give students the ability to optimize AM process parameters and part designs.
3. To spread awareness of quality assurance and new developments in AM technologies

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Apply CAD tools to create and optimize designs for AM.	Apply	Procedural Knowledge
CO2	Analyze STL files and resolve common file issues for successful 3D printing.	Analyze	Procedural Knowledge
CO3	Optimize process parameters to improve part quality and minimize material waste.	Evaluate	Critical Thinking
CO4	Prepare and process 3D models using slicing software.	Apply	Procedural Knowledge
CO5	Perform quality control tests on 3D-printed parts.	Evaluate	Experimental Design
CO6	Demonstrate the ability to work with emerging applications in AM.	Apply	Procedural Knowledge

CO-PO-PSO Mapping:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 01**	**PSO 02**	**PSO 03**
CO1	3	2	2	1	3	1	-	1	2	3	1	-	2	-
CO2	2	-	2	-	3	-	2	1	2	2		-	-	1
CO3	3	2	-	2	-	1	2	-	3		1	1	-	-
CO4	3	-	-	2	-	1	-	-	-	3	1	-	2	-
CO5	3	2	3	3	3	-	2	2	2	3	-	-	-	3
CO6	2	2	3	-	-	2	3	1	-	-	2	-	-	3

Assessments:

Teacher Assessment:

One component of Continuous Comprehensive Assessment (CCA) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
CCA	50
ESE	50

CCA are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1: Introduction to solid modelling and Working with sketch mode — 01 **Hrs.**

Aim and Objectives:

- Aim: To understand the basics of solid modeling and sketch creation in CAD software.
- Objectives:
  - Learn to use sketch tools to create basic 2D profiles.
  - Explore constraints and dimensions to define sketch geometry.

Outcomes:

- Proficiency in using sketch mode tools.
- Ability to create fully constrained sketches for solid modeling.

Theoretical Background:

Solid modeling is the foundation of 3D CAD design. Sketch mode allows the creation of 2D profiles that serve as the base for 3D features like extrusions and revolutions. Proper constraints ensure accuracy and flexibility in design.

Experimentation:

1. Open CAD software
2. Select a plane and enter sketch mode.
3. Use tools (e.g., line, rectangle, circle) to create a simple 2D profile.
4. Apply geometric constraints and dimensions to fully constrain the sketch.

Results and Discussions:

- Sketch created and fully constrained.
- Observed how constraints influence the sketch geometry.
- Discussed the importance of precision in creating sketches.

Conclusion:

A clear understanding of sketch mode was achieved, highlighting its importance as a foundation for solid modeling.

Experiment No. 2: Working with creating features (Extrude & Revolve) Working with advanced modeling tools (Sweep, Blend & Swept Blend) — 01 **Hrs.**

Aim and Objectives:

- Aim: To learn the creation of 3D features using basic and advanced modeling tools.
- Objectives:
  - Understand the use of extrude and revolve for simple 3D geometry.
  - Explore advanced tools like sweep, blend, and swept blend.

Outcomes:

• Proficiency in creating basic and complex 3D features. • Enhanced modeling skills for real-world applications. **Theoretical Background:** Features like extrude and revolve are used to create basic 3D shapes, while advanced tools like sweep and blend enable the design of complex geometries by following a path or blending profiles. **Experimentation:** 1. Create a sketch and use the **Extrude** and **Revolve** features. 2. Design a path and use the **Sweep** feature to create a model. 3. Use **Blend** to transition between two profiles and **Swept Blend** for varying transitions. **Results and Discussions:** • Successfully created 3D models using basic and advanced tools. • Observed the differences in outcomes between basic and advanced features. • Discussed the applicability of advanced tools in industrial designs. **Conclusion:** The experiment demonstrated the versatility of modeling tools in creating complex geometries efficiently.	
Experiment No. 3: Assembly modeling using appropriate assembly constrains **Aim and Objectives:** • Aim: To assemble individual parts into a complete assembly using constraints. • Objectives: o Understand assembly constraints like mate, align, and tangent. o Create a functional assembly from pre-designed parts. **Outcomes:** • Ability to assemble parts accurately using constraints. • Understanding of the role of constraints in functional assemblies. **Theoretical Background:** Assembly modeling involves combining multiple parts into a single assembly using constraints to define their relative positions. This process ensures proper functionality and alignment of components. **Experimentation:** 1. Import pre-designed parts into the assembly workspace. 2. Apply constraints like **Mate**, **Align**, and **Tangent** to position parts. 3. Verify the functionality and alignment of the assembly. **Results and Discussions:** • Successfully assembled parts into a cohesive model. • Observed the impact of constraints on part positioning. • Discussed potential issues in assemblies and their solutions. **Conclusion:** Assembly modeling is crucial for ensuring that parts work together as intended in a real-world application	01 **Hrs.**
Experiment No. 4: Working on STL file problems using suitable Software, Working on Online Repositories/open source software: Thingiverse and GrabCAD **Aim and Objectives:**	01 **Hrs.**

• Aim: To work with STL files and explore open-source repositories like Thingiverse and GrabCAD.
• Objectives:
  o Identify and fix common issues in STL files.
  o Download and modify files from online repositories.
Outcomes:
• Ability to edit and repair STL files.
• Familiarity with open-source resources for 3D printing.
Theoretical Background:
STL files describe the surface geometry of 3D models and are widely used in 3D printing. Errors like non-manifold edges and holes must be repaired for successful printing. Online repositories provide a vast library of 3D models.
Experimentation:
1. Import a faulty STL file into software like **MeshLab** or **Netfabb**.
2. Repair issues like non-manifold edges and holes.
3. Download a file from **Thingiverse** or **GrabCAD** and modify it in CAD software.
Results and Discussions:
• Successfully repaired STL files and modified downloaded models.
• Discussed common STL file issues and their fixes.
Conclusion:
Understanding STL files and open-source repositories is essential for efficient 3D printing workflows.	

Experiment No. 5: Part orientation, support and Tool path generation in open source - CURA Software, Build-time calculation, amount of model and support material consumption using CURA Software.
Aim and Objectives:
• Aim: To prepare a 3D model for printing using CURA software.
• Objectives:
  o Optimize part orientation and add supports.
  o Generate tool paths and calculate build time and material usage.
Outcomes:
• Proficiency in using CURA for part preparation.
• Understanding of the impact of orientation and supports on printing.
Theoretical Background:
CURA is an open-source slicing software used for preparing models for 3D printing. Proper orientation minimizes supports and improves print quality, while tool path generation calculates build time and material usage.
Experimentation:
1. Import a 3D model into CURA.
2. Experiment with different orientations and observe the impact on support structures.
3. Generate tool paths and calculate build time and material consumption.
Results and Discussions:
• Optimized part orientation reduced support material usage by 20%.
• Tool paths provided accurate estimates for build time and material consumption.
Conclusion:
	01 **Hrs.**

Efficient part preparation in CURA enhances printing efficiency and reduces material waste.

Experiment No. 6: Model printing using 3D Printer — 01 **Hrs.**

Aim and Objectives:

- Aim: To print a 3D model using an FDM 3D printer.
- Objectives:
  - Set up and calibrate the 3D printer.
  - Print a model and analyze the output.

Outcomes:

- Hands-on experience with 3D printing.
- Understanding of printer settings and calibration.

Theoretical Background:

3D printing involves layer-by-layer deposition of material to create a physical object. Calibration ensures precision and quality in printed parts.

Experimentation:

1. Calibrate the 3D printer (e.g., bed leveling, nozzle temperature).
2. Load the sliced model from CURA.
3. Print the model and remove it from the print bed.
4. Inspect the printed part for quality.

Results and Discussions:

- Printed part matched the CAD model with minimal deviations.
- Discussed issues like warping and solutions for improving print quality.

Conclusion:

3D printing provides a direct way to convert digital models into physical prototypes, highlighting the importance of calibration and preparation.

Textbooks:

1. "Additive Manufacturing Technologies" by Ian Gibson, David W. Rosen, Brent Stucker
2. "Rapid Prototyping: Principles and Applications" by Chua Chee Kai and Leong Kah Fai
3. "Introduction to 3D Printing" by B. K. Ghosh
4. "3D Printing and Additive Manufacturing: Principles and Applications" by Chee Kai Chua and Kah Fai Leong
5. "Advanced Modeling Techniques in CAD/CAM" by Kunwoo Lee

References:

1. "Additive Manufacturing: Materials, Processes, Quantifications and Applications" by M. K. S. Prakash
2. "Fundamentals of Additive Manufacturing" by M. C. Gupta
3. "Rapid Prototyping and Manufacturing" by Paul F. Jacobs
4. "3D Printing and Additive Manufacturing in Industry" by S. S. Rao
5. "Engineering Drawing and CAD Tools" by S. K. Sinha

Experiment wise Measurable Students Learning Outcomes:

1 Demonstrate proficiency in sketch mode tools for creating 2D profiles in CAD software

2	Create basic 3D features using Extrude and Revolve tools.
3	Assemble multiple parts into a cohesive model using constraints like Mate, Align, and Tangent.
4	Explore and utilize open-source repositories like Thingiverse and GrabCAD.
5	Optimize part orientation and support structures for efficient 3D printing.
6	Inspect printed parts for quality and address common printing issues like warping.

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D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Title: Entrepreneurship/ Economics and Management 1 **Course Code: RA124EEM301**

Prerequisites:	
Course Objectives:	
• To introduce the fundamental principles of entrepreneurship, economics, and management in the context of Robotics, and Automation Engineering. • To develop an understanding of economic decision-making, financial management, and business planning for technology-driven start-ups. • To enable students to apply management principles for optimizing production, automation, and industrial processes.	
Course Outcomes: After successful completion of the course the student will be able to	
CO1	Understand the fundamentals of entrepreneurship, economic principles, and business management relevant to engineering.
CO2	Analyze financial, managerial, and economic factors affecting technology startups and automation-based industries.
CO3	Apply management and economic strategies to enhance productivity and efficiency in robotics and automation businesses.

Syllabus

Unit I	**Fundamentals of Entrepreneurship and Innovation**	**9 hrs**
Introduction to Entrepreneurship: Characteristics, types, and importance in automation & robotics. Business Idea Generation & Innovation: Idea incubation, technology-driven startups, case studies of robotics startups. Legal & Ethical Aspects: Intellectual property rights (IPR), patents, trademarks, business ethics. Industry 4.0 & Entrepreneurship: Emerging trends in automation and AI-driven businesses.		
Unit II	**Engineering Economics & Financial Management**	**9 hrs**
Engineering Economics Basics: Demand and supply, cost analysis, breakeven analysis, risk assessment. Financial Planning & Funding: Venture capital, angel investors, crowdfunding, government schemes for tech startups. Project Feasibility & Cost Estimation: ROI calculations, financial forecasting, automation cost-benefit analysis. Economic Policies & Global Impact: Trade policies, economic trends affecting robotics industries.		
Unit III	**Management Principles & Industrial Automation**	**8 hrs**
Principles of Management: Leadership, strategic planning, organizational structures in automation industries. Operations & Supply Chain Management: Lean manufacturing, Six Sigma, Agile methodologies in automation. Marketing & Business Strategies: Market research, digital marketing for robotic products, competitive analysis.		

Sustainability & Corporate Social Responsibility (CSR): Green automation, environmental impact of robotics.
Reference Books
1. Peter F. Drucker, "Innovation and Entrepreneurship," Harper Business. 2. B.J. Harrison, "Engineering Economy," Pearson. 3. Philip Kotler, "Marketing Management," Pearson Education. 4. Charles Fine, "Clockspeed: Winning Industry Control in the Age of Temporary Advantage," Basic Books. 5. Michael E. Porter, "Competitive Strategy," Free Press.

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Total	Pass
CCA	Faculty	8	8	9	25	20
	Department	UT1		UT2	25	
		8	9	8		
ESE	Institute	17	17	18	50	20

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0/-: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	**Value Education Course 1**	**Course Code**	VEC1
Course Title	**Sustainable Development - 1**		

Teaching Scheme				**Evaluation Scheme**				
					Theory Marks		**Practical Marks**	
L	**T**	**P**	**Cr**	**Exam**	**Max**	**Min Marks for Pass**	**Max**	**Min for Pass**
2	0	0	2	CCA	100	40	-	-
Total Hours								
26	0	0	Total hrs: 26					

Prerequisites:
None

Subjects Included:

Sustainable Development Goals (SDG - Basic) 2 units

Environment Studies 2 units

Intellectual Property Rights (IPR) 1 unit

Course Objectives: (Min 3)

Understand the Concept of SDGs – Introduce students to the importance of sustainable development and the role of SDGs in global and local contexts.

Explore SDG Interconnections – Analyze how various SDGs are linked and the challenges in achieving them collectively.

Understand Environmental Issues – Examine environmental challenges and their impact on sustainable development.

Study Environmental Policies – Analyze national and global policies related to environmental sustainability.

Learn Intellectual Property Rights (IPR) – Understand the basics of patents, copyrights, trademarks, and their role in innovation.

1.

Course Outcomes: After successful completion of the course the student will be able to

CO1	**DEFINE** the key concepts of SDGs and LIST the 17 SDGs with their significance.
CO2	**EXPLAIN** interconnections between different SDGs and analyze their holistic impact.
CO3	**DESCRIBE** key environmental challenges and their implications for sustainable development.

CO4	**DISCUSS** major environmental policies and governance frameworks.
CO5	**UNDERSTAND** fundamental concepts of Intellectual Property Rights (IPR) and their applications.

Syllabus

Unit I	**Introduction to SDGs & Sustainability**	**6 hrs**
	Evolution from MDGs to SDGs, significance in the UN 2030 Agenda, India's contributions, real-world applications.	
Unit II	**SDG Targets & Interconnections**	**6 hrs**
	Understanding SDG indicators, interlinkages, roles of stakeholders, case studies, impact assessment frameworks.	
Unit III	**Environmental Challenges & Sustainability**	**5 hrs**
	Key environmental issues like climate change, biodiversity loss, pollution; impact on health and society, mitigation strategies.	
Unit IV	**Environmental Policies & Governance**	**5 hrs**
	National and global environmental policies, role of regulatory bodies, sustainability standards, case studies of successful interventions.	
Unit V	**Introduction to Intellectual Property Rights (IPR)**	**4 hrs**
	Basics of patents, copyrights, trademarks, importance in innovation and sustainability, protection of intellectual property in academia and industry.	

Scheme for Examination

Component	**Parameters**	**Marks**	**Total**	**Pass**
CCA	Viva Voce for assessment of Understanding	20	50	20
	Involvement, Participation, and Engagement	10		
	Quality of Submission of Report	10		
	Attendance	10		
End Evaluation	Performance (Internal)	25	50	20
	Oral Examination (Internal)	25		

CCA: Continuous Comprehensive Assessment (CCA)

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An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)
CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Basic Robotics Workshop (FAB Lab)	**L**	**T**	**P**	**Credit**
Course Code: RA124FEP301	**-**	**-**	**4**	**4**

Course Pre-Requisite: Basic knowledge of electronics, programming, and mechanical concepts.

Course Description: This workshop introduces students to the fundamentals of robotics, covering topics such as robotic components, basic electronics, programming, and mechanical design. Hands-on practical include assembling robotic systems, coding microcontrollers, working with sensors, and using 3D printing for custom robotic parts.

Course Objectives:

1. To provide an understanding of robotics principles and applications.
2. To develop skills in assembling and programming basic robotic systems.
3. To introduce students to 3D printing for custom robotic parts.
4. To implement automation and sensor integration in robotic projects.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Identify and describe key components of a robotic system.	Understand	Conceptual Knowledge
CO2	Assemble and wire a simple robotic system.	Apply	Procedural Knowledge
CO3	Program microcontrollers to control robotic movement.	Apply	Procedural Knowledge
CO4	Utilize 3D printing for designing custom robotic components	Evaluate	Experimental Design
CO5	Integrate sensors for autonomous robot functionality.	Analyze	Problem-Solving
CO6	Demonstrate the ability to work with emerging applications in AM.	Apply	Procedural Knowledge

CO-PO-PSO Mapping:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 01**	**PSO 02**	**PSO 03**
CO1	3	2	2	1	3	1	-	1	2	3	1	-	2	-
CO2	2	-	2	-	3	-	2	1	2	2	-	-	-	1
CO3	3	2	-	2	-	1	2		3		1	1	-	-
CO4	3	-	-	2	-	1	-	-	-	3	1	-	2	-
CO5	3	2	3	3	3	-	2	2	2	3	-	-	-	3
CO6	2	2	3	-	-	2	3	1	-		2	-	-	3

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Assessments:

Teacher Assessment:

One component of Continuous Comprehensive Assessment (CCA) 100% weights

Assessment	Marks
CCA	100

Course Contents:

Experiment No. 1: Introduction to Robotics & Basic Electronics **Aim and Objectives:** Aim: To understand the basic components of a robotic system and simple electronics used in robotics. **Objectives**: Identify motors, sensors, microcontrollers, and power sources. Learn basic circuit connections using a breadboard. **Outcomes**: • Ability to recognize key robotic components. • Hands-on experience with basic circuit assembly. **Theoretical Background:** Robots consist of mechanical structures, electronic components, and software control. Understanding motors, power sources, and microcontrollers is essential for building functional robots. **Experimentation**: Identify different robotic components. Wire a basic LED and motor circuit on a breadboard. Observe circuit functionality and troubleshoot errors. Results and Discussion: Successfully identified and tested basic robotic components. **Conclusion**: Understanding basic electronics is fundamental for robotics development.	06 **Hrs.**
Experiment No. 2: Assembly and Programming of a Simple Mobile Robot **Aim and Objectives:** Aim: To assemble and program a basic wheeled robot. **Objectives**: Assemble a robot chassis with motors and wheels. Interface a microcontroller (e.g., Arduino) with motor drivers. Write and upload basic movement control code. **Outcomes**: Ability to assemble and test a mobile robot. Basic understanding of microcontroller programming. Theoretical Background: Robots require both hardware (motors, wheels, chassis) and software (code to control movement). Programming microcontrollers is essential for movement automation. **Experimentation:**	06 **Hrs.**

Assemble a two-wheeled robot with motor drivers. Connect the robot to an Arduino/microcontroller. Write and upload a basic movement program. Results and Discussion: The robot successfully moved in predefined directions. **Conclusion**: Assembling and programming a robot is essential for understanding automation.	
Experiment No. 3: 3D Printing for Robotics **Aim and Objectives**: **Aim**: To design and print a custom robotic component using 3D printing. **Objectives**: Learn basic 3D modeling using CAD software. Prepare and slice a model for 3D printing. Print a robotic part (e.g., wheel, gripper, bracket). **Outcomes:** Ability to design and fabricate a 3D-printed component. Understanding of material selection and printing parameters. Theoretical Background: 3D printing allows custom robotic components to be manufactured efficiently. Proper design, slicing, and printing techniques ensure optimal results. **Experimentation**: Design a simple robotic component using CAD software. Slice the model using Cura or similar slicing software. Print the component using a 3D printer and inspect the output. **Results and Discussion:** Successfully printed a custom robotic component. **Conclusion**: 3D printing is an essential tool for rapid prototyping in robotics.	06 **Hrs.**
Experiment No. 4: Sensor Integration for Autonomous Robots **Aim and Objectives:** **Aim**: To integrate sensors and automate robot responses. **Objectives**: Interface ultrasonic/IR sensors with a microcontroller. Write code for obstacle detection and avoidance. Test and evaluate autonomous movement. **Outcomes**: Ability to integrate and use sensors in robotic applications. Understanding of automation and sensor-based navigation. Theoretical Background: Autonomous robots rely on sensors for perception and decision-making. Ultrasonic and infrared sensors help in detecting objects and avoiding obstacles. **Experimentation**: Connect an ultrasonic sensor to an Arduino/microcontroller. Write a program for obstacle detection.	06 **Hrs.**

Observe the robot avoiding obstacles autonomously. **Results and Discussion**: The robot successfully detected and avoided obstacles. **Conclusion**: Sensor integration is crucial for autonomous robotic functionality.	

Textbooks and Reference Books:

1. "Introduction to Robotics: Mechanics and Control" by John J. Craig
2. "Robotics, Vision and Control" by Peter Corke
3. "Arduino Robotics" by John-David Warren
4. "3D Printing for Dummies" by Richard Horne and Kalani Kirk Hausman
5. "Make: Getting Started with 3D Printing" by Liza Wallach Kloski & Nick Kloski

Experiment wise Measurable Students Learning Outcomes:

1. Identify basic robotic components and build simple circuits.
2. Assemble and program a mobile robot for movement.
3. Design and fabricate a custom robotic part using 3D printing.
4. Integrate sensors for obstacle detection and automate robotic movements.

Course Category	NC1	Course Code	NCMC1
Course Title	Design Thinking		

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Prerequisites: Basic engineering, problem-solving, communication, materials, human-centered design, business awareness.	
Course Objectives: (Min 3)	
1. To understand the principles of Design Thinking and its application in problem-solving. 2. To develop skills in user research, ideation, prototyping, and testing for innovative solutions.	
Course Outcomes: After successful completion of the course the student will be able to	
CO1	Apply Design Thinking methodologies to analyze and solve real-world problems.
CO2	Conduct user research, generate insights, and develop creative solutions.
CO3	Develop and test prototypes using iterative refinement for effective implementation.

Syllabus

Unit I	**Introduction to Design Thinking**	**4 hrs**
	Concept, importance, five stages of Design Thinking, case studies, iterative nature, problem-solving approach, role of collaboration, interdisciplinary teams.	
Unit II	**User Research and Ideation**	**4 hrs**
	Empathy, user research techniques (interviews, observations, surveys), data collection, analysis, problem statement formulation, brainstorming techniques (SCAMPER, Mind Mapping, Reverse Thinking), idea generation, converting insights into solutions.	
Unit III	**Prototyping, Testing, and Implementation**	**4 hrs**
	Prototyping, tools, materials, user testing methodologies, feedback analysis, iterative refinement, effective presentation, project documentation.	

References

Textbooks:

1.Brown, T. (2009). Change by Design: How Design Thinking Creates New Alternatives for Business and Society. Harper Business.
2.Kelley, T., & Kelley, D. (2013). Creative Confidence: Unleashing the Creative Potential Within Us All. Crown Business.

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO-PSO Mapping

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO1	PSO2	PSO3
CO1	3	2	3	2	2	1	2	0	2	2	1	1	3	2
CO2	2	3	2	2	0	0	1	2	3	1	2	2	2	3
CO3	3	2	3	2	3	2	1	0	2	3	2	2	2	3

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Design Thinking (Pr.)	**L**	**T**	**P**	**Credit**
Course Code: NCMC1	**1**	**0**	**2**	**-**

Course Pre-Requisite: Basic engineering, problem-solving, communication, materials, human-centered design, business awareness.

Course Description: This course introduces students to the principles and methodologies of Design Thinking, enabling them to approach problem-solving creatively and innovatively. Through hands-on activities and real-world projects, students will learn how to empathize with users, define problems, ideate solutions, prototype, and test their ideas effectively.

Course Objectives:

1. Introduce students to the Design Thinking process and its importance in problem-solving.
2. Develop empathy by understanding users' needs and challenges.
3. Apply Design Thinking principles to real-world challenges and projects.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	**Bloom's Cognitive level**	**Description**
CO1	Understand the fundamental principles of Design Thinking	Level 2	Understand
CO2	Apply empathy techniques to user research	Level 3	Apply
CO3	Ideate creative solutions for complex problems	Level 4	Analyze
CO4	Develop prototypes to visualize and test solutions	Level 5	Evaluate
CO5	Implement user feedback for solution refinement	Level 5	Evaluate
CO6	Present and document a Design Thinking project effectively	Level 6	Create

CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	3	0	2	3	1	0	0	1	3	2
CO2	0	2	2	3	0	2	0	1	2	2	1	0	2	3
CO3	2	2	1	0	2	2	3	1	2	3	1	1	2	3
CO4	2	3	1	2	3	2	0	2	2	0	2	0	2	1
CO5	2	0	2	0	0	0	3	1	0	3	1	2	3	1
CO6	3	2	0	2	2	3	2	0	0	3	2	0	2	2

Assessments:

Teacher Assessment:

One component of Continuous Comprehensive Assessment (CCA)

Assessment	Marks
CCA	50

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

NPTEL Course: Design Thinking - A Primer https://onlinecourses.nptel.ac.in/noc25_mg18/preview	
Course Contents:	
Experiment No. 1: Introduction to Design Thinking **Aim and Objectives:** Understand the five stages of Design Thinking and their applications. **Experimentation:** Case studies and group discussions. **Results and Discussions:** Understanding the iterative nature of design. **Conclusion:** Importance of Design Thinking in problem-solving.	**2 Hrs.**
Experiment No. 2: Empathy and User Research **Aim and Objectives:** Learn user research techniques like interviews and observations. **Outcomes:** Develop an understanding of user needs. **Experimentation:** Conducting real-life interviews. **Results and Discussions:** Analyzing collected data. **Conclusion:** Importance of empathy in design.	**2 Hrs.**
Experiment No. 3: Ideation and Brainstorming **Aim and Objectives:** Develop creative solutions using brainstorming techniques. **Outcomes:** Generate multiple innovative ideas. **Experimentation:** Group brainstorming sessions. **Results and Discussions:** Evaluating feasibility of ideas. **Conclusion:** Selecting the best approach for prototyping.	**2 Hrs.**
Experiment No. 4: Prototyping **Aim and Objectives:** Convert ideas into tangible prototypes. **Outcomes:** Develop low-fidelity prototypes. **Experimentation:** Using basic materials to create models. **Results and Discussions:** Testing usability. **Conclusion:** Importance of rapid prototyping.	**2 Hrs.**
Experiment No. 5: User Testing and Feedback **Aim and Objectives:** Evaluate the effectiveness of prototypes. **Outcomes:** Gather user feedback for refinement. **Experimentation:** Testing prototypes with real users. **Results and Discussions:** Identifying improvement areas. **Conclusion:** Importance of iterative improvement.	**2 Hrs.**
Experiment No. 6: Final Project Presentation **Aim and Objectives:** Document and present the Design Thinking project. **Theoretical Background:** Importance of storytelling in design. **Experimentation:** Presenting findings to peers and faculty. **Results and Discussions:** Constructive feedback. **Conclusion:** Reflection on the design process.	**2 Hrs.**

Teaching Scheme				Evaluation Scheme					
L	T	P	Cr	Exam	Theory % Marks			Practical % Marks	
					Max	Min for Pass		Max	Min for Pass
0		2			--	--	--	50	20
Total Hours									
0		26	Total: 26		---	--			

Textbooks:

1.Brown, T. (2009). Change by Design: How Design Thinking Creates New Alternatives for Business and Society. Harper Business.

2.Kelley, T., & Kelley, D. (2013). Creative Confidence: Unleashing the Creative Potential Within Us All. Crown Business.

References:

1.Liedtka, J., & Ogilvie, T. (2011). Designing for Growth: A Design Thinking Toolkit for Managers. Columbia University Press.

2.Plattner, H., Meinel, C., & Leifer, L. (2010). Design Thinking: Understand, Improve, Apply. Springer.

Experiment wise Measurable students Learning Outcomes:

Experiment 1: Understand the concept and process of Design Thinking.

Experiment 2: Apply empathy techniques in user research.

Experiment 3: Use brainstorming methods for creative problem-solving.

Experiment 4: Develop prototypes to visualize solutions.

Experiment 5: Conduct user testing and refine designs.

Experiment 6: Effectively document and present design projects.

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Code: NCMC2, Course Title: Professional and Technical Communication

Category: Non Credit Mandatory Course

Prerequisites: Basic English Grammar Skills	
Course Objective: Purposes of Course are: 1. This course is designed to equip students with essential professional and technical communication skills necessary for success in the modern workplace. 2. Emphasizing both written and verbal communication 3. The course covers a wide range of topics, including effective written communication, active listening and public speaking. 4. Develop strong logical reasoning aptitude & problem solving to clear company selection tests	
Course Outcomes: After Successful completion of course units, students will	
CO1	Analyse and evaluate spoken information critically for understanding the context and credibility of the source.
CO2	Demonstrate effective interpersonal communication skills for harmonious and productive interactions.
CO3	Articulate strategies for clear and coherent writing skills for personal & professional communication needs.
CO4	Develop skills for effective and authentic non-verbal communication to ace the professional communication needs.
CO5	Solve complex logical reasoning aptitude problems efficiently, improving selection test performance.

Syllabus

Unit I	**Development of Listening and Speaking Skills**	**04 Hrs.**
Introduction to Listening skills, Barriers to Listening skills, active Listening techniques, Listening for main ideas and details, Note taking strategies. Introduction to Speaking skills, Building vocabulary and fluency, Conversational Skills, Public speaking fundamentals. Speed and Fluency, Removing MTI.		
Unit II	**Development of Writing and Reading Skills**	**03 Hrs.**
Introduction to Effective Written Communication, fundamentals of grammar and punctuation, Paragraph Structure, Essay writing, Report writing, Formal letter writing. Importance of Reading, Comprehension and solving case studies, Synthesis writing		
Unit III	**Fundamentals of Technical Communication**	**03 Hrs.**

What is communication? Importance of communication, Communication Types – Verbal, Non-verbal, Why is non-verbal communication important? Making eye contact (or lack thereof), Shaking hands, -Crossing or uncrossing legs, Folding or unfolding arms, Fidgeting, Eye contact, Smiling or frowning, Communication styles		
Unit IV	**Business Communication**	**03 Hrs.**
Business communication theory, Email Etiquette, Digital Communication, Presentation Skills, Ethics in Business Communication, Kinesics and Pitch modulation		
Unit V	**Quantitative Aptitude**	**02 Hrs.**
1. Recap & Time and Work		
Unit VI	**Reasoning Ability**	**08 Hrs.**
1. Analytical Reasoning - I 2. Clock & Calendars 3. Coding and Decoding & Odd Man Out 4. Data Interpretation - Advanced **5.** Cubes & Dices		
Unit VII	**Career Skills**	**03 Hrs.**
1. Networking Skills 2. Linked In Profile Building & Internship Outreach **3.** ATS Resume		
Reference Books		

1. Communication Skills for Engineers by S. Mishra & C. Muralikrishna (Pearson),2011, ISBN - 8131799905, 9788131799901
2. Communication Skills for Technical Students by T.M. Farhathullah (Orient Longman)2002, ISBN - 9788125022473
3. Written Communication in English by Saran Freeman (Orient Longman) 1977, 8125004262
4. Essential English Grammar (Elementary & Intermediate) Raymond Murphy (CUP), 1990, ISBN 10-8175960299
5. Communication for Business: A Practical Approach by Shirley Tailor (Longman),2005, ISBN - 9780273687658
6. Developing Communication Skills by Krishna Mohan & Meera Banerji (Macmillan),2009, ISBN - 9780230638433

7. Business Correspondence and Report Writing, R. C. Sharma & Krishna Mohan (Tata McGraw Hill,2017, ISBN - 9789390113002
8. Technical communication: Principles and practice, Raman, Minakshi, and Sangita Sharma. 3rd ed. Oxford University Press, 2015, ISBN - 978-0199457496
9. https://ielts.org
10. NPTEL Course-Business English Communication IIT Madras
    Link https://youtu.be/GwF4ypDSr-A
11 NPTEL Course- Introduction to Effective Communication
    Link https://archive.nptel.ac.in/courses/109/104/109104030/

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Code: RA124PC401 **Course Title: Industrial Electronics and Electrical Technology**

Category: Program Specific

Teaching Scheme					EvaluationScheme		
					Theory%Marks		
L	T	P	Cr	Exam	Max	Min forPass	
3	0	3	3	CCA	50	20	40
39	0	0		ESE	50	20	

Prerequisites: Basic Electrical Engineering, Basic Electronics Engineering

Course Objective

1. Understand the Fundamentals of Microprocessors and Microcontrollers.
2. Introduce Arduino IDE for Embedded System Development
3. To understand selection of machines for specific applications.
4. To understand the construction, principle of operation of transformers, DC Machine & Induction Machine.
5. To test & analyse the performance of the machine.

Course Outcomes : After successful completion of the course the student will be able to		Bloom's Cognitive level	Descriptor
CO1	Understanding Microprocessor and Microcontroller Architecture.	BL- 2	Explain ideas or concepts
CO2	Introduction to Arduino IDE,Program Arduino IDE & Interfacing sensors with Arduino IDE	BL- 3	Execute or use concepts in practical situations
CO3	Test and evaluate performance of DC machines	BL- 4	Differentiate, organize, and attribute information
CO4	Explain the construction, operation, types and applications of induction motors	BL - 2	Describe the functioning of processes
CO5	Identify special purpose motor and its speed control method for given industrial application	BL- 5	Justify decisions or solutions

Syllabus

UnitI	Introduction to Microprocessors and Microcontrillers	7hrs

Introduction to microprocessors Architecture CPU, address bus, data bus and control bus, Interrupts ,Introduction and history of microcontrollers. Features of 8051 microcontroller. Block diagram of 8051-program status word (PSW), accumulator, and program counter. Memory organization, Pin out diagram-description of pins, special function registers (SFRs), I/O port organization, interrupts, role of embedded systems,sensors and actuators, data acquisition systems.

UnitII	Atmega328P and Arduino: Architecture, Programming, and Peripherals	7hrs
Open source embedded platforms, Atmega328P- features, architecture, portstructure, introduction to Arduino IDE-features, IDE overview, programming concepts: variables, functions, conditional statements.Concept of GPIO in Atmega 328P based Arduino board, UART concept, timers, interfacing with LED,LCD and keypad, serial communication using Arduino IDE Concept of ADC in Atmega 328P based Arduino board, interfacing with temperature sensor (LM35), LVDT, strain gauge,accelerometer,Introduce Arduino IDE for Embedded System Development		

UnitIII	D. C. Machines	8hrs
Construction, working principle of D.C. generator, emf equation of D. C. generator , working principle of D.C. motor, types of D.C. motor, back emf, torque equation for D.C. motor, characteristics of D.C. motor (series and shunt only), three-point starter for D.C shunt motor, methods for speed control of D.C. shunt and series motors, industrial applications.		
UnitIV	**Three Phase Induction Motor**	**8hrs**
Constructional feature, working principle of three phase induction motors, types; torque equation, torque slip characteristics; power stages; efficiency, starters (auto transformer starter, star delta starter); methods of speed control and industrial applications.		
UnitV	**Special Purpose Motors**	**9hrs**
Construction, working principle, characteristic and applications of stepper motors modes of operation , industrial applications, brushless DC motors construction & drives- unipolar and bipolar, single phase induction motors, construction, working principle & types, descriptive treatment for AC series motor		

Textbooks:

1] Ashfaq Husain, “Electrical Machines”, Dhanpat Rai & Sons
2]S. K. Bhattacharya, “Electrical Machine”, Tata Mc Graw Hill publishing Co. Ltd,2nd Edition
3] Nagrath & Kothari, “Electrical Machines”, Tata Mc Graw
4] Ajay Deshmukh, ‘Microcontrollers Theory and Applications’, TATA McGraw Hill

References:

1] Electrical Machines, Lowe, Nelson Publications.
2]A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electrical Machines”, TataMcGraw Hill Publication Ltd. Fifth Edition.
3]Permanent Magnet Synchronous and Brushless DC Motor Drives, R. Krishnan, CRC press
4] Smarajit Ghosh, “Electrical Machines”, Pearson Education, New Delhi.
[R5]Kenneth J. Ayala, ‘The 8051 Microcontroller’, Cengage Learning

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D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Scheme for Theory Examination

Component	Parameters	Marks	Total	Pass
CCA	Viva Voce for assessment of Understanding	20	50	20
	Involvement, Participation, and Engagement	10		
	Quality of Submission of Report	10		
	Attendance	10		
End Semester Evaluation (ESE)	Performance (External)	25	50	20
	Oral Examination (External)	25		

Component	Level	Unit1	Unit2	Unit3	Unit4	Unit5	Total	assing
Continuous Comprehensive Assessment(CCA)	Faculty	5	5	5	5	5	25	20
	Department	5	5	5	5	5	25	
		Unit Test 1(UT1)			Unit Test 2(UT2)			
End Semester Examination(ESE)	Institute	10	10	10	10	10	50	20

CO-PO Mapping

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

3:High,2:Moderate,1:Low, 0:NoMapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Industrial Electronics and Electrical Technology **Course Code:** RA124PC401	**L**	**T**	**P**	**Credit**
	3	**0**	2	3

Course Pre-Requisite: Basic Electrical Engineering, Basic Electronics Engineering

Course Description:

This course provides an in-depth introduction to the architecture and functioning of microprocessors and microcontrollers, focusing on their roles in embedded systems and data acquisition applications.

Course Objectives:

1.Understand the Fundamentals of Microprocessors and Microcontrollers:
2.Introduce Arduino IDE for Embedded System Development

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Understanding Microprocessor and Microcontroller Architecture.	BL- 2	Explain ideas or concepts
CO2	Introduction to Arduino IDE,Program Arduino IDE & Interfacing sensors with Arduino IDE	BL- 3	Execute or use concepts in practical situations
CO3	Test and evaluate performance of DC machines	BL- 4	Differentiate, organize, and attribute information
CO4	Explain the construction, operation, types and applications of induction motors	BL - 2	Describe the functioning of processes
CO5	Identify special purpose motor and its speed control method for given industrial application	BL- 5	Justify decisions or solutions
CO1	Understanding Microprocessor and Microcontroller Architecture.	BL- 2	Explain ideas or concepts

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2		2	3	-	-	-	-	-	2	2	2	2
CO2	3	3	3	3	3	-	-	-	-	-	2	3	2	2

CO 3	3	3	2	-	3	-	-	-	-	-	2	3	2	-
CO 4	3	3	-	3	3	-	-	-	-	-	2	3	2	-
CO 5	3	2	3	3	3	-	-	-	-	-	2	3	2	2

Assessments :

Teacher Assessment:

One component of CCA and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
CCA	50
ESE	50

CCA are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- Interfacing of LED to blink after every 1 sec. 02 **Hrs.**

Aim and Objectives: To interface an LED with a microcontroller (Atmega328P-based Arduino) and program it to blink on and off with a delay of 1 second.

Objectives: 1. To understand the basic concepts of digital output using GPIO pins.
2. To implement a simple embedded application by controlling an LED.

Outcomes: The ability to write and upload a simple Arduino program to control an LED.

Theoretical Background:

GPIO (General-Purpose Input/Output):

Digital Output:

Delay Function:

An LED (Light Emitting Diode)

Arduino IDE:

Experimentation:

Materials Required:

- Arduino Uno (or any Atmega328P-based board)
- LED
- Resistor (220Ω or 330Ω)
- Connecting wires
- Breadboard

Circuit Diagram:

1. Connect the anode (long leg) of the LED to a digital pin (e.g., Pin 13) of the Arduino. 2. Connect the cathode (short leg) to one terminal of a resistor. **3.** Connect the other terminal of the resistor to the Arduino's GND pin**.** Results and Discussions: The LED successfully blinks ON and OFF with a 1-second interval, demonstrating the implementation of digital output and delay. **Conclusion:** The experiment demonstrates the interfacing of an LED with an Atmega328P-based Arduino board and its programming using the Arduino IDE. By controlling the GPIO pin and utilizing the delay function, we successfully created a simple embedded system to blink an LED at a 1-second interval. This experiment provides foundational knowledge in embedded programming and digital output operations.	
Experiment No. 2:--- Interfacing of LCD to display the message and interface with keypad to display the key pressed. **Aim and Objectives:** **Aim:** To interface a 16x2 LCD with a microcontroller to display a custom message and integrate a 4x4 keypad to display the key pressed on the LCD. **Objectives:** 1. To understand the interfacing of a 16x2 LCD with a microcontroller. 2. To learn to program the LCD to display a custom message. **Outcomes:** 1. Ability to interface and control an LCD using a microcontroller. 2. Practical understanding of reading inputs from a keypad matrix. **Theoretical Background:** 1. LCD Basics 2. Keypad Basics 3. Microcontroller GPIO Operations **Experimentation:** Materials Required: ● Arduino Uno (or any Atmega328P-based board) ● 16x2 LCD ● 4x4 Keypad ● Resistors (as required) ● Potentiometer (for LCD contrast adjustment) ● Breadboard and connecting wires	02 **Hrs.**

5. Results and Discussions:

- The LCD successfully displayed a custom message on initialization.
- Each key press on the keypad was accurately detected and displayed on the LCD.

6. Conclusion:

The experiment successfully demonstrated the interfacing of a 16x2 LCD and a 4x4 keypad with an Atmega328P-based Arduino board. A custom message was displayed on the LCD, and the corresponding key pressed was dynamically updated on the display. This experiment provided practical knowledge in creating interactive embedded systems using microcontrollers.

Experiment No. 3:--- Display data using serial communication.

02 **Hrs.**

Aim and Objectives:

Aim:
To understand and implement serial communication using an Atmega328P-based microcontroller (e.g., Arduino) to send data from the microcontroller to a computer and display it on a serial monitor.

Objectives:
1. To understand the principles of serial communication and its role in data transmission.
2. To learn how to configure UART (Universal Asynchronous Receiver-Transmitter) for serial communication.

Outcomes:

1. Familiarity with serial communication concepts, including baud rate, data bits, and parity.
2. Ability to use UART for data transfer between a microcontroller and a computer.

Theoretical Background:

- Serial Communication Basics
- UART Protocol:
- Arduino Serial Communication:

Experimentation:

Materials Required:
- Arduino Uno (or any Atmega328P-based board)
- USB cable
- Computer with Arduino IDE

Results and Discussions:

- The Arduino successfully transmitted data ("Hello, Serial Communication!") via UART.
- The message was displayed correctly on the Serial Monitor.

Conclusion:

The experiment demonstrated the successful implementation of serial communication using an Atmega328P-based Arduino board. Data was transmitted via UART to a computer and displayed on the Arduino IDE's Serial Monitor. This experiment provided foundational knowledge of serial communication and its practical applications in embedded systems.

Experiment No. 4:--- Interfacing of temperature sensor (LM35) and show output on LCD/serial terminal. 02 **Hrs.**

1. Aim and Objectives:
To interface the LM35 temperature sensor with a microcontroller (Atmega328P-based Arduino) and display the measured temperature on an LCD or serial terminal**.**

Objectives:
1. To understand the working of the LM35 temperature sensor and its analog output.
2. To learn how to read analog data from a temperature sensor using the Arduino ADC (Analog to Digital Converter).

Outcomes:

1. Ability to interface and read data from the LM35 temperature sensor using the Arduino.
2. Understanding how to use the Arduino ADC to convert analog voltage to digital values.

Theoretical Background:
- LM35 Temperature Sensor:
- Analog to Digital Conversion (ADC):
- Arduino ADC Formula:
- LCD and Serial Communication:

Experimentation:

Materials Required:
- Arduino Uno (or any Atmega328P-based board)

● LM35 Temperature Sensor ● 16x2 LCD Display ● 10kΩ Potentiometer (for LCD contrast) ● Resistors, connecting wires, breadboard **Results and Discussions:** ● The temperature value from the LM35 sensor is successfully displayed on the 16x2 LCD and/or Serial Monitor. ● The readings correspond to the real-time temperature in Celsius. **Conclusion:** The experiment successfully demonstrated the interfacing of the LM35 temperature sensor with an Arduino board. By reading the analog output from the LM35 and using ADC for conversion, the temperature was displayed on both an LCD and the Serial Monitor.	
Experiment No. 5:--- Speed Control of Dc Motor **Aim and Objectives:** **Aim:** To draw the speed characteristics of DC motor by 1. Armature Voltage control method 2. Field control method **Objectives:** 1. To Implement Different Methods of Speed Control: 2. Explore various methods like Armature Voltage Control, Field Flux Control, and Armature Resistance Control. 3. To Investigate the Relationship Between Speed and armature voltage/field current 4. Examine how the speed changes with varying load conditions and how this is compensated using control methods. **Outcomes:** 1. Variable Speed Control 2. By controlling the speed, the DC motor can operate more efficiently, reducing energy consumption. **Theoretical Background:** ● Introduction to DC Motors ● Basic Theory of DC Motor Operation working with construction ● Types of DC Motor: Separately excited DC Motor. ● Self-excited DC Motor: DC Shunt Motor, DC Series Motor ● methods to control the speed of a DC motor: Armature voltage control & Field Control	2-- **Hrs.**

Experimentation:

Materials Required:
- DC Shunt Motor
- Voltmeter & Ammeter
- Tachometer
- Rheostat
- connecting wires

Results and Discussions:
 You would expect a **linear relationship** between the applied armature voltage and the motor speed. As the voltage increases, the speed of the motor should increase as well.
 In the field control method, reducing the field current will increase the speed of the motor, and this relationship can be graphed as well.

Conclusion:

The experiment demonstrated that speed control of a DC motor can be achieved using various methods.

Experiment No. 6: ---Study of Starters for AC & DC Motor — 2-- **Hrs.**

Aim and Objectives:
Aim: Study of Starters for AC & DC Motor
Objectives:
1. The objective of a starter for AC and DC motors is to provide a controlled way to start the motor, ensuring that it operates efficiently and safely
2. Limit Inrush Current
3. Control the Starting Process Protect the Motor
4. Smooth Transition Ensure Safe Operation

Outcomes:
1. Understanding Different Starting Methods for ac and dc motor
2. Motor Protection: Reduced Inrush Current
3. Prevent Overheating
4. Reduced Mechanical Stress
5. Overcurrent Protection: Safety Outcomes
6. Improved Operational Safety

Theoretical Background:

- Types of Induction motor starter –stator resistance, autotransformer, star delta & rotor resistance starter
- DC Motor Starters-3 points starter, 4 Point Starter

Experimentation: Materials Required: Basic Model of ac & dc starters **Results and Discussions:** **Conclusion:** Both **AC** and **DC motors** require appropriate starting mechanisms to ensure efficient operation and to prevent damage from excessive inrush currents. The choice of starter depends on the motor type, size, and application. DC motors often require more specialized control, especially in larger applications, while AC motors are more commonly controlled using methods like stator resistance, rotor **resistance starter, Star-Delta,** autotransformer or rotor resistance starter for smoother starts.	
Experiment No.7 :--- No load test and blocked rotor test on Three Phase Induction Motor. **Aim and Objectives:** **Aim:** To study No-load test and blocked rotor test on 3-phase induction motor. **Objectives:** 1. **No-Load Test**: Measures the motor's core losses, friction and windage losses, magnetizing current, and stray losses. 2. **Blocked Rotor Test**: Determines starting current, starting torque, rotor impedance, and other characteristics related to the motor's performance during startup. **Outcomes:** 1. The **No Load Test** is performed to measure the motor's performance when it runs without any mechanical load. This test helps assess the core losses, friction, and windage losses that occur when the motor operates without any external load. 2. The **Block Rotor Test** is performed to simulate the motor's starting conditions, where the rotor is blocked, and the stator is energized. This test helps to measure the locked rotor current and assess the motor's performance under fault or starting conditions. **Experimentation:** Theoretical Background: Three Phase Induction Motor working Principle No load and blocked rotor test on three phase induction motor **Results and Discussions:**	2Hr

□ The No Load Test is often used to determine the core losses and friction and windage losses in the motor. □ The motor's **efficiency** can't be evaluated accurately at no load because there is no output power being delivered to the mechanical load. □ The results can be used to estimate the motor's **no-load losses** for efficiency calculation under different operating conditions. □ The **blocked rotor current** is usually several times higher than the rated current (typically 5 to 7 times the full-load current). This high current is due to the very low impedance of the stator windings when the rotor is stationary. □ The **power factor** is low because the motor is primarily inductive at this point, with the motor not producing any mechanical work (no rotation). □ The **impedance** (stator and rotor combined) can be derived from the voltage, current, and power measured during the test. This is used to calculate the starting torque and performance at startup. □ The **locked rotor torque** and **starting conditions** can be evaluated. The torque is typically very low when compared to the full-load torque, and the motor struggles to start under these conditions. **Conclusion:** The study of No-load test and blocked rotor test on 3-phase induction motor has been done by obtaining the results of the experiment.	
Experiment No. 8:---Load Test On Three Phase Induction Motor **Aim and Objectives:** **Aim:** Load Test On Three Phase Induction Motor **Objectives:** 1. To evaluate the performance of the induction motor under different load conditions. **2.** To calculate efficiency, slip, input power, output power, and power factor. **Outcomes:** expected outcomes from performing such a test: 1. The input power is measured at different loading conditions (e.g., no-load, part-load, full-load) 2. The mechanical output power is derived from the torque and speed of the motor. 3. Efficiency **curves**: Typically, efficiency increases with load, peaking at or near full load, and then may slightly decrease if the motor is overloaded. 4. Power **Factor curve**: The power factor will be lower at no-load and increase as the load increases. 5. Slip **curve**: Slip increases as the load increases. **Experimentation:**	2Hr

Theoretical Background:
Construction and working of three phase induction motor

Results and Discussions:

The results can be used to plot graphs for:

- Efficiency vs Output power.
- Power factor vs output power.
- Input power vs Output power.
- Slip vs Output power
- Output Torque vs output power
- Speed vs output power

Conclusion:

The loading test provides essential data for evaluating the performance of a 3-phase induction motor. The motor's efficiency, power factor, slip, and output power can be used to determine its operational characteristics under different load conditions. The test results also help in diagnosing motor performance and identifying areas for improvement or maintenance

Textbooks:

1] Ashfaq Husain, "Electrical Machines", Dhanpat Rai & Sons
2]S. K. Bhattacharya, "Electrical Machine", Tata Mc Graw Hill publishing Co. Ltd,2nd Edition
3] Nagrath & Kothari, "Electrical Machines", Tata Mc Graw
4] Ajay Deshmukh, 'Microcontrollers Theory and Applications', TATA McGraw Hill

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References:

1] Electrical Machines, Lowe, Nelson Publications.
2]A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", TataMcGraw Hill Publication Ltd. Fifth Edition.
3]Permanent Magnet Synchronous and Brushless DC Motor Drives, R. Krishnan, CRC press
4] Smarajit Ghosh, "Electrical Machines", Pearson Education, New Delhi.[R5]Kenneth J. Ayala, 'The 8051 Microcontroller', Cengage Learning

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D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	Program Specific	Course Code	RA124PC402
Course Title	Computer Graphics for Robotics		

Prerequisites: Applied Mathematics I, Applied Mathematics II, Engineering Drawing, Computational Thinking and C- programming

Course Objectives: (Min 3)

1. To introduce students with fundamental concepts and theory of computer graphics.
2. To articulate the use of 2D and 3D interpolation methods for computer graphics.
3. To demonstrate the applications of 2D and 3D transforms for robot kinematics.
4. To present mathematical elements of important curves and surfaces.
5.

Course Outcomes: After successful completion of the course the student will be able to

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Describe the basics of different graphics systems and analytic geometry.	2	Understand
CO2	Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	3	Apply
CO3	Demonstrate the application of Bezier curves and interpolation in robot path planning	3	Apply
CO4	Apply concept of geometric algebra for modelling in robotic physics	3	Apply

Syllabus

Unit I	**Analytic geometry**	**7 hrs**
	2D analytic geometry - mathematical representation of line, conic sections, intersection of 2D lines, intersection of line and circle, 3D analytic geometry - mathematical representation of 3D line, planes, intersection of 3D lines, intersection of planes. Hidden surface removal	
Unit II	**Transforms:**	**8 hrs**
	Introduction to 2D and 3D transforms: Scaling, shear, rotation, reflection, Concept of homogenous co-ordinates, General Rotation andgeneral reflection matrix, Concatenated matrices, Application of 3D transformation to robotics: Cylindrical robot, Application of 3D transformation to robotics: Spherical robot/SCARA robot	
Unit III	**Interpolation:**	**8 hrs**
	Linear interpolation, Lagrange interpolation, Spline interpolation, Spatial	

	interpolation: Inverse distance weighted method, Nearest neighbour, Natural neighbour, Shape function, Cubic interpolation, Interpolating quaternion	
Unit IV	**Curves and Surfaces**	**8 hrs**
	Bezier curves. B- spline, 3D surfaces, Surfaces of revolution, Seep surfaces, Bezier Surface Patch, Applications of Bezier and β spline curves for robot path planning	
Unit V	**Geometric Algebra**	**8 hrs**
	Geometric products in 2D, geometric product in 3D, outer product of 3D vectors, axioms, inverse of vectors, reflection and rotation, applied geometric algebra for modelling of robotics physics	

References

1. Jon Vince, Mathematics for Computer Graphics, Springer, ISBN: : 978-1-84628-034-4
2. Chopra Rajiv, "Computer Graphics", S. Chand and Co. Pvt. Ltd., ISBN: 81-219-3581-4
3. Roger D, Adams A. J. "Mathematical elements for computer graphics", McGraw HillEducation, ISBN: 978- 0070486775
4. Davis Martin J, "Computer Graphics", Nova science Publishers, ISBN: 9781617618116

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Computer Graphics for Robotics Lab **Course Code:** RA124PC402	**L**	**T**	**P**	**Credit**
	0	**0**	**2Hrs/ Week**	**1**

Course Pre-Requisite: Applied Mathematics I, Applied Mathematics II, Engineering Drawing, Computational Thinking and C- programming

Course Description: The robots are required to perform complex motions while performing various industrial tasks.The controller of robots need co-ordinate data to move along desired path especially in case ofcontinuous motion. This subject provides methods for generating co-ordinate data for complex2D and 3D profiles. The subject is predominant to make students understand the fundamentalsof robot forward kinematics and robot simulation as well.

Course Objectives:

1. To introduce students with fundamental concepts and theory of computer graphics.
2. To articulate the use of 2D and 3D interpolation methods for computer graphics.
3. To demonstrate the applications of 2D and 3D transforms for robot kinematics.
4. To present mathematical elements of important curves and surfaces.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Describe the basics of different graphics systems and analytic geometry.	2	Understand
CO2	Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	3	Apply
CO3	Demonstrate the application of Bezier curves and interpolation in robot path planning	3	Apply
CO4	Apply concept of geometric algebra for modelling in robotic physics	3	Apply

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO 3**	**PO 4**	**PO5**	**PO 6**	**P O7**	**PO8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	2	-	-	-	-	-	-	-	-	-	1	1	1
CO2	1	2	2	-	2	-	-	-	-	-	-	1	1	1

CO3	1	2	2		2	-	-	-	-	-	-	1	1	1
CO4	1	2	2	1	2	-	-	-	-	-	-	1	1	1

Assessments :

Teacher Assessment:

One component of CCA and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
TW	25
PR	25

CCA are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- To Create 2D and 3D graphic elements **Aim and Objectives:** To Create 2D and 3D graphic elements **Outcomes:** Student will be able to: Describe the basics of different graphics systems and analytic geometry.	2 **Hrs.**
Experiment No. 2:--- Forward kinematics of planer robot using 2D transformation **Aim and Objectives:** Forward kinematics of planer robot using 2D transformation **Outcomes:** Student will be able to: Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	2 **Hrs.**
Experiment No. 3:--- Forward kinematics of articulated/SCARA robot using 2D transformation **Aim and Objectives:** Forward kinematics of articulated/SCARA robot using 2D transformation **Outcomes:** Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	2 **Hrs.**
Experiment No. 4:--- 2D curve generation: Bazier, B spline **Aim and Objectives:** 2D curve generation: Bazier, B spline **Outcomes:** Student will be able to: Demonstrate the application of Bezier curves and interpolation in robot path planning	2 **Hrs.**

Experiment No. 5:--- 3D surface generation: Surface of revolution, sweep surface **Outcomes:** **Aim and Objectives:** 3D surface generation: Surface of revolution, sweep surface **Outcomes:** Student will be able to: 1. Use of geometric transformations on graphics objects and their application in robot kinematics analysis. 2. Demonstrate the application of Bezier curves and interpolation in robot path planning	2 **Hrs.**
Experiment No. 6:--- Animations using transformations **Aim and Objectives:** Animations using transformations **Outcomes:** Student will be able to: Describe the basics of different graphics systems and transformations.	2 **Hrs.**

Textbooks:

1. Roger D, Adams A. J. "Mathematical elements for computer graphics", McGraw Hill Education, ISBN: 978- 0070486775
2. Davis Martin J, "Computer Graphics", Nova science Publishers, ISBN: 9781617618116

References:

1] Chopra Rajiv, "Computer Graphics", S. Chand and Co. Pvt. Ltd., ISBN: 81-219-3581-4

2] Davis Martin J, "Computer Graphics", Nova science Publishers, ISBN: 9781617618116

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Experiment wise Measurable students Learning Outcomes:

Assignment/ Experiment	Contents	CO-mapped
1	Creating 2D and 3D graphic elements	1
2	Forward kinematics of planer robot using 2D transformation	2
3	Forward kinematics of articulated/SCARA robot using 2D transformation	2
4	Generating Curves and Surfaces using Interpolation, 2D curve generation: Bazier, □ spline,	3
5	3D surface generation: Surface of revolution, sweep surface	2,3
6	Animations using transformations	2,3

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	**Program Specific**	**Course Code**	RA124PC402
Course Title	**Design of Machine Element**		

Teaching Scheme				Evaluation Scheme					
L	T	P	Cr	Exam	Theory Marks			Practical Marks	
					Max	Min Marks for Pass		Max	Min for Pass
2	0	0	2	CCA	50	20			
Total Hours				ESE	50	20	40	-	-
26	0	0	Total hrs: 26		100				

Prerequisites:

Course Objectives: (Min 3)

1 Define and explain various terms connected to the design of machine Elements-I like static strength, fatigue strength, Impact stresses, theories of failures, rigidity-based design, factor of safety, and stress concentration etc
2. Explain how engineering design make use of the principles learnt in science courses and identify their practical applications
3. Design and analyse problem-solving skill in design of machine elements with appropriate assumptions and correct methodology
4. Develop student's ability to understand the Stresses in threaded Fasteners under different loading conditions & Evaluate the forces, stresses, displacements and other related parameters necessary to design different springs
5. Demonstrate the ability to develop designs for different gears

Course Outcomes: After successful completion of the course the student will be able to

CO1	Understand the technique of theories of failure, stress concentration, fatigue strength etc.
CO2	Design shaft, keys, keyway, flange and coupling for specific applications
CO3	
CO4	Design machine elements like, gears, power screws, springs and other simple machine elements.
CO5	Apply the design concepts for the design of specific robotic elements

Syllabus

Unit I	Design Process: Machine Design, Traditional design methods, Basic procedure of Machine Design, Requisites of design engineer, Design of machine elements, Sources of design data, Use of standards in design, Selection of preferred sizes. Design of Simple Machine Parts: Factor of	**7 hrs**

	safety, Service factor, Design of simple machine parts, Cotter joint, Knuckle joint	
Unit II	Shafts: Design considerations in Transmission shafts with spur gear and pulley, splined Shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, ASME code for shaft design. Keys: Classification of keys, Design considerations in parallel and tapered sunk keys, Design of square, flat and Kennedy keys. Couplings: Design considerations, Classification, Design of Rigid, Muff coupling, Flange coupling and Flexible bushed pin coupling	**8 hrs**
Unit III	Power Screws: Types of screw threads, multiple threaded screws, Torque analysis with square and trapezoidal threads, Self-locking screw, Collar friction torque, Stresses in power screws, design of screw and nut, design of Screw jack.	**8 hrs**
Unit IV	Spur Gears: Classification of Gears, Selection of type of gears, Law of Gearing, Gear terminology, Standard system of gear tooth, force analysis, Interference and undercutting, number of teeth, gear tooth failures, selection of material. Specifications of spur gear, helical gear, bevel gear, worm gears (Design not included)..	**8 hrs**
Unit V	Springs and bearings Design of Helical Spring-Types, Materials, Static and Variable load Bearing -Antifriction Bearing-Types, Life of Bearing, Reliability Consideration, Selection of Ball and Roller	**8 hrs**

References

Text Books:

1. Bhandari V.B., “Design of Machine Elements”, Tata Mcgraw-hill publishing, 2020 ISBN 978-00-70-681798.
2. Machine Design by R.S Khurmi and J.K.Gupta, S.Chand Publishers, New Delhi. 2020 ISBN-13 – 8121925371-978-8121925372.
3. Mechanical Engineering Design, Joseph E Shigley and Charles R. Mischke, McGraw Hill International edition, 2003

4.Design of Machine Elements, M.F.Spotts, T.E. Shoup, L.E. Hornberger, S.R. Jayram and

C.V. Venkatesh, Pearson Education, 2006

References Books:

1. Design Data Hand Book - Mechanical Automobile -S.Md.Jalaludeen 2022 Edition
2. Design Data: Data Book of Engineers by PSG College-Kalaikathir Achchagam - Coimbatore Paperback – 15 November 2020
3. Design of Machine Elements by C.S.Sharma & Kamlesh Purohit, Prentice Hall of India Pvt. Ltd
4. C.S. Sharma and Kamlesh Purohit - Design of Machine Elements-PHI Learning Private Limited (2013)

Journal Papers:

1.https://www.sciencedirect.com/science/article/pii/.../pdf?md5...pid=1-s2.0...1
3. http://mechanicaldesign.asmedigitalcollection.asme.org/article.aspx?articleid=1451585
3. https://link.springer.com/article/10.1007/s00170-014-6152-5
4. https://eclass.upatras.gr/modules/document/file.php/MECH1178

Authors, *Title of Paper*, Name of Journal, Vol (issue), pp, Year, DOI

You Tube:

1.https://nptel.ac.in/courses/112/105/112105124

2.http://nptel.ac.in/cour ses/112105125/pdf/ Module-1_Lesson1.pdf

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	3	3	-	-	-	-	-	1	1	2	-	-

CO2	3	3	3	2	1	-	-	-	-	1	-	2	-	-
CO3	3	2	2	3	-	-	-	-	-	3	-	2	-	-
CO4	3	3	3	2	-	-	2	1	-	1	1	2	-	-
CO5	3	3	2	2	-	-	2	1	-	2	1	3	-	-

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	MDM 2	Course Code	RA124MDM402
Course Title	Mechatronics and Microcontroller		

Prerequisites:
Knowledge of basic of robotics.
Fundamentals of mathematics (linear algebra, calculus, differential equations)
Basics of programming (Python, C++, or MATLAB)
Understanding of control systems and mechatronics

Course Objectives:

5. Explain the principles of mechatronics, robotic system components, and their integration in automation and control systems.
6. Develop proficiency in microcontroller programming, interfacing, and communication protocols essential for robotic applications.
7. Analyze various sensors and actuators used in robotics, focusing on their working principles, interfacing techniques, and real-time data acquisition
8. Apply kinematic modeling, control algorithms (including PID), and trajectory planning techniques for designing robotic motion and automation systems.
9. Develop algorithms for robot motion planning and navigation.
10. Explore the integration of IoT, AI, and cloud computing with mechatronic systems to develop intelligent and connected robotic applications.

Course Outcomes: After successful completion of the course the student will be able to

		Bloom's Cognitive	
CO1	Demonstrate an understanding of mechatronic systems, robotic structures, and their role in automation and industry.	level	Descriptor
CO1	Write and implement embedded programs for microcontrollers to control robotic systems using sensors and actuators	3	Apply
CO2	Select and integrate appropriate sensors and actuators for robotic applications, ensuring efficient data processing and motion control.	3	Apply
CO3	Apply kinematic modeling, PID control, and trajectory planning techniques to develop robotic motion control systems.	3	Apply
CO4	Build and test real-world robotic applications such as line-following robots, robotic arms, and IoT-connected robotic systems.	3	Apply
CO5	Utilize simulation tools (MATLAB, ROS, Gazebo) and emerging technologies like AI and IoT for advanced robotic system design.	3	Apply

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Syllabus

Unit I	Introduction to Mechatronics & Robotics	5 hrs
	Definition & Scope of Mechatronics Components of Mechatronic Systems: Sensors, Actuators, Controllers, Interfaces Fundamentals of Robotics: Types, Applications, Degrees of Freedom (DOF)Basic Electronics Review: Ohm's Law, Kirchhoff's Laws, Circuit ComponentsIntroduction to Embedded Systems for Robotics	
Unit II	Microcontrollers	6 hrs
	Introduction to Microcontrollers: Architecture, Types (PIC, AVR, ARM, Arduino)Programming Microcontrollers: Basics of Embedded C, Python, and Arduino IDEI/O Interfacing: Digital & Analog Inputs/Outputs, PWM, ADC Communication Protocols: UART, SPI, I2C, CAN BusInterrupts & Timers for Real-Time Control	
Unit III	Sensors & Actuators	5 hrs
	Types of Sensors:Proximity Sensors (IR, Ultrasonic, LiDAR)Motion Sensors (Gyroscope, Accelerometer, IMU)Vision Sensors (Cameras, OpenCV Basics)Types of Actuators:DC Motors, Servo Motors, Stepper MotorsPneumatics & Hydraulics in RoboticsMotor Driver Circuits (L298N, H-Bridge)	
Unit IV	Robotics System Design & Control	5 hrs
	Kinematics & Dynamics of Robotics,PID Control for Motion & Stability,Trajectory Planning & Motion Control,Introduction to ROS (Robot Operating System), Simulation Tools: MATLAB, Gazebo	
Unit V	Project-Based Learning & Case Studies	5 hrs
	Microcontroller-Based Robotics Projects:Line Follower Robot,Obstacle Avoidance Robot Robotic Arm Control using Microcontroller,IoT-Based Smart Robot,Industry Case Studies: Industrial Robots, AGVs, Drones,Future Trends: AI in Robotics, Edge Computing, Swarm Robotics	

References

Mechatronics: Principles and Applications – Godfrey C. Onwubolu

- Covers fundamental mechatronics concepts, sensors, actuators, and control systems.

Introduction to Mechatronics and Measurement Systems – David G. Alciatore, Michael B. Histand

- Provides an overview of mechatronic components, interfacing, and control techniques.

Microcontroller Theory and Applications with the PIC18F – M. Rafiquzzaman

- Explains microcontroller programming, interfacing, and applications for embedded systems.

Programming Arduino: Getting Started with Sketches – Simon Monk

Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2	PS O3
CO 1	3	2	1	-	2	-	-	-	-	-	-	1	1	-
CO 2	3	3	2	2	1	-	-	-	-	-	-	2	1	1
CO 3	3	3	3	2	3	1	-	-	-	-	-	2	1	1
CO 4	2	3	3	3	3		1	-	-	-	1	3	1	1
CO 5	3	2	3	3	3	1	-	-	-	2	1	3	1	1

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	**OE2**	**Course Code**	RA124OE402
Course Title	**Financial Management and Costing**		

Prerequisites:

Course Objectives: (Min 3)

1.Understand financial management principles, goals, and tools.
2.Manage working capital and analyze fund flows.
3.Apply costing methods for material, labor, and overhead.
4.Implement budgetary control and variance analysis.

Course Outcomes: After successful completion of the course the student will be able to

CO1	Analyze financial statements and ratio performance.
CO2	Evaluate projects using capital budgeting techniques.
CO3	Manage working capital and cost of capital effectively.
CO4	Apply costing methods for accurate cost estimation.
CO5	Implement budgetary control and variance analysis for cost optimization.

Syllabus

Unit I	**Financial Management & Capital Budgeting**	**8 hrs**
	Financial function, Scope, goals and tools. Sources of finance, corporate planning and financial management. Financial Statements: Balance sheet, profit and loss account. Ratio Analysis: Classification, Ratio Analysis and its limitations. Operating and Financial Leverage. Control of Capital Expenditure, Evaluation Process-Payback approach, Accounting of Rate of Return, Present Value Method Vs Internal Rate of Return. Replacement cost and discounted cash flow.	
Unit II	**Working Capital Management**	**8 hrs**
	Concept and design of Working Capital, types of working capital, sources of working capital, time value of money, cost and capital, cost of capital. Funds Flow Analysis: Concepts, Objectives, and Techniques of Funds Flow Statement.	
Unit III	**Costing**	**8 hrs**
	Methods of costing and elements of cost. Material Cost: Different methods of pricing of issue of materials. Material losses - Wastage and its consideration. Labour Cost: Different methods wages and incentive plans. Principles of good remunerating system, labour turnover and its methods.	

	Depreciation: Concept, importance and different methods of depreciation. Estimation of material, machining and labour cost machining. Overheads: Classification, collection of overheads, Primary and Secondary apportionment of overheads, absorption of overheads. Machine hour and labour hour rate. Under and over absorption of overheads. Estimation of overheads.	
Unit IV	**Budgetary control and variance Analysis**	**8 hrs**
	Material, Labour, Overhead, Sales. Profit, Product-mix and Yield Variance. Cost control: Capital cost control-the nature of control, elements of cost control programme, project planning and scheduling, cost reporting and corrective action. Capital cost control repetitive operating cost, standard costs, cost reporting and corrective action.	
Unit V	**Types of Costing Methods**	**7 hrs**
	Concept, development & use of standard costing, Marginal Costing: Use of Marginal Costing in decision-making Activity based costing: Concept, cost drives, applications. Process costing: Concept, transfer cost, concept of by products, joint costing, scrap, waste, losses, cost of quality.	

References

Text Books:

1. N. K. Prasad, “Principles and Practice of Cost Accounting”, Syndicate Pvt. Ltd., Calcutta
2. M. Pandy, “Financial Management”, New Delhi Vikas Publication House Pvt. Ltd., ISBN 81-259-0638-X
3. M. Y. Khan, P. K. Jain, “Financial Management”, Tata McGraw Hill Publishing Ltd.
4. B. K. Bhar, “Cost Accounting Methods and Problems”, Academic Publishers, Calcutta

References Books:

1. Henry M. Steiner, “Engineering Economics Principles”, McGraw Hill Publication.
2. C.B. Gupta, “Fundamentals of Business”, Sultan Chand & Co.,
3. P. A. Samualson, “Economics”, McGraw Hill International.
4. K. K. Dewett, “Modem Economic Theory”, Sultan Chand & Co., ISBN 81-219-0331-1
5. Colin Drury, “Management and Cost Accounting”, English Language Book Society, Chapman & Hall London.

Scheme for Examination

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Component	Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Total	Pass
CCA	Faculty	5	5	5	5	5	25	20
	Department	UT1		UT2			25	
		5	5	5	5	5		
ESE	Institute	10	10	10	10	10	50	20

CCA: Continuous Comprehensive Assessment (CCA), ESE: End Semester Examination, UT: Unit Test

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Robot Operating System	**L**	**T**	**P**	**Credit**
Course Code: RA124CSEC403	**1**		**2**	**2**

Course Pre-Requisite: python or C++

Course Description: The Robot Operating System (ROS) offers a set of libraries and tools designed to assist software developers in creating robotic applications. It provides features such as hardware abstraction, device drivers, libraries, visualization tools, message passing, and package management. ROS is widely used in some of the most advanced and innovative robots today. With a strong developer community and robust support for integrating ROS with various robotic systems, it has become an ideal choice for a wide range of industrial applications.

Course Objectives:

1.To introduce students with the fundamental concepts and principles of robotic automation.

2. To explain the use of various devices connected to robotic modules.

3. To demonstrate an understanding of various types of robotic applications.

4. To apply and analyze industry-based projects and advanced learning.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Demonstrate the execution of Robot Operating System (ROS) commands.	3	Apply
CO2	Integrate the robot with embedded systems.	3	Apply
CO3	Develop and simulate robotic applications.	3	Apply

CO-PO Mapping:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	2	2		3			2			3	2	2	2
CO 2	3	3	3	2	3	2		3	2	2	3	3	3	2
CO 3	3	3	3	3	3	2		3	3	3	3	3	3	2

Assessments :

Teacher Assessment:

Two components of CCA, One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
CCA	10
CCA	30
CCA	10
ESE	50

CCA are based on assignment/declared test/quiz/seminar/Group Discussions etc.

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:-Introduction to ROS Definition and purpose as a meta-operating system,Objectives of ROS, Components of ROS, ROS Ecosystem, History and Evolution, Ros Terminology , Message Communication, Coordinate Transformation, File system, Build System. **Contents in ROS** Basics of Ubuntu, Ros Command list, Ros shell commands, Ros execution commands ,Ros Information commands, Roscommands, Ros package commands,Tools:3D Visualisation Tool (Rviz) , Ros GUI development Tool (rqt): Installing and Running rqt ,rqt Plugins ,rqt_graph ,rqt_plot	**5 Hrs.**
Unit 2:- ROS Embedded system OpenCR: Characteristics, Board Specification, Establish Development Environment, basics of serial communication, python/c++ and serial communication, TurtleBot3 Firmware: Hardware, Software, Development environment, Remote Control,Simulation using RViz.	**4Hrs.**
Unit 3:-Manipulator, Navigation and Slam Introduction, Manipulator Structure and Control, Manipulator and ROS, Gazebo Setting, Gazebo Simulation Applying to the Actual Platform, Navigation and Components, Navigation of Mobile Robot, Robot hardware Constraints for SLAM, Measured Target	**4 Hrs.**

Environment of SLAM,ROS Packages for SLAM, Execute SLAM,SLAM Application	

Textbooks:

1. "ROS Robotics Projects" by RamkumarGandhinathan
2. "Learning ROS for Robotics Programming" by Aaron Martinez and Enrique Fernández
3. Concise Introduction to Robot Programming with ROS2 by Francisco Martin Rico

1. **References:**
2. Programming Robots with ROS_ A Practical Introduction to the Robot Operating System (PDF Drive)
3. Jason M. O'Kane, A Gentle Introduction to ROS, independently published, ISBN 9781492143239

4. C. Fairchild, T. L. Harman, "ROS Robotics by Example" Pakt Publishing, ISBN: 9781785286704
5. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners", Apress Publication, ISBN: 9781484234044.

Unit wise Measurable students Learning Outcomes:

1. Demonstrate proficiency in executing ROS commands, managing ROS packages, and utilizing essential tools like Rviz and rqt.

2. Describe the characteristics and specifications of OpenCR and establish a ROS development environment for embedded systems.

3. Simulate and control a robotic manipulator using Gazebo and ROS.

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Robot Operating System	**L**	**T**	**P**	**Credit**
Course Code: RA124CSEC403	**1**	**0**	**2**	**2**

Course Pre-Requisite:C++ / Python

Course Description: The Robot Operating System (ROS) offers a set of libraries and tools designed to assist software developers in creating robotic applications. It provides features such as hardware abstraction, device drivers, libraries, visualization tools, message passing, and package management. ROS is widely used in some of the most advanced and innovative robots today. With a strong developer community and robust support for integrating ROS with various robotic systems, it has become an ideal choice for a wide range of industrial applications.

Course Objectives:

1. To Introduce students with the fundamental concepts and principles of robotic automation.
2. To explain the use of various devices connected to robotic modules.
3. To demonstrate an understanding of various types of robotic applications.
4. To apply and analyze industry-based projects and advanced learning.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Demonstrate the execution of Robot Operating System (ROS) commands.	3	Apply
CO2	Demonstrate the execution of Robot Operating System (ROS) commands.	3	Apply
CO3	Develop and simulate robotic applications.	3	Apply
CO4	Write a program to implement G-mapping for a robot.	3	Apply
CO5	Integrate the robot with embedded systems.	3	Apply
CO6	To understand the principles and operations of industrial robots in production lines.	3	Apply

CO-PO Mapping:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	2	2		3			2			3	2	2	2
CO 2	3	2	2		3			2			3	2	2	2
CO 3	3	3	3	3	3	2		2	2	2	3	3	3	2
CO 4	3	3	3	3	3	2		2	2	2	3	3	3	2

CO 5	3	2	3	2	3	2		3	3	3	3	3	3	2
CO 6	3	2	3	2	3	3	2	3	3	3	3	3	2	2

Assessments :

Teacher Assessment:

One component of CCA and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
CCA	50
ESE	50

CCA are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:- ROS Essentials: Introduction to ROS Topics, Services, Actions and Nodes. 2**Hrs.**

Aim:

To understand and implement the fundamental concepts of ROS, including Topics, Services, Actions, and Nodes, and explore their roles in enabling communication and task execution in robotic systems.

Objectives:

1. To gain theoretical knowledge of the architecture and communication framework of ROS.
2. To learn how to create and manage ROS nodes, topics, services, and actions.
3. To analyze the interplay between ROS components in a robotic system.
4. To develop hands-on experience with implementing ROS functionalities in a simulated or physical environment.

To evaluate the performance and efficiency of communication protocols in ROS

Outcomes:

1. Proficient understanding of ROS communication paradigms: Topics, Services, and Actions.

2. Ability to create and manage ROS nodes for robot control and data exchange.

Theoretical Background:

- Overview of ROS architecture and its communication framework.
- Definition and roles of Topics, Services, Actions, and Nodes.
- Communication flow in ROS: Publisher-Subscriber, Client-Server, and Action protocols.
- Real-world examples of implementing ROS in robotic systems.

Experimentation:

1. **Environment Setup:**
   - Install and configure ROS on a compatible system.
2. **Creating and Testing Nodes:**
   - Write Python or C++ scripts to create Publisher and Subscriber nodes.
   - Test inter-node communication using custom messages.
3. **Exploring Services and Actions:**
   - Develop a ROS Service and test it using a Client.
   - Implement Actions for asynchronous task execution.
4. **Simulation:**
   - Use Rviz or Gazebo to simulate and visualize communication between nodes.

Results and Discussions:

- Analyze the behavior of Topics, Services, and Actions in the implemented system.
- Evaluate the communication latency and reliability between nodes.
- Discuss challenges faced during implementation and potential solutions.
- Compare the use cases of Topics, Services, and Actions in different scenarios.

Conclusion:

This study provided a comprehensive understanding of ROS communication mechanisms and their implementation. By exploring Topics, Services, Actions, and Nodes, students gained the theoretical and practical expertise needed to build efficient and robust robotic systems. Future work may involve applying these concepts to more complex robotic platforms and real-world applications.

Experiment No. 2:- Simple interaction with the course simulation environment and Nodes.
 	
Aim:
 	
To familiarize students with the course simulation environment and enable basic interaction with simulated robotic systems using fundamental ROS commands and tools.
 	
Objectives:
 	
1. To understand the setup and features of the simulation environment.
2. To learn how to use tools like Rviz, Gazebo, and rqt for robot visualization and control.
3. To perform simple tasks such as moving a robot or simulating sensor data.
4. To establish a foundation for more complex robotic simulations and programming.
 	
Outcomes:
 	
1. Basic understanding of the course simulation environment and its functionalities.
2. Proficiency in using ROS-based simulation tools like Rviz, Gazebo, and rqt.
3. Ability to interact with and control a simulated robot.
4. Skills to debug and analyze robot behavior in a virtual environment.
 	
Theoretical Background:
 	
• Introduction to simulation environments in robotics.
• Overview of ROS-based tools:
  ○ **Rviz:** For 3D visualization of robots, sensor data, and environments.
  ○ **Gazebo:** For dynamic robot simulation with realistic physics.
  ○ **rqt:** For GUI-based monitoring and control of ROS systems.
• Understanding how simulations mimic real-world robotic scenarios.
 	
Experimentation:
 	
1. **Setup the Simulation Environment:**
  ○ Install necessary ROS packages for Rviz, Gazebo, and rqt.
  ○ Launch the course-provided simulation workspace.
2. **Simple Robot Interaction:**
  ○ Use ROS commands to launch a robot model in the simulation.
	2 **Hrs.**

o Move the robot using basic publisher-subscriber commands. o Visualize sensor data (e.g., lidar or camera) in Rviz. 3. **GUI Exploration:** o Utilize rqt plugins to monitor and control robot parameters. o Create simple visualizations of robot movements and data streams. **Results and Discussions:** • Summarize the interaction process and the steps involved. • Analyze how the simulation environment mimics real-world scenarios. • Discuss the accuracy of sensor data and robot movement in the simulation. • Highlight any challenges faced during setup or interaction and solutions to overcome them. **Conclusion:** This exercise provided a hands-on introduction to the course simulation environment. Students learned to interact with simulated robots and tools, gaining practical experience that serves as a stepping stone to more complex simulations and real-world applications. Future activities will build upon these skills to explore advanced robotic behaviors and programming.	
Experiment No. 3:- Building Robot Environment: Using URDF and ROS Simulation Tools **Aim:** To construct a software representation of a robot using the Unified Robot Description Format (URDF), configure it through the ROS parameter server, and enhance the simulation environment by integrating real-world object representations. **Objectives:** 1. To understand the structure and purpose of URDF for robot modeling. 2. To create a digital representation of a robot using URDF files. 3. To configure robot parameters using the ROS parameter server. 4. To incorporate real-world objects into the simulation environment for realistic scenarios. 5. To validate the robot's interaction with its virtual environment.	2 **Hrs.**

Outcomes:

1. Proficiency in designing robot models using URDF.
2. Knowledge of configuring and retrieving robot parameters via the ROS parameter server.
3. Skills to add and manipulate objects in a simulation environment.
4. Ability to create a realistic and interactive robot simulation.

Theoretical Background:

- **Unified Robot Description Format (URDF):**
  - XML-based format for defining robot models, including links, joints, and physical properties (mass, inertia, geometry).
  - Hierarchical representation of robot structures.
- **ROS Parameter Server:**
  - A centralized storage for configuration parameters in ROS.
  - Accessing and modifying robot parameters during runtime.
- **Simulation Environment:**
  - Adding objects like walls, obstacles, or furniture to mimic real-world environments.
  - Tools like Rviz and Gazebo for visualization and physics-based simulations.

Experimentation:

1. **URDF Creation:**
   - Define a robot model with links, joints, and sensors using URDF.
   - Visualize the model in Rviz to ensure accuracy.
2. **Parameter Configuration:**
   - Set up the ROS parameter server to store and retrieve robot-specific parameters (e.g., joint limits, sensor configurations).
   - Test dynamic parameter updates during simulation.
3. **Environment Enhancement:**
   - Add real-world objects (e.g., tables, doors) to the Gazebo simulation environment.
   - Test object interactions with the robot, such as navigation around obstacles.
4. **Simulation Validation:**
   - Launch the robot model in the enhanced environment.
   - Validate motion control, sensor outputs, and environmental interactions.

Results and Discussions:

• **Robot Model:** Successfully created and visualized using URDF. • **Parameter Management:** Demonstrated dynamic configuration of robot settings using the ROS parameter server. • **Environment Integration:** Real-world objects were added and interacted with appropriately in the simulation. • **Challenges and Solutions:** Discussed issues encountered (e.g., model inaccuracies or collision detection) and methods for resolving them. **Conclusion:** This exercise enabled students to build and simulate a robot environment effectively using URDF and ROS tools. By integrating real-world object representations, students gained practical experience in creating realistic simulations that are essential for testing robotic applications. These skills will support future work in advanced robot design and deployment in complex environments.	
Experiment No. 4:- Autonomous Navigation: Map creation with G Mapping package, autonomously navigate a known map with ROS navigation. **Aim:** To create a map of an environment using the GMapping package and enable a robot to autonomously navigate within the mapped area using the ROS navigation stack. **Objectives:** 1. To understand the principles of SLAM (Simultaneous Localization and Mapping) for map creation. 2. To learn the use of the GMapping package for building a map from sensor data. 3. To configure and utilize the ROS navigation stack for path planning and obstacle avoidance. 4. To achieve autonomous navigation of a robot within a known map. 5. To evaluate the robot's navigation accuracy and efficiency in a simulated or real-world environment. **Outcomes:** 1. Practical knowledge of creating maps using the GMapping package.	2 **Hrs.**

2. Proficiency in configuring the ROS navigation stack for autonomous navigation.
3. Ability to implement SLAM techniques and use sensor data effectively.
4. Hands-on experience in planning and executing robot navigation tasks.
5. Skills to troubleshoot and optimize navigation performance.

Theoretical Background:

- **Simultaneous Localization and Mapping (SLAM):**
  - An overview of SLAM algorithms and their role in autonomous robotics.
  - Integration of laser scans or sensor data to build accurate maps.
- **GMapping Package:**
  - A ROS package based on the particle filter algorithm for 2D SLAM.
  - Key parameters and configurations for effective map building.
- **ROS Navigation Stack:**
  - Components: Map Server, Costmap, AMCL (Adaptive Monte Carlo Localization), and Path Planner.
  - Principles of path planning, localization, and obstacle avoidance.

Experimentation:

1. **Map Creation Using GMapping:**
   - Setup the GMapping package and configure sensor inputs (e.g., lidar).
   - Drive the robot manually or autonomously to collect data and generate a 2D map.
   - Save the created map for future navigation tasks.
2. **Navigation Stack Configuration:**
   - Load the generated map into the ROS map server.
   - Configure AMCL for localization and costmaps for obstacle avoidance.
3. **Autonomous Navigation:**
   - Set navigation goals within the mapped environment.
   - Use the ROS navigation stack to plan and execute paths.
   - Observe the robot's behavior in avoiding obstacles and reaching targets.
4. **Simulation or Real-world Testing:**
   - Validate navigation in a simulated Gazebo environment or a physical test area.

Results and Discussions:

• **Map Creation:** Successfully generated an accurate 2D map using GMapping. • **Navigation Performance:** The robot autonomously navigated to assigned goals while avoiding obstacles. • **Analysis:** Discussed navigation accuracy, obstacles encountered, and areas for improvement. • **Challenges:** Highlighted challenges such as sensor noise, localization drift, or map inaccuracies, along with potential solutions. **Conclusion:** This exercise provided an in-depth understanding of autonomous navigation using ROS. Students successfully created maps with GMapping and utilized the ROS navigation stack for path planning and execution. These skills are crucial for designing and implementing autonomous robots in real-world applications, such as delivery or inspection tasks. Further exploration could involve optimizing SLAM parameters or integrating 3D mapping for more complex environments.	
Experiment No. 5:- Manipulation: Motion planning, pick and place behaviors using industrial robots with ROS Move It **Aim:** To implement motion planning and pick-and-place operations using industrial robots with the ROS MoveIt framework, enabling precise and efficient robotic manipulation. **Objectives:** 1. To understand the fundamentals of motion planning for robotic manipulators. 2. To learn the configuration and application of the ROS MoveIt framework. 3. To program and simulate pick-and-place tasks for industrial robots. 4. To evaluate the performance of motion planning algorithms in handling dynamic environments. 5. To gain hands-on experience with integrating sensors and actuators for manipulation tasks.	2**Hrs.**

Outcomes:

1. Proficiency in using the MoveIt framework for motion planning and control.
2. Capability to configure and simulate pick-and-place tasks with industrial robots.
3. Understanding of kinematics and path planning for robotic arms.
4. Ability to troubleshoot and optimize robotic manipulation processes.
5. Practical insights into applying industrial robotic solutions in manufacturing and automation.

Theoretical Background:

- **Motion Planning:**
  - Concepts of inverse kinematics, path planning, and trajectory generation.
  - Algorithms such as RRT (Rapidly-Exploring Random Tree) and PRM (Probabilistic Roadmap).
- **ROS MoveIt Framework:**
  - Overview of MoveIt components: Motion Planning, Planning Groups, and Visualization.
  - MoveIt Setup Assistant for configuring robotic manipulators.
  - Integration with Gazebo for simulation and Rviz for visualization.
- **Pick-and-Place Behaviors:**
  - Workflow for picking objects, planning paths, and placing them in desired locations.
  - Use of grippers and end-effectors in manipulation tasks.

Experimentation:

1. **Robot Model Configuration:**
   - Load an industrial robot URDF model into the MoveIt Setup Assistant.
   - Configure planning groups, end-effectors, and virtual joints.
2. **Motion Planning:**
   - Use the MoveIt motion planning pipeline to plan and execute robot arm movements.
   - Visualize motion paths in Rviz and simulate in Gazebo.
3. **Pick-and-Place Task Implementation:**
   - Program pick-and-place tasks using MoveIt APIs.
   - Simulate object grasping using a gripper model or virtual sensors.
   - Test object placement at specified coordinates.
4. **Dynamic Environment Handling:**

o Introduce obstacles to the environment and evaluate the robot's ability to re-plan paths. 5. **Performance Evaluation:** o Measure precision, speed, and success rate of pick-and-place operations. **Results and Discussions:** • **Motion Planning Results:** Demonstrated successful path planning and execution for industrial robots. • **Pick-and-Place Behaviors:** Completed object manipulation tasks with high accuracy. • **Challenges and Solutions:** Addressed issues like collision avoidance, sensor noise, and gripper accuracy through parameter tuning and algorithm refinement. • **Performance Metrics:** Evaluated efficiency and adaptability of motion planning in dynamic scenarios. **Conclusion:** This exercise provided a practical understanding of robotic manipulation using ROS MoveIt. Students successfully implemented motion planning and pick-and-place behaviors, simulating industrial scenarios. These skills are critical for developing advanced robotic systems for automation tasks. Future work may include integrating real-world sensors, improving gripper control, and optimizing algorithms for complex manipulation challenges.	
Experiment No. 6:- Mini Project: Building production line application with industrial robot **Aim:** To design and develop a production line application incorporating an industrial robot to perform automated tasks, improving efficiency, precision, and repeatability in a manufacturing process. **Objectives:** • To understand the principles and operations of industrial robots in production lines.	2 **Hrs.**

- To integrate robotic systems with other production components.
- To automate specific tasks such as material handling, assembly, or packaging.
- To analyze the performance improvements in production efficiency and quality.

Outcomes:

- Successful design and implementation of a production line model using an industrial robot.
- Demonstration of enhanced productivity and reduced manual intervention.
- Ability to troubleshoot and optimize robotic operations within a production line.
- Gained hands-on experience in programming and operating industrial robots.

Theoretical Background:

Industrial robots are automated, programmable machines capable of performing a variety of tasks with high precision and speed. These robots are extensively used in manufacturing processes such as welding, material handling, assembly, and packaging. A typical industrial robot consists of mechanical arms, actuators, sensors, controllers, and software interfaces.

Key Components:

- **Mechanical Arm:** Provides physical movement and flexibility.
- **Actuators:** Drive the robot's movements.
- **Sensors:** Provide environmental feedback.
- **Controller:** Serves as the robot's brain, executing programmed instructions.

Benefits of Industrial Robots:

- Increased production efficiency.
- High precision and consistency.
- Reduction in labor costs.
- Enhanced workplace safety by performing hazardous tasks.

Theoretical Background:

Production lines in industrial settings often require repetitive tasks that are prone to human error. Automating these tasks using industrial robots improves both

productivity and consistency. The integration of sensors and controllers allows robots to adapt to dynamic environments and maintain high operational accuracy.

The automation process can be divided into three primary stages:

1. **Design:** Determining tasks for automation and selecting appropriate robots.
2. **Programming:** Writing code to control robotic movements and interactions.
3. **Implementation:** Installing and testing the robot within the production environment.

Experimentation:

Materials Required:

- Industrial robot (e.g., 6-axis robotic arm)
- Conveyor belt system
- Sensors (proximity, vision)
- Programmable Logic Controller (PLC)
- Software tools for robot programming (e.g., RoboDK, ABB RobotStudio)

Procedure:

1. **Setup:** Install the robotic arm on the production line alongside the conveyor belt.
2. **Task Definition:** Identify specific tasks such as pick-and-place or assembly operations.
3. **Programming:** Write and upload control programs to the robot's controller.
4. **Sensor Integration:** Connect sensors to provide environmental feedback.
5. **Testing:** Run the production line and fine-tune robot parameters.
6. **Data Collection:** Measure task completion time, error rate, and productivity.

Results and Discussions:

The industrial robot successfully automated the predefined tasks, leading to a noticeable improvement in task efficiency and precision. Key findings include:

- **Efficiency Improvement:** Production time per unit decreased by 20%.

- **Error Reduction:** Manual errors were completely eliminated.
- **Consistency:** The robot maintained consistent quality throughout the experiment.

Challenges Faced:

- Initial calibration and programming required significant effort.
- Sensor integration posed compatibility issues.
- Minor delays due to unforeseen software bugs.

Conclusion:

The experiment demonstrated the feasibility and benefits of using industrial robots in a production line. The project highlighted key advantages such as enhanced efficiency, reduced human intervention, and improved task precision. Future work may focus on further automation enhancements and integration of machine learning for adaptive robotic behavior.

Textbooks:

1. "ROS Robotics Projects" by Ramkumar Gandhinathan
2. "Learning ROS for Robotics Programming" by Aaron Martinez and Enrique Fernández

References:

1. Programming Robots with ROS_ A Practical Introduction to the Robot Operating System (PDFDrive)
2. Jason M. O'Kane, A Gentle Introduction to ROS, independently published, ISBN 9781492143239
3. C. Fairchild, T. L. Harman, "ROS Robotics by Example" Pakt Publishing, ISBN: 9781785286704
4. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners", Apress Publication, ISBN:9781484234044.

Experiment wise Measurable students Learning Outcomes:

1 Demonstrate an understanding of fundamental ROS concepts, including topics, services, actions, and nodes.

2 Execute basic communication between nodes and verify system responses in a simulated environment.

3.Develop robot models using URDF and simulate them in ROS-supported simulation tools.

4. Implement autonomous navigation strategies on a pre-mapped environment using ROS navigation packages.

5. Design and execute motion planning for robotic arms using ROS MoveIt.

6. Integrate robot models, motion planning, and navigation in a production line simulation

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)
Course Code: HSM2401P01, Course Title: Soft Skills: Workplace and Life Readiness
Category: Ability Enhancement Course

Prerequisites: Basic English Grammar Skills
Course Objective: Purposes of Course are:
5. This course is designed to equip students with essential professional and technical communication skills necessary for success in the modern workplace. 6. Emphasizing both written and verbal communication 7. The course covers a wide range of topics, including effective written communication, active listening and public speaking.

Course Outcomes: After Successful completion of course units, students will	
CO1	Express effectively through verbal or oral communication and Write precise briefs, essays, summaries or reports and technical documents for official communication.
CO2	Students will understands ethics and values for being a good professional
CO3	Learn to work in a heterogeneous and multidisciplinary teams and handle conflicting situations in corporate world
CO4	Students will develop their leadership qualities for being a successful professional
CO5	Students will be able to constructively participate in group discussion, meetings, prepare and deliver presentations

Syllabus

Unit I	**Self-Introduction & SWOC Analysis**	**02 Hrs.**
Difference between hard skills and Soft skills, Introduction of SWOC Analysis, Importance of Soft Skills in corporate setting, Formal / Informal self-introduction, goal setting, and how to maintain your attitude towards various circumstances. Applications of SWOC in domain specific Industry		
Unit II	**Writing Skills**	**02Hrs.**

Practicing and understanding various formats of writing skills. Discussion on types of reports, various formats of report writing. Understanding Email etiquette and types of email. Writing emails on different topics. Practicing resume writing and its various formats. Types of application and how to write them.

Unit III	**Professionalism & Ethics**	**03 Hrs.**

Understanding ethics and morals, Importance of Professional Ethics, hindrances due to absence of Work ethics, Professional etiquette – Introductions, with colleagues, attire, events, dinning, telephone, travelling, netiquette, social media, writing. Stress as integral part of life, Identifying signs and sources of stress, Steps to cope with stress – open communication, positive thinking, Belief in oneself, ability to handle failure, Retrospective thinking for future learning, Organizing skills to enhance time management, Focusing on goals, smart work vs hard work, Prioritizing activities, Perils of procrastination, Daily evaluation of "to-do" list. Case studies about development of ethics

Unit IV	**Group Discussion & Personal Interview**	**03 Hrs.**

Introduction to Group Discussion, Difference between Group Discussion and debate, Etiquettes while conducting Group Discussion, Professional Phases to be used in Group Discussion, handling complexities in GD, Understanding types of Interview, Grooming and etiquette while giving an Interview, Understanding Job Description and Studying Company Profile, Strategies and techniques to ace the interview.

Unit V	**Interpersonal & Intrapersonal Skills**	**03 Hrs.**

Differences of interpersonal and interpersonal skills, Introduction of team building, Introduction to leadership and types of Leadership, Identifying your weakness and focussing on your strength to become a good leader, Introduction to Presentation Skills, 5P's of Presentation, Types of Presentation

	Practical/ Lab Sessions	
Lab Session	**Activities**	**Duration (Hrs.)**
1	Speaking Skills- Self Introduction: Introduce your friend	2
2	Team Building Activity	2

3	How to study job description and company profile : "Job Detective"	2
4	Grooming and image management	2
5	Speaking Skills- JAM Session	2
6	Speaking Skills- Debate session	2
7	Group Discussion	2
8	Group Discussion	2
9	Case study analysis : Problem solving and critical thinking : "The Problem-Solvers' Challenge"	2
10	Presentation Skills	2
11	Presentation Skills	2
12	Personal Interview – Conducting of mock interview	2
13	Personal Interview – Conducting of mock interview	2

Reference Books

1. Indrajit Bhattacharya, "An Approach to Communication Skills", Dhanpat Rai.
2. Simon Sweeney, "English for Business Communication", Cambridge University Press.
3. Sanjay Kumar and Pushpa Lata, "Communication Skills", Oxford University Press.
4. Atkinson and Hilgard's, "Introduction to Psychology", 14th Edition.
5. Kenneth G. Mcgee, "Heads Up: How to Anticipate Business Surprises & Seize Opportunities First", Harvard Business School Press, Boston, Massachusetts.
6. R. Gajendra Singh Chauhan and Sangeeta Sharma, "Soft Skills-An integrated approach to maximize personality", Wiley Publication, ISBN: 987-81-265-5639-7

MOOC / NPTEL Courses:

1. NPTEL Course "Developing Soft skills & Personality" https://nptel.ac.in/courses/109/104/109104107/
2. NPTEL Course "Communication Skills" https://nptel.ac.in/courses/109/104/109104030/
3. NPTEL Course "Effective Writing" https://nptel.ac.in/courses/109/107/109107172/

4. NPTEL Course "Interpersonal Skills"
   https://nptel.ac.in/courses/109/107/109107155/

Marking Scheme for Evaluation

Marking Scheme for ISE (100)		
No	**Component**	**Marks**
1	Assignment 6 Assignments*5 Marks each = 30Marks	30
2	Quiz - Pre & Post Diagnostic Test-15 Marks Quiz on Unit 1 & 2 -15 Marks	30
3	Micro Project: Content creation- 15 Marks Presentation of the Report-15 Marks	30
4	Participation in Teaching Learning Process	10
	Total Marks:	**100**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	0	0	0	0	0	0	1	3	0	2
CO2	0	2	0	0	0	0	3	1	0	0	2
CO3	0	0	2	0	0	1	3	3	1	3	2
CO4	0	0	0	2	0	0	3	1	0	2	2
CO5	0	0	0	0	2	0	2	2	1	1	3

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Title: Entrepreneurship/ Economics and Management 2 **Course Code: RA124EEM402**

Prerequisites:	
Course Objectives:	
• To introduce students to technology commercialization and the startup ecosystem. • To explore digital transformation, smart manufacturing, and cybersecurity in robotics and automation. • To understand the impact of human-machine interaction and workforce management in automated industries.	
Course Outcomes: After successful completion of the course the student will be able to	
CO1	Analyze the process of technology commercialization and the startup ecosystem.
CO2	Understand digital transformation, Industry 4.0, and cybersecurity in automation.
CO3	Evaluate the impact of automation on employment, team leadership, and workplace ethics.

Syllabus

Unit I	**Technology Commercialization & Startup Ecosystem**	**9 hrs**
Technology Transfer & Commercialization: Converting research innovations into market-ready products. Incubation & Accelerator Programs: Support systems for tech startups, case studies of robotics incubators. Entrepreneurial Challenges in Automation: Market adaptation, funding hurdles, scaling a robotics business.		
Unit II	**Digital Transformation & Smart Manufacturing**	**9 hrs**
IoT & Industry 4.0 in Manufacturing: Smart factories, digital twins, predictive maintenance. AI & Machine Learning in Business Decisions: Data-driven decision-making for entrepreneurs. Cybersecurity & Data Protection: Security risks in automated industries, blockchain applications.		
Unit III	**Human-Machine Interaction & Workforce Management**	**8 hrs**
Impact of Automation on Employment: Workforce shifts, upskilling, job creation vs. displacement. Leadership & Team Management in Tech Startups: Building and managing high-performing teams. Workplace Ethics & Safety in Robotics Industry: Ethical AI, worker safety in human-robot collaboration.		

Reference Books

6. Peter F. Drucker, "Innovation and Entrepreneurship," Harper Business.
7. B.J. Harrison, "Engineering Economy," Pearson.
8. Philip Kotler, "Marketing Management," Pearson Education.
9. Charles Fine, "Clockspeed: Winning Industry Control in the Age of Temporary Advantage," Basic Books.
10. Michael E. Porter, "Competitive Strategy," Free Press.

D Y Patil College of Engineering, Akurdi, Pune

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)
Scheme for Examination

Component	Level	Unit I	Unit II	Unit III	Total	Pass
CCA	Faculty	8	8	9	25	20
	Department	UT1		UT2	25	
		8	9	8		
ESE	Institute	17	17	18	50	20

CO-PO Mapping

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

3: High, 2: Moderate, 1: Low, 0/-: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Course Category	VEC-2	Course Code	
Course Title	Sustainable Development - 2		

Teaching Scheme				Evaluation Scheme				
					Theory Marks		Practical Marks	
L	T	P	Cr	Exam	Max	Min Marks for Pass	Max	Min for Pass
2	0	0	2	CCA	100	40	-	-
Total Hours								
26	0	0	Total hrs: 26					

Prerequisites:

None

Subjects Included:

Universal Human Values (UHV) 3 units

Constitution of India 1 unit

Corporate Laws 1 unit

Course Objectives: (Min 3)

Understand Universal Human Values (UHV) – Develop ethical, moral, and professional values in students.

Apply UHV in Personal and Professional Life – Explore human relationships, harmony, and responsible behavior.

Develop Ethical Decision-Making Skills – Analyze real-life scenarios and case studies to build decision-making abilities.

Study Constitutional Rights and Duties – Understand fundamental rights, directive principles, and governance structure.

Understand Corporate Laws – Explore the regulatory framework governing businesses and corporate ethics.

1.

Course Outcomes: After successful completion of the course the student will be able to

CO1	**DEFINE** the fundamental concepts of Universal Human Values (UHV).
CO2	**EXPLAIN** the significance of ethical values and human relationships in society.
CO3	**ANALYZE** ethical dilemmas and decision-making frameworks in professional contexts.

CO4	**DESCRIBE** the fundamental rights, duties, and governance structure of India.
CO5	**UNDERSTAND** key aspects of corporate laws and ethical business practices.

Syllabus

Unit I	**Introduction to Universal Human Values (UHV)**	**6 hrs**
	Meaning and importance of UHV, ethical values, role in personal and professional life, self-exploration.	
Unit II	**Human Relationships & Harmony**	**6 hrs**
	Role of relationships in family, society, and workplace; conflict resolution; social responsibility; sustainability in human interactions.	
Unit III	**Ethical Decision-Making**	**6 hrs**
	Case studies on ethical dilemmas, corporate ethics, moral reasoning, frameworks for ethical decision-making.	
Unit IV	**Constitution of India**	**4 hrs**
	Fundamental rights and duties, directive principles, governance structure, significance of constitutional amendments, case laws.	
Unit V	**Corporate Laws & Business Ethics**	**4 hrs**
	Overview of business laws, corporate governance, ethical leadership, corporate social responsibility (CSR), impact of regulations on industries.	

Scheme for Examination

Component	Parameters	Marks	Total	Pass
CCA	Viva Voce for assessment of Understanding	20	50	20
	Involvement, Participation, and Engagement	10		
	Quality of Submission of Report	10		
	Attendance	10		
End Evaluation	Performance (Internal)	25	50	20
	Oral Examination (Internal)	25		

CCA: Continuous Comprehensive Assessment (CCA)

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B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3

3: High, 2: Moderate, 1: Low, 0: No Mapping

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

Title of the Course: Robot Software Simulation	**L**	**T**	**P**	**Credit**
Course Code: NCMC4	**0**	**0**	**2**	**2**

Course Pre-Requisite:C++ / Python, Fundamental knowledge of industrial robotics and automation

Course Description: This course provides hands-on experience with industrial robotics simulation and programming. Students will learn to analyze and implement forward and inverse kinematics, trajectory planning, vision-based automation, and offline programming using tools like RoboAnalyzer, RoboDK, MATLAB, and OpenCV. The course bridges theoretical concepts with practical applications, enabling students to work on real-world robotic automation projects.

Course Objectives:

1. To Introduce students with the fundamental concepts and principles of robotic automation.
2. To explain the use of various devices connected to robotic modules.
3. To demonstrate an understanding of various types of robotic applications.
4. To apply and analyze industry-based projects and advanced learning.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Apply forward and inverse kinematics to industrial robots and validate results using simulation tools.	3	Apply
CO2	Analyze and develop robot programs using industrial robot programming languages like RAPID, KRL, or MELFA	4	Analyze
CO3	Implement vision-based object detection and integrate it with robotic motion.	3	Apply
CO4	Design and optimize robotic trajectories for industrial tasks using RoboDK.	5	Evaluate
CO5	Develop offline robot programs and generate executable code for industrial applications.	6	Create

CO-PO Mapping:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	2	-	2	2	1	-	-	1	-	1	1	-	-
CO 2	3	-	3	-	2	-	1	2	-	3	-	-	2	-
CO 3	2	3	3	3	2	2	3		2	2	2	-	-	2
CO 4	3	-	3	3	-	2	-	3	-	2	2	-	-	3
CO 5	3	2	-	3	2	--	3	3	-	-	3	-	1	-

Assessments :

Teacher Assessment:

Based on Continuous Comprehensive Assessment (CCA)

Assessment	Marks
CCA	50

CCA: Assessment is based on oral examination

Course Contents:

Forward Kinematics of an Industrial Robot **Objective:** • To understand and validate the forward kinematics of a robotic arm using RoboAnalyzer. **Tools Required:** • RoboAnalyzer software • MATLAB or equivalent simulation tool **Procedure**: 1. Select an industrial robot model (e.g., KUKA, ABB, FANUC). 2. Identify and define the DH parameters of the robot. 3. Implement forward kinematics equations using RoboAnalyzer. 4. Simulate the robot's movement to visualize the transformation of coordinate frames. 5. Compare the simulation results with theoretical calculations. **Expected Outcome:** Students will be able to compute and validate the forward kinematics of an industrial robot	2 **Hrs.**
Experiment No. 2:- Inverse Kinematics of an Industrial Robot **Objective:** To compute and validate the inverse kinematics of a robotic arm using MATLAB or an open-source tool. **Tools Required:** MATLAB / Open-source software (e.g., Python with sympy, OpenRAVE) **Procedure:** 1. Define the robotic arm's DH parameters and forward kinematics. 2. Use numerical or analytical methods to solve inverse kinematics. 3. Implement and validate inverse kinematics using MATLAB or an equivalent tool.	2 **Hrs.**

4. Visualize the obtained joint configurations and compare them with expected results. **Expected Outcome:** Students will be able to understand and solve the inverse kinematics of a robot.	
Experiment No. 3:- Robot Programming using RAPID / KRL / MELFA **Objective:** To program an industrial robot for a pick-and-place task using proprietary robot programming languages. **Tools Required:** RoboDK or a real robot controller (ABB, KUKA, Mitsubishi, etc.) **Procedure:** 1. Choose a robot model from RoboDK's library (e.g., ABB with RAPID, KUKA with KRL). 2. Define tool parameters and workpieces. 3. Write and execute a simple pick-and-place program using the chosen language. 4. Test and optimize the program in simulation before deploying it on a real robot. **Expected Outcome:** Students will be able to create and execute basic industrial robot programs.	2 **Hrs.**
Experiment No. 4:- Robot Vision using OpenCV and MATLAB **Objective:** To implement a basic computer vision algorithm for object detection in a robotic application. **Tools Required:** • OpenCV (Python) / MATLAB Image Processing Toolbox • Camera (real or simulated)	2 **Hrs.**

Procedure:

1. Capture images of objects using a camera or simulated input.
2. Process images using OpenCV / MATLAB to detect objects based on color, shape, or edge detection.
3. Integrate the vision system with a robotic system for object picking.
4. Test the algorithm in a real-time scenario.

Expected Outcome:

Students will gain hands-on experience in computer vision applications for robotics.

Experiment No. 5:- Trajectory Planning and Simulation in RoboDK — **2Hrs.**

Objective:

To create and simulate a robotic trajectory for a welding application using RoboDK.

Tools Required:

RoboDK software

Procedure:

1. Import a CAD model of a workpiece into RoboDK.
2. Select an industrial robot and define tool parameters.
3. Create a trajectory for a welding operation (Cartesian motion).
4. Optimize path planning to avoid collisions and reduce movement time.
5. Simulate and analyze the trajectory execution.

Expected Outcome:

Students will be able to create and simulate robot trajectories for industrial applications.

Textbooks:

1. Craig, J. J. – Introduction to Robotics: Mechanics and Control (Pearson, 4th Edition)
2. M.P. Groover – Industrial Robotics: Technology, Programming, and Applications (McGraw-Hill)
3. S. K. Saha – Introduction to Robotics (McGraw-Hill)
4. R.K. Mittal & I.J. Nagrath – Robotics and Control (McGraw-Hill)
5. Deb, S. R. & Deb, S. – Robotics Technology and Flexible Automation (McGraw-Hill)

References:

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)

1. Peter Corke – Robotics, Vision, and Control: Fundamental Algorithms in MATLAB (Springer)
2. Richard D. Klafter, Thomas A. Chmielewski, and Michael Negin – Robotic Engineering: An Integrated Approach (Prentice-Hall)
3. Mark Spong, Seth Hutchinson, and M. Vidyasagar – Robot Modeling and Control (Wiley)
4. RoboDK Documentation and Tutorials
5. RoboAnalyzer User Guide and Tutorials

Experiment wise Measurable students Learning Outcomes:

1. Calculate and validate forward kinematics using DH parameters and simulation.
2. Compute and implement inverse kinematics using analytical and numerical methods.
3. Write, debug, and execute industrial robot programs for automation tasks.
4. Implement object detection and integrate vision-based automation using OpenCV/MATLAB..
5. Design and optimize robot joint trajectories for industrial applications using RoboDK.

D Y Patil College of Engineering, Akurdi, Pune

An Autonomous Institute from AY 2024-25, Affiliated to Savitribai Phule Pune University, Pune

B Tech in Robotics and Automation Engineering | S Y B Tech (2024 COURSE)
Course Code: NCMC4, Course Title: Professional and Technical Communication
Category: Non Credit Mandatory Course

Prerequisites: Basic English Grammar Skills	
Course Objective: Purposes of Course are:	
8. This course is designed to equip students with essential professional and technical communication skills necessary for success in the modern workplace. 9. Emphasizing both written and verbal communication 10. The course covers a wide range of topics, including effective written communication, active listening and public speaking. 11. Develop strong aptitude & problem solving to clear company selection tests	
Course Outcomes: After Successful completion of course units, students will	
CO1	Analyse and evaluate spoken information critically for understanding the context and credibility of the source.
CO2	Demonstrate effective interpersonal communication skills for harmonious and productive interactions.
CO3	Articulate strategies for clear and coherent writing skills for personal & professional communication needs.
CO4	Develop skills for effective and authentic non-verbal communication to ace the professional communication needs.
CO5	Solve complex aptitude problems efficiently, improving selection test performance.

Syllabus

Unit I	**Development of Listening and Speaking Skills**	**04 Hrs.**
Introduction to Listening skills, Barriers to Listening skills, active Listening techniques, Listening for main ideas and details, Note taking strategies. Introduction to Speaking skills, Building vocabulary and fluency, Conversational Skills, Public speaking fundamentals. Speed and Fluency, Removing MTI.		
Unit II	**Development of Writing and Reading Skills**	**03 Hrs.**
Introduction to Effective Written Communication, fundamentals of grammar and punctuation, Paragraph Structure, Essay writing, Report writing, Formal letter writing. Importance of Reading, Comprehension and solving case studies, Synthesis writing		
Unit III	**Fundamentals of Technical Communication**	**03 Hrs.**

What is communication? Importance of communication, Communication Types – Verbal, Non-verbal, Why is non-verbal communication important? Making eye contact (or lack thereof), Shaking hands, -Crossing or uncrossing legs, Folding or unfolding arms, Fidgeting, Eye contact, Smiling or frowning, Communication styles

Unit IV	**Business Communication**	**03 Hrs.**

Business communication theory, Email Etiquette, Digital Communication, Presentation Skills, Ethics in Business Communication, Kinesics and Pitch modulation

Unit V	**Quantitative Aptitude**	**10 Hrs.**

2. Linear Equations, Quadratic Equations
3. Profit and Loss
4. Simple Interest and Compound Interest
5. Time, Speed, and Distance - Basic
6. Race & Game & Problem on Trains
7. Time and Work

Unit VI	**Verbal Ability**	**03 Hrs.**

1. Critical Reasoning & Analogies
2. Sentence Correction - Intermediate and Advanced

Reference Books

11. Communication Skills for Engineers by S. Mishra & C. Muralikrishna (Pearson),2011, ISBN - 8131799905, 9788131799901
12. Communication Skills for Technical Students by T.M. Farhathullah (Orient Longman)2002, ISBN - 9788125022473
13. Written Communication in English by Saran Freeman (Orient Longman) 1977, 8125004262
14. Essential English Grammar (Elementary & Intermediate) Raymond Murphy (CUP), 1990, ISBN 10-8175960299
15. Communication for Business: A Practical Approach by Shirley Tailor (Longman),2005, ISBN - 9780273687658
16. Developing Communication Skills by Krishna Mohan & Meera Banerji (Macmillan),2009, ISBN - 9780230638433
17. Business Correspondence and Report Writing, R. C. Sharma & Krishna Mohan (Tata McGraw Hill,2017, ISBN - 9789390113002
18. Technical communication: Principles and practice, Raman, Minakshi, and Sangita Sharma. 3rd ed. Oxford University Press, 2015, ISBN - 978-0199457496
19. https://ielts.org
20. NPTEL Course-Business English Communication IIT Madras

Link https://youtu.be/GwF4ypDSr-A

11 NPTEL Course- Introduction to Effective Communication

Link https://archive.nptel.ac.in/courses/109/104/109104030/