K. K. Wagh Institute of Engineering Education and Research, Nasik (Autonomous w. e. f. A.Y.2022-23)
Course Structure: Robotics and Automation Semester – III S. Y. B. Tech.

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Evaluation Scheme and Marks							Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU/ TW	PR	OR	Total	TH	TU	PR / OR	Total
RB222001	BSC	Applied Mathematics –III	3	1	-	20	60	20	25	-	-	125	3	1	-	4
RB222002	DCC	Manufacturing Technology	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222003	DCC	Electrical and Electronics Systems	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222004	ESC	Computer Graphics for Robotics	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222005	DCC	Robot Path Planning	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222006	LHSM	Universal Human Values- II	1	-	-	-	-	-	25	-	-	25	1	-	-	1
RB222007	DCC	Manufacturing Technology Lab	-	-	2+2	-	-	-	25	-	50	75	-	-	2	2
RB222008	DCC	Electrical and Electronics Systems Lab	-	-	2	-	-	-	25	25 *	-	50	-	-	1	1
RB222009	ESC	Computer Graphics for Robotics Lab	-	-	2	-	-	-	25	25 *	-	50	-	-	1	1
RB222010	PSI	Basic Robotics Workshop	-	-	2	-	-	-	25#	-	-	25	-	-	1	1
		Total	**16**	**1**	**10**	**100**	**300**	**100**	**150**	**50**	**50**	**750**	**16**	**1**	**5**	**22**

Assessment of 25 marks will be done considering consistent progress of work throughout the semester

K. K. Wagh Institute of Engineering Education and Research, Nasik (Autonomous w. e. f. A.Y.2022-23)
Course Structure: Robotics and Automation Semester – IV S. Y. B. Tech.

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Assessment Scheme of Marks							Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU/ TW	PR	OR	Total	TH	TU	PR /OR	Total
RB222011	DCC	Robot Kinematics and Dynamics	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222012	DCC	Design of Machine Elements	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222013	DCC	Hydraulics and Pneumatics	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222014	DCC	Robot Operating System	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222015	LHSM	Industrial Management	3	-	-	20	60	20		-	-	100	3	-	-	3
RB222016	AC	Human Rights	1	-	-	-	-	-		-	-	-	-	-	-	-
RB222017	DCC	Robot Kinematics and Dynamics Lab	-	-	2+2	-	-	-	25	25	25	75	-	-	2	2
RB222018	DCC	Robot Operating System Lab	-	-	2	-	-	-	25	25*	-	50	-	-	1	1
RB222019	DCC	Hydraulics and Pneumatics Lab	-	-	2	-	-	-	25	25*	-	50	-	-	1	1
RB222020	PSI	Project Based Learning	-	-	2	-	-	-	25 #	-	-	25	-	-	1	1
		Total	**16**	**-**	**10**	**100**	**300**	**100**	**100**	**75**	**25**	**700**	**15**	**-**	**5**	**20**

Assessment of 25 marks will be done considering consistent progress of work throughout the semester and Project Presentation at end of semester.

K. K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

S. Y. B. Tech. Robotics and Automation
Pattern 2022 Semester: III
RB222001: Name of Subject: Applied Mathematics-III

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week **Tutorial:01hr/week**	**03** **01**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks** **Tutorial / Term work: 25 Marks**

Prerequisite Courses: - Higher Secondary Mathematics

Course Objectives:

Find General solution of higher-order linear differential equation with constant & Variable coefficient using different Methods. Find Laplace transform and Fourier transform of functions using definition & properties & solve Ordinary D.E. using L.T. Recognize nature of vector fields, use different vector differential operators& able to evaluate Line, surface &Volume integrals& its application Solve boundary value problems for Laplace's equation, heat equation, the wave equation by separation of variables. Find Laplace transform and Fourier transform of functions using definition & properties & solve Ordinary D.E. using L.T

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Identify nature of vector field, understand basic concept of L.D.E., Fourier Series, Fourier Transform, Laplace transform.	2-Understanding
CO2	Calculate Laplace transform, Fourier Series, Fourier Transform, Directional Derivative, Line Integral and solve L.D.E. using different Methods. Develop & Solve mass spring system, P.D.E. & Evaluate Surface, Volume Integral.	3- Apply
CO3	APPLY Integral transform techniques such as Laplace transform and Fourier transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.	3- Apply
CO4	APPLY Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to reliability engineering and probability theory in testing and quality control.	3- Apply
CO5	Apply Concept of Differential equations, Vector Calculus, Statistics and Probability to various applications including real life problem.	4 -Analyze

COURSE CONTENTS

Unit I	**Transforms**	**(07hrs+2hrsTutorial)**	**COs Mapped - CO1, CO2, CO3**

Laplace Transform (LT): LT of standard functions, properties and theorems, Inverse LT, Application of LT to solve LDE.

Fourier Transform (FT): Full range Fourier Series, Fourier series of even function and odd function & Half range Fourier series, Harmonic Analysis, Fourier integral theorem, Fourier transform, Fourier Sine & Cosine transform, Inverse Fourier Transforms.

Unit II	**Linear Differential Equations with Constant Coefficient**	**(07hrs+ 2hrsTutorial)**	**COs Mapped - CO1, CO2**

LDE of nth order with constant coefficients, Method of variation of parameters, Cauchy's & Legendre's DE, Simultaneous DE.

Unit III	**Applications of Linear Differential Equations& Partial Differential Equations**	**(07hrs+ 2hrsTutorial)**	**COs Mapped –CO2, CO3,CO5**

Modelling of Mass-spring systems, Free & Forced Damped and undamped systems. Basic concepts, method of separation of variables, modelling of Vibrating String, Wave equation, one and two dimensional Heat flow equations.

Unit IV	**Statistics and Probability**	**(07hrs+ 2hrsTutorial)**	**COs Mapped - CO3, CO4,CO5**

Measures of central tendency, Measures of dispersion: Standard deviation, Coefficient of variation, Moments, Skewness and Kurtosis, Correlation and Regression, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates. Probability, Probability distributions: Binomial, Poisson and Normal distributions

Unit V	**Vector Calculus**	**(07hrs+ 2hrsTutorial)**	**COs Mapped - CO4,CO5**

Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoid and Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.
Linear Algebra

Text Books

1. B.V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publication, Delhi.
3. Advanced Engineering Mathematics,7e, by peter V.O'Neil(Thomson Learning)

Reference Books

1. Erwin Kreyszig ,"Advanced Engineering Mathematics" ,Wiley Eastern Ltd.
2. P. N. Wartikar and J. N. Wartikar,"Applied Mathematics" (Volumes I and II), Pune Vidyarthi Griha Prakashan, Pune.
3. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments (Total 3 Assignment, Unit I and II 20 marks, Unit III and IV 20 marks and Unit V 10 marks & 50 marks will be converted to 10 Marks)	10
2	Tests on each unit using LearniCo (Each test for 15 M and total will be converted out of 10 M)	10

List of Tutorial Assignments		
Sr. No.	**Title**	**CO Mapped**
1	Examples on Laplace transform properties and theorems.	CO1, CO2, CO3
2	Examples on Inverse Laplace transform properties and theorems.	CO1, CO2, CO3
3	Examples on Fourier series, Fourier series of even function and odd function & Half range Fourier series.	CO1, CO2
4	Examples Fourier transform, Fourier Sine & Cosine transform, Inverse Fourier Transforms.	CO1, CO2
5	Solve problems on matrices using Mat lab.	CO1, CO2, CO3,CO4
6	Solve system of equations using Mat lab.	CO1, CO2, CO3, CO4
7	Examples on LDE of nth order with constant coefficients.	CO1, CO2, CO3
8	Examples on Method of variation of parameters, Cauchy's & Legendre's DE, Simultaneous DE.	CO1, CO2, CO3
9	Examples on Applications of LDE to chemical engineering problems and mass spring system.	CO3, CO4,CO5
10	Examples on modeling of Vibrating string, Wave equation, one and two dimensional Heat flow equations.	CO3, CO4,CO5
11	Examples on Vector differentiation.	CO4,CO5
12	Examples on Vector Integration.	CO4,CO5

Guidelines for Tutorial / Termwork Assessment		
Sr. No.	**Components for Tutorial / Termwork Assessment**	**Marks Allotted**
1	Assignment on computational software	5
2	Tutorial (Each tutorial carries 15 marks)	15
3	Attendance (Above 95 % : 05 Marks, below 75% : 0 Marks)	5

S. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: III
RB222002: Name of Subject: Manufacturing Technology

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs./week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**

Prerequisite Courses: Applied and Modern Physics

Course Objectives:

Course Objectives	Description
1	Understand the sand casting process
2	Analyse the various metal forming processes.
3	Understand the metal joining process.
4	Understand advanced manufacturing process

Course Outcomes	Description Student will be able to:	Blooms Level
1	Classify various casting processes.	2. Understand
2	Describe various forming processes	2. Understand
3	Classify various metal joining processes	2. Understand
4	Explain various machining processes.	2. Understand
5	Apply robotics in manufacturing.	3. Apply

Course context, Relevance, Practical Significance:

Manufacturing is a basic subject of engineering which deals with the various manufacturing processes & applications of robotics in manufacturing processes. Syllabus includes various basic manufacturing processes such as casting, special casting process, metal forming process, joining process and application in robotics for such processes.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Sand casting process**: Introduction of sand casting. Patterns, Pattern materials, pattern allowances and design. Core prints and core seats. Mould strength, Ingredients of moulding materials and their effect on mould strength, testing of moulding sand. Melting: types of melting furnace, Solidification: progressive and directional solidification; rate of solidification Casting Design consideration, Metal pouring, Gating system, Principles of gating, design of gating system, solidification time, riser design, cleaning, finishing of casting. Defects and respective	7

Unit	Contents	Lecture Hrs.
	remedies in casting. Special Casting Process. Application of Robot in Sand Casting.	
2	**Material Forming 1** **Fundamentals of Material Forming:** Introduction of forming processes. Concept of plastic deformation Classification of material forming process, Theory of plasticity, **Rolling of Metals:** Scope and importance of rolling. Types of Rolling Mills - Construction and working. Defects in rolling. Application of Robot in Rolling. **Forging**: Introduction, Classification of forging processes. Forging equipment- Hammers, presses, Upstter etc., construction, working Basic forging operations, Types of forging dies, Cleaning and finishing of forgings, Forging defects and the remedies. Application of Robot in Forging	7
3	**Material Forming 2** **Sheet Metal working processes:** Classification of cutting and forming, Types of dies, Elements of press tools, Application of Robot in press working, **Wire Drawing:** Introduction to rod and wire drawing machines - construction and working. Preparation of stock for wire drawing. Wire drawing dies, material and design. Maximum reduction in wire in one pass, forces required in drawing. **Extrusion:** Types: Direct, Indirect, impact, hydrostatic extrusion. Dies for extrusion, stock preparation. Extrusion ratio, Circumscribing circle diameter (CCD), Shape factor. Equipment (with and without friction), extrusion defects. Application of Robot in Wire Drawing and Extrusion.	7
4	**Metal Joining Process** **Welding:** Introduction & classification of welding processes, Types of Electrodes, coding of Electrodes, Electrode efficiency, fluxes, welding symbols. **Arc welding processes,** Tungsten inert gas (TIG), Metal Inert gas(MIG), Plasma arc, stud welding, **Gas welding, Electric resistance welding**: processes and equipment used, Spot, Seam, Projection welding, Resistance tube welding, - merits, limitations and applications. **Solid state welding, Special welding processes:** Laser, electron Beam welding, Thermit welding. Application of Robot in welding	7
5	**Machining Processes** Turning, Milling, drilling Processes, Abrasive jet machining, Ultrasonic machining, Chemical machining, Electrochemical machining, Electro discharge machining, Electron beam machining, laser beam machining, Plasma arc machining, Ion Beam machining, wire cut EDM. Application of Robot in machining process	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Sand casting process	2,3	1,5	1,3,7	1
2	Material Forming 1	2,3	2,5	1,3,7	1
3	Material Forming 2	2,3	2,5	1,2,7	1
4	Metal Joining Process Welding	2,3	3,5	1,2,4	1
5	Machining Processes	2,3	4,5	1,2,3,5,7	1

Reference Books

1. Rao P.N., "Manufacturing Technology, Foundry, Forming and welding", Tata McGraw-hill publishing, 2006, ISBN 0-07-463180-2.
2. Dieter, "Mechanical Metallurgy", McGraw hill, ISBN0071004068.
3. Rowe G.W., "Principles of Industrial Metal Working Process", Edward Arnold, ISBN8123904282.
4. Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co., ISBN8176190020
5. KalpakjianSerope and Schmid Steven, "Manufacturing Engineering & Technology", 2004. ISBN 10: 0131976397 ISBN 13: 9780131976399
6. Little Richard., "Welding & Welding Technology", Tata Mc-graw hill, 1992, ISBN 0-07-099409-9.
7. Parmar R.S., "Welding Process and Technology", 2ed.,Khanna Publishers, ISBN-10: 8174091262, ISBN-13: 978-8174091260
8. HMT, "Production Technology", Tata McGraw Hill Publishing Co., 1980. ISBN: 0-07- 096443-2
9. Degarmo, Black and Kosherth, "Materials & Processes in manufacturing", 8th Edition, Prentice Hall of India Ltd, Delhi, 2002. ISBN: 8126525223

Text Books

1. S.K. Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology" Vol I ,II, Media Promoters, ISBN-10: 8185099154
2. S.K. Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology" Vol I , Media Promoters, ISBN-10: 8185099154
3. R.K Jain., "Production Technology", Khanna Publishers, 2008, ISBN 81-7409-099-1.
4. P.C Sharma., "A Text Book of Production Technology- Manufacturing Processes", S. Chand & Co., 2008, ISBN: 81-219-111-4-1.

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: III RB222003: Name of Subject: Electrical and Electronics System		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs./week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**
Prerequisite Courses: Applied and Modern Physics, Fundamentals of Electrical Engineering, Fundamentals of Electronics Engineering		

Course Objectives	Description
1	Study of basic electronics components with identification and testing, practical applications of all components and interfacing
2	Study of all switches with identification and testing, practical applications of all switches and interfacing
3	Study of all power electronics components with identification and testing, practical applications of all devices
4	Understand and compare the principles of working of various electrical machines with their applications in industry

Course Outcomes	Description Student will be able to:	Blooms Level
1	Describe basics of electronic components with identification and testing	2- Understand
2	Recognize small electronic systems and their applications	2- Understand
3	Identify role of different electrical and electronic components in robotics	2- Understand
4	Demonstrate applications of electrical machines	3- Apply
5	Apply basics of electronics and electrical systems in robotics and Automation.	3- Apply

Course context, Relevance, Practical Significance:

The Electrical and Electronics System solves challenges which are related to design of robots. This subject therefore provide sound foundation for robotics and automation engineering students which basically deals with the study of various electronics and electrical components and their application in robots.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Electronics Components & Applications**: Resistor, Inductor, Capacitor, Diode, Transistor, Field effect transistors, Types & Applications, Operation amplifier & its applications, Integrated circuits & types of Integration.	7

Unit	Contents	Lecture Hrs.
2	**Switches and Power Supply** : Transistor as a switch, Relays ,Types of Switches (SPST, SPDT, DPST, DPDT, Toggle switch ,Simple ON OFF, push buttons) Basics of Power Supply, Voltage Regulator ICs 78XX,79XX, Types of batteries/Cell	7
3	**Power Devices** : Construction, Working And applications Of SCR , DIAC, TRAIC, UJT, MOSFET, Opto-couplers and Opto-isolaters, Signal Conditioning & Operations in it (Amplification, Attenuation, Filtration)	7
4	**D. C. Machines** : Construction, working principle of D.C. generator, emf equation of D. C. generator (derivation not expected), Motor operation power angle characteristics, 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), threepoint starter for D.C shunt motor, methods for speed control of D.C. shunt and series motors, industrial applications,SMPS	7
5	**Motors** : Constructional feature, working principle of three phase induction motors, types, torque slip characteristics, efficiency, starters , methods of speed control, Construction, working principle, characteristic and applications of stepper motors, A.C. and D.C servomotors, universal motors, industrial applications, brushless DC motors, linear induction motors,Spindle motor,variable Frequency drive.	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Electronics Components & Applications	1,2,3	1,2,3	1,3,7	1,2
2	Switches and Power Supply	1,2,3	1,2,3	1,3,7	1,2
3	Power Devices	1,2,3	1,2,3	1,3,7	1,2
4	D. C. Machines	1,2,3	4,5	1,3,7	1,2
5	Motors	1,2,3	4,5	1,2,3,7	1,2

Reference Books

1. M. Ramamoorty, O. Chandra Sekhar, "Electrical Machines", PHI Learning Pvt. Ltd., 2017, ISBN: 9788193593820
2. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", Tata McGraw Hill Publication Ltd.
3. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC press, ISBN: 978-0-8247-5384-9
4. B.L. Thereja, "Basic Electronics", S. Chand and Co. Ltd., ISBN: 812192555X

Text Books

1. Edward Hughes "Electrical and Electronics Technology", ELBS, Pearson Education. ISBN: 978-0-13-206011-0
2. S. K. Bhattacharya, "Electrical Machine", Tata Mc Graw Hill publishing Co. Ltd, ISBN: 97800706692151
3. Nagrath and Kothari, "Electrical Machines", Tata Mc Graw Hill, ISBN: 978-0-07-069967-0
4. M H Rashid "Power Electronics: Circuits, Devices and Applications", Pearson Education, ISBN: 9332584583

S. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: III
RB222004: Name of Subject: Computer Graphics for Robotics

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 03 hrs. /week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**

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

Course Objectives:

Course Objectives	**Description**
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 Outcomes	**Description** Student will be able to:	**Blooms Level**
1	Describe the basics of different graphics systems and analytic geometry.	2 – Understand
2	Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	3- apply
3	Demonstrate the application of Bezier curves and interpolation in robot path planning	3- apply
4	Apply concept of geometric algebra for modelling in robotic physics	3- apply

Course context, Relevance, Practical Significance:

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 of continuous motion. This subject provides methods for generating co-ordinate data for complex 2D and 3D profiles. The subject is predominant to make students understand the fundamentals of robot forward kinematics and robot simulation as well.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Analytic geometry** 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	7
2	**Transforms:** Introduction to 2D and 3D transforms: Scaling, shear, rotation, reflection, Concept of homogenous co-ordinates, General Rotation and general reflection matrix, Concatenated matrices, Application of 3D transformation to robotics: Cylindrical robot, Application of 3D transformation to robotics: Spherical robot/SCARA robot	7
3	**Interpolation:** Linear interpolation, Lagrange interpolation, Spline interpolation, Spatial interpolation: Inverse distance weighted method, Nearest neighbour, Natural neighbour, Shape function, Cubic interpolation, Interpolating quaternion	7
4	**Curves and Surfaces** 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	7
5	**Geometric Algebra** 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	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Analytic geometry	1,2	1	1,2	1, 2
2	Transforms	1,2,3	2	1,3,5	1, 2
3	Interpolation	2,3	3	1,2,3	1, 2
4	Curves and Surfaces	2,3	2,3	1,2, 3, 5	1, 2
5	Geometric Algebra	4	4	1, 2, 4	1, 2

Reference Books:

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 Hill Education, ISBN: 978- 0070486775
4. Davis Martin J, "Computer Graphics", Nova science Publishers, ISBN: 9781617618116

S. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: III
RB222005: Name of Subject: Robot Path Planning

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs/week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**

Prerequisite Courses: Applied Mathematics I, Applied Mathematics II, Computational Thinking and C- programming,

Course Objectives:

Course Objectives:	**Description**
1	To introduce students the concept of robot motion planning
2	To demonstrate various algorithms for roadmap methods and critical path planning
3	To explain cell decomposition and potential field method for path planning
4	To present methods of path planning to deal with moving obstacles.

Course Outcomes:

Course Outcomes	**Description** Student will be able to:
1	Formulate robot motion planning problems.
2	Apply algorithms for Roadmap methods.
3	Use Cell decomposition for critical path planning
4	Generate joint trajectory for path planning using robot dynamics
5	Analyse multiple moving objects

Course context, Relevance, Practical Significance:

Robotic path planning is trying to answer a different question from the previously discussed toolpath planning - instead of removing or adding material to fabricate an object, robotic path planning determines how an object can navigate through a space with known or unknown obstacles while minimizing collisions. The subject has become extremely broad and covers not only the traditional areas of finding collision free paths, but automatic assembly, warehouse automation, multi robot cooperation, robotic surgery, etc. The course would cover the fundamental concepts and mathematics required to understand, analyse, and design algorithms required for motion planning of serial robotic arms and mobile robots.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Unit 1: An overview of robot motion planning problems** Aspects of motion planning, configuration space formulation, planning approaches, configuration of space of a rigid body, embedding in Euclidean space, parameterization, quaternions, path and multiple connectedness, obstacle configuration space.	7
2	**Unit 2: Roadmap methods:** Visibility graph method, retraction approaches, freeway method, silhouette method, Voronoi graph, D* algorithm.	7
3	**Unit 3: Cell decomposition:** Exact cell decomposition: critical curves and non-critical regions, decomposition of free space, general approach to path planning, Approximate cell decomposition: Divide and label method, approximate and decompose, hierarchical graph searching	7
4	**Unit 4: Potential field methods:** Potential field in translational case, Potential field in translational case, potential guide path planning, depth first planning, best first planning, other potential functions.	7
5	**Unit 5: Multiple moving objects:** Moving obstacles, planning with velocity bound, multiple robots, centralised and decoupled planning,	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	An overview of robot motion planning problems	1,2	1	1,2,3,5,7	1
2	Roadmap methods	2,3	2	1,2,3,5,7	1
3	Cell decomposition	1,2	3	1,2,3,5,7	1
4	Potential field methods	1,2	4	1,2,3,5,7	1
5	Multiple moving objects	2,3,4	5	1,2,3,5,7	1

References Books:

1. Steve LaValle, Planning Algorithms, Cambridge Univ. Press, New York, 2006, ISBN: 978-0521862059
2. Sebastian Thrun, Wolfram Burgard, and Dieter Fox Lynch, Probabilistic Robotics, MIT Press, 2005, ISBN: 9780262201629
3. Jean-Claude Latombe, Robot Motion Planning, Springer New York, NY, 2012, ISBN: 978-0-7923-9206-4
4. Steven M. Lavalle, Planning Algorithms, Cambridge University Press, ISBN: 9780521862059.

S. Y. B. Tech. Robotics and Automation
Pattern 2022 Semester: III
RB222006: Name of Subject: Universal Human Values (UHV-2)

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory : 01 hrs./week	**01**	**TW: 25 Marks**

Prerequisite Courses: NA

Course Objectives:

- To help the students appreciate the essential complementarity between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
- To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
- To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature. Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in theirown right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and thestudents to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

Course Outcomes: At the end of the course, the students will be able to

	Course Outcomes	**Bloom's Level**
CO1	**Recognize** the significance of value inputs in formal education and Its applications.	2 - Understand
CO2	**Apply** the understanding of ethical conduct to formulate the Strategy for ethical life and profession.	3 - Apply
CO3	**Distinguish** between values and skills, happiness and accumulation of physical facilities, the Self and the Body, Intentionand Competence of an individual, etc.	4 – Analyze
CO4	**Analyze** the value of harmonious relationship based on trust and respect in their life and profession	4 – Analyze
CO5	**Examine** the role of a human being in ensuring harmony in society and nature.	4 – Analyze

COURSE CONTENTS

Unit 1: Introduction-Basic Human Aspiration, its fulfilment through All-encompassing Resolution The basic human aspirations and their fulfilment through Right understanding and Resolution, Right understanding and Resolution as the activities of the Self, Self being central to Human Existence; All-encompassing Resolution for a Human Being, its details and solution of problems in the light of
Resolution

Unit 2: Right Understanding (Knowing)- Knower, Known & the Process
The domain of right understanding starting from understanding the human being (the knower, the experiencer and the doer) and extending up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in
existence (human conduct).

Unit 3: Understanding Human Being
Understanding the human being comprehensively as the first step and the core theme of this course; human being as co-existence of the self and the body; the activities and potentialities of the self; Basis for harmony/contradiction in the self

Unit 4: Understanding Nature and Existence
A comprehensive understanding (knowledge) about the existence, Nature being included; the needand process of inner evolution (through self-exploration, self-awareness and self-evaluation), particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence).

Unit 5: Understanding Human Conduct, All-encompassing Resolution & Holistic Way of Living Understanding Human Conduct, different aspects of All-encompassing Resolution (understanding,wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolutioncovering all four dimensions of human endeavor viz., realization, thought, behavior and work(participation in the larger order) leading to harmony at all levels from Self to Nature and entire
Existence

Text Book

1. R R Gaur, R Asthana, G P Bagaria, 2019 (2nd Revised Edition), A Foundation Course in Human Values and Professional Ethics. ISBN 978-93-87034-47-1, Excel Books, New Delhi.

Reference Books

1. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
2. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond &Briggs, Britain.
3. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
4. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limitsto Growth – Club of Rome's report, Universe Books.
5. A Nagraj, 1998, Jeevan Vidya EkParichay, Divya Path Sansthan, Amarkantak.
6. P L Dhar, RR Gaur, 1990, Science and Humanism, Commonwealth Publishers.
7. A N Tripathy, 2003, Human Values, New Age International Publishers.
8. Subhas Palekar, 2000, How to practice Natural Farming, Pracheen (Vaidik) Krishi Tantra Shodh,Amravati.
9. E G Seebauer& Robert L. Berry, 2000, Fundamentals of Ethics for Scientists &Engineers, OxfordUniversity Press
10. M Govindrajran, S Natrajan& V.S. Senthil Kumar, Engineering Ethics (including Human Values),Eastern Economy Edition, Prentice Hall of India Ltd.

11. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books.
B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Book Co., Lucknow.Reprinted 2008.

8. Subhas Palekar, 2000, How to practice Natural Farming, Pracheen (Vaidik) Krishi Tantra Shodh,Amravati.
9. E G Seebauer& Robert L. Berry, 2000, Fundamentals of Ethics for Scientists &Engineers, OxfordUniversity Press
10. M Govindrajran, S Natrajan& V.S. Senthil Kumar, Engineering Ethics (including Human Values),Eastern Economy Edition, Prentice Hall of India Ltd.
11. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books.
12. B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Book Co., Lucknow.Reprinted 2008.

S. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: III
RB222007: Name of Subject: Manufacturing Technology Lab

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02 + 02 hrs./week	**02**	**Term work : 25 Marks** **Oral : 50 Marks**

Prerequisite Courses: Applied and Modern Physics

Course Objectives:

Course Objectives	Description
1	Understand the sand casting process
2	Analyse the various metal forming processes.
3	Understand the metal joining process.
4	Understand advanced manufacturing process

Course Outcomes	**Description** Student will be able to:	**Blooms Level**
1	Classify various casting processes.	2. Understand
2	Describe various forming processes	2. Understand
3	Classify various metal joining processes	2. Understand
4	Explain various machining processes.	2. Understand
5	Apply robots in manufacturing.	3. Apply

Course context, Relevance, Practical Significance:

Manufacturing is a basic subject of engineering which deals with the various manufacturing process & application of robot in such process. The syllabus includes the various basic manufacturing processes like casting & special casting process, metal forming process & also joining process and for such process the application of robot.

Course Contents:

Assignment/ Experiment	**Contents**	**Pr. Hrs.**
1	Permeability testing	2
2	Green compression test for moulding sand	2
3	Moisture content of the green sand	2
4	Assignment on forging and rolling	4
5	Assignment on sheet metal working , Wire drawing and extrusion	4
6	Assignment on any two non-conventional machining process	4
7	Assignment on robotic application in manufacturing	2

Assignment/ Experiment	Contents	Pr. Hrs.
Job 1	Making simple solid pattern involving wood turning operation and preparing mould.(one job)	4
Job 2.	Simple Arc welding job (one job)	4

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Permeability testing	1,5	1,3,7	1
2	Green compression test for moulding sand	1,5	1,3,7	1
3	Moisture content of the green sand	1,5	1,3,7	1
4	Assignment on forging and rolling	2,5	1,3,7	1
5	Assignment on sheet metal working , Wire drawing and extrusion	2,5	1,2,7	1
6	Assignment on any two non-conventional machining process	4,5	1,2,3,5,7	1
7	Assignment on robotic application in manufacturing	4,5	1,2,3,5,7	1
Job 1	Making simple solid pattern involving wood turning operation and preparing mould.(one job)	1,5	1,3,7,9,12	1
Job 2.	Simple Arc welding job (one job)	3,5	1,2,3,4,9,12	1

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: III RB222008: Name of Subject: Electrical and Electronics Systems Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02 hrs./week	**01**	**Term work :25 Marks** **PR : 25 Marks**
Prerequisite Courses: Applied and Modern Physics, Fundamentals of Electrical Engineering, Fundamentals of Electronics Engineering		

Course Objectives	Description
1	Study of basic electronics components with identification and testing, practical applications of all components and interfacing
2	Study of all switches with identification and testing, practical applications of all switches and interfacing
3	Study of all power electronics components with identification and testing, practical applications of all devices
4	Understand and compare the principles of working of various electrical machines with their applications in industry

Course Outcomes	Description Student will be able to:	Blooms Level
1	Describe of basic electronics components with identification and testing	2- Understand
2	Recognize small electronics systems and their applications	2- Understand
3	Identify role of different electrical and electronics components in robotics	2- Understand
4	Demonstrate applications of electrical machines	3- Apply
5	Use basic electronics and electrical in robotics and Automation systems.	3- Apply

Course context, Relevance, Practical Significance:

The Electrical and Electronics System solves challenges which are related to design of robots. This subject therefore provide sound foundation for robotics and automation engineering students which basically deals with the study of various electronics and electrical components and their application in robots.

Course Contents:

Practical No.	Contents	Pr. Hrs.
1	To identify various components with specifications	2
2	Study of different switches with power supply module.	2
3	To obtain V-I characteristics of PN Junction Diode	2

Practical No.	Contents	Pr. Hrs.
4	To Study Transistor Input/Output Characteristics	2
5	Build and test any one op-amp circuit	2
6	Speed control of DC shunt motor	2
7	Brake test on DC shunt motor.	2
8	No load and blocked rotor test on 3 phase Induction Motor.	2
9	Load test on 3 phase Induction Motor.	2
10	Load test on single phase Induction Motor	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	To identify various components with specifications	1,2,3	1,3,7	1,2
2	Study of different switches with power supply module.	1,2,3	1,3,7	1,2
3	To obtain V-I characteristics of PN Junction Diode	1,2,3	1,3,7	1,2
4	To Study Transistor Input/output Characteristics	1,2,3	1,3,7	1,2
5	Build and test any one op-amp circuit	1,2,3	1,3,7	1,2
6	Speed control of DC shunt motor	4,5	1,3,7	1,2
7	Brake test on DC shunt motor.	4,5	1,3,7	1,2
8	No load and blocked rotor test on 3 phase Induction Motor.	4,5	1,2,3,7	1,2
9	Load test on 3 phase Induction Motor.	4,5	1,2,3,7	1,2
10	Load test on single phase Induction Motor	4,5	1,2,3,7	1,2

S. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: III
RB222009: Name of Subject: Computer Graphics for Robotics Lab

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02 hrs./week	**01**	**Term work : 25 Marks** **Practical : 25 Marks**

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

Course Objectives:

Course Objectives	Description
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 Outcomes	**Description** Student will be able to:	**Blooms Level**
1	Describe the basics of different graphics systems and analytic geometry.	2 – Understand
2	Use of geometric transformations on graphics objects and their application in robot kinematics analysis.	3- apply
3	Demonstrate the application of Bezier curves and interpolation in robot path planning	3- apply
4	Apply concept of geometric algebra for modelling in robotic physics	3- apply

Course context, Relevance, Practical Significance:

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 of continuous motion. This subject provides methods for generating co-ordinate data for complex 2D and 3D profiles. The subject is predominant to make students understand the fundamentals of robot forward kinematics and robot simulation as well.

Course Contents:

Sr. No.	**Contents**	**Lecture Hrs.**
Computer programming in C/C++ or python for:		
1	Creating 2D and 3D graphic elements	**2**
2	Forward kinematics of planer robot using 2D transformation	**2**
3	Forward kinematics of articulated/SCARA robot using 2D transformation	**2**

4	2D curve generation: Bazier, β spline	**2**
5	3D surface generation: Surface of revolution, sweep surface	**2**
6	Algorithm for hidden surface removal	**2**

Course Mapping:

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

S. Y. B. Tech. (E&TC) Pattern 2022 Semester: III RB222010: Name of Subject: Basic Robotics Workshop		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02 hrs./week	**01**	**TW: 25 Marks**

Prerequisite Courses, if any: - Electronics Engineering.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level (Cognitive domain)
CO1	Identify various electronics and mechanical components used in robotics systems.	2 – Understand
CO2	Demonstrate PCB design and manufacturing for simple circuits.	3 – Apply
CO3	Execute PLC circuit for simple applications.	3 - Apply
CO4	Configure ARDUINO and Raspberry Pi kits for given applications.	4 – Analyze

List of Laboratory Experiments / Assignments

Sr. No.	Laboratory Experiments / Assignments	CO Mapped
1.	Introduction to Input Devices: Demonstration and hands on practice of various types of sensors such as, Temperature sensors, gas sensors, humidity sensors, LVDT, Strain Gauge, IR Sensors, Proximity etc.	**CO1**
2	Introduction to output Devices: Demonstration and hands on practice of LED and LCD display, servo motors, types of motors, relays.	**CO1**
3	PCB Design and manufacturing.	**CO2**
4	Introduction to PLC and hands on training on PLC trainer.	**CO3**
5	Demonstration of mechanical parts such as gears, bearings, pulleys, drives etc. and their specifications.	**CO1**
6	Introduction to ARDUINO and Raspberry Pi.	**CO4**

Unit	Contents	CO-mapped	PO mapped	PSO mapped
1	Introduction to Input Devices: Demonstration and hands on practice of various types of sensors such as, Temperature sensors, gas sensors, humidity sensors, LVDT, Strain Gauge, IR Sensors, Proximity etc.	1	1,3,5,9,12	1, 2
2	Introduction to output Devices: Demonstration and hands on practice of LED and LCD display, servo motors, types of motors, relays.	1	1,3,5,9,12	1, 2
3	PCB Design and manufacturing.	2	1,3,5,9,12	1, 2
4	Introduction to PLC and hands on training on PLC trainer.	3	1,3,5,9,12	1, 2
5	Demonstration of mechanical parts such as gears, bearings, pulleys, drives etc. and their specifications.	1	1,3,5,9,12	1, 2
6	Introduction to ARDUINO and Raspberry Pi.	4	1,3,5,9,12	1, 2

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222011: Name of Subject: Robot Kinematics and Dynamics		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs/week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**

Prerequisite Courses: Engineering Mathematics 1, Engineering Mathematics 2 Engineering Mechanics

Course Objectives:

Course Objective	Description
1	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2	To understand robot work envelope geometries and motion control methods
3	To understand robot forward kinematics and inverse kinematics
4	To articulate robot forward dynamics and inverse dynamics

Course Outcomes	Description Student will be able to:	Blooms levels
1	Select the type of mechanism for the robotic applications	2- Understand
2	Demonstrate robot work envelope geometries and motion control methods	3 – Apply
3	Perform forward and inverse kinematic for a given application	3 – Apply
4	Analyse manipulator forces and torques using forward and inverse robot dynamics	4 – Analyse

Course context, Relevance, Practical Significance:

Robot kinematics is the study of relationship between the dimensions and connectivity of kinematic chains and the position, velocity and acceleration of each of the links in the robotic system, in order to plan and control movement and to compute actuator forces and torques. The relationship between mass and inertia properties, motion, and the associated forces and torques is studied as part of robot dynamics. In practical robot programming, robot kinematics and dynamics plays an important role in motion planning, singularity avoidance, redundancy, collision avoidance etc.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Kinematics of mechanisms** Links, pairs, degree of freedom, Mechanisms, kinematics inversions of 4 bar and slider crank chain, kinematics analysis in simple mechanisms,	7

	velocity and acceleration polygons, Analytical methods, computer approach. Description of common mechanisms, applications of mechanisms.	
2	**Robotics manipulation** Robot classification, Robot configurations, work envelope geometries, motion control methods, Robot specifications: Number of axes, capacity and speed, reach and stroke, tool orientation, repeatability, precision, and accuracy, operating environment.	7
3	**Robot Arm forward Kinematics** types of grippers, Robot kinematics-Types- 2D, 3D Transformation, Homogeneous co-ordinate frames, translations and rotations, composite homogeneous transformations, Denavit-Hartenberg (D-H) Representation, Forward kinematics analysis of manipulators. Simulation of forward kinematics.	7
4	**Robot Arm Inverse Kinematics** Inverse kinematics problem, inverse kinematics for open chains and closed chains, analytical approaches to solve inverse kinematics problems, numerical solutions for inverse kinematic problems, Inverse kinematics examples for articulated robots (ABB & KUKA) UR 5, KUKA IIWA, SCARA etc. Simulation of Inverse kinematics.	7
5	**Robot Arm Dynamics** Robot dynamics–Rigid body dynamics, Lagrange Euler dynamic model, Recursive Newton-Euler formulation: Forward and backward Newton-Euler formulations. Forward and inverse dynamics. Case study on development of robot configuration for any given application considering the aspects of kinematics and dynamics of robot manipulator.	7

Course Mapping:

Unit	**Contents**	**Blooms Taxonomy Level**	**CO-mapped**	**PO mapped**	**PSO mapped**
1	Kinematics of mechanisms	2	1	1, 2	1,2
2	Robotics manipulation	2	2	3	1, 2
3	Robot Arm forward Kinematics	3, 4	3	4, 5	1, 2
4	Robot Arm Inverse Kinematics	3, 4	3	3, 4, 5	1, 2
5	Robot Arm Dynamics	3, 4, 5	4	3, 4, 5, 6, 9	1, 2

Reference/Text books:

1. Hartenberg and Denavit, "Kinematics and Synthesis of Linkages", McGraw Hill Book Co.
2. Deb S.R., ―Robotics, Tata McGraw Hill Publications, New Delhi.
3. Yoram Koren, "Robotics for Engineers", McGraw Hill Book Co.
4. Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology-Programming and Applications", McGraw Hill Book Co.
5. S. S. Ratan , Theory of Machines, Tata McGraw Hill [ISBN0070591202]
6. J. E. Shigley and J.J.Uicker Jr., Theory of Machines and Mechanism, McGraw Hill [ISBN019515598X]
7. G K Grover', "Mechanical Vibration", Nemchand and brothers. [ISBN8185240752]

Handbooks:

1. Siciliano, Bruno, Khatib, Oussama (Eds.), "Handbook of Robotics" Springer, ISBN: 978-3-540-30301-5
2. Shimon Y. Nof (Ed.) 'Handbook of Industrial Robotics', Wiley & Sons Inc. ISBN:978-0-471-17783-8
3. Thomas R. Kurfess (Ed.) 'Robotics And Automation Handbook', CRC Press, ISBN: 0-8493-1804-1

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222012: Name of Subject: Design of Machine Element		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs/week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**
Prerequisite Courses: Engineering Drawing, Engineering Mechanics		

Course Objectives:

Course Objectives	Description
1	Understand the basic procedure for machine design
2	Understand the theories of failures and Factor of safety to design mechanical component.
3	Understand design belt drives and selection of belt, rope and chain drives.
4	Understand the basic knowledge to analyse, design and select machine elements required in transmission systems
5	Demonstrate knowledge on basic machine elements used in design of machine elements like gear to withstand the loads and deformations for a given practical application. Understand types of temporary joints and its design procedure
6	Understand, identify and quantify failure modes for mechanical parts such as shaft, power screws and bearings.

Course Outcomes	Description Student will be able to:
1	Describe the various steps involved in the Design Process.
2	Study principles involved in evaluating the shape and dimensions of a component.
3	Articulate strength and functional requirement of machine elements.
4	Learn to use standard practices and standard data.
5	Learn to use catalogues and standard machine components.

Course context, Relevance, Practical Significance:

Design of Machine Element is a basic subject of engineering which deals with the various machine element design. The syllabus includes the various design approach for basic robot component like shaft, bearing, gear, belt drive and chain drive as it is required in robot design.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Design of Simple Machine Elements**: Introduction to the design process, Factors influencing machine design, Design Process-Traditional design methods, Basic procedure of Machine Design,	7

Unit	Contents	Lecture Hrs.
	Concept of stress and strain (linear, lateral, shear and volumetric), Hooke's law, Poisson's ratio, Modulus of elasticity, Modulus of rigidity, Working stress, Generalized Hooke's law, Factor of safety, Service factor, Design of simple machine elements, Design of components subjected to eccentric loading.	
2	**Design of Belt, Rope and Chain Drive:** Materials and construction of flat and V belts, Geometric relationships for length of belt, Power rating of belts, Concept of slip & creep, Initial tension, Effect of centrifugal force, Maximum power condition, Selection of Flat and V-belts from manufacturer's catalogue, Belt tensioning methods, Relative advantages and limitations of Flat and V- belts, Construction and applications of timing belts, Construction of wire ropes, Stresses in wire rope, Selection of wire ropes, Rope drums construction and design, Types of chains and its Geometry, Selection criteria for chain drive, Polygon effect of chain, Modes of failure for chain, Lubrication of chains.	7
3	**Gear Design:** Gear fundamentals, Force analysis and bearing loads-spur, helical and worm gear, Spur Gears-Various design consideration, Beam Strength, tangential loading module calculations, Width calculations, Type of gear tooth failures, Estimation of dynamic load by velocity factors and Spott's equation, Types of Gear Trains, Analysis of epicyclic gear trains, Holding torque – Simple, compound and epicyclic gear trains, Torque on sun and planetary gear train, Compound epicyclic gear train, Bevel epicyclic gear train, Selection criteria of harmonic drives in robotics	7
4	**Design of Shaft and Bearing:** Classification of shafts, Shafts-Design considerations in transmission shafts with spur gear and pulley, Splined Shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, Types of bearings, Comparison of bearing friction characteristics, Basics of hydrodynamic theory of lubrication, Design methods for journal bearings, Rolling Contact Bearings-Type, static and dynamic loading capacity, Stribeck's equation, Concept of equivalent load, Load life relationship, Selection of bearing from manufacturer's catalogue, Design for variable load and speeds.	7
5	**Design of Power screw:** Power Screws-Types of screw threads Forms of threads, Multiple start screws, Torque analysis and Design of power screws with square and trapezoidal threads, Self-locking screw, Collar friction torque, Stresses in power screws, Recirculating ball screw.	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Design of Simple Machine Elements	1,2,3	1,2	1,2,3	1
2	Design of Belt, Rope and Chain Drive	1,2,3	3,4	1,2,3	1
3	Gear Design	1,2,3	1,5	1,2,3,5	1
4	Design of Shaft and Bearing	1,2,3	1,6	1,2,3	1
5	Design of Power screw	1,2,3	1,6	2,3,4	1

Reference Books

1. Orthewein and William C. Orthewein, "Machine Component Design", West Publishing Co. (23 May 1989), ISBN No. 0314242570.
2. Black paulH.and Adams O. Eugene, "Machine Design", 3ed, McGraw-hill Book Company, 1999, ISBN 0–07-085037-2.
3. Hall Allens, Holowenko Alfred R., Laughlin Herman G., "Theory & Problems of Machine Design", McGraw-hill Book Company, 2000, ISBN 48333-7

Text Books

1. Shigley J. E. and Mischke C. R., "Mechanical Engineering Design", McGraw- Hill publication Co. Ltd., 1989, ISBN 0-07-049462-2.
2. Spotts M. F. and Shoup T. E., "Design of Machine Elements", 8ed., Pearson Education pvt. Ltd., 2008, ISBN 81 -7758- 4219.
3. Bhandari V.B., "Design of Machine Elements", Tata Mcgraw-hill publishing, 2007, ISBN 978-00-70-681798.
4. Kannaiah, "Machine Design", Scitech publications Pvt. Ltd., 2007, ISBN 81- 88429-10-4.
5. RAGHAVENDRA, Design Of Machine Elements I Dme I, CBS Publishers and Distributors, Pvt. Ltd., 2019, ISBN: 978-93-890-1718-2

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222013: Name of Subject: Hydraulics and Pneumatics		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs/week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**
Prerequisite Courses: NA		
Course Objectives:		

Course Objectives	Description
1	Understand the sand casting process
2	Analyse the various metal forming processes.
3	Understand the metal joining process.
4	Understand advanced manufacturing process

Course Outcomes:

Course Outcomes	Description
1	Understanding the principle of industrial fluid power
2	Classification & identification of components for Hydraulics & Pneumatics
3	Perform the PLC programme on electro hydraulic kit
4	Organize hydraulic and pneumatic circuits for given application
5	Evaluate the hydraulic and pneumatic systems based on various evaluation criteria

Course Outcomes	**Description** Student will be able to:
1	Exemplify the basic principles of Industrial fluid power.
2	Select and specify various components for hydraulic and pneumatic systems.
3	Execute PLC program for electro-hydraulic circuit applications
4	Organize hydraulic and pneumatic circuits for given application
5	Evaluate the hydraulic and pneumatic systems based on various evaluation criteria

Course context, Relevance, Practical Significance:

Actuation system is a basic subject of robotics engineering which deals with the various hydraulic & pneumatic components for application of robot. The syllabus includes the various basic hydraulic circuits design, electro hydraulic circuit design and the application of robot.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Introduction to fluid power and automation** Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws	7
2	**Hydraulic system Components** • Pumps: Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump Selection factors. • Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors). **Control Components:** Classification of control valves, Directional Control Valves- Symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, check valves, Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.	7
3	**Hydraulic Circuit Design and Analysis** Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Counter balance Valve Application, Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Speed Control of Hydraulic Cylinder and motors, Safety circuit, Accumulators, types, construction and applications with circuits, Intensifier circuits and their applications, Proportional control valves and servo valves.	7
4	**Pneumatic system** Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, Choice of working medium. Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit. Pneumatic Actuators: Linear cylinder - Types, Cascade design of Pneumatic circuit, Use of Logic gates - OR and AND gates in pneumatic applications.	7
5	**Electro-hydraulics and electro-pneumatic systems** PLC based electro-hydraulic systems, PLC programming using ladder logic for automation and robotics applications, Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid	7

Unit	Contents	Lecture Hrs.
	control of directional control valves, Use of relay and contactors. Control circuitry for simple applications. Troubleshooting of fluid power systems Identifying root cause, suggest remedies, steps to be followed in troubleshooting.	

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Introduction to fluid power and automation	1,2	1	1,3	--
2	Hydraulic system Components	2,3	2	1,2,3	--
3	Hydraulic Circuit Design and Analysis	3,4	3	1,2,3,4	1, 2
4	Pneumatic system	3,4	4	1,2,3,4	1, 2
5	Electro-hydraulics and electro-pneumatic systems	3,4	5	2,3,5	1, 2

Reference Books

1. Peter Rohner, Industrial hydraulic control, Wiley Edition, 1995, ISBN: 0471334987
2. Mujumdar S.R., Pneumatic Systems, Tata McGraw Hill, 2002 Edition. ISBN: 9780074602317
3. Esposito, Fluid Power with Applications, Pearson Education India, 2003, ISBN: 9788177585803
4. Bolton W., Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering, Pearson, Education (Singapore) Pvt Ltd., ISBN 81-7808-339-6.
5. Industrial hydraulics manual by Vickers, Inc.

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222014: Name of Subject: Robot Operating System		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs/week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**
Prerequisite Courses: NA		
Course Objectives:		

Course Objectives	Description
1	To introduce students with fundamental concepts and theory of robotic automation
2	To articulate the use of different types of devices to which robotic modules are connected
3	To demonstrate the knowledge about understanding of various types of robotic applications
4	To apply and analyse industry based project & advanced learning.

Course Outcomes	Description Student will be able to:	Blooms level
1	Describe message communication of robot operating system.	2 – Understand
2	Demonstrate robot operating commands.	3 – Apply
3	Program and simulate robot applications.	3 – apply
4	Write the program for G-mapping in robot.	3 – Apply
5	Interface robot with embedded systems.	3 – Apply

Course context, Relevance, Practical Significance:

Robot Operating System provides libraries and tools to help software developers create robot applications. It includes hardware abstraction, device drivers, libraries, visualizers, message passing, package management, and more. ROS is being used for many of the world's most exciting and capable robots. The developer community and support for using ROS with robots now makes this an excellent choice for a large variety of industrial applications.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Introduction to Robot Operating System** Introduction, Meta-operating system , Objective of Ros ,Components of Ros, Ros ecosystem , History of Ros , Ros versions ,Ros Terminology , Message Communication, Coordinate Transformation, File system, Build System.	7
2	**ROS Commands and Tools**	7

Unit	Contents	Lecture Hrs.
	Ros Command list Ros shell commands Ros execution commands Ros Information commands Ros catkin commands Ros package commands Tools:3D Visualisation Tool (Rviz) , Ros GUI development Tool (rqt): Installing and Running rqt ,rqt Plugins ,rqt_image_view ,rqt_graph ,rqt_plot,	
3	**Basic ROS Programming and Manipulator** Introduction: Standard Unit, Coordinate Representation, Programming Rules. Creating and Running Publisher and Subscriber Nodes .**Manipulator:** Introduction, Manipulator Structure and Control, Manipulator and ROS, Open Manipulator Modelling and Simulation, Gazebo Setting Move It, move group, Move It , Setup Assistant, Gazebo Simulation Applying to the Actual Platform, Service robots: Delivery service robots.	7
4	**ROS Embedded system** OpenCR: Characteristics, Board Specification, Establish Development Environment, Rosserial: rosserial server, rosserial client, rosserial Protocol, Constraints of rosserial, Installing rosserial, Examples of rosserial.TurtleBot3 Firmware: Hardware, Software, Development environment, Remote Control, Simulation using RViz.	7
5	**Navigation and Slam** Navigation and Components, Navigation of Mobile Robot, Map, Pose of Robot, Sensing, Path Calculation and Driving, SLAM Practice, Robot hardware Constraints for SLAM, Measured Target Environment of SLAM,ROS Package for SLAM, Execute SLAM,SLAM Application, SLAM rocess,Coordinate Transformation (TF). Actual Platform, Service robots: Delivery service robots.	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Introduction to Robot Operating system	1,2	1,5	1,3,7	1, 2
2	ROS Commands and Tools,	2,3	2,5	1,3,7	1, 2
3	Basic ROS Programming and Manipulator	1,2,3	2,5	1,2,7	1, 2
4	ROS Embedded system	3,4	3,5	1,2,4	1, 2
5	Navigation and Slam	3,4	4,5	1,2,3,5,7	1, 2

Reference Books:

1. Jason M. O'Kane, A Gentle Introduction to ROS, independently published, ISBN 9781492143239
2. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners", Apress Publication, ISBN: 9781484234044.
3. Morgan Quigley, Brian Gerkey, William D. Smart, "Programming Robots with ROS", O'Reilly Media Inc., ISBN: 9781449325503
4. C. Fairchild, T. L. Harman, "ROS Robotics by Example" Pakt Publishing, ISBN: 9781785286704

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222015: Name of Subject: Industrial Management		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03 hrs./week	**03**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**
Prerequisite Courses: NA		
Course Objectives:		

Course Objectives	Description
1	Students are exposed to know the importance of Industrial Management.
2	Acquire knowledge about concept of Entrepreneurship
3	To provide basics of understanding to the students with reference to working of business organization, large scale industries and small scale industries.

Course Outcomes	Description Student will be able to:	Blooms level
CO1	Recognize comprehensive theoretical knowledge about Management & Organization.	2 – Understand
CO2	Explain principle role & operation of Business sectors & organizations.	2 – Understand
CO3	Recognize the need for work-study and importance of quality control.	2 – Understand
CO4	Discuss role of supply chain management, role of IT tools in SCM.	2 – Understand
CO5	Describe management information system (MIS) & government policies.	2 – Understand

Course context, Relevance, Practical Significance:

Industrial Management deals with the development, improvement, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, materials and/or processes. It also deals with designing new product prototypes more efficiently. It incorporates the principle and methods of engineering analysis and synthesis with the mathematical, physical and social sciences together to specify, predict, and evaluate the results of systems or processes.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Management** Introduction-Thought and its Development, Scope and Functional areas	7

Unit	Contents	Lecture Hrs.
	of management, Management as a science, art of profession Management and Administration Roles of Management, Levels of Management, functions of Management, Contribution of F.W.Taylor, Henri Fayol, Elton Mayo, Structure of an industrial organization, Hierarchy of various job positions in Electronics & IT industries, Functions of different departments. Relationship between individual departments.	
2	**Business sectors & organizations** Private sector, Cooperative sectors, public sector, joint sector, Services sector, Various forms of business organizations – Sole Proprietorship, Partnership firms, Joint stock companies –their features, relative merits, demerits& suitability. Charter documents of Companies Decisions in setting up an Enterprise – opportunity and idea generation, Business Plan, Business size and location decisions, Challenges in business sectors, Setting up of Business outside India : Issues in choosing location; Structure and the processes involved	7
3	**Work Study & Quality control** Introduction, definition, objectives, steps in work study, Method study: definition, objectives, steps of method study, Work Measurement: purpose, types of study, stopwatch methods, steps, allowances, standard time, Calculations, work sampling, Production Planning and Control Quality control: statistical quality control, Control charts for variables and attributes, Acceptance Sampling- Single sampling, Double sampling plans, Introduction to TQM.	7
4	**Supply chain management** Goals, advantages, process, Strategic sourcing, Networks, Make vs Buy, inventory management, Role of IT,ERP tools, agile and reverse supply chain, Areas & practices of Supply Chain Management for Electronic Manufacturing, supply chain challenges, Digital supply chain.	7
5	**Management information system (MIS) & Government policies** Types of Information Systems, Developing Secure Information Systems, Security Policies, E- commerce, On-line trading, Information Security Standard, Industrialization in India. Industrial Policy Resolutions, Science, Technology and Innovation Policy of India, Relevant Government Policies, Impact of Government policies of decisions of setting up an enterprise. Start-up India Policy; Registration process	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	Management	1,2	1,5	1,3,7	1, 2
2	Business sectors & organizations	2,3	2,5	1,3,7	1, 2
3	Work Study & Quality control	1,2,3	2,5	1,2,7	1, 2
4	Supply chain management	3,4	3,5	1,2,4	1, 2
5	Management information system (MIS) & Government policies	3,4	4,5	1,2,3,5,7	1, 2

Text Books:

1. O.P. Khanna, "Industrial Engineering & Management", Dhanpat Rai, ISBN: 9788189928353
2. Michael J Dixon, "Challenges to Modern Business", ISBN: 979-8582703549
3. Stephen Robbins, "Management" , Pearson Education, 17th Edition, 2003
4. Roberts Lusier Thomson, "Management Fundamentals Concepts", Application, Skill Development, SAGE publication. ISBN: 978-1544384191
5. Noam Wasserman, "The Founder's Dilemmas: Anticipating and Avoiding the Pitfalls That Can Sink a Startup,'Princeton University Press, ISBN: 978-0691158303

S. Y. B. Tech. (Robotics and Automation)
Pattern 2022 Semester: IV
RB2220016: Name of Subject: Audit Course: Human Rights

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory : 01 hrs/week	**AC**	**-**

Prerequisite Courses: NA

Course Outcomes: On completion of the course, students will be able to:

	Course Outcomes	**Bloom's Level**
CO1	Articulate the importance and different approaches to Human rights	2 - Understand
CO2	Articulate the different mechanisms of United Nations to ensure and protect the Human Rights	2 - Understand
CO3	Interpret the different Constitutional provisions and legislations to protect Human Rights in India	3 - Apply
CO4	Analyse the functions of NHRC, Judiciary and PIL for protecting Human Rights in India	4 - Analyse
CO5	Examine the challenges to Human Rights of different vulnerable sections	4 - Analyse

COURSE CONTENTS

Unit 1	**Human Rights**	**3 Hrs**	**COs Mapped: CO1**

Meaning, Evolution and Importance, Approaches: Western, Marxian, Feminist and Third World

Unit 2	**UNO and Human Rights**	**3 Hrs**	**COs Mapped: CO2**

Universal Declaration of Human Rights, International Covenants on Civil and Political Rights (ICCPR), International Covenant on Social Economic and Cultural Rights (ICSECR), The Office of the United Nations High Commissioners for Human Rights(UNHCHR)

Unit 3	**Human Rights in India**	**3 Hrs**	**COs Mapped:CO2**

Constitutional Provisions- Fundamental Rights, Directive Principles of State Policy, Some important Legislations- 1) Protection of Civil Rights Act-1955, 2) Prevention of Atrocities (SC and ST) Act 1989, 3) Sexual Harassment of Women at workplace (Prevention, Prohibition and Redressal) Act, 2013, 4) The Rights of Persons with Disabilities Act-2016, 5) Right to information Act 2005. Agencies Protecting Human Rights; Judiciary, Public Interest Litigation, National Human Rights Commission and Media

Unit 4	**Challenges to Human Rights**	**2 Hrs**	**COs Mapped:CO2**

Human Rights Violations against Women, Children, Other marginalised sections like Minorities, Dalits, Adivasis and Women, Refugees
OR **Successful completion of a suitable NPTEL course identified and approved by the BoS (Robotics and Automation).**

Text Books

1. A Modern Approach to Verbal & Non-Verbal Reasoning, Dr. R S Aggarwal
2. S. Chand's Advanced Objective General Knowledge, Dr. R S Aggarwal

Reference Books

1. Andrew Clapham, Human Rights: A Very Short Introduction, Oxford University Press, New York, 2007
2. Darren J O Byrne,(ed), Human Rights: An Introduction, Pearson, New Delhi,2004
3. Chiranjeevi Nirmal, Human Rights in India, Oxford University Press, New Delhi,1997.
4. Pavithran K S,(ed), Human Rights in India: Discourse and Contentions, Gyan books, NewDelhi,2018
5. Ujwal Kumar Singh, (ed), Human Rights and peace: Ideas, Laws, Institutions and Movements, Sage, New Delhi,2009

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222017: Name of Subject: Robot Kinematics and Dynamics Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02+02 hrs/week	**02**	**Term work : 25 Marks** **Practical : 25 Marks** **Oral : 25 Marks**
Prerequisite Courses: Engineering Mechanics, Computer Graphics for Robotics		
Course Objectives:		

Course Objective	Description
1	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2	To understand robot work envelope geometries and motion control methods
3	To understand robot forward kinematics and inverse kinematics
4	To understand robot forward dynamics and inverse dynamics

Course Outcomes	Description Student will be able to:	Blooms levels
1	Select the type of mechanism for the robotic applications	2- Understand
2	Demonstrate robot work envelope geometries and motion control methods	3 – Apply
3	Perform forward and inverse kinematic for a given application	3 – Apply
4	Analyse manipulator forces and torques using forward and inverse robot dynamics	4 – Analyse

Course context, Relevance, Practical Significance:

Robot kinematics is the study of relationship between the dimensions and connectivity of kinematic chains and the position, velocity and acceleration of each of the links in the robotic system, in order to plan and control movement and to compute actuator forces and torques. The relationship between mass and inertia properties, motion, and the associated forces and torques is studied as part of robot dynamics. In practical robot programming, robot kinematics and dynamics plays an important role in motion planning, singularity avoidance, redundancy, collision avoidance etc.

Course Contents:

Sr. No.	Contents	Practical Hrs.
1	Computer Program for analysis of mechanism	2

2	Design of mechanisms for robots	2
3	Robotics mechanism for articulated robot and manipulation using teach pendant	2
4	Robot Arm forward Kinematics analysis	4
5	Robot Arm Inverse Kinematic analysis	4
6	Determination of mass moment of inertia and radius of gyration of robotic links	2
7	Robot Arm Dynamics	4
8	Case study on development of robot configuration for any given application considering the aspects of kinematics and dynamics of robot manipulator.	2

Course Mapping:

Assignment/ Experiment	**Contents**	**CO-mapped**	**PO mapped**	**PSO mapped**
1	Computer Program for analysis of mechanism	1	1, 2,5	1,2
2	Design of mechanisms for robots	1	1, 2,3	1,2
3	Robotics mechanism for articulated robot and manipulation using teach pendant	2	3,9,12	1, 2
4	Robot Arm forward Kinematics analysis	3	4, 5,9,12	1, 2
5	Robot Arm Inverse Kinematic analysis	3	3, 4, 5	1, 2
6	Determination of mass moment of inertia and radius of gyration of robotic links	4	3, 4, 5, 6, 9	1, 2
7	Robot Arm Dynamics	4	3, 4, 5, 6, 9	1, 2
8	Case study on development of robot configuration for any given application considering the aspects of kinematics and dynamics of robot manipulator.	3,4	3, 4, 5, 6, 9	1, 2

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222018: Name of Subject: Robot Operating System Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02 hrs./week	**01**	**Term work : 25 Marks** **Practical : 25 Marks**
Prerequisite Courses:		
Course Objectives:		

Course Objectives	Description
1	To introduce students with fundamental concepts and theory of robotic automation
2	To articulate the use of different types of devices to which robotic modules are connected
3	To demonstrate the knowledge about understanding of various types of robotic applications
4	To apply and analyse industry based project & advanced learning.

Course Outcomes	Description Student will be able to:	Blooms level
1	Describe message communication of robot operating system.	2 – Understand
2	Demonstrate robot operating commands.	3 – Apply
3	Program and simulate robot applications.	3 – apply
4	Write the program for G-mapping in robot.	3 – Apply
5	Interface robot with embedded systems.	3 – Apply

Course context, Relevance, Practical Significance:

Robot Operating System provides libraries and tools to help software developers create robot applications. It includes hardware abstraction, device drivers, libraries, visualizers, message passing, package management, and more. ROS is being used for many of the world's most exciting and capable robots. The developer community and support for using ROS with robots now makes this an excellent choice for a large variety of industrial applications.

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	ROS Essentials: Introduction to ROS Topics, Services, Actions and Nodes.	2
2	Simple interaction with the course simulation environment.	2
3	Building robot environment: Software representation of a Robot using Unified Robot Description Format (URDF), ROS parameter server and adding real-world object representations to the simulation environment	2
4	Autonomous Navigation: Map creation with G Mapping package, autonomously navigate a known map with ROS navigation.	4

Sr. No.	Contents	Pr. Hrs.
5	Manipulation: Motion planning, pick and place behaviours using industrial robots with ROS Move It	2
6	Robot Vision: Object detection, pose estimation	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	ROS Essentials: Introduction to ROS Topics, Services, Actions and Nodes.	1,5	1,3,5,7	1, 2
2	Simple interaction with the course simulation environment.	2,5	1,3,5,7	1, 2
3	Building robot environment: Software representation of a Robot using Unified Robot Description Format (URDF), ROS parameter server and adding real-world object representations to the simulation environment	3,5	1,2,4,5,6,7, 9,12	1, 2
4	Autonomous Navigation: Map creation with G Mapping package, autonomously navigate a known map with ROS navigation.	4,5	1,2,3,5,6,7, 9,12	1, 2
5	Manipulation: Motion planning, pick and place behaviours using industrial robots with ROS Move It	4,5	1,2,3,5,6,7, 9,12	1, 2
6	Robot Vision: Object detection, pose estimation	3,5	1,2,4,5,9,12	1, 2

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222019: Name of Subject: Hydraulics and Pneumatics Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02 hrs. /week	**01**	**Term work : 25 Marks** **Practical : 25 Marks**
Prerequisite Courses:		
Course Objectives:		

Course Objectives	Description
1	Understand the sand casting process
2	Analyse the various metal forming processes.
3	Understand the metal joining process.
4	Understand advanced manufacturing process

Course Outcomes:

Course Outcomes	Description
1	Understanding the principle of industrial fluid power
2	Classification & identification of components for Hydraulics & Pneumatics
3	Perform the PLC programme on electro hydraulic kit
4	Organize hydraulic and pneumatic circuits for given application
5	Evaluate the hydraulic and pneumatic systems based on various evaluation criteria

Course Outcomes	Description Student will be able to:
1	Exemplify the basic principles of Industrial fluid power.
2	Select and specify various components for hydraulic and pneumatic systems.
3	Execute PLC program for electro-hydraulic circuit applications
4	Organize hydraulic and pneumatic circuits for given application
5	Evaluate the hydraulic and pneumatic systems based on various evaluation criteria

Course context, Relevance, Practical Significance:

Actuation system is a basic subject of robotics engineering which deals with the various hydraulic & pneumatic components & application of robot. The syllabus includes the various basic hydraulic circuits design & also electro hydraulic circuit design & the application of robot.

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	Experiment on measurement of hydraulic pump efficiency.	2
2	Experiment on design of speed control hydraulic circuits.	2
3	Experiment on design of regenerative circuits	2
4	Experiment on design of electro-hydraulic sequencing circuits	2
5	Experiment on pneumatic circuits by demonstrating logic gates.	4
6	Experiment on electro-pneumatic circuits	2
7	Experiment on programmable logic controllers: Ladder logic programming.	2
8	Microprocessor programming for basic operations	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Experiment on measurement of hydraulic pump efficiency.	2	1,2,3	--
2	Experiment on design of speed control hydraulic circuits.	3	1,2,3,4	1, 2
3	Experiment on design of regenerative circuits	3	1,2,3,4	1, 2
4	Experiment on design of electro-hydraulic sequencing circuits	3	1,2,3,4	1, 2
5	Experiment on pneumatic circuits by demonstrating logic gates.	4	1,2,3,4	1, 2
6	Experiment on electro-pneumatic circuits	5	2,3,5	1, 2
7	Experiment on programmable logic controllers: Ladder logic programming.	3	1,2,3,4	1, 2

S. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV RB222020: Name of Subject: Project Based Learning		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02hrs. /week	**01**	**TW: 25 Marks**
Prerequisite Courses: NA		
Course Objectives: 1. To emphasizes learning activities that are long-term, interdisciplinary and student-centric. 2. To inculcate independent learning by problem solving with social context. 3. To engages students in rich and authentic learning experiences. 4. To provide every student the opportunity to get involved either individually or as a group so as to develop team skills and learn professionalism.		

Prerequisites for the course: For better learning experience, along with traditional classroom teaching and laboratory learning; project based learning has been introduced with an objective to motivate students to learn by working in group cooperatively to solve a problem. Project-based learning (PBL) is a student-centric pedagogy that involves a dynamic classroom approach in which it is believed that students acquire a deeper knowledge through active exploration of real-world challenges and problems. Students learn about a subject by working for an extended period of time to investigate and respond to a complex question, challenge, or problem. It is a style of active learning and inquiry-based learning. Problem based learning will also redefine the role of teacher as mentor in learning process. Along with communicating knowledge to students, often in a lecture setting, the teacher will also to act as an initiator and facilitator in the collaborative process of knowledge transfer and development.

Course Outcomes	Description	Bloom's Level
CO1	To apply their practical skills for lifelong learning	3 - Apply
CO2	To Implement interdisciplinary knowledge to solve societal problems	3 - Apply
CO3	To Develop ability to work as an individual and as a team member	3 - Apply

Course context, Relevance, Practical Significance: The problem-based project oriented model for learning is recommended. The model begins with the identifying of a problem, often growing out of a question or "wondering". This formulated problem then stands as the starting

point for learning. Students design and analyze the problem within an articulated interdisciplinary or subject frame. A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific and grows out of students' wondering within different disciplines and professional environments. A chosen problem has to be exemplary. The problem may involve an interdisciplinary approach in both the analysis and solving phases. By exemplarity, a problem needs to refer back to a particular practical, scientific, social and/or technical domain. The problem should stand as one specific example or manifestation of more general learning outcomes related to knowledge and/or modes of inquiry. There are no commonly shared criteria for what constitutes an acceptable project. Projects vary greatly in the depth of the questions explored, the clarity of the learning goals, the content and structure of the activity.

Course Contents:

Unit and Chapter	Contents	Lecture hours
1	A few hands-on activities that may or may not be multidisciplinary	2
2	Use of technology in meaningful ways to help them investigate, collaborate, analyse, synthesize and present their learning.	2
3	Activities may include- Solving real life problem, investigation /study and Writing reports of in depth study, field work.	4

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	3	CO1	PO1, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO1, PSO1, PSO2	PSO 1, PSO2
2	3	CO2	PO1, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO1, PSO1, PSO2	PSO 1, PSO2
3	4	CO3	PO1, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO1, PSO1, PSO2	PSO 1, PSO2