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

T. Y. B. Tech.
Robotics and Automation (Pattern 2022)
Semester: V
Course Code:223001:Name of Subject: Control System Engineering

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

Prerequisite Courses: - Mathematics, Fundamentals of Electronics Engineering, Fundamentals of Electrical Engineering

Course Objectives: The course aims to:
1. To understand basic concepts of the classical control theory.
2. To model physical systems mathematically.
3. To analyze behavior of system in time and frequency domain.
4. To design controller to meet desired specifications.

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

	Course Outcomes	**Bloom's Level**
CO1	Express physical system and its internal dynamics and input-output relationships by means of block diagrams, mathematical model and transfer functions.	3-Apply
CO2	Explain the relationships between the parameters of a control system and its stability, accuracy, transient behaviour.	3-Apply
CO3	Identify the parameters that the system is sensitive to. Determine the stability of a system and parameter ranges for a desired degree of stability.	3-Apply
CO4	Plot the Bode, Nyquist, Root Locus diagrams for a given control system and identify the parameters and carry out the stability analysis.	3- Apply
CO5	Determine the frequency response of a control system and use it to evaluate or adjust the relative stability.	4-Analyze
CO6	Explain the role of feedback loops in maintaining stability, accuracy, and robustness in robotic systems.	3-Apply

COURSE CONTENTS

Unit I	**UNIT: 1Basics of Control System**	**(07hrs)**	**COs Mapped –CO1, CO2**

Control system fundamentals, classification of control systems, types of control system: feedback, tracking, regulator system, feed forward system, transfer function, concept of pole and zero, modeling of Electrical and Mechanical systems (Only series linear and rotary motion) using differential equations and transfer function , analogy between electrical and mechanical systems, block diagram algebra, signal flow graph, Mason's gain formula.

Unit II	Time domain analysis	(07hrs)	COs Mapped –CO2, CO3

Concept of transient and steady state response, standard test signals: step, ramp, parabolic and impulse signal, type and order of control system, time response of first and second order systems to unit impulse, unit step input, time domain specifications of second order systems, derivation of time domain specifications for second-order under-damped system for unit step input, steady state error and static error coefficients, number-PID control-Analytical design for PD, PI,PID control systems

Unit III	Stability analysis and Root Locus	(06hrs)	Cos Mapped CO3, CO4

Concept of stability: BIBO, nature of system response for various locations of poles in S-plane. Routh's-Hurwitz criterion. Root Locus: Angle and magnitude condition, Basic properties of root locus. Construction of root locus, Stability analysis using root locus

Unit IV	Frequency domain analysis	(07hrs)	COs Mapped –CO4, CO5

Introduction, Frequency domain specifications, correlation between time and frequency domain specifications, polar Plot, Nyquist plot, stability analysis using Nyquist plot, Introduction to Bode plot, sketching of Bode plot, stability analysis using Bode plot.

Unit V	Feedback Control & Advanced Control Techniques	(07hrs)	COs Mapped –CO6

Introduction to feedback control systems, Stability analysis (e.g., Lyapunov stability), State feedback control, Vision Based Control, **Advanced Control Techniques:** Adaptive control, Robust control, Model predictive control (MPC)

CourseMapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	**Basics of Control System**	3	1,2	1	1
2	**Time domain analysis**	3	2,3	1,2,3	1
3	**Stability analysis and Root Locus**	3	3,4	1,2,3	1
4	**Frequency domain analysis**	3,4	4,5	1,2,3,4,5	1
5	**Application of control system in robotics**	3	6	1,2,3,4,5	1,2

Text Books

[T1] I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers, 6th edition, 2017.
[T2] Katsuhiko Ogata, "Modern control system engineering", Prentice Hall, 2010.
[T3] Nise N. S. "Control Systems Engineering", John Wiley & Sons, Incorporated, 2011
[T4] R. Anandanatrajan and P. Ramesh Babu, "Control Systems Engineering", Scitech Publication,3rd edition, 2011
[T5] C. D. Johnson, "Process Control Instrumentation Technology, 8th edition, PHI Learning Pvt. Ltd., 2013

Reference Books
[R1] B. C. Kuo, “Automatic Control System”, Wiley India, 8th Edition, 2003. [R2] Richard C Dorf and Robert H Bishop, “Modern control system”, Pearson Education, 12th edition, 2011. [R3] D. Roy Choudhary, "Modern Control Engineering", PHI Learning Pvt. Ltd., 2005. [R4] B. Wayne Bequette, “Process Control: Modeling, Design and Simulation”, PHI, 2003. [R5] Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar [R6] Feedback Control of Dynamic Systems" by Gene F. Franklin, J. Da Powell, and Abbas Emami-Naeini

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr.No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission on each unit (total will be converted out of 10 M)	10

List of Assignments		
Sr.No.	**Title**	**CO Mapped**
1	Reduce the given block diagram and determine overall transfer function.	CO1
2	Determine transfer function of the system represented by signal flow graph using Mason’s gain formula.	CO2
3	Determine time domain specifications of given second order systems.	CO2
4	Determine static error constants and steady state error for the given systems	CO1,CO2
5	Investigate closed loop stability of a given systems using Routh Hurwitz stability criterion	CO1,CO2, CO3,CO4
6	Sketch the root locus of a given systems and comment on stability	CO1,CO2, CO3,CO4
7	Sketch the polar plot of given systems. 8. Sketch the Nyquist plot of a given system, determine stability margins and comment on stability	CO1,CO2, CO3
8	Sketch the Nyquist plot of a given system, determine stability margins and comment on stability	CO1,CO2, CO3
9	Sketch the Bode plot of a given systems, determine stability margins and comment on stability	CO3, CO4,CO5
10	Determine the tuning parameters of PID controller using open loop step response and closed loop ultimate cycle methods of Ziegler and Nichol	CO3, CO4,CO5,CO 6

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K. K. Wagh Institute of Engineering Education and Research, Nashik
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T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: V
223002: Name of Subject: Artificial Intelligence for Robotics

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

Prerequisite Courses: - Applied Mathematics III

Course Objectives:

1. Understand the algorithms search in AI
2. Analyze the Machine Learning Algorithms
3. Understand Machine vision in robotics
4. Understand Intelligent robotic systems

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

	Course Outcomes	**Bloom's Level**
CO1	Select appropriate artificial intelligence method/algorithm to handle various issues in robotics	2. Understand
CO2	Demonstrate various algorithms used in artificial intelligence	2. Understand
CO3	Apply artificial intelligence algorithms to robotics problems	4. Apply
CO4	Compare the performance of AI algorithms	5. Analyze
CO5	Build solution methodology to solve complex problems in flexible automation	6. Create

COURSE CONTENTS

Unit I	**Search algorithms in AI**	**(07 hrs)**	**COs Mapped: CO1, CO2**

Algorithms for uninformed and informed search, Heuristics search, hill climbing, branch and bound, breadth first search, depth first search, best first search, A* algorithm, D* algorithm. Metaheuristics: Simulated annealing, Tabu search, ant colony optimization

Unit II	**Machine Learning Algorithms**	**(07 hrs)**	**COs Mapped: CO2, CO5**

Supervised and unsupervised learning, Least square regression, Logistic regression, Neural networks, Support vector machine, K-Means clustering, Principal Component Analysis, fuzzy logic, genetic algorithm, Reinforcement learning, Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, Kalman filter

Unit III	**Machine vision in robotics**	**(07 hrs)**	**COs Mapped: CO3, CO5**
Basic principles of digital imaging, machine vision algorithms, imaging based automatic sorting and inspection, image processing, imaging based robot guidance			
Unit IV	**Intelligent robotic systems**	**(07 hrs)**	**COs Mapped: CO3, CO5**
Applications of intelligent systems for path planning for serial robots, mobile robot motion planning, robot Control in dynamic environments, autonomous robots, obstacle avoidance			
Unit V	**Artificial intelligence in flexible Automation**	**(07 hrs)**	**COs Mapped: CO4, CO5**
Applications of various intelligent systems for FMS functional segmentation schemes including control, real time scheduling, tool management, process planning, route optimization for AS/RS systems			

Reference Books

1. Steger, Carsten, Markus Ulrich, Christian Wiedemann. Machine Vision Algorithms and Applications (2nd ed.). Wiley, 2018. ISBN 978-3-527-41365-2.
2. Mikell P Groover, Automation, Production System and Computer Integrated Manufacturing, Prentice Hall, Publications, 2016. ISBN: 9789332549814
3. Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN: 9788131804896
4. Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN: 9788121939485
5. Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978-93-85046-52-0
6. Ramesh Jain, Rangachar Kasturi, Brian G. Schunck, Machine Vision, McGraw-Hill, Inc., 1995, ISBN 0-07-032018-7

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

K. K. Wagh Institute of Engineering Education and Research, Nasik
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T. Y. B. Tech.
Pattern 2022 Semester: V
Course Code: ROB223003 Course Subject : Microprocessors and Microcontrollers

Teaching Scheme: Theory :03hrs/week	Credit Scheme:	Examination Scheme:
Course Type :DCC	03	Continuous Comprehensive Evaluation: 20Marks InSem Exam: 20Marks EndSem Exam: 60Marks

Prerequisite Courses: -N.A.

Course Objectives: Students able to :

1. Explain microprocessor and microcontroller architectures and their applications in robotics and automation systems.
2. Acquire proficiency in programming microcontrollers and interfacing them with external devices, sensors, and actuators for control and automation tasks.
3. Explore advanced topics such as communication protocols, real-time operating systems, and system-on-chip architectures.

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

	Course Outcomes	Bloom's Level
CO1	Explain Microprocessor and microcontroller architectures and their applications in robotics and automation systems.	2-Understanding
CO2	Implement programming concepts of microcontrollers, synthesizing knowledge in assembly language and high-level languages for practical implementation in robotics and automation tasks.	3-Apply
CO3	Demonstrate effective problem-solving skills in automation applications.	3- Apply
CO4	Differentiate real-time operating systems and system-on-chip architectures, fostering higher-order thinking in the selection and implementation of solutions for robotic systems and automation.	4- Analyze

Course context, Relevance, Practical Significance:
This course equips students with theoretical knowledge and practical skills in microprocessors and microcontrollers, focusing on their applications in robotics and automation engineering. Students will learn about the architecture, programming, interfacing, and advanced topics such as communication protocols and real-time operating systems, preparing them to design and implement innovative solutions for robotics and automation challenges.

COURSE CONTENTS

Unit I	**Introduction to Microprocessors and Microcontrollers in Robotics and Automation**	**(7hrs)**	**Cos Mapped CO1**

Overview of microprocessors and microcontrollers and their significance in robotics and automation, Basics of digital electronics: binary number system, logic gates, Boolean algebra, Introduction to microprocessor and microcontroller architectures, Applications of microprocessors and microcontrollers in robotic systems and automation processes.

Unit II	Microprocessor Architecture and Programming for Robotics	(7hrs)	Cos Mapped CO2
Internal architecture of microprocessors with emphasis on components relevant to robotics,Memory organization and addressing modes tailored to robotic applications,Instruction set architecture (ISA) focusing on instructions commonly used in automation tasks,Introduction to assembly language programming for robotics.			
Unit III	**Microcontroller Architecture and Interfacing in Automation**	**(7hrs)**	**Cos Mapped CO3**
Introduction to microcontroller architectures suitable for automation tasks (e.g., AVR, PIC),Peripherals and I/O ports relevant to automation processes,Interrupt handling and real-time control for automation systems,Timers, counters, and PWM modules for precise timing and control,Interfacing sensors, actuators, and other devices with microcontrollers in automation application.			
Unit IV	**Communication Protocols for Robotics and Automation**	**(7hrs)**	**Cos Mapped CO3,CO4**
Serial communication protocols (UART, SPI, I2C) for data exchange in robotics and automation systems, Networking protocols for communication between robotic systems and automation controllers, Wireless communication standards (e.g., Bluetooth, Wi-Fi, Zigbee) and their applications in robotics and automation, Integration of communication protocols for seamless interaction between robotic components and automation processes.			
Unit V	**Applications in Robotics and Automation**	**(7hrs)**	**Cos Mapped CO3,CO4**
Real-time operating systems (RTOS) for embedded systems in robotics and automation System-on-Chip (SoC) architectures and their role in automation controllers Case studies showcasing microprocessor and microcontroller applications in robotics and automation Project work: designing and implementing robotic systems or automation solutions using microprocessors and microcontrollers, integrating concepts learned throughout the course			

Text Books

1. "Microprocessor Architecture, Programming, and Applications with the 8085" by Ramesh S. Gaonkar ISBN-13: 978-9339219817
2. "Microcontroller Theory and Applications: HC12 and S12" by Daniel J. Pack and Steven F. Barrett ISBN-13: 978-0136152057
3. "Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers" by Jonathan Valvano ISBN-13: 978-1463590154
4. "Microprocessors and Microcontrollers: Architecture, Programming, and Interfacing using 8085, 8086, and ARM" by Subrata Ghoshal ISBN-13: 978-1108723523
5. "PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18" by Muhammad Ali Mazidi, Rolin McKinlay, and Danny Causey ISBN-13: 978-0136072299

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	20

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T. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: V ROB223004:Name of Subject: Artificial Intelligence for Robotics Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical:02hrs./week	**01**	**Term work : 25Marks** **Oral :25 Marks**
Prerequisite Courses: Applied Mathematics III		
Course Objectives:		

Course Objectives	Description The course aims :
1	Understand Fundamentals of Artificial Intelligence for Robotics.
2	Programming in C/Matlab in fuzzy logic application, annealing/genetic algorithm, ant colony optimization algorithm
3	To learn and apply real time planning and scheduling problems

Course Outcomes	Description On completion of the course, students will be able to–	Blooms Level
CO1	Analyze the problems of C or Matlab to implement fuzzy logic application for autonomous robot system, solving inverse kinematic problems, ant colony optimization algorithm	4-Analyze
CO2	Understand computer vision techniques, intelligent programming, and reinforced learning to teach robots to make human-like decisions	2- Understand
CO3	Write program using Visual Prolog to create an expert system, obstacle avoidance in mobile robots	3-Apply
CO4	Implement A* algorithm to Solve 8-puzzle problem	3-Apply
CO5	Solving real time planning and scheduling problems using software like Witness/Pro-model	3-Apply

Course context, Relevance, Practical Significance:

The course typically helps to enable machines to sense, comprehend, act and learn human like activities. There are mainly 4 types of Artificial Intelligence: reactive machines, limited memory, theory of mind, and self-awareness.

Course Contents: (Perform any 7)

Assignment/ Experiment	Contents	Pr.Hrs.
1	Programming in C or Matlab to implement fuzzy logic application for autonomous robot system	2
2	Programming in C/Matlab to implement simulated annealing/genetic algorithm for solving inverse kinematic problems	2

3	Programming in C/Matlab to solve traveling salesman problem using ant colony optimization algorithm	2
4	Write program using Visual Prolog to create an expert system	2
5	Write program for obstacle avoidance in mobile robots using any one algorithm	2
6	Implement A* algorithm to Solve 8-puzzle problem using. Assume any initial configuration and define goal configuration clearly	2
7	Define the operators for controlling domestic robot; use these operators to plan an activity to be executed by the robot. For example, transferring two/three objects one over the other from one place to another. Use Means-Ends analysis with all the steps revealed	2
8	Solving real time planning and scheduling problems using software like Witness/Pro-model	2

Course Mapping:

Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Programming in C or Matlab to implement fuzzy logic application for autonomous robot system	1,2	1,2	1
2	Programming in C/Matlab to implement simulated annealing/genetic algorithm for solving inverse kinematic problems	1,2	1,2	1
3	Programming in C/Matlab to solve traveling salesman problem using ant colony optimization algorithm	2	1,2,3,4	1
4	Write program using Visual Prolog to create an expert system	2,3	1,2,4	1
5	Write program for obstacle avoidance in mobile robots using any one algorithm	2,3	1,2	1
6	Implement A* algorithm to Solve 8-puzzle problem using. Assume any initial configuration and define goal configuration clearly	4,5	1,2,4,5	1
7	Define the operators for controlling domestic robot; use these operators to plan an activity to be executed by the robot. For example, transferring two/three objects one over the other from one place to another. Use Means-Ends analysis with all the steps revealed	4,5	1,2,4,5	1
8	Solving real time planning and scheduling problems using software like Witness/Pro-model	4,5	1,2,4,5	1

T. Y. B. Tech. Pattern 2022 Semester: V Course Code: ROB223005 Course Subject : Microprocessors and Microcontrollers lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical : 02 hrs./week	**01**	**Term work : 25 Marks** **Practical : 25 Marks**
Prerequisite Courses: N.A		
Course Objectives:		

Course Objectives	Description
1	Explain microprocessor and microcontroller architectures and their applications in robotics and automation systems.
2	Acquire proficiency in programming microcontrollers and interfacing them with external devices, sensors, and actuators for control and automation tasks.
3	Explore advanced topics such as communication protocols, real-time operating systems, and system-on-chip architectures.

Course Outcomes	Description Student will be able to:	Blooms level
1	Explain Microprocessor and microcontroller architectures and their applications in robotics and automation systems.	2-Understanding
2	Implement programming concepts of microcontrollers, synthesizing knowledge in assembly language and high-level languages for practical implementation in robotics and automation tasks.	3-Apply
3	Demonstrate effective problem-solving skills in automation applications.	3- Apply
4	Differentiate real-time operating systems and system-on-chip architectures, fostering higher-order thinking in the selection and implementation of solutions for robotic systems and automation.	4- Analyze

Course context, Relevance, Practical Significance:

This course equips students with theoretical knowledge and practical skills in microprocessors and microcontrollers, focusing on their applications in robotics and automation engineering. Students will learn about the architecture, programming, interfacing, and advanced topics such as communication protocols and real-time operating systems, preparing them to design and implement innovative solutions for robotics and automation challenges.

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	Basic Assembly Language Programming.	2
2	i. Implement logical operations (AND, OR, XOR, NOT) in assembly language. ii. Develop programs to manipulate data in memory (copy, move, swap).	2
3	Sensor Interfacing and Data Acquisition	2
4	Control DC motors using microcontroller PWM outputs for speed control.	2
5	Interface servo motors for angular control in robotic applications	2
6	Implement serial communication between two microcontrollers using UART.	2
7	Implement interrupt-based timers for real-time control tasks.	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Basic Assembly Language Programming.	2,3	1,2,12	1
2	iii. Implement logical operations (AND, OR, XOR, NOT) in assembly language. iv. Develop programs to manipulate data in memory (copy, move, swap).	2,3	1,2,12	1
3	Sensor Interfacing and Data Acquisition	2,3	1,2,5,12	1
4	Control DC motors using microcontroller PWM outputs for speed control.	2,3	1,2,5,12	1
5	Interface servo motors for angular control in robotic applications	2,3	1,2,5,12	1
6	Implement serial communication between two microcontrollers using UART.	2,3	1,2,5,12	1
7	Implement interrupt-based timers for real-time control tasks.	2,3	1,2,5,12	1

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T. Y. B. Tech.
Pattern 2022 Semester: V
Course Code : ROB223006 Course Name: Elective 1 (A)Python Programming

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: - students are expected to have a good understanding of basic computer principles.

Course Objectives: Course Objectives:
Prime objective is to give students a basic introduction to programming and problem solving with computer language Python. And to introduce students not merely to the coding of computer programs, but to computational thinking, the methodology of computer programming, and the principles of good program design including modularity and encapsulation.
1. To understand problem solving, problem solving aspects, programming and to know about various program design tools.
2. To learn problem solving with computers
3. To learn basics, features and future of Python programming.
4. To acquaint with data types, input output statements, decision making, looping and functions in Python
5. To learn features of Object Oriented Programming using Python

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

	Course Outcomes	Bloom's Level
CO1	Inculcate and apply various skills in problem solving	1
CO2	Choose most appropriate programming constructs and features to solve the problems in diversified domains.	2
CO3	Exhibit the programming skills for the problems those require the writing of well documented programs including use of the logical constructs of language, Python.	2
CO4	Demonstrate significant experience with the Python program development environment	2

COURSE CONTENTS

Unit I	Basics of Python Programming	(7hrs)	Cos Mapped CO1

Basics of Python Programming: Features of Python, History and Future of Python, Writing and executing Python program, Literal constants, variables and identifiers, Data Types, Input operation, Comments, Reserved words, Indentation, Operators and expressions, Expressions in Python.

Unit II	Decision Control Statements	(7hrs)	Cos Mapped CO2

Decision Control Statements: Decision control statements, **Selection/conditional** branching Statements: if, if-else, nested if, if-elif-else statements. **Basic loop** Structures/Iterative statements: while loop, for loop, selecting appropriate loop. Nested loops, The break, continue, pass, else statement used with loops. Other data types- Tuples, Lists and Dictionary.

Unit III	Functions and Modules	(7hrs)	Cos Mapped CO3

Need for functions, **Function:** definition, call, variable scope and lifetime, the return statement. Defining functions, Lambda or anonymous function, documentation string, good programming practices. Introduction to modules, Introduction to packages in Python, Introduction to standard library modules.

Unit IV	Strings and Dictionaries	(7hrs)	Cos Mapped CO4

Strings and Operations- concatenation, appending, multiplication and slicing. Strings are immutable, strings formatting operator, built in string methods and functions. Slice operation, ord() and chr() functions, in and not in operators, comparing strings, Iterating strings, the string module.

Dictionaries- creating, assessing, adding and updating values.

Unit V	Object Oriented Programming	(7hrs)	Cos Mapped CO4

Programming Paradigms-monolithic, procedural, structured and object oriented, **Features of Object oriented programming**-classes, objects, methods and message passing, inheritance, polymorphism, containership, reusability, delegation, data abstraction and encapsulation. **Classes and Objects:** classes and objects, class method and self-object, class variables and object variables, public and private members, class methods.

Text Books

1 Reema Thareja, "Python Programming Using Problem Solving Approach", Oxford University Press, ISBN 13: 978-0-19-948017-6

2 R. Nageswara Rao, "Core Python Programming", Dreamtech Press; Second edition ISBN10: 938605230X, ISBN-13: 978-9386052308 ASIN: B07BFSR3LL

Reference Books

1. R. G. Dromey, "How to Solve it by Computer", Pearson Education India; 1st edition, ISBN10: 8131705625, ISBN-13: 978-8131705629 Maureen Spankle, "Problem Solving and Programming Concepts", Pearson; 9th edition, ISBN-10: 9780132492645, ISBN-13: 978- 0132492645
2. Romano Fabrizio, "Learning Python", Packt Publishing Limited, ISBN: 9781783551712, 1783551712
3. Paul Barry, "Head First Python- A Brain Friendly Guide", SPD O'Reilly, 2nd Edition, ISBN:978-93-5213-482-3

Strength of CO-PO Mapping														
	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO2	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO3	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO4	2	1	2	-	2	-	-	-	-	-	-	1	1	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: V
223006A: Name of Subject: Elective I (B): Reverse Engineering

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

Prerequisite Courses: - Computer Graphics for Robotics, Design of Machine Elements

Course Objectives:
Understand the Reverse Engineering.
Understand the Methodologies and Techniques for Reverse Engineering.
Understand Reverse Engineering–Hardware and Software.
Apply Selection of a Reverse Engineering System

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

	Course Outcomes	**Bloom's Level**
CO1	Demonstrate the use of reverse engineering system to various applications	2. Understand
CO2	Interpreting the terminologies related to re-engineering, forward engineering, and reverse engineering.	3 Apply
CO3	Disassemble products and specify the interactions between its subsystems and their functionality	3 Apply
CO4	Implement the Reverse Engineering methodologies	3 Apply

COURSE CONTENTS

Unit I	**Introduction to Reverse Engineering**	**(07 hrs)**	**COs Mapped: CO1**

What is Reverse Engineering, Use of Reverse Engineering, Reverse Engineering–The Generic Process, Scanning: Contact Scanners, Noncontact Scanners, Point Processing, and Application Geometric Model Development. Applications of reverse engineering

Unit II	**Methodologies and Techniques for Reverse Engineering**	**(07 hrs)**	**COs Mapped: CO2, CO3**

3-D Laser Scanners, Computer-aided Reverse Engineering, What Is Not Reverse Engineering, Computer aided (Forward) Engineering, Computer-aided Reverse Engineering, Computer Vision and Reverse Engineering, Coordinate Measuring Machines, Active Illumination 3-D Stereo: Benefits and Drawbacks, Structured-light Range Imaging, Source Illumination Categories, sheet-of-light Range Imaging, Scanner Pipeline, Data Collection, Mesh Reconstruction, Surface Fitting.

Unit III	**Reverse Engineering–Hardware and Software**	**(07 hrs)**	**COs Mapped: CO2, CO3**

Introduction, Reverse Engineering Hardware, Contact Methods, Noncontact Methods, Destructive Method, Reverse Engineering Software, Reverse Engineering Software Classification, Reverse Engineering Phases, Fundamental Reverse Engineering Operations.

Unit IV	Selection of a Reverse Engineering System	(07 hrs)	COs Mapped: CO3, CO4

The Selection Process: Identify the Business Opportunity and Technical requirements, Vendor and System Information Gathering, Benchmarking, Point Capture Devices, contact Devices–Hard or Manual Probe, Touch-trigger Probe, Continuous Analogue Scanning Probe, Noncontact Devices, Triangulation, "Time-offlight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, Issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing approaches.

Unit V	Rapid prototyping for Reverse Engineering	(07 hrs)	COs Mapped: CO3, CO4

Modelling Cloud Data in Reverse Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, The Adaptive Slicing Approach for Cloud Data Modelling, Planar Polygon Curve Construction for a Layer, Correlation Coefficient, Initial Point Determination, Constructing the First Line Segment (S1), constructing the Remaining Line Segments (Si, Determination of Adaptive Layer Thickness)

Reference Books

1. K. Otto and K. Wood (2001) Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall (ISBN 10: 0130212717 / ISBN 13: 9780130212719).
2. Raja and Fernandes (2008) Reverse Engineering: An Industrial Perspective, Springer-Verlag (ISBN: 978-1-84628-855-5).
3. Sokovic and Kopac (2006) RE as necessary phase by rapid product development, Journal of Materials Processing Technology, Elsevier (doi:10.1016/j.jmatprotec.2005.04.047).
4. Eldad Eilam (2005) Reversing: Secrets of Reverse Engineering, Wiley (ISBN: 0-7645-7481-7).
5. Robert W. Messler (2014) Reverse Engineering: Mechanisms, Structures, Systems & Materials, McGraw-Hill Education (ISBN: 9780071825160).

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

(Autonomous from Academic Year 2022-23)

T. Y. B. Tech. **Pattern 2022 Semester: VI** **Code ROB223014 Course Name : Elective I (C) JAVA Programming**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: -

Course Objectives:

1. Make the students familiar with basic concepts and techniques of object oriented programming in Java.
2. Develop an ability to write various programs in Java for problem solving.

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

	Course Outcomes	**Bloom's Level**
CO1	Understand the basic principles of Java programming language	1
CO2	Apply the concepts of classes and objects to write programs in Java	2
CO3	Demonstrate the concepts of methods & Inheritance	2
CO4	Use the concepts of interfaces & packages for program implementation	2
CO5	Understand multithreading and Exception handling in Java to develop robust programs	2

COURSE CONTENTS

Unit I	**JAVA Fundamentals**	**(08hrs)**	**Cos Mapped CO1, CO2, CO4, CO5**

Review of Object oriented concepts, Evolution of Java, Comparison of Java with other programming languages, Java features, Java and World Wide Web, Java Run Time Environment. JVM architecture. Overview of Java Language, Simple Java Program, Java Program Structure. Installing and Configuring Java.

Java Tokens, Java Statements, Constants, variables, data types. Declaration of variables, Giving values to variables, Scope of variables, arrays, Symbolic constants, Typecasting, Getting values of variables, Standard default values, Operators, Expressions, Type conversion in expressions, Operator precedence and associatively, Mathematical functions, Control statements- Decision making & looping.

Unit II	**Classes and Objects**	**(8hrs)**	**Cos Mapped CO2**

Class Fundamentals, Creating Objects, Accessing Class members, Assigning Object reference variables, Methods, Constructors, using objects as parameters, Argument passing, returning objects, Method Overloading, static members, Nesting of Methods , this keyword, Garbage collection, finalize methods, ,

final variables and methods, final class.

Unit III	Methods & Inheritance in JAVA	(8hrs)	Cos Mapped CO3

Abstract Methods and classes, Strings ,One dimensional and two dimensional arrays , wrapper classes, enumerated types, Command line arguments

Inheritance: Inheritance in Java, Creating Multilevel hierarchy, Constructors in derived class, Method overriding, Dynamic method dispatch.

Unit IV	Interfaces & Packages	(8hrs)	Cos Mapped CO4

Interfaces: Define, implement and extend, Accessing Interface variables, Default interface methods, Using static method in interface

Packages: Java API Packages, Using System Packages, Creating accessing and using a package, Importing packages, Adding a class to a Package, Hiding classes

Unit V	Multithreading & Exception Handling	(8hrs)	Cos Mapped CO5

Introduction to multithreading: Introduction, Creating thread and extending thread class. Concept of Exception handling: Introduction, Types of errors, Exception handling syntax, Multiple catch statements. I/O basics, Reading console inputs, Writing Console output. Applets: Concepts of Applets, differences between applets and applications, life cycle of an applet, types of applets, creating a simple applet.

Text Books

1. E Balagurusamy, "Programming with JAVA", Tata McGraw Hill, 6th Edition
2. Herbert Schildt, "Java: The complete reference", Tata McGraw Hill, 7th Edition.

Reference Books

1. T. Budd, "Understanding OOP with Java", Pearson Education, 2nd Updated Edition.
2. Y. Daniel Liang (2010), "Introduction to Java programming", Pearson Education, India, 7th Edition.
3. Cay Horstmann , "Core Java Volume 1", Kindle, 11th Edition.

Strength of CO-PO Mapping														
	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2	-	2	-	2	-	-	-	-	-	-	1	-	-
CO2	2	-	2	-	2	-	-	-	-	-	-	1	-	-
CO3	2	-	2	-	2	-	-	-	-	-	-	1	-	-
CO4	1	-	2	-	2	-	-	-	-	-	-	1	-	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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

T. Y. B. Tech.
Robotics and Automation (Pattern 2022)
Semester: V
ROB223006D:Elective I(D)- Digital Signal Processing

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

Prerequisite Courses: - Mathematics, Fourier series, Fourier transform, Z transform

Course Objectives: At the end of the course, a student will be able to –
1. Understand basics of digital signals and systems and understand the basic mathematical tools needed for the analysis of discrete systems
2.Analyze discrete signals as well as discrete systems in frequency domain and apply related numerical analysis for the same.
3. Understand the basics of filter design with clear understanding of the notion of digital filtering which includes FIR and IIR filters

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

	Course Outcomes	**Bloom's Level**
CO1	Classify discrete time signal and system and determine Z and inverse Z-transform of DTS	2-Understanding
CO2	Recognize types of discrete-time signals and properties of discrete-time systems.	2-Understanding
CO3	Compute the response of discrete-time systems to various input signals.	3-Apply
CO4	Evaluate and analyze the frequency domain characteristics of Discrete-Time Systems	4-Analyze
CO5	Design and implement different frequency selective FIR and IIR filters.	3-Apply

COURSE CONTENTS

Unit I	**Discrete Time Signals and Systems**	**(07hrs)**	**COs Mapped –CO1, CO2**

Basic elements of Digital signal Processing System,Analog, Discrete-time and Digital signals, Basic sequences and sequence operations, Discrete time systems, Properties of D. T. Systems and Classification, Linear Time Invariant Systems, impulse response, linear convolution and its properties, properties of LTI systems: stability, causality, Periodic Sampling, Sampling Theorem, Frequency Domain representation of sampling, reconstruction of a band limited Signal, A to D conversion Process: Sampling, quantization and encoding

Unit II	Frequency analysis of discrete time signals	(07hrs)	COs Mapped CO1,CO2,CO 3

Discrete Time Fourier Transform: Representation of Sequences by Fourier Transform, Symmetry properties of D. T., F. T. theorems: Linearity, time shifting, frequency shifting, time reversal, differentiation, convolution theorem, Frequency response analysis of first and second order system, steady state and transient response,

Z-Transform:Revision of Z-transform, Numerical of Z transform, Inverse Z transform using partial fraction and power series method

Unit III	Discrete Fourier Transform	(06hrs)	CosMapped CO3,CO4

Definition and Properties of DFT, Circular convolution, Linear convolution using circular convolution, Fast Fourier Transform: Radix 2 DIT and DIF algorithms

UnitIV	Structure of IIR	(07hrs)	COs Mapped – CO5

Advantages and disadvantages of digital filter over analog filters, classification of digital filters: FIR and IIR, design of analog low pass Butterworth filter, Chebyshev filter, design of IIR filters from analog filters using bilinear transformation, impulse invariance.

Unit V	Symmetric & Anti-symmetric FIR filters	(07hrs)	COs Mapped –CO5

Introduction to FIR filters, Linear phase filter – Windowing techniques – rectangular, triangular, Blackman and Kaiser windows – Frequency sampling techniques – Structure for FIR systems.

Course Mapping:

Unit	Content	Blooms Taxonomy Level	CO mapped	PO mapped	PSO mapped
I	**Introduction to Discrete Time Signals and Systems**	2	1,2	1,2	1
II	**Frequency analysis of discrete time signals**	2,3	1,2,3	1,2	1
III	**Discrete Fourier Transform**	3,4	3,4	1,2,3,4,5	1
IV	**Structure of IIR**	3	5	1,2,3,4,5	1
V	**Symmetric & Anti-symmetric FIR filters**	3	5	1,2,3,4,5	1,2

Text Books

[T1] Proakis J. G and D. G. Manolakis, "Digital Signal processing, Principles, Algorithms and Applications", Prentice Hall of India.

[T2]Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill, 1998, ISBN 0-07-044705-5

[T3]P.Ramesh Babu "Digital Signal Processing" 4th Edition, Scitech Publication, Chennai

[T2] Johnson J. R, "Introduction to Digital Signal Processing", Prentice Hall of India.

[T3] Rabiner, Gold, "Theory and Applications of Digital Signal Processing", Tata McGraw Hill.

[T4] E. C. Ifeachor& B. W. Jarvis, "Digital Signal Processing- A Practical Approach", Pearson Education,New Delhi

Reference Books

[R1] Oppenheim A., Schafer R., Buck J., “Discrete time signal processing”, 2nd Edition, Prentice Hall, 2003, ISBN-81-7808-244-6
[R2] Rebizant, Waldemar, Szafran, Janusz, Wiszniewski, Andrzej, “Digital Signal Processing in Power System Protection and Control”, 1st Edition. Springer, 2011, ISBN 0857298011, 9780857298010

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Timely Submission of Assignments (Total 3Assignment,Unit I and II 20marks, Unit III and IV20marksand Unit V10 marks &50 marks will be converted to 10 Marks)	10
2	Tests on each unit using LMS (Each test for15 M and total will be converted out of 10M)	10

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T. Y. B. Tech. Pattern 2022 Semester: V Course Code : ROB223007 Course Name: Elective 1 (A)Python Programming Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02 hrs. /week	**01**	**Term work : 25 Marks** **Practical : 25 Marks**
Prerequisite Courses: students are expected to have a good understanding of basic computer principles.		
Course Objectives:		

Course Objectives	Description
1	To understand problem solving, problem solving aspects, programming and to know about various program design tools.
2	To learn problem solving with computers
3	To learn basics, features and future of Python programming.
4	To acquaint with data types, input output statements, decision making, looping and
5	To learn features of Object Oriented Programming using Python

Course Outcomes:

Course Outcomes	Description
1	Inculcate and apply various skills in problem solving
2	Choose most appropriate programming constructs and features to solve the problems in diversified domains.
3	Exhibit the programming skills for the problems those require the writing of well documented programs including use of the logical constructs of language, Python.
4	Demonstrate significant experience with the Python program development environment
5	Inculcate and apply various skills in problem solving

Course context, Relevance, Practical Significance:

The Python programming course introduces students to the fundamentals of Python language, covering topics such as basic syntax, decision control statements, functions, modules, strings, dictionaries, and object-oriented programming (OOP). Through this course, students gain practical skills in writing and executing Python programs, making decisions using control statements, defining and using functions and modules, manipulating strings and dictionaries, and implementing OOP concepts like classes, objects, and inheritance. Python's simplicity, versatility, and extensive libraries make it a valuable tool across various domains such as software development, data science, web development, and automation, making this course highly relevant for students aiming to build a strong foundation in programming for real-world applications.

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	Basics of Python Programming	2
2	Programs using Decision Control Statements	2
3	Programs using Functions and Modules	2
4	Programs using Strings	2
5	Programs using Dictionaries	2
6	Programs using Object Oriented Programming	2
7	Mini project	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Basics of Python Programming	1	1,2	-
2	Programs using Decision Control Statements	2	1,2	-
3	Programs using Functions and Modules	2	1,2	-
4	Programs using Strings	3	1,2	-
5	Programs using Dictionaries	3	1,2	-
6	Programs using Object Oriented Programming	4	1,2	-
7	Mini project	1,2,3,4	1,2	-

T. Y. B. Tech.
Robotics and Automation
Pattern 2022, Semester: V
ROB223006: Subject Name: Elective I Reverse Engineering Lab

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

Prerequisite Courses: Engineering Mechanics

Course Objectives:

Course Objectives	**Description** The course aims :
1	Understand the problem in the existing process.
2	Collect the large number of data/ information for the product
3	Analyze of the products and extraction of real time data.

Course Outcomes	**Description** On completion of the course, students will be able to–	**Blooms Level**
CO1	Understand the problem in the existing process	2 Understand
CO2	Understand the ways to redesign and improve the performance of the system.	2 Understand
CO3	Understand the principles behind the design of the product	2 Understand
CO4	Analyze of the products and extraction of real time data	4-Analyze

Course context, Relevance, Practical Significance:
The objective of the module is to go through the Reverse Engineering process as it is a self-learning tool used to summarize the process of reconstructing/ reformation of an already existing object.

Course Contents: (Perform any 7)

Assignment/ Experiment	**Contents**	**Pr.Hrs.**
1	Study of static and dynamic program analysis concepts and terminology	2
2	Study of steps into reverse engineer software	2
3	Study of mechanisms which makes reverse engineering tasks more challenging	2
4	Study of Selection of a Reverse Engineering System	2
5	Study of Rapid prototyping for Reverse Engineering	2
6	Study of Integration of RE and RP for Layer-based Model Generation	2

Course Mapping:

Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Study of static and dynamic program analysis concepts and terminology	1,2	1,2	1
2	Study of steps into reverse engineer software	1,2	1,2	1
3	Study of mechanisms which makes reverse engineering tasks more challenging	2	1,2,3,4	1
4	Study of Selection of a Reverse Engineering System	2,3	1,2,4	1
5	Study of Rapid prototyping for Reverse Engineering	2,3	1,2	1
6	Study of Integration of RE and RP for Layer-based Model Generation	2	1,2	1

T. Y. B. Tech. Pattern 2022 Semester: VI Course Code : ROB223017 Course Name : Elective II (C) JAVA Programming 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	Make the students familiar with basic concepts and techniques of object oriented programming in Java.
2	Develop an ability to write various programs in Java for problem solving.

Course Outcomes:

Course Outcomes	Description
1	Understand the basic principles of Java programming language
2	Apply the concepts of classes and objects to write programs in Java
3	Demonstrate the concepts of methods & Inheritance
4	Use the concepts of interfaces & packages for program implementation
5	Understand multithreading and Exception handling in Java to develop robust programs

Course context, Relevance, Practical Significance:

The course covers Java fundamentals including object-oriented concepts, classes, methods, inheritance, interfaces, packages, multithreading, and exception handling. It emphasizes practical application and relevance in software development, providing students with essential skills for creating versatile and scalable applications. Mastering Java is crucial for aspiring software developers, enabling them to build robust and platform-independent solutions, thus enhancing their career prospects in the technology sector

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	Write some simple programs in Java such as: i) To find factorial of number. ii) To display first 50 prime numbers. iii) To find sum and average of N numbers	2
2	Write a program in Java to implement a Calculator with simple arithmetic operations such as add, subtract, multiply, divide, factorial etc. using switch case and other simple java statements. The objective of this assignment is to learn Constants, Variables, and Data Types, Operators and Expressions, Decision making statements in Java.	2
3	Write a program in Java with class Rectangle with the data fields width, length, area and colour. The length, width and area are of double type and colour is of string type. The methods are get_length(), get_width(), get_colour() and find_area(). Create two objects of Rectangle and compare their area and colour. If the area and colour both are the same for the objects then display " Matching Rectangles", otherwise display " Non-matching Rectangle"	2
4	Write a program in JAVA to demonstrate the method and constructor overloading	2
5	Write Programs in Java to sort i) List of integers ii) List of names. The objective of this assignment is to learn Arrays and Strings in Java	2
6	Write a Program in Java to add two matrices. The objective of this assignment is to learn Arrays in Java	2
7	Write a program in Java to create a player class. Inherit the classes Cricket_player, Football_player and Hockey_player from player class. The objective of this assignment is to learn the concepts of inheritance in Java	2
8	Write a program to create multiple threads and demonstrate how two threads communicate with each other.	2
9	Write a java program in which data is read from one file and should be written in another file line by line.	2
10	A Mini project in Java: A group of 4 students can develop a small application in Java	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Write some simple programs in Java such as: i) To find factorial of number. ii) To display first 50 prime numbers. iii) To find sum and average of N numbers	1	1,2	-
2	Write a program in Java to implement a Calculator with simple arithmetic operations such as add, subtract, multiply, divide, factorial etc. using	1	1,2	-

	switch case and other simple java statements. The objective of this assignment is to learn Constants, Variables, and Data Types, Operators and Expressions, Decision making statements in Java.			
3	Write a program in Java with class Rectangle with the data fields width, length, area and colour. The length, width and area are of double type and colour is of string type. The methods are get_length(), get_width(), get_colour() and find_area(). Create two objects of Rectangle and compare their area and colour. If the area and colour both are the same for the objects then display " Matching Rectangles", otherwise display " Non-matching Rectangle"	2	1,2	-
4	Write a program in JAVA to demonstrate the method and constructor overloading	2	1,2	-
5	Write Programs in Java to sort i) List of integers ii) List of names. The objective of this assignment is to learn Arrays and Strings in Java	2	1,2	-
6	Write a Program in Java to add two matrices. The objective of this assignment is to learn Arrays in Java	3	1,2	-
7	Write a program in Java to create a player class. Inherit the classes Cricket_player, Football_player and Hockey_player from player class. The objective of this assignment is to learn the concepts of inheritance in Java	3	1,2	-
8	Write a program to create multiple threads and demonstrate how two threads communicate with each other.	4	1,2	-
9	Write a java program in which data is read from one file and should be written in another file line by line.	4	1,2	-
10	A Mini project in Java: A group of 4 students can develop a small application in Java	5	1,2	-

T. Y. B. Tech.
Robotics and Automation Pattern2022,
Semester: V
ROB223007D:Elective I(D): Digital Signal Processing Lab

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

Prerequisite Courses: Mathematics, Fourier series, Fourier transform, Z transform

Course Objectives:

Course Objectives	**Description** The course aims :
1. Understand basics of digital signals and systems and understand the basic mathematical tools needed for the analysis of discrete systems 2.Analyze discrete signals as well as discrete systems in frequency domain and apply related numerical analysis for the same. 3. Understand the basics of filter design with clear understanding of the notion of digital filtering which includes FIR and IIR filters	

Course Outcomes	**Description** On completion of the course, students will be able to–	**Blooms Level**
CO1	Classify discrete time signal and system and determine Z and inverse Z-transform of DTS	2-Understanding
CO2	Recognize types of discrete-time signals and properties of discrete-time systems.	2-Understanding
CO3	Compute the response of discrete-time systems to various input signals.	3-Apply
CO4	Evaluate and analyze the frequency domain characteristics of Discrete-Time Systems	4-Analyze
CO5	Design and implement different frequency selective FIR and IIR filters.	3-Apply

Course context, Relevance, Practical Significance:

In the context of robotic engineering, Digital Signal Processing (DSP) plays a crucial role in various aspects of robot design, control, perception, and interaction with the environment. Robots rely on various sensors such as cameras, lidar, ultrasonic sensors, and inertial measurement units (IMUs) to perceive their environment. DSP techniques are used to process and interpret sensor data, enabling robots to extract meaningful information for navigation, object detection, and obstacle avoidance. DSP opens avenues for research and innovation in robotics, enabling the development of novel algorithms, sensors, and control strategies to address emerging challenges and applications in fields such as service robotics, aerial robotics, and soft robotics.

Course Contents: Students are expected to perform minimum Seven experiments:

Assignment/ Experiment	Contents	Pr.Hrs.
1	Generate the discrete-time standard test signals viz. impulse, unit step, ramp, parabolic, exponential and sinusoidal signal.	2
2	Implement the basic operations on the given signals.	2
3	Implement Linear Convolution of the given two discrete time sequences.	2
4	Obtain the transfer function and plot is pole-zero plot in z-domain.	2
5	Find the DTFT of the given sequence and plot its magnitude and phase plot	2
6	Write a program to design and implement FIR filters using windowing method for the given specifications.*(By Python or Matlab)	
7	Write a Program to design and implement digital IIR filter using Butterworth approximations for the given specifications of a low-pass filter.*(By Python or Matlab)	2
8	Write a Program to design and implement digital IIR filter using Chebyshev approximations for the given specifications of a low-pass filter.*(By Python or Matlab)	2

Course Mapping: (Perform any 5)

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Generate the discrete-time standard test signals viz. impulse, unit step, ramp, parabolic, exponential and sinusoidal signal.	1,2	1,2	1
2	Implement the basic operations on the given signals.	1,2	1,2	1
3	Implement Linear Convolution of the given two discrete time sequences.	3	1,2	1
4	Obtain the transfer function and plot is pole-zero plot in z-domain.	2	1,2	1
5	Find the DTFT of the given sequence and plot its magnitude and phase plot	3	1,2	1
6	Write a program to design and implement FIR filters using windowing method for the given specifications.*(By Python or Matlab)	5	1,2	1

7	Write a Program to design and implement digital IIR filter using Butterworth approximations for the given specifications of a low-pass filter.*(By Python or Matlab)	5	1,2	1
8	Write a Program to design and implement digital IIR filter using Chebyshev approximations for the given specifications of a low-pass filter.*(By Python or Matlab)	5	1,2	1

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

T. Y. B. Tech.
Pattern 2022 Semester: V
Course Code : ROB223008 Course Name: Data Analytics

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: - Statistics

Course Objectives:

1. Develop proficiency in handling and preprocessing data from various sources.
2. Master basic and inferential statistical methods for data analysis.
3. Understand and apply advanced analytics techniques for predictive modeling and pattern recognition.
4. Gain practical experience in applying data analytics tools and methodologies to real-world datasets and scenarios.

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

	Course Outcomes	**Bloom's Level**
CO1	Demonstrate specialist knowledge of how a range of data sources and analytical methods are used to inform decision making across multiple domains.	2-Understanding
CO2	Demonstrate familiarity with the use of appropriate contemporary programming languages to manipulate data and perform statistical analyses.	3- Apply
CO3	Select and apply contemporary data analytics research techniques to investigate social, policy, scientific and organizational problems.	3- Apply
CO4	Synthesize insights from a range of analyses to develop evidence-based solutions to complex problems.	4-Analyze

COURSE CONTENTS

Unit I	**Introduction to data analytics**	**(7hrs)**	**Cos Mapped CO1**

Significance & applications of data analytics, Data collection, data processing, data transformation, data integration, data visualization, basic statistics, inferential statistics

Unit II	**Descriptive analytics**	**(7hrs)**	**Cos Mapped CO2**

Uni-variate/multi-variate statistics, bi-variate associations, correlations, covariance, analysis of variance(ANOVA)

Unit III	**Predictive analytics**	**(7hrs)**	**Cos Mapped CO3**

Multiple regression, conjoint analysis, neural networks, data clustering, Data mining			
Unit IV	**Classification techniques**	**(7hrs)**	**Cos Mapped CO3**
Linear classifiers, Quadratic classifiers, Support vector machines, Random forests.			
Unit V	**Prescriptive analytics**	**(7hrs)**	**Cos Mapped CO4**
Decision tree analysis, Expert system, principal component analysis, genetic algorithms			

Text Books

3 Acharya Seema and Chellappan, Big Data and Analytics, Willey India Pvt. Ltd. (2015), ISBN:9788126554782

Reference Books

1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, Willey India Pvt. Ltd. (2016), ISBN: 978-1-118-87622-0
2. Michael Minelli, Michale Chambers, Ambiga Dhiraj, Big Data Analytics: Emerging Business Intelligence and analytics trends for today‘s business, Willey India Pvt. Ltd.

Strength of CO-PO Mapping														
	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2	-	2	2	3	-	-	2	2	3	-	2	--	-
CO2	2	-	1	1	3	-	-	2	2	3	-	2	-	-
CO3	2	-	2	3	3	3	-	2	2	3	-	3	-	-
CO4	2	-	3	3	3	3	-	2	2	3	-	3	-	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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K. K. Wagh Institute of Engineering Education and Research, Nashik
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T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: V
ROB2312309 : Name of Subject: Financial Management

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :02 hrs/week	**02**	**CCE: 50 Marks**

Prerequisite Courses: ---

Course Objectives:

- To provide thorough grounding of financial management concepts and preparation of Financial Statements with their analysis.
- To gain expert knowledge of principles and concepts used in finance
- To learn to manage short-term resources of a business firm
- To be able to find out the best course of action among several financial options
- To help understand costing and management accounting techniques that could be utilized for decision making and control.

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

	Course Outcomes	**Bloom's Level**
CO1	Explain Financial Statements: Balance sheet, profit and loss account	2. Understand
CO2	Apply capital budgeting techniques and evaluate their limitations	3. Apply
CO3	Demonstrate how materials, labor and overhead costs are added to a product at each stage of the production cycle.	3. Apply

COURSE CONTENTS

Unit I	**Financial Management**	**(08 hrs)**	**COs Mapped: CO1**

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.

Unit II	**Capital Budgeting and Working Capital Management**	**(08 hrs)**	**COs Mapped: CO2**

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.
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 and Cost Control**	**(08 hrs)**	**COs Mapped: CO3**

Methods of costing and elements of cost, 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, and absorption of overheads. Machine hour and labour hour rate. Under and over absorption of overheads. Estimation of overheads. Costing methods: marginal Costing, Activity based costing

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.

Reference Books

1. Khan M. Y., Jain P. K., Basic Financial Management, Tata McGraw Hill, Delhi, 2005.
2. Chandra, Prasanna. Financial Management, Tata McGraw Hill, Delhi.
3. Bhabatosh Banerjee, Fundamentals of Financial Management, PHI, Delhi, 2010
4. Chandra Bose D, Fundamentals of Financial Management, PHI, Delhi, 2010
5. Preeti Singh, Fundamentals of Financial Management, Ane, 2011.

Strength of CO-PO Mapping

	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1		1	1			2				1	3	1
CO2		1	1			2				1	3	1
CO3		1	1			2				1	3	1

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 30 M)	30
2	Timely Assignments Submission on each unit (5 M for each unit)	20

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T. Y. B. Tech. Robotics and Automation Pattern 2022 Semester: VI ROB223010: Name of Subject: Seminar		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical :02 hrs/week **Tutorial : 01 hr/week**	**02**	**Term work: 25 Marks** **Tutorial : 25 marks**
Prerequisite Courses, if any: -		
1. The objective of Seminar is to test the student on his/her ability for self-study and his/her ability to communicate - Written and oral. 2. Seminar will be in the form of a report submitted by the student: a) On topic of his/her choice based on literature survey/ a case study wherever applicable/possible, and approved by the staffin- charge. b) A report with 20-25 pages of A-4 size paper, 1.5 spaced typed material, and appropriately bound. c) Title font/figures/graphs shall be black and white.		

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T. Y. B. Tech.
Robotics and Automation (Pattern 2022)
Semester: VI
ROB223011: Name of Subject: Sensor Technology

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory:03hrs/week	**03**	**CCE: 20Marks** **In Sem Exam: 20 Marks** **EndSemExam:60Marks**

Prerequisite Courses: -
1. Basic Electrical Engineering 2. Basic Electronics Engineering

Course Objectives: The course aims to:

1. Familiarity with sensor principles and Technologies
2. Master Sensor interfacing and signal conditioning
3. Explore Sensor Fusion and Integration
4. Examine Applications of Sensor Technology
5. Explore Emerging Trends and Future Directions

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

	Course Outcomes	**Bloom's Level**
CO1	Explain the underlying principles of sensor operation in robotics and automation	2- Understanding
CO2	Understand the role of sensors in various robotic applications such as industrial automation, autonomous navigation, and manipulation tasks.	2- Understanding
CO3	Use sensor data to solve practical problems related to sensor integration, calibration, and troubleshooting in robotic systems	3-Apply
CO4	Analyze sensor data to evaluate the performance and reliability of sensors in specific robotic tasks and environments	4-Analyze
CO5	Develop the ability to analyze and assess the suitability of sensors for specific robotic tasks and environments.	4- Analyze

COURSE CONTENTS

Unit I	**Introduction to Sensors & Transducers**	**(07hrs)**	**COs Mapped - CO1, CO2**

Introduction to sensor Technologies in Robotics, Definition and classification of sensors, Role of sensors in robotics and automation, Role of Transducer in measurement Systems, Block Diagram Measurement system Basic principles of sensor operation, Types of sensors: contact and non-contact, Characteristics of sensors: accuracy, precision, resolution, sensitivity, etc., Overview of sensor selection criteria

Unit II	Sensor Principles & Technologies	(08hrs)	COs Mapped - CO1, CO2,CO3

Types of Sensors: Distance and proximity: Ultrasonic sensors, LiDAR, infrared sensors. Position and orientation: Encoders, gyroscopes, accelerometers, Force/torque sensors, Vision sensors (cameras, depth sensors), Inertial sensors (accelerometers, gyroscopes), Tactile sensors, Environmental sensors (temperature, humidity, gas)- Working principle & operation of each sensor, Basic Principle of working of Resistive, Capacitive and Inductive sensors, Optical sensors (photodiodes, phototransistors, etc.), Ultrasonic sensors, Hall effect sensors, Comparative analysis of different sensor technologies

Unit III	Sensor Interfacing & Signal Conditioning	(07hrs)	COsMapped –CO3, CO4

Analog and digital sensor interfaces, Signal conditioning techniques: Amplification, Filtering, Linearization, Analog-to-digital conversion (ADC) methods, Digital signal processing (DSP) for sensor data, Practical considerations in sensor interfacing and signal conditioning

UnitIV	Sensor Fusion and Integration	(07hrs)	COs Mapped - CO3,CO4,CO 5

Sensor fusion concepts and importance in robotics and automation, Integration of multiple sensors for enhanced performance, Kalman filtering and other fusion algorithms, Applications of sensor fusion in: Localization and mapping, Object tracking and recognition
Navigation and path planning, Feedback control systems

Unit V	Application of Sensor Technology	(07hrs)	COs Mapped - CO3, CO4,CO5

Role of sensors in robotics and automation systems, Case studies and practical applications:
Position and motion sensing in robotic manipulators, Vision sensors for object detection and localization, Proximity sensors for obstacle avoidance, Force and torque sensors for robotic grippers, Environmental sensors for industrial automation (temperature, humidity, etc.), Feedback control systems utilizing sensor feedback, Emerging trends and future directions in sensor technology for robotics and automation

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
I	Introduction to Sensors & Transducers	2	1,2	1	1
II	Sensor Principles & Technologies	2	1,2,3	1,2,3,4,5	1
III	Sensor Interfacing & Signal Conditioning	3,4	3,4	1,2,3,4,5	1,2
IV	Sensor Fusion and Integration	3,4	3,4,5	1,4,5	1,2
V	Application of Sensor Technology	3,4	3,4,5	1,2,3,4,5, 6	1,2

Learning Resources

Text Books:

1. Sawhney A. K., "Electrical and Electronics Measurements and Instrumentation", Dhanpat Rai & Sons, 4 th Edition, 1994.
2. D. Patranabis, “Sensors and Transducers”, Prentice Hall India Learning Private Limited, 2nd Edition.

Reference Books
1] Robotics: Modelling, Planning and Control" by Bruno Siciliano et al. 2] Sensors and Actuators in Mechatronics: Design and Applications" by Andrzej M. Pawlak 3] Introduction to Autonomous Robots" by Nikolaus Correll et al. 4] Fundamentals of Industrial Automation" by Ricardo Suárez Fernández 5] Sensor Technology Handbook" by Jon S. Wilson 6] B.C. Nakra, K.K. Chaudhary, “Instrumentation, Measurement and Analysis”, McGraw Hill Education India Private Limited, 4th Edition 7] John G. Webster, "Instrumentation and Sensors Handbook", CRC Press, 1 st Edition, 1999.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr.No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments (Total 3Assignment,Unit I and II 20marks, Unit III and IV20marksand Unit V10 marks & 50 marks will be converted to 10 Marks)	10
2	Tests on each unit using LMS (Each test for15 M and total will be converted out of 10M)	10

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K. K. Wagh Institute of Engineering Education and Research, Nashik
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T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: IV
ROB223012 : Name of Subject: Robot Programming

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

Prerequisite Courses: Robot Kinematics and Dynamics

Course Objectives:

Programming a robot is usually a key task in simulation not only for creating factory simulations but for testing robots. With Visual Components, students can manually create statements that define the actions and logic of a robot program. The robot routine and subroutines can easily be visualized and modified. At the end of this course, students will get familiar with the statements and routines behind a robot program. Students will also learn how to connect external axes to a robot and how to utilize loops in your robot routine.

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

	Course Outcomes	**Bloom's Level**
CO1	Explain different robot programming methods	2
CO2	Recognize the components of robot programming	2,3
CO3	Develop simple programs to simulate robot movements	3,4
CO4	Develop complex robot programs for specific application	3,4
CO5	Describe the safety rules in robot handling	3

COURSE CONTENTS

Unit I	**Introduction to Robot Programming**	**(07 hrs)**	**COs Mapped: CO1**

Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands- Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.

Unit II	**VAL Language**	**(07 hrs)**	**COs Mapped: CO2, CO3**

Robot Languages-Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications.

VAL II Language:

VAL-II programming-basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot.

Unit III	**RAPID Language**	**(07 hrs)**	**COs Mapped: CO2, CO3**

RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot-manual mode, automatic mode, subroutine command based programming. Move master command language-Introduction, syntax, industry problems

Unit IV	KAREL Programming Language	(07hrs)	COs Mapped: CO3

KAREL language overview-controller, input output system. Language elements-character set, operators, reserved words, data types, arrays (multi-dimensional and variable sized). Use of operators, Program control, Routines, industry problems.

Unit V	Study of Virtual Robot	(07 hrs)	COs Mapped: CO3, CO4

Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, Jogging, components, work planning, program modules, input and output signals- Singularities-Collision detection-Repeatability measurement of robot-Robot economics. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.

Reference Books

1. S. R. Deb, Robotics technology and flexible automation, Tata McGraw Hill publishing company limited, 1994.
2. Mikell. P. Groover, Industrial Robotics Technology, Programming and Applications, McGraw Hill Co., 1995.
3. Danny Staple, Learn Robotics Programming: Build and control AI-enabled autonomous robots using the Raspberry Pi and Python, Packt Publishing Ltd, 2021
4. FANUC America Corporation SYSTEM R-30iB Controller KAREL reference manual
5. Klafter. R.D, Chmielewski.T.A. And Noggin's., Robot Engineering: An Integrated Approach, Prentice Hall of India Pvt. Ltd., 1994.
6. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., Robotics control, sensing, vision and intelligence, McGrawHill Book co, 1987.
7. Craig. J. J. Introduction to Robotics mechanics and control, Addison-Wesley, 1999.

Strength of CO-PO Mapping

	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	1	3	1	3	-	1	1	-	-	-	-	1	2	1
CO2	1	-	1	-	-	1	2	-	-	-	-	1	2	1
CO3	2	2	-	1	-	1	-	-	-	-	-	1	1	3
CO4	3	-	1	-	1	1	1	-	-	-	-	1	2	2
CO5	3	-	1	-	1	1	-	-	-	-	-	1	2	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

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T.Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: VI
ROB223014: Name of Subject: Micro electro mechanical systems

Teaching Scheme	Course Type	Credit Scheme	Examination Scheme:
Theory:03 hrs/week	**DEC**	**03**	**INSEM 20 marks** **ENDSEM 60 marks** **CCE 20 marks**

Prerequisite Courses: Applied Electronics Engineering ,Sensory Technology

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

Sr.No.	Description
1	Articulate the core concepts of MEMS technology
2	Gain proficiency in various micro fabrication techniques, including photolithography, thin film deposition, etching, and bonding.
3	Evaluate different types of sensors and actuators utilized in MEMS, such as electrostatic sensors, thermal actuators, and piezoresistive sensors.
4	Explore Advanced MEMS Concepts and Real-World Applications

Course Outcomes:

Course Outcomes	Description Student will be able to:
CO1	Explain the operation of micro devices, micro systems and their applications
CO2	Design the micro devices, micro systems using the MEMS fabrication process
CO3	Compare a knowledge of basic approaches for various sensor design
CO4	Compare a knowledge of basic approaches for various actuator design.

Course context, Relevance, Practical Significance:
This course provides an in-depth examination of Micro-electromechanical Systems (MEMS), encompassing foundational concepts, fabrication methodologies, sensor and actuator functionalities, and practical applications. Students will gain expertise in micro fabrication techniques and explore the diverse array of sensors and actuators used in MEMS devices. Additionally, they will investigate advanced topics such as polymer and optical MEMS, culminating in a comprehensive understanding of MEMS technology and its real-world implications across industries.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Unit 1: Introduction to MEMS** What is MEMS? , Definition and Classification, History of MEMS, Intrinsic Characteristics of MEMS: Militarization, Microelectronics Integration, Parallel Fabrication with precision, Sensors and Actuator: Energy domains and transducers, Sensor Consideration, Actuator Consideration, Review of Electrical and Mechanical Concepts: Semiconductor devices, Stress and strain analysis, Flexural beam bending, Torsional deflection.	7

2	**Unit 2: Micro fabrication** Overview of Microfabrication : Photolithography, Thin film Deposition, Thermal oxidation of Silicon, wet etching, Silicon anisotropic etching, wafer dicing, wafer bonding etc., The Microelectronics Fabrication Process Flow , Silicon-Based MEMS Processes, New Materials and Fabrication Processes, LIGA Process , Assembly of 3D MEMS , Foundry process.	7
3	**Unit 3: Sensors and actuators** Electrostatic sensors, Parallel plate capacitors, Applications, Interdigitated Finger capacitor, Comb drive devices, Micro Grippers, Micro Motors , Thermal Sensing and Actuation , Thermal expansion ,Thermal couples , Thermal resistors , Thermal Bimorph ,Applications , Magnetic Actuators , Micromagnetic components , Case studies of MEMS in magnetic actuators, Actuation using Shape Memory Alloys Piezoresistive sensors , Piezoresistive sensor materials , Stress analysis of mechanical elements , Applications to Inertia, Pressure, Tactile and Flow sensors ,Piezoelectric sensors and actuators , piezoelectric effects, piezoelectric materials , Applications to Inertia , Acoustic, Tactile and Flow sensors.	7
4	**Unit 4: Polymer and Optical MEMS** Polymers in MEMS, Polimide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene , Fluorocarbon, Application to Acceleration, Pressure, Flow and Tactile sensors. Optical MEMS, Lenses and Mirrors, Actuators for Active Optical MEMS.	7
5	**Unit 5: Case Studies of Selected MEMS products** Blood pressure sensor, Microphone, Acceleration sensors, Gyros, Zigbee, Ultrasonic Distance ranging sensors, Metal Detector, Wireless Cameras and voice transmissions etc.	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	**Introduction to MEMS**	2	1	1	1
2	**Micro fabrication**	3	2	3	1
3	**Sensors and actuators**	4	3	2	1
4	**Polymer and Optical MEMS**	5	4	5	1
5	**Case Studies of Selected MEMS products**	6	5	11	1

References Books:

1. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4. James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 2010.
6. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
7. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.

Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

T.Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: VI
ROB223014: Name of Subject: Micro electro mechanical systems

Teaching Scheme	Course Type	Credit Scheme	Examination Scheme:
Theory:03 hrs/week	**DEC**	**03**	**INSEM 20 marks** **ENDSEM 60 marks** **CCE 20 marks**

Prerequisite Courses: Applied Electronics Engineering ,Sensory Technology

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

Sr.No.	Description
1	Articulate the core concepts of MEMS technology
2	Gain proficiency in various micro fabrication techniques, including photolithography, thin film deposition, etching, and bonding.
3	Evaluate different types of sensors and actuators utilized in MEMS, such as electrostatic sensors, thermal actuators, and piezoresistive sensors.
4	Explore Advanced MEMS Concepts and Real-World Applications

Course Outcomes:

Course Outcomes	Description Student will be able to:
CO1	Explain the operation of micro devices, micro systems and their applications
CO2	Design the micro devices, micro systems using the MEMS fabrication process
CO3	Compare a knowledge of basic approaches for various sensor design
CO4	Compare a knowledge of basic approaches for various actuator design.

Course context, Relevance, Practical Significance:
This course provides an in-depth examination of Micro-electromechanical Systems (MEMS), encompassing foundational concepts, fabrication methodologies, sensor and actuator functionalities, and practical applications. Students will gain expertise in micro fabrication techniques and explore the diverse array of sensors and actuators used in MEMS devices. Additionally, they will investigate advanced topics such as polymer and optical MEMS, culminating in a comprehensive understanding of MEMS technology and its real-world implications across industries.

Course Contents:

Unit	Contents	Lecture Hrs.
1	**Unit 1: Introduction to MEMS** What is MEMS? , Definition and Classification, History of MEMS, Intrinsic Characteristics of MEMS: Militarization, Microelectronics Integration, Parallel Fabrication with precision, Sensors and Actuator: Energy domains and transducers, Sensor Consideration, Actuator	7

	Consideration, Review of Electrical and Mechanical Concepts: Semiconductor devices, Stress and strain analysis, Flexural beam bending, Torsional deflection.	
2	**Unit 2: Micro fabrication** Overview of Microfabrication : Photolithography, Thin film Deposition, Thermal oxidation of Silicon, wet etching, Silicon anisotropic etching, wafer dicing, wafer bonding etc., The Microelectronics Fabrication Process Flow , Silicon-Based MEMS Processes, New Materials and Fabrication Processes, LIGA Process , Assembly of 3D MEMS , Foundry process.	7
3	**Unit 3: Sensors and actuators** Electrostatic sensors, Parallel plate capacitors, Applications, Interdigitated Finger capacitor, Comb drive devices, Micro Grippers, Micro Motors , Thermal Sensing and Actuation , Thermal expansion ,Thermal couples , Thermal resistors , Thermal Bimorph ,Applications , Magnetic Actuators , Micromagnetic components , Case studies of MEMS in magnetic actuators, Actuation using Shape Memory Alloys Piezoresistive sensors , Piezoresistive sensor materials , Stress analysis of mechanical elements , Applications to Inertia, Pressure, Tactile and Flow sensors ,Piezoelectric sensors and actuators , piezoelectric effects, piezoelectric materials , Applications to Inertia , Acoustic, Tactile and Flow sensors.	7
4	**Unit 4: Polymer and Optical MEMS** Polymers in MEMS, Polimide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene , Fluorocarbon, Application to Acceleration, Pressure, Flow and Tactile sensors. Optical MEMS, Lenses and Mirrors, Actuators for Active Optical MEMS.	7
5	**Unit 5: Case Studies of Selected MEMS products** Blood pressure sensor, Microphone, Acceleration sensors, Gyros, Zigbee, Ultrasonic Distance ranging sensors, Metal Detector, Wireless Cameras and voice transmissions etc.	7

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
1	**Introduction to MEMS**	2	1	1	1
2	**Micro fabrication**	3	2	3	1
3	**Sensors and actuators**	4	3	2	1
4	**Polymer and Optical MEMS**	5	4	5	1
5	**Case Studies of Selected MEMS products**	6	5	11	1

References Books:

1. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4. James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and

Application," Springer, 2010.
6. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
7. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.
8. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

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T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: VI
ROB 223014A: Name of Subject: Elective II (B) Additive Manufacturing

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

Prerequisite Courses: - Manufacturing Technology, Reverse Engineering, Engineering Mechanics

Course Objectives:
Understand the Additive Manufacturing
Understand Light and LASER based Techniques
Understand Extrusion and energy based Techniques
Analyze the Hardware and Software for AM

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

	Course Outcomes	**Bloom's Level**
CO1	Explain the principles, methods, possibilities and limitations as well as environmental hazards of Additive Manufacturing technologies	2. Understand
CO2	Identify the characteristics of the different materials used in Additive Manufacturing technologies.	2. Understand
CO3	Explore the potential of additive manufacturing technologies in real life applications	2. Understand

COURSE CONTENTS

Unit I	**Additive Manufacturing (AM) Overview**	**(07 hrs)**	**COs Mapped: CO1, CO2**

Introduction to AM, Historical Development, Additive v/s Conventional Manufacturing, Role of AM in Product development cycle, Rapid prototyping, Relevance of AM in Industry 4.0, Current industry and manufacturing trends driving AM, AM Process-Chain, Reverse engineering, Advantages, Types of materials, Classification of AM Processes (Process-based, material form based, application-based – direct and indirect processes and Micro- and Nano-additive processes), Process Planning for Additive Manufacturing.

Unit II	Light and LASER based Techniques	(07 hrs)	COs Mapped: CO2, CO3

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks,
Limitations and Applications. Light-Based Photo-curing: Stereolithography (SLA), Digital Light Processing (DLP), Direct Laser Writing (DLW), Continuous Liquid Interface Production (CLIP)
Laser-Based Melting: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Electron-Beam Melting (EBM), Laser Blown Powder, Laser Wire Deposition, Laser Engineered Net Shaping (LENS), 3D Laser Cladding.

Unit III	Extrusion and energy based Techniques	(07 hrs)	COs Mapped: CO2, CO3

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks,
Limitations and Applications. Extrusion-Based Deposition: Fused Deposition Modeling (FDM), Fused Filament Fabrication (FFF), Direct Ink Writing (DIW), Robocasting, Bio-printing Inkjet(droplet)-Based Deposition and Fusion: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jetting, Binder Jetting, Multi-Jet Fusion, Color-jet Printing (CJP), Energy Deposition Techniques: Plasma/TIG/MIG/Arc Deposition, Electron Beam-based DED, Direct Metal Deposition (DMD).

Unit IV	Materials and Design for AM	(07 hrs)	COs Mapped: CO3

Introduction, Materials: Metals, Polymers, Ceramics & Bio-ceramics, Composites, Hierarchical Materials, Biomimetic Materials, Shape-Memory Alloys, 4D Printing & Bio-active materials, Material selection, AM Material Specific Process Parameters: Processes, Heat or Chemical Treatments, Phase Transformations, Process Selection for various applications, DfAM: Process specific strategies, Rules and Recommendations, Quality considerations and Post-Processing techniques: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing, Heat treatments, Hot isostatic pressing, Materials science, Surface enhancement Techniques and its Material Science Analysis of AM's error sources

Unit V	Hardware and Software for AM	(07 hrs)	COs Mapped: CO3

Construction of Basic AM Machines: Equipment Layout and sub-system Design, Construction, Working, Equipment Topology/Layout Frame Designs, 3D Printer Design Considerations (Filament, Frame, Build Platform, Extruder Design, Nozzles, Print Bed, Heated build/Base Plate, Heater, Dispenser, Optical system, Cooling system, Gas Recirculation System, Laser controller, Gas Filtration, Inert Gas Cooling system, Powder Handling System, Loading/unloading System.

Software and Controller: Types of In-fill, Types of slicing, Software Integration (with Process, Slicing, etc), Control system (PLC and safety PLC, micro control/ Microcontroller, Micro-processor control), CAD Software and Controller Interfacing, CURA Software, Relevant G/M Codes, Standard firmware (Merlin Software, etc), In-process Monitoring, Calibration

Reference Books

1. L. Lu, J. Y. H. Fuh and Y.S. Wong, “Laser-Induced Materials and Processes for Rapid Prototyping”, Springer, 2001
2. Andreas Gebhardt and Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing" Hanser Publishers, Munich, 2016.
3. Ben Redwood, FilemonSchöffer& Brian Garret, "The 3D Printing Handbook: Technologies, design and applications", 3D Hubs B.V. 2017
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, “Laser Cladding”, CRC Press, 2004
5. Andreas Gebhardt, “Understanding Additive”, Hanser Publishers, Munich, 2011
6. Ben Redwood, Filemon Schöffer & Brian Garret, “The 3D Printing Handbook – Technologies,
7. Design and Applications” Part One:3D Printing Technologies and Materials, 3D Hubs, 2017
8. Chee Kai, Kah Fai, Chu Sing, ‘Rapid Prototyping: Principles and Applications”, 2nd Ed., 2003
9. D. T. Pham and S.S. Dimov, “Rapid Manufacturing” Springer, 2001
10. Rupinder Singh J. Paulo Davim, “Additive Manufacturing - Applications and Innovations” CRC Press, 2019
11. I. Gibson, D. W. Rosen, B. Stucker, “Additive Manufacturing Technologies” Springer, 2010
12. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, “3D Printing and Additive Manufacturing Technologies” Springer, 2019

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

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

T. Y. B. Tech. **Pattern 2022 Semester: V** **Course Code: ROB223006 Course Subject : Elective 1(C) Flexible Manufacturing Systems**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: - Manufacturing Technology.

Course Objectives:

1. Understand Flexible Manufacturing Systems (FMS) and their importance in modern industry.
2. Learn about Cellular Manufacturing for enhanced production flexibility.
3. Master Computer-Aided Manufacturing (CAM) techniques, including CNC programming.
4. Explore the integration of computers in manufacturing for efficiency.
5. Gain insight into Automated Material Handling Systems for streamlined operations.

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

	Course Outcomes	**Bloom's Level**
CO1	Explain FMS and its applications	2-Understanding
CO2	Demonstrate applications of group technology and tool management system	2-Understanding
CO3	Perform CNC programming	3- Apply
CO4	Apply the concept of computer integrated manufacturing in FMS scenario	3- Apply

COURSE CONTENTS

Unit I	**FMS Introduction and Description**	**(08hrs)**	**Cos Mapped CO1**

Limitations with conventional manufacturing, Need for FMS Introduction, Definition, Basic Component of FMS, and Significance of FMS, General layout and configuration of FMS, Principle Objectives of FMS, Benefits and limitations of FMS, Areas of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology, Hierarchy of CIM, FMS Justification.

Unit II	**Cellular Manufacturing**	**(8hrs)**	**Cos Mapped CO2**

Introduction, Description and Classifications of Cell, Unattended Machining, Cellular versus Flexible Manufacturing. Group Technology: Introduction, Definition, Reasons for Adopting Group Technology,

Benefits of Group Technology Affecting Many Areas of a Company, Obstacles to Application of GT

Unit III	Computer Aided Manufacturing	(8hrs)	Cos Mapped CO3

Concepts and features of NC, CNC & DNC - feedback devices ,Interpolators., Point-to-point and contouring systems –Interchangeable tooling system – preset & qualified tools – ISO specification – Machining center – Turning center, CNC Programming: -Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Manual part programming – steps involved – G-codes and M-codes, sample program in lathe & milling. CAM package – canned cycles - Programming.

Unit IV	Computer Integrated Manufacturing	(8hrs)	Cos Mapped CO4

Computer application in manufacturing automation, Computer aided inspection and quality control. Computer integrated production management system, inventory, material requirement planning, manufacturing resource planning, enterprise resource planning. Rapid Product Development and Manufacture, Extended Enterprises.

Unit V	Automated Material Movement and Storage System	(8hrs)	Cos Mapped CO4

Introduction, Types of AGV and Their principle of working, Advantages, Limitation and General AGV Guide path, Robots, Benefits of using Industrial Robots, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet Flotation System, Queuing Carrousels and Automatic Work Changers, Coolant and Chip Disposal and Recovery system

Text Books

6. H. K. Shivanand, M. M. Benal, Flexible Manufacturing System, V. Koti, New Age Pub. ISBN:9386070227
7. Groover M.P, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India, ISBN: 9789332572492

Reference Books

1. Nanua Singh, Approach to Computer Integrated Design and Manufacturing, , John Wiley and Sons, ISBN:9780471585176
2. Luggen, Flexible Manufacturing Cells and Systems, , PHI, ISBN: 9780133217384

Strength of CO-PO Mapping												
	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	2	-	1	1	3	-	-	2	2	3	-	2
CO2	2	-	3	3	3	3	-	2	2	3	-	3
CO3	2	-	3	3	3	3	-	2	2	3	-	3
CO4	2	-	3	3	3	3	-	2	2	3	-	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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

T. Y. B. Tech.
Pattern 2022 Semester: VI
Course Code: ROB223014 Course Name : Elective 2: Cloud Computing

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: - Database Management

Course Objectives:
1. To introduce the fundamentals of Cloud computing, its technologies, Challenges and Applications
2. To give Insights into the virtualization technologies and Architecture.
3. To know the relationship between Cloud and SOA.
4. To classify and evaluate Cloud Security Issues.

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

	Course Outcomes	**Bloom's Level**
CO1	Understand the basic concepts of Cloud Computing.	1
CO2	Describe the underlying principles of different Cloud Service Models.	2
CO3	Classify the types of Virtualization.	2
CO4	Examine the Cloud Architecture and understand the importance of Cloud Security.	3
CO5	Develop applications on Cloud Platforms.	3

COURSE CONTENTS

Unit I	**Fundamentals of Cloud Computing**	**(7hrs)**	**Cos Mapped CO1**

Introduction to Cloud Computing, History of Cloud Computing, Characteristics of Cloud Computing, Cloud Types: NIST, Cloud cube, Cloud service models, Cloud Computing deployment models, Exploring the Cloud Computing Stack, Advantages, Disadvantages and Applications of cloud computing.

Unit II	**Cloud Service Models**	**(7hrs)**	**Cos Mapped CO2**

Introduction and benefits of Cloud services, Characteristics, benefits, applications of different cloud service models, Software as a service(SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Network as a service (NaaS), Identity as a service (IdaaS), Database as a service (DbaaS), Comparison of cloud services.

Unit III	**Virtualization**	**(7hrs)**	**Cos Mapped CO3**

Introduction to Virtualization, Difference between Cloud Computing and Virtualization Types of Virtualization: Hardware, Software, Operating system, Server, Storage, Methods of implementing storage Virtualization, Network Virtualization Types, Advantages, Disadvantages, Virtualization Architecture and Software, Virtual Clustering, Applications of Virtualization.

Unit IV	**Service Oriented Architecture and Cloud Security**	**(7hrs)**	**Cos Mapped CO4**

Cloud Computing Architecture (COA): Design principles, Cloud computing life cycle (CCLC), Cloud computing reference architecture, Service Oriented Architecture (SOA) characteristics and fundamental components.

Cloud Security: Cloud CIA security model (Confidentiality, Integrity and Availability), Cloud computing security architecture, Service provider security issues, Cloud Security Issues and challenges, Security issues in virtualization, Host Security, Data Security, Firewalls.

Unit V	**Cloud Environment and Application Development**	**(7hrs)**	**Cos Mapped CO5**

Cloud Platforms: Google App Engine, Compute Services, Storage Services, Communication Services, Amazon Web Services Architecture and core concepts, Application Lifecycle, Cost Model, Microsoft Azure Cloud services Azure core concepts, Windows Azure Platform Appliance.

Text Books

1. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah, "Cloud Computing: Black Book", Dreamtech Press.
2. Surbhi Rastogi, "Cloud Computing Simplified", 2021 Edition, BPB Publications.
3. Kai Hwang, Geoffrey.C.Fox., Jack J. Dongarra, "Distributed and Cloud Computing: From Parallel Processing to Internet of Things", MK Publications, Elsevier

Reference Books

1. Kamal Kant Hiran, et al. "Cloud Computing: Master the concepts, Architecture and Applications with Real-world examples and Case Studies", 1st Edition, BPB Publication.
2. Judith Hurwitz, "Cloud Computing for dummies", 2nd Edition, Wiley India.
3. A. Srinavasan, J. Suresh, "Cloud Computing: A Practical Approach for Learning and 5. Implementation", Pear

Strength of CO-PO Mapping														
	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2	-	1	-	2	-	-	-	-	-	-	1	-	-
CO2	2	-	1	-	2	-	-	-	-	-	-	1	-	-
CO3	2	-	1	-	2	-	-	-	-	-	-	1	-	-
CO4	2	-	1	-	2	-	-	-	-	-	-	1	-	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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

T. Y. B. Tech. Robotics and Automation
Pattern 2022, Semester: VI
ROB223015A: Name of Subject: Elective III (A) Finite Element Analysis

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

Prerequisite Courses: - Engineering Mechanics, Design of Machine Elements

Course Objectives:
Understand the finite element analysis problems
Analyze the problems of Trusses
Analyze the two-dimensional problem using constant strain triangles problems
Analyze the Dynamic analysis problems

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

	Course Outcomes	**Bloom's Level**
CO1	Model and analyse 1D and 2D problems	2. Understand
CO2	Perform finite element modelling of triangular element and 2-D iso-parametric elements	3 Apply
CO3	Analyse truss subjected to loading	4 Analyze
CO4	Analyse steady state heat transfer - 1D and 2D heat conduction and convection	3 Apply
CO5	Identify meshing techniques quality aspects of meshing	3 Apply

COURSE CONTENTS

Unit I	**Introduction**	**(07 hrs)**	**COs Mapped: CO1, CO2**

Introduction, One Dimensional Problem, Finite Element modeling, Coordinate and Shape function, Derivation of stiffness matrix and Load Vector using Potential Energy approach, Properties of Stiffness Matrix, Assembly of Global Stiffness Matrix and Load Vector, Elimination and penalty approach, shape function, Quadratic Shape Function. Steady state heat transfer - 1D and 2D heat conduction and convection, governing differential equation, boundary conditions, formulation of element

Unit II	Trusses	(07 hrs)	COs Mapped: CO2, CO3
Introduction to different approaches used in FEA such as direct approach, Variational approach, weighted residual, energy approach, Galerkin and Raleigh Ritz approach, Introduction to Plane trusses, Assembly of global Stiffness Matrix for Banded Skyline solutions			
Unit III	**Two-Dimensional Problem Using Constant Strain Triangles**	**(07 hrs)**	**COs Mapped: CO3, CO4**
Introduction, finite element formulation, load considerations and boundary conditions, problem modelling, member end forces, plane frame. Formulation of elemental stiffness matrix and load vector for Plane stress/strain such as Linear Strain Rectangle (LSR), Constant Strain Triangles (CST), Pascal's triangle , primary and secondary variables, properties of shape functions			
Unit IV	**Axi-symmetric solids subjected to axi-symmetric loading**	**(07 hrs)**	**COs Mapped: CO4, CO5**
Introduction, axi-symmetric formulation, finite element modelling of triangular elements, Two dimensional iso-parametric elements, Introduction, four node quadrilateral, introduction to higher order elements			
Unit V	**Dynamic analysis**	**(07 hrs)**	**COs Mapped: CO4, CO5**
Types of dynamic analysis, General dynamic equation of motion, point and distributed mass, lumped and Consistent mass, Mass matrices formulation of bar and beam element. Undamped-free vibration- Eigenvalue problem, Evaluation of eigenvalues and eigenvectors (natural frequencies and mode shapes)			

Reference Books

1. **1.** Dary L. Logan, A First Course in the Finite Element Method,
2. R. D. Cook, Concepts and Applications of Finite Element Analysis, Wiley, India
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India.
4. Seshu P., Text book of Finite Element Analysis‖, PHI Learning Private Ltd. New Delhi, 2010.
5. Bathe K. J., Finite Element Procedures‖, Prentice-Hall of India (P) Ltd., New Delhi.
6. Fagan M. J., Finite Element Analysis, Theory and Practice‖, Pearson Education Limited
7. Kwon Y. W., Bang H., Finite Element Method using MATLAB‖, CRC Press, 1997
8. S. Moaveni, Finite element analysis, theory and application with Ansys‖,
9. Fundamental of Finite Element Analysis, David V. Hutton, Tata McGraw-Hill 8. Gokhale N. S., Deshpande S. S., Bedekar S.
10. Thite A. N., Practical Finite Element Analysis‖, Finite to Infinite, Pune

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**

1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

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

T. Y. B. Tech.
Robotics and Automation (Pattern 2022)
Semester: VI
ROB223015B Elective-III(B)- Power Electronics & Drives

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 03 hours / week Practical:2hrs/Week	**03** **01**	**CCE: 20Marks** **In Sem Exam: 20Marks** **End Sem Exam:60Marks** **TW-25Marks** **PR/OR-25 Marks**

Prerequisite Courses: - Mathematics, Fundamentals of Electronics Engineering, Fundamentals of Electrical Engineering

Course Objectives: The course aims :
To enable students to gain knowledge and understanding in the following aspects:
1. Understand Fundamentals of power electronic devices and characteristics.
2. Understand The concepts and operating principles of power electronics circuits.
3. Understand Electrical Drives for Robotics

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

	Course Outcomes	**Bloom's Level**
CO1	Examine the characteristics of various devices and application of firing circuits used in power electronics.	4-Analyze
CO2	Analyze the performance characteristics of AC voltage regulators, choppers, inverters, rectifiers	4-Analyze
CO3	Analyze the operation and performance of different chopper configurations, including voltage and current-fed choppers, in both continuous and discontinuous conduction modes.	4-Analyze
CO4	Analyze the operating principles and characteristics of various electric motors to determine their suitability for robotics applications.	4-Analyze
CO5	Implement control techniques for electric drives to achieve desired motion control in robots	3-Apply

COURSE CONTENTS

Unit I	**Power Semiconductor Devices**	**(07hrs)**	**COs Mapped - CO1**

Introduction, Scope and Application, Classification of Power Converters, Construction and characteristics of Thyristors, MOSFET, IGBT, IGCT and GTO, etc. Comparison of Controllable switches.

Unit II	Rectifiers	(07hrs)	COs Mapped - CO1, CO2

Single phase Converter: Fully controlled converter, Half controlled converter (Semi- converter)- Operation of all converters with R & RL load, derivation of Average and RMS output voltage , Three phase converters: Fully controlled converter, Half controlled converter (Semi converter)- Operation of all converters, Dual Converters, Numerical on converters. Application of Power Electronics: D.C. Motor Speed control

Unit III	DC Choppers & AC Chopper	(06hrs)	Cos Mapped –CO2, CO3

Introduction, Classification, Basic Chopper Operation, Control strategies, Chopper configurations, Thyristor chopper circuits, Switched mode power supply: step down (buck), Step up (boost) and step down/step up (buck/boost) converters, Four Quadrant Operation of choppers.

AC Voltage Regulator- : Single phase AC Voltage regulator; operation with R and RL Load, derivation of Average and RMS output voltage, Three Phase Ac Regulator

Unit IV	INVERTERS	(07hrs)	COs Mapped – CO2

Introduction, Classification, single phase half and full bridge VSI, Pulse Width Modulated Inverter(PWM) Inverters, Performance Parameters of Inverter, Voltage control of single phase Inverter, Series inverter, Parallel inverter, Current Source Inverter, Thyristor based Inverters

Unit V	Electrical Drives for Robotics	(07hrs)	COs Mapped - CO4,CO5

Overview of electric drives and their significance in robotics, Role of electrical drives in enabling motion control in robots , Classification of electric motors: DC, AC (induction, synchronous), Schemes for DC Motor Speed control, DC Chopper Drives, Control of AC Drives: Basic Principle of operation, Speed control of Induction Motor, Synchronous Motor Drives, stepper Operating principles and characteristics of electric motors, Selection criteria for motors in robotics applications, control techniques for electric drive, power Electronics Converters for motor drives

Course Mapping:

Unit	Contents	Blooms Taxonomy Level	CO-mapped	PO mapped	PSO mapped
I	Power Semiconductor Devices	4	1	1,2	1
II	Rectifiers	4	1,2	1,2,3,4	1,2
III	DC Choppers & AC Chopper	4	2,3	1,2,3,4	1,2
IV	INVERTERS	4	2	1,2,3,4,5	1,2
V	Electrical Drives for Robotics	3,4	4,5	1,2,3,4,5	1,2

Text Books
[T1] M. H. Rashid - Power Electronics 2nd Edition, Pearson publication. [T2] Ned Mohan, T.M. Undel and, W.P. Robbins - Power Electronics, 3rd Edition, John Wiley and Sons [T3] B.W. Williams: Power Electronics 2nd edition, John Wiley and sons [T4] Ashfaq Ahmed- Power Electronics for Technology, LPE Pearson Edition [T5] Dr. P.S. Bimbhra, Power Electronics, Third Edition, Khanna Publication [T6] K. Hari Babu, Power Electronics, Scitech Publication.References
Reference Books
1] P. S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi. 2] M.D. Singh, K B Khanchandani, 'Power Electronics', second edition, TATA McGraw Hill. 3] Vedam Subramanyam, "Power Electronics – Devices, Converters and Applications", Revised 2nd edition,New Age Publications. 4] Dubey, Joshi and Doradla, "Thyristorised controller", New age Publication. 5] B. K. Bose, 'Modern Power Electronics & AC Drives', Prentice Hall India.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr.No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments (Total 3Assignment,Unit I and II 20marks, Unit III and IV20marks and Unit V10 marks &50 marks will be converted to 10 Marks)	10
2	Tests on each unit using LMS (Each test for15 M and total will be converted out of 10M)	10

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

T. Y. B. Tech.
Pattern 2022 Semester: VI
Course Code: ROB223015 Course Name :Elective III(C) Swarm Intelligence for Robotics

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: - Artificial Intelligence for Robotics, Robot Path Planning

Course Objectives:

1. Understand swarm intelligence principles and its applications in robotics.
2. Learn Particle Swarm Optimization (PSO) mechanics, parameters, and variants for optimization tasks.
3. Explore Ant Colony Optimization (ACO) principles and its application in solving combinatorial problems.
4. Study Artificial Bee Colony (ABC) algorithm and its variants for optimization tasks.
5. Discover robotics applications of swarm intelligence, including path planning and obstacle avoidance.

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

	Course Outcomes	**Bloom's Level**
CO1	Demonstrate the working principles of swarm intelligent algorithms	1
CO2	Tune algorithm specific parameters of swarm intelligence algorithms for given application	2
CO3	Apply swarm intelligence algorithms for robotics applications	3
CO4	Evaluate the performance of swarm intelligent algorithm	3
CO5	Modify the algorithm suitably for new applications	3

COURSE CONTENTS

Unit I	**Introduction to swarm intelligence**	**(7hrs)**	**Cos Mapped CO1**

Basic philosophy, Need of swarm intelligence, Traditional approach vs. Swarm intelligence, Models of swarm behaviour, introduction to swarm intelligence methods: Particle swarm optimization, ant colony optimization, artificial bee colony, shuffled frog leaping algorithm, firefly algorithm etc. Applications of swarm intelligence to robotics systems

Unit II	**Particle swarm optimization**	**(7hrs)**	**Cos Mapped CO2**

Introduction, Mechanism of working of particle swarm optimization algorithm, parameter selection, convergence criteria, adaptive mechanisms, variants of PSO algorithm, hybridization, performance of algorithm - convergence rate and accuracy, termination criteria

Unit III	Ant colony optimization	(7hrs)	Cos Mapped CO3
Introduction, Mechanism of working of ant colony optimization algorithm, collective intelligence, parameter selection, convergence, elitist ant system, Rank based ant systems, recursive ant colony optimization, Applications to combinatorial optimization problems.			
Unit IV	**Artificial bee colony optimization**	**(7hrs)**	**Cos Mapped CO4**
Artificial bee colony meta-heuristic: Initialization, employed bees, onlooker bees, scout bees, honey foraging behavior, Global Guided ABC Algorithm, Hybrid Guided Artificial Bee Colony (HGABC) Algorithm, hybridized artificial bee colony with simulated annealing, genetic algorithm etc.			
Unit V	**Applications of swarm intelligence in robotics**	**(7hrs)**	**Cos Mapped CO4**
Swarm intelligence in following robotics applications: Robot path planning, Trajectory generation, inverse kinematics and dynamics, Robotic controller design, robot clustering, robot sorting, robot collaboration, Obstacle avoidance etc.			

Text Books

1. Aboul Ella Hassanien, Eid Emary, 'Swarm Intelligence: Principles, Advances, and Applications', CRC Press, ISBN: 9781498741071
2. Pakize Erdogmus (Ed.) 'Particle Swarm Optimization with Applications', IntechOpen, ISBN: 9781789231489

Reference Books

1. Christian Blum, Daniel Merkle, Swarm Intelligence: Introduction and Applications, Springer, ISBN: 9783540740896
2. Pawar P. J., 'Evolutionary Computations for Manufacturing', Studium Press, 2019, ISBN: 978-93-85046-52-0

Strength of CO-PO Mapping														
	PO													
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO2	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO3	2	1	2	-	2	-	-	-	-	-	-	1	1	-
CO4	2	1	2	-	2	-	-	-	-	-	-	1	1	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each Unit	10
2	LMS Test on Each Unit	10
	Total	**20**

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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: VI** **223015A: Name of Subject: Elective III Automobile Engineering**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks** **CCE: 20 Marks**

Prerequisite Courses: - I. C. Engine, Thermodynamics, Basic Electrical & Electronics

Course Objectives:
Understand basics of Automobile Engineering & various Automotive system
Understand vehicle layout, vehicle specifications & important of automobile
To make the student conversant with drive train & transmission
To make the student conversant with Suspension, Steering, Brakes systems & Tyre Wheel assembly.

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

	Course Outcomes	**Bloom's Level**
CO1	Understand various transmission systems, Suspension, brakes,	2. Understand
CO2	Analyze Vehicle Performance & Vehicle Safety	3. Analyze
CO3	Handle technical & management problems in automotive industries	3. Analyze
CO4	Diagnosis the faults of automobile vehicles	4. Apply

COURSE CONTENTS

Unit I	Introduction to Automobile Engineering	**(07 hrs)**	**COs Mapped: CO1, CO2**

Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.

Unit II	Drive Train & Transmission	**(07 hrs)**	**COs Mapped: CO2, CO3**

Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive

Unit III	Front & Rear Axle, Steering System, Wheel & Tyres	**(07 hrs)**	**COs Mapped: CO3, CO4**

Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Wheel and Tyres: Wheel construction, alloy wheel, wheel alignment and balancing, type of tyres, tyre construction, tyre materials, factors affecting tyre life.

Unit IV	Suspension & Brakes System	**(07 hrs)**	**COs Mapped: CO3, CO4**

Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self leveling suspension (active suspension), damping and shock absorbers Types of brake systems - drum, disc, operation- mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.

Unit V	Vehicle Performance, Safety & Modern Trends **&** Vehicle maintenance	**(07 hrs)**	**COs Mapped: CO3, CO4**

Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise

Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system

Reference Books

1. K. Newton and W. Seeds, T.K. Garrett, “Motor Vehicle”, 13thEdition, Elsevier publications

2. Hans Hermann Braess, Ulrich Seiffen, “Handbook of Automotive Engineering “, SAE Publications.

3. William H. Crouse., “Automotive Mechanics”, Tata McGraw Hill Publishing House.

4. Joseph Heitner, “Automotive Mechanics”, C.B.S Publishers And Distributors.

5. SAE Manuals and Standards

6. Narang G. B. S , “ Automobile Engineering”, S. Chand and Company Ltd.

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

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T. Y. B. Tech.
Robotics and Automation
Pattern2022, Semester: VI
223016A:Name of Subject: Elective III(A) Finite Element Analysis Lab

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

Prerequisite Courses: Engineering Mechanics, Design of Machine Elements

Course Objectives:

Course Objectives	**Description** The course aims :
1	Understand Fundamentals of Finite Element Analysis.
2	Understand theory and characteristics of finite elements that represent engineering structures
3	To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Course Outcomes	**Description** On completion of the course, students will be able to–	**Blooms Level**
CO1	Examine different mathematical Techniques used in FEM analysis and.	4-Analyze
CO2	Analyze the problems of Nodes and elements	4-Analyze
CO3	Analyze the use of FEA in Structural and thermal problem	4-Analyze
CO4	Analyze the applications of FEA in heat transfer problem	4-Analyze
CO5	Implement finite element modeling techniques	3-Apply

Course context, Relevance, Practical Significance:
The course typically covers fundamental concepts Based on the finite element method (FEM), it is a technique that makes use of computers to predict the behavior of varied types of physical systems, such as the deformation of solids, heat conduction, and fluid flow.

Course Contents: (Perform any 7)

Assignment/ Experiment	**Contents**	**Pr.Hrs.**
1	**Computer** program for axial bar subjected to axial forces	2
2	Computer program for truss subjected to plane forces	2
3	Computer program for beams subjected to transverse forces and moments	2
4	Computer program for frames subjected to transverse forces and moments	2
5	Stress and deflection analysis of two dimensional truss using FEA software	2

6	Stress and deflection analysis of any machine component consisting of 2-D elements using FEA software	2
7	Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software	
8	Modal analysis of any machine components	2
9	Computer program for 1-D temperature analysis	2
10	Thermal analysis of member subjected to loading	2
11	Shear force and Bending Moment Calculations of Shaft using FEA software	2
12	Analysis of component subjected to self-weight	
13	Thermal analysis of composite wall	

Course Mapping:

Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Computer program for axial bar subjected to axial forces	1,2	1,2	1
2	Computer program for truss subjected to plane forces	1,2	1,2	1
3	Computer program for beams subjected to transverse forces and moments	2	1,2,3,4	1
4	Computer program for frames subjected to transverse forces and moments	2,3	1,2,4	1
5	Stress and deflection analysis of two dimensional truss using FEA software	2,3	1,2	1
6	Stress and deflection analysis of any machine component consisting of 2-D elements using FEA software	2	1,2	1
7	Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software	2	1,2	1
8	Modal analysis of any machine components	4,5	1,2,4,5	1
9	Computer program for 1-D temperature analysis	4,5	1,2,3,4,5	1,2
10	Thermal analysis of member subjected to loading	4,5	1,2,3,4,5	1,2
11	Shear force and Bending Moment Calculations of Shaft using FEA software	4,5	1,2,3,4,5	1,2
12	Analysis of component subjected to self-weight	4,5	1,2,3,4,5	1,2
13	Thermal analysis of composite wall	4,5	1,2,3,4,5	1,2

T. Y. B. Tech.
Robotics and Automation Pattern2022,
Semester: VI
223016B Elective-III(B) Power Electronics & Drives Lab

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

Prerequisite Courses: Mathematics, Fundamentals of Electronics Engineering, Fundamentals of Electrical Engineering

Course Objectives:

Course Objectives	**Description** The course aims :
1	Understand Fundamentals of power electronic devices and characteristics.
2	Understand The concepts and operating principles of power electronics circuits.
3	Electrical Drives for Robotics

Course Outcomes	**Description** On completion of the course, students will be able to–	**Blooms Level**
CO1	Examine the characteristics of various devices and application of firing circuits used in power electronics.	4-Analyze
CO2	Analyze the performance characteristics of AC voltage regulators, choppers, inverters, rectifiers	4-Analyze
CO3	Analyze the operation and performance of different chopper configurations, including voltage and current-fed choppers, in both continuous and discontinuous conduction modes.	4-Analyze
CO4	Analyze the operating principles and characteristics of various electric motors to determine their suitability for robotics applications.	4-Analyze
CO5	Implement control techniques for electric drives to achieve desired motion control in robots	3-Apply

Course context, Relevance, Practical Significance:

The course typically covers fundamental concepts such as power semiconductor devices, converter topologies, control techniques, and applications in motor drives and power systems. Relevance is in industrial applications, power electronics and drives control the speed and torque of electric motors, enabling précis e and efficient operation in manufacturing processe

Course Contents: (Perform any 7)

Assignment/ Experiment	**Contents**	**Pr.Hrs.**
1	Study of Single phase Half Wave Half Controlled Rectifier with R & RL Load	2

2	Study of Single phase Wave Half Controlled bridge Rectifier with R & RL Load	2
3	Study of 3- phase AC to DC full controlled converter.	2
4	Study of DC –DC Buck Converter	2
5	Study of DC-DC Boost Converter	2
6	Single phase A.C. voltage regulator with R and RL load using Diac & Triac	2
7	Single phase A.C. voltage regulator with R and RL load using Thyristor	
8	Study of VSI fed 3-Phase Induction motor(using v/f control PWM Inverter) Speed control characteristics	2
9	Study of a Thyristor based DC-drive with closed loop speed control.	2
10	Study of speed control of PMSM Drive	2
11	Study of speed control of BLDC (Hardware)	2

Course Mapping:

Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Study of Single phase Half Wave Half Controlled Rectifier with R & RL Load	1,2	1,2	1
2	Study of Single phase Wave Half Controlled bridge Rectifier with R & RL Load	1,2	1,2	1
3	Study of 3- phase AC to DC full controlled converter.	2	1,2,3,4	1
4	Study of DC –DC Buck Converter	2,3	1,2,4	1
5	Study of DC-DC Boost Converter	2,3	1,2	1
6	Single phase A.C. voltage regulator with R and RL load using diac & triac	2	1,2	1
7	Single phase A.C. voltage regulator with R and RL load using Thyristor	2	1,2	1
8	Study of VSI fed 3-Phase Induction motor(using v/f control PWM Inverter) Speed control characteristics	4,5	1,2,4,5	1
9	Study of a Thyristor based DC-drive with closed loop speed control.	4,5	1,2,3,4,5	1,2
10	Study of speed control of PMSM Drive	4,5	1,2,3,4,5	1,2
11	Study of speed control of BLDC (Hardware)	4,5	1,2,3,4,5	1,2

T. Y. B. Tech. Pattern 2022 Semester: VI Course Code: Course Name :Elective III(C) Swarm Intelligence for Robotics Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02 hrs. /week	**01**	**Term work : 25 marks** **Oral: 25 Marks**
Prerequisite Courses: Artificial Intelligence for Robotics, Robot Path Planning		
Course Objectives:		

Course Objectives	Description
1	Understand swarm intelligence principles and its applications in robotics.
2	Learn Particle Swarm Optimization (PSO) mechanics, parameters, and variants for optimization tasks.
3	Explore Ant Colony Optimization (ACO) principles and its application in solving combinatorial problems.
4	Study Artificial Bee Colony (ABC) algorithm and its variants for optimization tasks.
5	Discover robotics applications of swarm intelligence, including path planning and obstacle avoidance.

Course Outcomes:

Course Outcomes	Description
1	Demonstrate the working principles of swarm intelligent algorithms
2	Tune algorithm specific parameters of swarm intelligence algorithms for given application
3	Apply swarm intelligence algorithms for robotics applications
4	Evaluate the performance of swarm intelligent algorithm
5	Modify the algorithm suitably for new applications

Course context, Relevance, Practical Significance:

The course on Swarm Intelligence offers students a deep dive into innovative problem-solving techniques inspired by nature. By studying principles like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Artificial Bee Colony (ABC), students gain valuable insights into tackling complex optimization challenges. In today's rapidly evolving technological landscape, where efficient solutions are crucial across various industries, mastering swarm intelligence methods becomes highly relevant. The practical significance lies in their applicability to real-world problems, from optimizing supply chains to enhancing robotic systems. Ultimately, this course equips students with valuable skills sought after in fields where optimization and efficiency are paramount, ensuring their readiness to contribute meaningfully to modern problem-solving scenarios

Course Contents:

Sr. No.	Contents	Pr. Hrs.
1	Robot path planning and Trajectory generation	2
2	Inverse robot kinematics	2
3	Inverse robot dynamics	2
4	Robot controller design	2
5	Robot clustering and sorting	2
6	Obstacle avoidance	2
7	Robot vision system	2

Course Mapping:

Assignment/ Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Robot path planning and Trajectory generation	1	1,2	-
2	Inverse robot kinematics	2	1,2	-
3	Inverse robot dynamics	2	1,2	-
4	Robot controller design	3	1,2	-
5	Robot clustering and sorting	4	1,2	-
6	Obstacle avoidance	4	1,2	-
7	Robot vision system	5	1,2	-

T. Y. B. Tech.
Robotics and Automation
Pattern2022, Semester: VI
223016A:Name of Subject: Elective III Automobile Engineering Lab

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

Prerequisite Courses: Basic Electrical & Electronics

Course Objectives:

Course Objectives	Description The course aims :
1	Understand Fundamentals of Automobile Engineering.
2	Understand theory and characteristics of every basic component of automobile
3	To learn and apply techniques used in checking and setting of each component of any vehicle

Course Outcomes	Description On completion of the course, students will be able to–	Blooms Level
CO1	To maintain the electrical, electronic and mechanical systems that are part of the automotive vehicles	4-Analyze
CO2	To determine mechanical failures in gasoline and diesel vehicle engines, in accordance with the principles of electromechanical operation using electronic diagnostic equipment	4-Analyze
CO3	To participate in production systems in the automotive industry	4-Analyze
CO4	To adapt electromechanical, pneumatic, and hydraulic equipment using modern technology	4-Analyze

Course context, Relevance, Practical Significance:
Automotive engineering draws on almost all areas of engineering: thermodynamics and com- bustion, fluid mechanics and heat transfer, mechanics, stress analysis, materials science, elec- tronics and controls, dynamics, vibrations, machine design, linkages, and so forth.

Course Contents: (Perform any 7)

Assignment/ Experiment	Contents	Pr.Hrs.
1	Study of an Automobile Chassis	2
2	Study of Differential Mechanism of an Automobile	2
3	Study of Multiple Clutch of an Automobile	2
4	Study of Braking System (Hydraulic / Air Brake)	2
5	Study and Demonstration of different circuit of carburetor	2
6	Checking the spark plug and setting the port and check the	2

	ignition in the spark plug	
7	Study the Electrical System of an Automobile	
8	Study the assembly of Car Engine	2

Course Mapping:

Experiment	Contents	CO-mapped	PO mapped	PSO mapped
1	Study of an Automobile Chassis	1,2	1,2	1
2	Study of Differential Mechanism of an Automobile	1,2	1,2	1
3	Study of Multiple Clutch of an Automobile	2	1,2,3	1
4	Study of Braking System (Hydraulic / Air Brake)	2,3	1,2,3	1
5	Study and Demonstration of different circuit of carburetor	2,3	1,2	1
6	Checking the spark plug and setting the port and check the ignition in the spark plug	2	1,2	1
7	Study the Electrical System of an Automobile	2	2,3	1
8	Study the assembly of Car Engine	3,4	1,2,3	1

(Autonomous from Academic Year 2022-23)

T. Y. B. Tech. Robotics and Automation Pattern 2022, Semester: IV ROB223017: Name of Subject: Swarm Robotics		
Teaching Scheme: Theory :03hrs/week	**Credit Scheme:**	**Examination Scheme:**
Course Type:ESC	**03**	**In Sem Exam: 20 Marks End Sem Exam: 60 Marks CCE: 20 Marks**

Prerequisite Courses: - N.A.

Course Objectives:

1. To make the students familiar with basic concepts and techniques of Swarm Robotics.
2. Able to implement basic Swarm algorithms for navigation and path planning in robotic applications.

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

	Course Outcomes	**Bloom's Level**
CO1	Explain the fundamental principles, characteristics, and applications of swarm robotics, demonstrating knowledge of its historical context and contemporary challenges.	2-Understand
CO2	Demonstrate competence in applying a range of swarm robotics algorithms for tasks such as exploration, mapping, navigation, and cooperative manipulation, effectively addressing real-world challenges in dynamic environments.	3-Apply
CO3	Examine emerging trends, ethical considerations, and future directions in swarm robotics, demonstrating an understanding of the societal impact and potential applications of advanced swarm robotics technologies.	4-Analyse
CO4	Differentiate skills in designing and implementing various swarm robotics architectures, including centralized, decentralized, and distributed approaches, to achieve efficient coordination and cooperation among robotic agents.	4-Analyse

COURSE CONTENTS

Unit I	Introduction to Swarm Robotics	**(07 hrs.)**	**COs Mapped: CO1**

Definition and basic concepts of swarm robotics, History and evolution of swarm robotics, Characteristics and advantages of swarm robotics, Applications of swarm robotics in various fields, Challenges and limitations of swarm robotics.

Unit II	Swarm Intelligence	**(07 hrs)**	**COs Mapped: CO2,CO3**

Overview of swarm intelligence and its relevance to swarm robotics, Biological inspirations: ant colonies, bird flocks, fish schools, etc. Emergent behaviour and self-organization in swarms, Key algorithms and techniques: Ant Colony Optimization, Particle Swarm Optimization, etc. Mathematical modelling of swarm behaviours.

Unit III	Swarm Robotics Architectures	**(07 hrs)**	**COs Mapped: CO2, CO3**

Centralized vs. decentralized vs. distributed architectures, Communication mechanisms in swarm robotics, Role differentiation and task allocation strategies, Coordination and cooperation mechanisms, Case studies of different swarm robotics architectures in real-world applications.

Unit IV	Swarm Robotics Algorithms	**(07 hrs)**	**COs Mapped: CO3,CO4**

Basic algorithms for swarm robotics: flocking, aggregation, dispersion, etc. Exploration and mapping algorithms in swarm robotics, Swarm navigation and path planning techniques, Cooperative manipulation and transportation algorithms, Swarm behaviour adaptation and learning algorithms.

Unit V	Emerging Trends and Future Directions in Swarm Robotics	**(07 hrs)**	**COs Mapped: CO3,CO4**

Multi-robot systems and swarm robotics, Swarm robotics in dynamic and uncertain environments Human-swarm interaction and collaboration, Swarm robotics for search and rescue missions, Ethical considerations and societal impacts of swarm robotics, Cutting-edge developments and future directions in swarm robotics.

Reference Books

1. "Swarm Robotics "edited by Giandomenico Spezzano, ISBN978-3-03897-922-7 (Paperback) ISBN978-3-03897-923-4 (PDF).
2. Swarm Robotics from Biology to Robotics. Edited by: Ester Martinez Martin. *ISBN 978-953-307-075-9*, PDF ISBN 978-953-51-5880-6, Published 2010-03-01.

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation (20 Marks)**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted to 10 M)	10
2	Timely Assignment Submission on each unit for 15 marks and total will be converted to 10 marks.	10

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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: VI** **ROB223018: Name of Subject: Nutrition and Weight Management**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :02 hrs/week	**02**	**CCE: 50 Marks**

Prerequisite Courses: - Basic Biology, Anatomy and Physiology

Course Objectives:
Understand the principles of nutrition and their role in maintaining health and managing weight.
Analyze dietary patterns and assess nutritional needs of individuals based on various factors such as age, gender, activity level, and health status.
Evaluate the impact of nutrition on weight management, including factors such as energy balance, metabolism, and dietary composition.

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

	Course Outcomes	**Bloom's Level**
CO1	Understand the fundamental principles of nutrition and their implications for maintaining overall health.	2. Understand
CO2	Comprehend the relationship between dietary intake, energy balance, and weight management strategies.	2. Understand
CO3	Interpret nutritional information from various sources to make informed decisions about dietary choices.	2. Understand
CO4	Demonstrate knowledge of factors influencing food behaviors and dietary patterns within different populations or cultural contexts.	2. Understand
CO5	Apply evidence-based nutrition principles to create personalized dietary plans for individuals to achieve specific health and weight objectives.	3. Apply

COURSE CONTENTS

Unit I	**Obesity epidemic**	**(07 hrs)**	**COs Mapped: CO2, CO4**

Causes of obesity epidemic, eating habits, lack of exercise, managing obesity crisis, nutrition transition, international strategies.

Unit II	**Body Mass Index**	**(07 hrs)**	**COs Mapped: CO1, CO3**
Meaning of body mass index (BMI), BMI chart, BMI for age percentiles, proportion of body fats, weight statistics, BMI, Waist Circumference and disease Risk.			
Unit III	**Heath risk analysis**	**(07 hrs)**	**COs Mapped: CO2, CO4**
Health risk analysis due to high or low body fat, its effect on Heart disease, Diabetes, cancer, Gallbladder Disease, Breathing Problems, Reproductive Problems, Psychological and Social Impact of Being Overweight, causes of underweight and its Health consequences			
Unit IV	**Balancing energy and weight**	**(07 hrs)**	**COs Mapped: CO1, CO5**
Food Nutrition and body weight, Importance of nutrition for energy, structure, body process regulations, six classes of nutrient: carbohydrates, lipid, proteins, water, vitamins, minerals, dietary reference intakes, tools for choosing healthy diet, Amount of calories required, energy to stay alive, energy to keep moving, energy to process food, calculating energy need, biology of body weight.			

Reference Books

1. Lori A. Smolin, Mary B. Grosvenor, Nutrition and weight management, Chelsea House, 2010
2. G E Mullin, L. J. Cheskin, L.E. Matarese, Integrative weight management, Springer Science & Business, 2014.

Strength of CO-PO Mapping

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

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 30 M)	30
2	Timely Assignments Submission on each unit (5 M for each unit)	20

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T. Y. B. Tech. Robotics and Automation
Pattern 2022 Semester: VI
ROB223020: Name of Subject: Research Methodology

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical :02 hrs/week	**01**	**Term work: 50 Marks**

Prerequisite Courses, if any: -

Course Objectives:

1. To orient students towards research-related activities and developing skills in literature review, data collection, and critical analysis
2. To develop the students with the skills to design, execute, and evaluate research studies.

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

	Course Outcomes	**Bloom's Level**
CO1	**Understand the formulation research problem formulation** effectively, considering feasibility, relevance, and significance.	2. Understand
CO2	**Analyse research related information** like existing research, literature, and data.	4. Analyse
CO3	Prepare the research proposal report consisting of literature survey, research gap identified and research significance.	6. Create

COURSE CONTENTS

	COs mapped
01 Literature review: Collect the existing literatures on any research idea in civil engineering and identify the research gap. 02 Report and seminar presentation: Prepare the research proposal based on the earlier identified research gap (report should be checked for plagiarism) and present the idea. (Introduction, Objectives, Scope of work, Methodology) 03 Collection of standard format and guidelines of research proposal: Identify the national and international funding agencies and prepare research proposal for any one of the funding agencies (in a group of students of not more than five). 04 Prepare a report on different citation styles and referencing styles adopted by different publishers and prepare the list of references as per any standard style. 05 Write a report on case study of any existing patent/copy right/trademark on the selected topic for literature review.	**CO1, CO2, CO3**

Guidelines for Conduction

Subject faculty will conduct the sessions on course content. Faculty will form small groups of students. Each group has to select one problem in the field of Robotics and Automation Engineering and decide the topic for literature review. Topics will be based on study, identification of problems and improvement in existing systems in Robotics and Automation Engineering.

Guidelines for Termwork Assessment

A continuous assessment will be done by Subject Faculty/Mentor/Guide. Assessment will be based on the Assignments mentioned in the course content.

Reference Books

Research Methodology Methods & Techniques, C. K. Kothari, 2nd edition, New Age International, New Delhi.

Strength of CO-PO Mapping														
	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	2	2	2	2	2	3	3	2	3	3	2
CO2	3	3	3	2	2	2	2	2	3	3	2	3	3	2
CO3	3	3	3	2	2	2	2	2	3	3	2	3	3	2
Average	3	3	3	2	2	2	2	2	3	3	2	3	3	2