Maharashtra State Board Of Technical Education, Mumbai

Learning and Assessment Scheme for Post S.S.C Diploma Courses

Programme Name	**: Diploma In Automation and Robotics**		
Programme Code	**: AO**	**With Effect From Academic Year**	**: 2023-24**
Duration Of Programme	**: 6 Semester**	**Duration**	**: 16 WEEKS**
Semester	**: Sixth** **NCrF Entry Level : 4.0**	**Scheme**	**: K**

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme											
						Actual Contact Hrs./Week			Self Learning (Activity/ Assignment /Micro Project)	Notional Learning Hrs /Week		Paper Duration (hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
																	Practical						
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
(All Compulsory)																							
1	MANAGEMENT	MAN	AEC	315301	1	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125
2	EMERGING TRENDS IN ELECTRONICS	ETE	DSC	316337	-	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125
3	INDUSTRIAL INTERNET OF THINGS	IIT	DSC	316342	-	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175
4	INDUSTRIAL ROBOTICS AND APPLICATIONS	ARS	DSC	316343	-	4	-	4	2	10	5	3	30	70	100	40	25	10	-	-	25	10	150
5	CAPSTONE PROJECT	CPE	INP	316004	-	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150
ELECTIVE (Any - One)																							
6	DRONE TECHNOLOGY	DRT	DSE	316335	2	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
	VLSI APPLICATIONS	VLS	DSE	316340	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
	AR & VR	AVA	DSE	316344	1	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
Total					**2**	**18**		**12**	**10**		**20**		**150**	**350**	**500**		**125**		**100**		**175**		**900**

Abbreviations : CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment,SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends : @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

Course Category : Discipline Specific Course Core (DSC) , Discipline Specific Elective (DSE) , Value Education Course (VEC) , Intern./Apprenti./Project./Community (INP) , AbilityEnhancement Course (AEC) , Skill Enhancement Course (SEC) , GenericElective (GE)

Programme Name/s	: Architecture Assistantship/ Automobile Engineering./ Artificial Intelligence/ Agricultural Engineering/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Architecture/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Fashion & Clothing Technology/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Food Technology/ Computer Hardware & Maintenance/ Instrumentation & Control/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Instrumentation/ Interior Design & Decoration/ Interior Design/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Medical Laboratory Technology/ Medical Electronics/ Production Engineering/ Printing Technology/ Polymer Technology/ Surface Coating Technology/ Computer Science/ Textile Technology/ Electronics & Computer Engg.
Programme Code	: AA/ AE/ AI/ AL/ AN/ AO/ AT/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DC/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ FC/ HA/ IC/ IE/ IF/ IH/ IS/ IX/ IZ/ LE/ ME/ MK/ ML/ MU/ PG/ PN/ PO/ SC/ SE/ TC/ TE
Semester	: Fifth / Sixth
Course Title	: MANAGEMENT
Course Code	: 315301

I. RATIONALE

Effective management is the cornerstone of success for both organizations and individuals. It empowers diploma engineers/ professionals to accomplish their tasks with finesse and efficiency through strategic planning and thoughtful execution, projects can optimize finances, enhance safety measures, facilitate sound decision-making, foster team collaboration and cultivate a harmonious work environment. The diploma engineers require leadership and management skills with technical knowledge of the core field to carry out various tasks smoothly. This course aims to instill fundamental management techniques, empowering diploma engineers/ professionals to enhance their effectiveness in the workplace.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Apply the relevant managerial skills for achieving optimal results at workplace.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use relevant management skills to handle work situation
- CO2 - Apply appropriate techniques of product, operations and project management
- CO3 - Use comprehensive tools of recent management practices
- CO4 - Plan suitable marketing strategy for a product / service
- CO5 - Utilize supply chain and human resource management techniques for effective management

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

MANAGEMENT **Course Code : 315301**

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315301	MANAGEMENT	MAN	AEC	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : 1 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

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3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Justify the importance of management thoughts in Indian knowledge system. TLO 1.2 Describe the importance of management in day to day life. TLO 1.3 Explain Henry Fayol’s principles of management. TLO 1.4 Describe the role of each level of management in its management hierarchy. TLO 1.5 Practice the self management skills for a given situation TLO 1.6 Apply the required managerial skills for a given situation	**Unit - I Introduction to Management** 1.1 Evolution of management thoughts from ancient/medieval to modern times in India (IKS) 1.2 Management: meaning, importance, characteristics, functions & challenges. 1.3 Introduction to scientific management- Taylor's & Fayol's principles of management 1.4 Levels & functions of management at supervisory level. 1.5 Self management skills: Self awareness, self discipline, self motivation, goal setting, time management, decision making, stress management, work life balance and multitasking 1.6 Overview of Managerial Skills: negotiation skills, team management, conflict resolution, feedback, leadership	Presentations Case Study Interactive session Quiz competition Mixed Picture Puzzle

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Identify the appropriate creativity technique for new product development TLO 2.2 Describe the new product development process for a product / service TLO 2.3 Comprehend the importance of various strategic steps Product Management TLO 2.4 Elaborate Agile product management TLO 2.5 Explain the significance of the Project Management TLO 2.6 Describe the various tools of project management	**Unit - II Product, Operations and Project Management** 2.1 Creativity and innovation management: creativity techniques - brainstorming, checklist, reverse brainstorming, morphological analysis, six thinking hats. 2.2 New product development, change management 2.3 Product Management -meaning, strategic steps for sustainable design of a product 2.4 Agile product management- concept, benefits, principles and manifesto 2.5 Project Management: importance, areas within project management,4Ps and phases 2.6 Tools of Project Management: PERT and CPM, GANTT & Chart Overview of Estimate and Budget	Presentations Case Study Video Demonstrations Presentations Role Play
3	TLO 3.1 Understand the importance of quality management tools TLO 3.2 Explain the importance of various techniques for optimization and waste minimization TLO 3.3 State the importance of ISO quality standards TLO 3.4 Describe ERP TLO 3.5 State the importance of ISO TLO 3.6 Recognize the importance of customer satisfaction as a competitive advantage	**Unit - III Management Practices** 3.1 Quality circle, kaizen, Six Sigma, TQM 3.2 5S, Kanban card system, TPM, Lean Manufacturing: Meaning, Steps and Importance 3.3 Quality Standards and ISO: Meaning, ISO 9001:2016, ISO 14000, OSHA 2020 3.4 The overview of ERP along with example 3.5 Service quality and customer/client satisfaction, servicescape	Presentation Case study Interactive session Quiz Video Demonstration Lecture Using Chalk-Board
4	TLO 4.1 Explain the importance of marketing techniques TLO 4.2 Explain the importance of needs, wants and desires in marketing TLO 4.3 Interpret the traditional and digital marketing techniques TLO 4.4 Plan different aspects of an event management	**Unit - IV Marketing Management** 4.1 Marketing management: meaning, significance, Seven P's of Marketing 4.2 Needs, wants and demands in marketing. Customer relationship management 4.3 Types of marketing: traditional and digital marketing 4.4 Event management: types, different aspects of event management, crisis management	Case Study Interactive session based video Role Play Flipped Classroom Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 State the importance of supply chain and logistics management TLO 5.2 Explain the components of supply chain and logistics Management TLO 5.3 Describe the role of information technology in supply chain & logistics management TLO 5.4 State the significance of Human Resource Management TLO 5.5 Analyze the various methods of recruitment, selection and training for an organization TLO 5.6 List the qualities of a successful supervisor	**Unit - V Supply Chain & Human Resource Management** 5.1 The overview of Supply Chain and logistics Management 5.2 Components of Supply Chain and logistics Management 5.3 Role of information technology in supply chain & logistics management 5.4 Overview of Human Resource Management-Meaning,significance,scope and principles 5.5 Recruitment, selection and training of human resources. Chalk Circle 5.6 Qualities of a successful supervisor /team leader and types of leadership	Presentations Video Demonstrations Case Study Collaborative learning Video Demonstrations Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment / Article

- Make a one page note based on a book of management you read.
- Write a short article on inventory management exploring online learning resources.
- Prepare a report on ISO standards applicable to your field. a. IATF 16949-2016 / SLA-TS 16949-2016, - Automotive Industry b. ISO 22000 — Food safety management c. ISO 50001 — Energy management d. ISO/IEC 27001 - Cyber Security e. ISO/DIS 4931-1 - Buildings and civil engineering works
- Prepare a 4 quadrant matrix of time management for managing the tasks.
- Prepare a report on any one software used for Supply Chain and Logistics Management.
- Prepare a GANTT Chart for project management related to your field.

Note Taking

- Watch a Tedx Talk Video on managerial skills and take notes in the form of keywords.

Case Study

- Prepare a case study and discuss the same on following topics a.Self Management Skills b.Six Thinking Hats c.Kaizen d.Quality Circle e.Safety Measures in different organizations related to your field
- Study the recruitment and selection process of any organization related to your field.
- Prepare a case study on management lessons based on life of Chhatrapati Shivaji Maharaj
- Conduct outbound training on managerial skills. Make a video and upload on social media.

Quizes

- Participate in online quizzes related to areas of management .

Assignment

- Workshops to be conducted for students on following topics a. creativity techniques b. time management c. stress management d. negotiation and conflict e. goal setting f. meditation new product development

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED : NOT APPLICABLE

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Management	CO1	13	8	6	4	18
2	II	Product, Operations and Project Management	CO2	8	2	4	6	12
3	III	Management Practices	CO3	8	4	4	6	14
4	IV	Marketing Management	CO4	8	2	4	6	12
5	V	Supply Chain & Human Resource Management	CO5	8	4	4	6	14
Grand Total				**45**	**20**	**22**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- MCQ Based Class Test, Self Learning Activities / Assignment

Summative Assessment (Assessment of Learning)

- Summative Assessment (Assessment of Learning) MCQ based

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3

CO1	1	1	1	-	-	2	3			
CO2	1	3	3	-	1	3	3			
CO3	1	3	1	-	1	1	3			
CO4	1	2	2	-	1	2	3			
CO5	1	1	2	-	1	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	A. K. Gupta	Engineering Management	S. Chand, ISBN: 81-219-2812-5, 2007, 2nd Edition
2	O. P. Khanna	Industrial Engineering &management	Dhanpat Rai Publication, ISBN: 978-8189928353, 2018
3	Harold Koontz and Heinz Weinrich	Essentials of Management	Tata McGraw Hill Education ISBN: 9789353168148, 2020, 12th edition
4	E. H. McGrath	Basic Managerial Skills for All	PHI ISBN: 978-8120343146, 2011, 9th Edition
5	Andrew DuBrin	Management Concepts and Cases	Cengage Learning, ISBN: 978-8131510537, 2009, 9th edition
6	K. Dennis Chambers	How Toyota Changed the World	Jaico Books ISBN: 978-81-8495-052-6, 2009
7	Jason D. O'Grandy	How Apple changed the Wolrd	Jaico Publishing House ISBN: 978-81-8495-052-0, 2009
8	Subhash Sharma	Indian Management	New Age International Private Limited ; ISBN-978-9389802412, 2020, 1st edition
9	Chitale, Dubey	Organizational Behaviour Text and Cases	PHI LEARNING PVT. LTD., ISBN: 978-9389347067, 2019, 2nd Edition

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.debonogroup.com/services/core-programs/six-thinking-hats/	Six Thinking Hats
2	https://hbr.org/1981/09/managing-human-resources	HR Management
3	https://theproductmanager.com/topics/agile-product-management/	Agile Product Management
4	https://www.cdlogistics.ca/freight-news/the-5-components-of-supply-chain-management	Supply Chain Management
5	https://www.infosectrain.com/blog/understanding-the-concepts-of-gantt-chart-and-critical-path-methodology-cpm	PERT, CPM, GANTT Chart
6	https://www.simplilearn.com/best-management-tools-article	Management Tools
7	https://www.psychometrica.in/free-online-psychometric-tests.html	Psychometric Tests
8	https://www.investopedia.com/terms/e/erp.asp	ERP
9	https://asq.org/quality-resources/quality-management-system	QMS
10	https://testlify.com/test-library/creative-thinking/	Psychometric Tests
11	https://www.mindtools.com/	Management Skills
12	https://www.investopedia.com/terms/d/digital-marketing.asp	Digital Marketing

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MANAGEMENT **Course Code : 315301**

MSBTE Approval Dt. 24/02/2025 **Semester - 5 / 6, K Scheme**

EMERGING TRENDS IN ELECTRONICS **Course Code : 316337**

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electronics & Tele-communication Engg./ Electronics & Communication Engg./ Electronics Engineering/ Industrial Electronics/ Electronics & Computer Engg.**
Programme Code	**: AO/ DE/ EJ/ ET/ EX/ IE/ TE**
Semester	**: Sixth**
Course Title	**: EMERGING TRENDS IN ELECTRONICS**
Course Code	**: 316337**

I. RATIONALE

The rapid advancement in electronics is driven by innovations in computing, communication, automation ,technologies such as AI, ML, IoT, quantum computing. Modern manufacturing techniques, including surface mount technology and automated assembly improves production quality and sustainability. Next-generation telecom networks enable faster and more reliable data exchange. This course will help student to acquire knowledge in Emerging trends in electronics.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences: "Acquire knowledge of Emerging Trends in Electronics fields."

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Select the appropriate processor for a specific type of application.
- CO2 - Suggest the relevant techniques in the electronic system manufacturing process.
- CO3 - Suggest a different telecom network for the given application.
- CO4 - Connect IoT Devices to cloud platforms for data storage and analysis.
- CO5 - Interpret drone component functions, government guidelines, and application areas.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316337	EMERGING TRENDS IN ELECTRONICS	ETE	DSC	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
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4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
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7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the architecture of given specific modern processors. TLO 1.2 Compare the salient features of ESP32 and ESP8266. TLO 1.3 Establish the relationship between Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL). TLO 1.4 Differentiate between Single Agent and Multi-Agent with examples. TLO 1.5 Compare classical computing with quantum computing with a suitable example.	**Unit - I Advanced Processors and Technology** 1.1 Graphical Processing Unit (GPU): Introduction, features, Overview of processor architecture, superscalar concept, advantages and applications 1.2 ESP 32: features, pin out, Interfacing board, Comparison with ESP 8266 and Arduino Uno, simple programs and applications 1.3 Artificial Intelligence/Machine Learning [AI/ML]: Definitions, applications and advantages of AI, Definition and Types of ML(Machine Learning) such as Supervised, Unsupervised and Reinforcement. Relationship between DL (Deep Learning), ML and AI. Agents in AI: Single Agent and Multi-Agent 1.4 Quantum Computing: Introduction, qubit (quantum bit), comparison of classical versus Quantum systems, Applications of Quantum Computing	Video Demonstrations Presentations Collaborative learning Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Compare SMD technology over traditional (through-hole components) technology in terms of size, performance, and manufacturing efficiency. TLO 2.2 Explain the Human-Machine Interface (HMI) concept in smart manufacturing. TLO 2.3 Analyze the role of robotics in smart manufacturing. TLO 2.4 Suggest modern machines of the given specifications for electronic system assembly and manufacturing. TLO 2.5 Evaluate the significance of environmental standards such as EPEAT and RoHS in electronic manufacturing and their impact on sustainability. TLO 2.6 Explain the concept of Open Source Assembly and Testing.	**Unit - II Smart Manufacturing Processes and Tools** 2.1 Surface Mount Technology (SMT): Introduction, characteristics, advantages, applications 2.2 HMI and Robotics in Smart Manufacturing Process : Introduction, functionality, types, benefits, Robotics in Smart Manufacturing: Functionality, benefits, types of Robots: Articulated Robots, Selective Compliance Articulated Robot Arm (SCARA),Autonomous Mobile Robots (AMRs), Cobots. 2.3 Modern Electronic Assembly and Manufacturing Process: Introduction, classification of machines used in electronic assembly, role, features, and specifications of different machines. Pick-and-Place Machine: Working principle and operation, specifications, Automatic Component Insertion Machine: Functionality and working mechanism, advantages over manual component placement. Reflow soldering Method :Overview of soldering techniques in PCB assembly, working principle, stages of the reflow soldering process (Preheating, Soaking, Reflow, Cooling) 2.4 Environmental standards for electronic manufacturing such as: Electronic Product Environmental Assessment Tool (EPEAT) and Restriction of Hazardous Substances (RoHS) standards 2.5 Introduction to Open Source Assembly and Testing (OSAT)	Video Demonstrations Presentations Site/Industry Visit Flipped Classroom
3	TLO 3.1 Explain the function of the given network component. TLO 3.2 Interpret the spectrum used in the present Telecom sector. TLO 3.3 Compare the mobile generations. TLO 3.4 Explain the Multi Protocol Label Switching in NGN core. TLO 3.5 Analyze Fiber to the Home (FTTH) technology, its architecture, and components of Optical Line Termination (OLT) and Optical Network Unit (ONU). TLO 3.6 Assess the effect of Optical Transport Network(OTN) on data transmission.	**Unit - III Next Generation Telecom Network** 3.1 NGN architecture: Features, Functional block diagram, Network components: Media Gateway, Media Gateway Controller, and Application Server 3.2 NGN Wireless Technology: Telecom network Spectrum: Licensed and unlicensed radio bands, Mobile network evolution (3G to 5.5G) and comparative features 3.3 NGN Core: Concepts, features and advantages 3.4 Fiber to the Home (FTTH): Features, architecture and components: Optical Line Termination (OLT) ,Optical Network Unit (ONU) 3.5 Synchronous Digital Hierarchy (SDH), Optical Transport Network(OTN): Introduction, features and applications	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe different IoT architectures and their role in data processing. TLO 4.2 Compare different cloud service providers based on their capabilities and applications. TLO 4.3 Explain how IoT enhances efficiency and automation in different industrial sectors. TLO 4.4 Explain the applications and benefits of Industry 5.0 in smart manufacturing. TLO 4.5 Differentiate between Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), along with their applications across various domains.	**Unit - IV IIoT and Immersive Technologies** 4.1 Internet of Things (IoT): Introduction, functions of Cyber physical system components, architectures, IoT sensor to cloud data routes 4.2 Introduction to Cloud computing, Cloud service providers (AWS, AZURE, GOOGLE Cloud, ThingSpeak), ThingSpeak: Features, collecting and retrieving data from ThingSpeak, applications 4.3 Applications of IoT in Industries: Automotive, Discrete Manufacturing, Telecom and Agro- industries 4.4 Industry 5.0 and Industrial IoT (IIoT): Introduction, evolution from I1.0 to I5.0, applications and benefits of I5.0, Compare I3.0, I4.0 and I5.0, Architecture of I5.0 4.5 Introduction to Immersive Technologies: Overview of Virtual reality (VR), Augmented Reality (AR), Mixed reality (MR) and Extended reality (XR)	Lecture Using Chalk-Board Hands-on Collaborative learning Flipped Classroom
5	TLO 5.1 Classify drones based on structural configuration. TLO 5.2 Describe the functions of different drone components. TLO 5.3 Interpret relevant government drone regulations. TLO 5.4 Identify the utility of drones in the given application.	**Unit - V Drone Systems and Applications** 5.1 Overview of Drone Technologies, Types of Drones: Multi-Rotor, Single-Rotor, Fixed-Wing, Hybrid 5.2 Hardware Components of drones: Frame, Propellers, Motors, Electronic speed controller, Flight controllers, Gimbal, Radio transmitter and receiver, GPS, Camera, Power distribution panel, Landing gears, Sensors: accelerometer, gyroscope and magnetometers, Batteries: lithium polymer and lithium-ion 5.3 Regulations and safety considerations: Category of zones: Red zone, Inner yellow zone, Outer yellow zone, Green zone, DGCA rules and regulations for registration, operation and pilot license of drones 5.4 Drone Applications: Photography, Logistics, Medical, Agriculture, Defence, Surveillance, Disaster management	Presentations Video Demonstrations Model Demonstration Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Develop a simple ESP32-based sensor data logging system and explain the interfacing process.
- Implement a basic IoT-based LED control program using ESP32 and document the code.
- Develop a smart home automation system using an ESP32 microcontroller, allowing users to control home appliances (lights, fans, etc.) via a smartphone using Wi-Fi and a web-based dashboard or mobile app.

- Collect temperature and humidity data using DHT11/DHT22 sensors and send it to an IoT platform like ThingSpeak.
- Use networking tools like Cisco Packet Tracer to simulate MPLS functionality.
- Detect gas leaks using an MQ-6 sensor and send alerts to users via SMS or an IoT platform.
- Use an ultrasonic sensor in dustbins to detect the garbage level and send notifications to the waste collection department.
- Assemble a simple quadcopter using a frame, motors, electronic speed controllers, and a flight controller.

Student Activity

- Prepare a report on Open Source Assembly and Testing (OSAT).
- Prepare a report on automatic electronic components assembly machine.
- Prepare a PowerPoint presentation on upcoming 5G technology.
- Prepare a report on quantum bits (qubits) and their role in quantum processing using diagrams.
- Prepare a PowerPoint presentation on various Government of India schemes related to drones.
- Prepare a report on the application area of different types of drones.
- Prepare a report on the eligibility criteria for Remote Pilot License and the DGCA approved Remote Pilot Training Organizations near your area.
- Create a PowerPoint presentation on GPU architecture and its role in AI and gaming applications.
- Prepare a PowerPoint presentation on the functions of various sensors and actuators used in drones.
- Prepare internet-based reports on real-world applications of AI and ML in different industries.

Assignment

- Compare the working of superscalar processors with real-world examples.
- Explore anti-drone technology.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED : NOT APPLICABLE

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Advanced Processors and Technology	CO1	10	2	6	8	16
2	II	Smart Manufacturing Processes and Tools	CO2	9	4	4	6	14
3	III	Next Generation Telecom Network	CO3	9	4	4	6	14
4	IV	IIoT and Immersive Technologies	CO4	8	2	4	6	12
5	V	Drone Systems and Applications	CO5	9	4	4	6	14
Grand Total				**45**	**16**	**22**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests (MCQs) of 30 marks will be conducted and average of two-unit tests considered. Formative assessment of self learning of 25 marks should be assessed based on self learning activity such as Microproject/assignment/activities. (60 % weightage to process and 40 % to product)

Summative Assessment (Assessment of Learning)

- Online MCQ type Exam

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	1	2	3	3	2	3			
CO2	2	1	2	2	2	1	2			
CO3	2	1	2	2	3	1	2			
CO4	2	2	2	3	2	2	3			
CO5	1	1	2	2	2	1	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Sudhir Warier	The ABC of Fiber Optics Communication	Artech House Publishers ISBN: 978-1630814144
2	David Hanes, Salgueiro Gonzalo, et al.	IoT Fundamentals: Networking Technologies, Protocols and use cases for Internet of Things	Pearson Education ISBN: 978-9386873743
3	Saroj Kaushik	Artificial Intelligence	Cengage Learning India Pvt. Ltd. ISBN: 978-9355730428
4	Dharna Nar, Radhika Kotecha	Drone Technology for Beginners- Learn | Build | Fly Drones	Drone School India and Ane Books Pvt Ltd. ISBN: 978-8197222184
5	Garvit Pandya	Basics of Unmanned Aerial Vehicles : Time to start working on Drone Technology	Notion Press Media Pvt Ltd. ISBN: 978-1637453865
6	Bhushan Patil, Manisha Vohra	Introduction to Extended Reality (XR) Technologies	John Wiley & Sons Inc. ISBN: 978-1119857228
7	Guy A. Boy	The Handbook of Human-Machine Interaction A Human-Centered Design Approach	CRC Press ISBN: 9780367111939

Sr.No	Author	Title	Publisher with ISBN Number
8	S K. Saha	Introduction to Robotics	Tata McGraw-Hill Education ISBN: 978-9355326461

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.rohsguide.com/rohs-faq.htm	RoHS Guide
2	http://www.trai.gov.in/	TRAI official website for Next Generation Network
3	https://www.tec.gov.in/	Technical Enginnering Centre Technical Reports.
4	https://cfdflowengineering.com/working-principle-and-compone nts-of-drone/	Introduction about drone components
5	https://www.twi-global.com/technical-knowledge/faqs/industry -5-0	Industry 5.0
6	https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-Y.20 12-200609-S!!PDF-E&type=items	Next Generation Networks – Frameworks and functional architecture mode
7	https://www.dgca.gov.in/digigov-portal/?page=jsp/dgca/Invent oryList/headerblock/drones/RPAS.html	DGCA Drone rules
8	https://circuitdigest.com/microcontroller-projects/programmi ng-esp32-with-arduino-ide	Programming ESP32 Board with Arduino IDE
9	https://cloud.google.com/learn/artificial-intelligence-vs-machine-learning	Artificial intelligence (AI) vs. machine learning (ML)
10	https://www.plugxr.com/augmented-reality/ar-vr-mr-xr/	AR vs VR vs MR vs XR – What is the difference?
11	https://www.electronicsandyou.com/electronics-assembly-equip ment-guide.html	Electronic system assembly and machines
12	https://esp32io.com/	ESP 32 Tutorials
13	https://randomnerdtutorials.com/getting-started-with-esp32/	Getting Started with the ESP32 Development Board
14	https://learnesp32.com/videos/course-introduction/course-int roduction	Learn ESP32

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

INDUSTRIAL INTERNET OF THINGS **Course Code : 316342**

Programme Name/s : **Automation and Robotics**
Programme Code : **AO**
Semester : **Sixth**
Course Title : **INDUSTRIAL INTERNET OF THINGS**
Course Code : **316342**

I. RATIONALE

Internet of Things (IoT) enables real-time monitoring, predictive maintenance, and remote control of industrial assets, leading to increased efficiency, reduced downtime, and optimized production. This Industrial IoT (IIoT) course explores vital components of IoT such as sensors, gateways, cloud computing, and communication protocols. It will help students become familiar with this technological transformation and develop the ability to design, create, and deploy advanced, smart IoT solutions to thrive in the rapidly evolving industrial landscape. Additionally, this course will provide students with hands-on experience in IIoT technologies, industrial communication protocols, and cloud-based data analytics.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:
Maintain industrial systems based on IoT.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the architecture of IoT.
- CO2 - Integrate sensors and actuators to develop IoT based applications using NodeMCU.
- CO3 - Use IoT communication protocols for data handling.
- CO4 - Describe the role of IIoT in Industry 4.0.
- CO5 - Analyze data for predictive maintenance in industry applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316342	INDUSTRIAL INTERNET OF THINGS	IIT	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the architecture of IoT system. TLO 1.2 List types of IoT system. TLO 1.3 Illustrate design of IoT system with sketch. TLO 1.4 Explain IoT enabling technology for the given application. TLO 1.5 Describe the challenges in IoT based system.	**Unit - I Basics of Internet of Things (IoT)** 1.1 Basics of IoT: Need, history, definition, characteristics, architecture of IoT with block diagram, IoT applications 1.2 Types of IoT system 1.3 Physical and logical design of IoT 1.4 Overview of enabling technologies for IoT: Big data analytics, cloud computing, wireless sensor networks, embedded systems with example 1.5 IoT system challenges for design and security	Video Demonstrations Lecture Using Chalk-Board Presentations Collaborative learning
2	TLO 2.1 Describe the architectural block diagram of NodeMCU with sketch. TLO 2.2 Use NodeMCU open-source IoT platform for given application. TLO 2.3 Configure Wi-Fi on NodeMCU. TLO 2.4 Interface sensors and actuators with NodeMCU for IoT applications. TLO 2.5 Connect wireless modules with NodeMCU.	**Unit - II Fundamental of NodeMCU and Arduino IDE** 2.1 NodeMCU ESP8266: Features, specifications, hardware architecture, pins configuration, UART, I2C, SPI 2.2 Arduino IDE setup, creating, compiling and uploading programs from Arduino IDE to NodeMCU 2.3 Wi-Fi configuration on NodeMCU: Wi-Fi libraries, code for connecting NodeMCU to Wi-Fi networks 2.4 Programming and interfacing sensors and actuators with NodeMCU: 2.4.1 Sensors: Gas, pressure, vibration, current, voltage, proximity, liquid/gas flow 2.4.2 Actuators: Solenoids, servo drives, pneumatic and hydraulic actuators. 2.5 Wireless communication module with NodeMCU: Interface RFID, bluetooth modules	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board Collaborative learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Illustrate the IoT communication protocols with suitable example. TLO 3.2 Configure NodeMCU as webserver. TLO 3.3 Describe the procedure for data communication using MQTT protocol. TLO 3.4 Explain the given IoT network technology with suitable application. TLO 3.5 Discribe the given Industrial communication protocol with suitable example.	**Unit - III IoT Communication Protocol** 3.1 IoT Protocols: HTTP-REST, MQTT, CoAP, (features, methods, communication, applications) 3.2 Procedure to create webserver with NodeMCU connection on Web page for NodeMCU and control applications remotely 3.3 Data Communication using MQTT with NodeMCU: Connect to a broker, publish and subscribe topics, collect, send and receive data using MQTT 3.4 IoT networking technology: LoRa, NBIoT (Features and applications) 3.5 Industrial communication protocols: 3.5.1 Modbus (RTU): Basics, working, and implementation 3.5.2 OPC-UA: Introduction 3.5.3 Modbus communication between IoT gateway and PLC 3.5.4 OPC-UA for industrial automation 3.5.5 Data transfer from PLC/SCADA to cloud using MQTT	Video Demonstrations Lecture Using Chalk-Board Collaborative learning Presentations
4	TLO 4.1 Differentiate IoT and IIoT. TLO 4.2 Explain role of IIoT in Industry 4.0. TLO 4.3 Describe the architecture of IIoT system. TLO 4.4 Select appropriate IIoT components for various applications. TLO 4.5 Interface PLC and SCADA system with IoT gateway. TLO 4.6 Explain real-time data processing in edge computing.	**Unit - IV Overview of Industrial IoT** 4.1 IIoT basics: Compare IoT and IIoT, benefits of IIoT 4.2 Role of IIoT in industry 4.0 and smart manufacturing 4.3 IIoT system architecture and deployment: 4.3.1 IIoT Layers: Sensor, edge, gateway, cloud, analytics 4.3.2 Selecting IIoT components: Sensors, PLCs, edge devices, cloud 4.4 PLC-based automation and SCADA systems for IIoT 4.5 Real time edge computing - Introduction and data processing	Video Demonstrations Presentations Lecture Using Chalk-Board Collaborative learning
5	TLO 5.1 Identify relevant cloud for storage and processing tools of industrial data. TLO 5.2 Describe data logging and visualization in IIoT. TLO 5.3 Distinguish preventive and predictive maintenance. TLO 5.4 Explain the concept of digital twin. TLO 5.5 Analyze data for predictive maintenance in industry applications.	**Unit - V Cloud Computing & Predictive Maintenance in IIoT** 5.1 Overview of IoT cloud platforms: AWS, Azure, Google Cloud, ThingSpeak 5.2 Cloud-based storage and processing for industrial data 5.3 Data logging and visualization: Using Grafana, Node-RED, and Power BI for industrial dashboards, real-time monitoring dashboards 5.4 Digital Twin in IIoT 5.5 Predictive maintenance and industrial data analytics: Preventive and predictive maintenance, machine learning for industrial analytics, vibration and temperature-based fault detection, condition monitoring using IIoT sensors	Video Demonstrations Presentations Case Study Collaborative learning

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

INDUSTRIAL INTERNET OF THINGS **Course Code : 316342**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Establish a connection between the NodeMCU-ESP8266 and a computer using appropriate cables and drivers. LLO 1.2 Configure Arduino IDE for NodeMCU programming.	1	*Installation and configuration of Arduino IDE for NodeMCU	2	CO1 CO2
LLO 2.1 Interface LED and switch with NodeMCU to turn ON and OFF LED.	2	Interfacing LED and Switch with NodeMCU	2	CO2
LLO 3.1 Control relay operation using NodeMCU and IR sensor.	3	*Interfacing relay and IR sensor with NodeMCU	2	CO2
LLO 4.1 Interface DHT11 sensor with NodeMCU. LLO 4.2 Measure humidity and temperature using DHT 11 and NodeMCU.	4	Interfacing Humidity sensor with NodeMCU	2	CO2
LLO 5.1 Detect object motion using PIR sensor and NodeMCU.	5	Interfacing PIR Sensor with NodeMCU	2	CO2
LLO 6.1 Configure NodeMCU to connect to a WiFi network and troubleshoot connectivity issue.	6	*Connecting NodeMCU to Wi-Fi network	2	CO2
LLO 7.1 Use HTTP protocol to send sensor data from NodeMCU to a web server (Use any cloud service).	7	*Transmission of data from NodeMCU to Web Server.	2	CO3
LLO 8.1 Set up MQTT communication to publish and subscribe to topics using NodeMCU.	8	*Implementation of MQTT Protocol with NodeMCU	2	CO3
LLO 9.1 Measure data from LDR to monitor light intensity and transmit it to cloud. LLO 9.2 Control intensity of LED according to the data received from cloud (Use any cloud service).	9	*Monitoring and controlling light intensity using NodeMCU	2	CO2 CO3
LLO 10.1 Transmit sensor data to an IoT cloud platform.	10	Transmission of sensor data to ThingSpeak cloud using NodeMCU	2	CO2 CO3
LLO 11.1 Develop an MQTT-based IoT application for remote control.	11	*Controlling devices using MQTT and NodeMCU	2	CO2 CO3
LLO 12.1 Integrate a Bluetooth module with NodeMCU/Raspberry Pi. LLO 12.2 Display real-time sensor data on a smartphone.	12	*Bluetooth Integration with IoT gateway for sensor data	2	CO2
LLO 13.1 Measure fluid flow and transmit data to cloud. LLO 13.2 Control intensity of LED according to the data received from cloud (Use any cloud service).	13	Monitoring and controlling fluid flow using NodeMCU	2	CO2 CO3 CO4
LLO 14.1 Send data from sensors to the cloud for analysis. LLO 14.2 Control actuators based on the data analysis to maintain optimal conditions.	14	Monitoring of air quality, temperature, humidity, and other environmental parameters	2	CO2 CO3 CO4
LLO 15.1 Use vibration and temperature sensors data to monitor the condition of industrial equipment. LLO 15.2 Transmit data to the cloud for real-time analysis. LLO 15.3 Activate actuators for maintenance or shutdown to prevent equipment damage.	15	*Monitoring the condition of industrial equipment using vibration and temperature sensors.	2	CO2 CO3 CO4 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 16.1 Set up Raspbian OS on Raspberry Pi.	16	*Configuring Raspberry Pi (Gateway)	2	CO4
LLO 17.1 Set up network and SSH for remote access.	17	*Configuring Raspberry Pi as an IoT gateway	2	CO4
LLO 18.1 Interface a DHT22 sensor with Raspberry Pi. LLO 18.2 Measure sensor data using Python.	18	Interfacing DHT22 sensor with Raspberry Pi to monitor temperature and humidity data.	2	CO2 CO4
LLO 19.1 Implement MQTT communication between devices.	19	*Connecting Raspberry Pi to NodeMCU using MQTT	2	CO3
LLO 20.1 Configure Mosquitto as a local broker on Raspberry Pi.	20	*Setting up a local MQTT broker on Raspberry Pi	2	CO3
LLO 21.1 Measure industrial sensor data using Modbus protocol.	21	*Interfacing a Raspberry Pi with a PLC (Modbus RTU)	2	CO3 CO4
LLO 22.1 Store sensor data in a time-series database.	22	*Storing industrial data to InfluxDB and Grafana using Raspberry Pi	4	CO5
LLO 23.1 Visualize IIoT data using Grafana dashboards.	23	Creating a real-time dashboard using Grafana	2	CO5
LLO 24.1 Transmit IoT gateway data to AWS cloud.	24	Transmission of data from Raspberry Pi (gateway) to cloud	2	CO3 CO5
LLO 25.1 Develop an IoT workflow using Node-RED.	25	Using Node-RED for industrial automation	4	CO4 CO5
LLO 26.1 Implement an edge computing application on Raspberry Pi. LLO 26.2 Set up a cloud computing service to process data from Raspberry Pi.	26	Demonstration of edge computing vs. cloud computing using Raspberry Pi	4	CO4 CO5
LLO 27.1 Acquire equipment data from sensors. LLO 27.2 Use machine learning to predict equipment maintenance.	27	*Implementing predictive maintenance using machine learning	2	CO5
LLO 28.1 Acquire sensor data from industrial equipment using IIoT devices. LLO 28.2 Analyze acquired data using data analytics techniques to detect faults in industrial equipment.	28	Implementing fault detection in industrial equipment using IIoT and data analytics	2	CO4 CO5
LLO 29.1 Develop an end-to-end IIoT system by integrating hardware, software, and cloud.	29	Building a complete IIoT system from data collection to intelligent control	4	CO2 CO3 CO4 CO5
LLO 30.1 Use electrical power sensors to measure and transmit data to the cloud for analysis.	30	Power consumption monitoring using electrical power sensors	2	CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Compare various Raspberry Pi models (Pi 4, Raspberry Pi 3B+, Raspberry Pi Zero W, and Raspberry Pi 400) for IIoT applications, focusing on their CPU, RAM, connectivity features, and suitability for industrial use.
- Explain the role of Raspberry Pi as an IIoT gateway, detailing its functionality, key features, and advantages in industrial IoT applications.
- Compare edge and cloud computing in IIoT on the basis of processing capabilities, latency, and data handling.
- Describe data transfer between industrial sensors, PLCs, IIoT gateways and cloud platforms.
- List the industrial communication protocols supported by Raspberry Pi and explain how it manages various protocols such as MQTT, Modbus, OPC-UA, HTTP, and WebSockets for IIoT applications.
- Compare different IIoT gateways with their features, protocols, and applications.
- Explain different Industrial communication protocols supported by IIoT gateways.
- Describe the process by which Raspberry Pi gathers data from PLC-connected sensors (e.g., temperature, pressure) and transmits it to the cloud for data analytics.

Micro project

- Develop a Weather Monitoring System – Collect and display weather parameters data using NodeMCU/Raspberry Pi and sensors
- Design an IoT-based Smart Home System – Control home appliances using NodeMCU and MQTT.
- Develop an RFID-based Smart Attendance System – Use an RFID module with NodeMCU for automatic attendance recording and display it on cloud
- Design a Smart Irrigation System – Automate watering based on soil moisture sensor data using IIoT gateway
- Design an IIoT-enabled Remote Machine health Monitoring System – Use an IIoT gateway to send real-time machine health data from PLC (temperature, vibration) to the cloud.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	NodeMCU ESP8266 Processor: Tensilica L106 32-bit microcontroller Wi-Fi: 2.4 GHz, IEEE 802.11 b/g/n GPIO: 11 Digital I/O, UART, I2C SPIPower: 3.3V	1,2,3,4,5,6,7,8,9,10,11
2	Arduino IDE This is an open-source Arduino Software (IDE) used to write code and upload it to the board. This software can be used with any Arduino board.	1,2,3,4,5,6,7,8,9,11,12,13,14,15,10
3	Servo Motor (MG996R, DS3218, Industrial-Grade Servo) Use Case: Robotic arms, industrial valves, smart actuators Interface: PWM	11
4	Power Supply (12V/24V) with Buck Converter to step down voltage for Raspberry Pi	11

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
5	DC Motor (12V/24V High-Torque Motor) Use Case: Industrial automation, conveyor belts, robotic arms Interface: PWM (via Motor Driver)	11,27,28,29
6	Stepper Motor (NEMA 17, NEMA 23, NEMA 34) Use Case: CNC machines, precision industrial control nterface: Step/Direction via Stepper Driver (A4988, TB6600)	11,27,28,29
7	Water Flow Sensor (YF-S201) Use Case: Water usage monitoring in factories Flow Rate: 1-30 L/min Interface: Pulse Output	13
8	Gas Sensor (MQ-2) Detectable Gases: Methane, Propane, Smoke Operating Voltage: 5V	14
9	BMP280 (Barometric Pressure Sensor) Use Case: Weather stations, altitude monitoring in drones Range: 300-1100 hPa, ±1 hPa accuracy Interface: I2C/SPI	14
10	Raspberry Pi 4 Model B CPU: Quad-core Cortex-A72 (ARM v8) 64-bit @ 1.5 GHz RAM: 2GB/4GB/8GB LPDDR4 Storage: microSD card slot Connectivity: 2.4/5 GHz Wi-Fi, Bluetooth 5.0, Gigabit Ethernet Ports: 2× USB 3.0, 2× USB 2.0, HDMI	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17
11	Raspberry Pi OS (64-bit / 32-bit, Lite/Desktop) Purpose: Primary OS for Raspberry Pi, supports industrial applications Installation Tool: Raspberry Pi Imager	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17
12	Yocto Project-based OS Purpose: Custom Linux OS for embedded and industrial applications Best for: Advanced IIoT custom builds	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17
13	Pneumatic Solenoid Valve (12V/24V, 5/2 Way, 3/2 Way) Use Case: Industrial automation, air-based control systems Interface: GPIO (via Relay Module)	21,22
14	Hydraulic Cylinder (12V/24V Solenoid Control) Use Case: Heavy industrial equipment automation Interface: GPIO (via Relay or MOSFET Switch)	21,22
15	Modbus Protocol (For Industrial Automation & PLC Communication) Library: pymodbus (pip install pymodbus) Best for: Reading data from industrial controllers	21,22,25,26,27,28,29
16	Grafana (Real-Time IIoT Data Visualization) Installation: sudo apt install grafana Best for: Industrial sensor data monitoring	22
17	InfluxDB (Time-Series Database for Industrial Data Logging) Installation: sudo apt install influxdb Best for: Storing real-time sensor data	22
18	Node-RED (Visual Flow-Based IIoT Programming) Installation: sudo apt install node-red Best for: Creating industrial dashboards, automation	25

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
19	TensorFlow Lite (For Edge AI on Raspberry Pi in Industrial Applications) Installation: pip install tflite-runtime Best for: Industrial image processing	26
20	VL53L0X (Time-of-Flight Distance Sensor) Use Case: Precision object measurement in factories Range: 30mm - 2m Interface: I2C	27,28,29
21	Raspberry Pi Camera Module v2 Use Case: Industrial inspection, object detection Resolution: 8 MP Interface: CSI (Camera Serial Interface)	27,28,29
22	Thermal Camera (MLX90640 32x24 IR Sensor) Use Case: Industrial temperature scanning, safety monitoring Temperature Range: -40°C to 300°C Interface: I2C	27,28,29
23	ADXL345 (Accelerometer - Vibration Sensor) Use Case: Machine health monitoring, predictive maintenance Range: ±2g/4g/8g/16g Interface: I2C/SPI	27,28,29,15
24	LoRaWAN Gateway Software (For Long-Range Wireless IIoT Communication) Software: ChirpStack LoRa Server Best for: Connecting remote IIoT devices	27,28,29,30
25	OPC UA (For Secure Industrial Data Exchange) Software: FreeOpcUa (pip install opcua) Best for: SCADA & Industrial IoT applications	29,30
26	PZEM-004T (Energy Meter Sensor) Use Case: IoT-based smart energy monitoring Parameters: Voltage, current, power, energy Interface: UART	30
27	Temperature & Humidity Sensor (DHT22) Temperature Range: -40°C to 80°C, ±0.5°C accuracy Humidity Range: 0-100% RH, ±2-5% accuracy	4,18,14
28	SHT31 (High Precision Temp & Humidity Sensor) Use Case: Precision climate control in pharmaceuticals, food industry Range: Temperature (-40°C to 125°C), Humidity (0-100%) Interface: I2C	4,8,14
29	MQTT Broker (For IoT & Industrial Communication) Software: Mosquitto (sudo apt install mosquitto mosquitto-clients) Best for: IIoT data exchange between devices	8,19
30	12V/24V Power Supply & Relays (SRD-05VDC, SRD-12VDC, or SSR-40DA Solid-State Relay) MOSFET Module (IRF520 or IRLZ34N for High-Current Loads)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Internet of Things (IoT)	CO1	10	4	4	4	12

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Fundamental of NodeMCU and Arduino IDE	CO2	14	4	4	8	16
3	III	IoT Communication Protocol	CO3	12	2	6	6	14
4	IV	Overview of Industrial IoT	CO4	12	4	4	6	14
5	V	Cloud Computing & Predictive Maintenance in IIoT	CO5	12	2	4	8	14
Grand Total				**60**	**16**	**22**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks each will be conducted, and the average of both unit test scores will be considered out of 30 marks for formative assessment. Laboratory learning will be assessed for 25 marks. Each practical will be evaluated with a weighting of 60% for the process and 40% for the product.

Summative Assessment (Assessment of Learning)

- End semester assessment will be conducted for 70 marks. Additionally, the end semester summative assessment for laboratory learning will be of 25 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	1	1	1	3			
CO2	3	3	3	3	2	2	3			
CO3	3	3	3	3	2	2	3			
CO4	3	2	3	3	3	3	3			
CO5	3	3	3	3	3	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Arshdeep Bahga and Vijay Madisetti	Internet of Things: A Hands-on Approach	University Press ISBN:9788173719547
2	David Hanes, GonzaloSalgueiro, Patrick Grossetete, Rob Barton, Jerome Henry	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	Cisco Press ISBN:978-1587144561
3	Raj Kamal	Internet Of Things (IOT): Architecture and Design Principles	McGraw Hill Education (India)Private Limited ISBN:9789390727384

Sr.No	Author	Title	Publisher with ISBN Number
4	Rahul Dubey	An Introduction to Internet of Things:Connecting Devices, Edge Gateway, and Cloud with Applications	Cengage India Private Limited ISBN: 9789353500931931
5	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress ISBN:978-1484220467
6	Frank Lamb	Industrial Automation	McGraw Hill Education (India) Private Limited ISBN:978-0071816458
7	Derek Molloy	Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux	Wiley India ISBN:978-1119188681
8	Simon Monk	Raspberry Pi Cookbook	O'Reilly Media ISBN:978-1491939108

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.arduino.cc/en/software	Arduino IDE software
2	https://nptel.ac.in/courses/106105166	Introduction to internet of things, by Prof. Sudip Misra IIT Kharagpur (nptel course)
3	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013827284022149120 72/overview	Getting Started with ESP8266- Infosys Springboard course
4	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013842651241504768 19950_shared/overview	IoT Raspberry Pi for Programmers with Projects- Infosys Springboard course
5	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_014157703591428096 275/overview	Introduction to Microsoft Azure IoT
6	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013749078912589824 50/overview	Raspberry Pi Course
7	https://professionalprograms.mit.edu/online-program-internet-of-things/	MIT Professional Education: Industrial Internet of Things 2
8	https://www.coursera.org/learn/industrial-internet-of-things	Coursera: Industrial Internet of Things (IIoT) – University of Michigan
9	https://thinger.io/	Thinger.io (Open-source IoT Cloud Platform)
10	https://nptel.ac.in/courses/106105195	Introduction to Industry 4.0 and Industrial Internet of Things, by Prof. Sudip MisraIIT Kharagpur (nptel course)

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

INDUSTRIAL ROBOTICS AND APPLICATIONS **Course Code : 316343**

Programme Name/s : **Automation and Robotics**
Programme Code : **AO**
Semester : **Sixth**
Course Title : **INDUSTRIAL ROBOTICS AND APPLICATIONS**
Course Code : **316343**

I. RATIONALE

Industrial robots are widely utilized in manufacturing sectors to boost productivity, competitiveness, and operational efficiency. They are particularly valuable for performing tasks that are dirty, monotonous, or hazardous, thereby improving workplace safety and reducing human labor. This course is specifically designed to provide students with the essential knowledge and practical skills needed to meet the growing demands of the manufacturing as well as processing industries. This course covers a range of applications, including robotic systems used in welding, automobile production, medical device manufacturing, and material handling, preparing students for the diverse challenges they will encounter as the 21st-century workforce.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:
Use robotic systems for various industrial applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the use of robot vision system for relevant application.
- CO2 - Develop VAL program for various robotic applications.
- CO3 - Apply the fundamentals of Robot Operating System (ROS) in programming.
- CO4 - Troubleshoot robot for basic applications.
- CO5 - Recognize the various emerging robot technologies.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316343	INDUSTRIAL ROBOTICS AND APPLICATIONS	ARS	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the block diagram of robot vision system. TLO 1.2 Compare different lighting techniques. TLO 1.3 Explain the concept of segmentation and their types. TLO 1.4 List industrial applications of vision controlled robotic systems.	**Unit - I Robot Vision System** 1.1 Robot vision - Overview, sensing and digitizing function for image devices, lighting techniques, analog to digital signal conversions (sampling, encoding, image storage) 1.2 Image processing and analysis for image data reduction, segmentation, thresholding, region drawing, edge detecting, feature extraction, object recognition 1.3 Overview of industrial applications of vision controlled robotic systems	Model Demonstration Video Demonstrations Hands-on Collaborative learning Presentations
2	TLO 2.1 Enlist different robot languages. TLO 2.2 List various generations of programming languages. TLO 2.3 State capabilities and limitations of lead through programming methods. TLO 2.4 Develop programs to perform simple robotic operations. TLO 2.5 State capabilities and limitations of lead through programming method.	**Unit - II Robot Languages & Programming** 2.1 Textual robot languages, generations of robot programming languages, robot language structure, constant, variables and other data objects, motion, end-effector and sensor commands, computations and operations , program control and sub- routines, communications and data processing, monitor mode commands 2.2 Robot programming: Methods of programming a robot, lead through programming methods, robot program as a path in space, motion Interpolation, WAIT , SIGNAL and DELAY commands, branching, capabilities and limitations of lead through methods 2.3 Functioning modes of teach pendant 2.4 Simple program for pick and place activity 2.5 Simple program to palletize the object 2.6 Simple program for Insertion (Bolt, Bearing, etc.)	Model Demonstration Video Demonstrations Presentations Collaborative learning Hands-on

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Describe the need for a robot operating system. TLO 3.2 Differentiate between operating system & robot operating system. TLO 3.3 List different platforms of robot operating systems. TLO 3.4 Explain ROS architecture. TLO 3.5 Enlist advantages of the robot operating system.	**Unit - III Robot Programming using ROS 2** 3.1 Overview, need of robot operating system, history 3.2 Difference between OS, ROS 1 and ROS 2 3.3 ROS 2 supporting libraries, basic ROS equation 3.4 ROS 2 computing platforms, ROS 2 architecture and concepts, design goals of ROS, nomenclature, advantages of ROS	Model Demonstration Video Demonstrations Case Study Hands-on Collaborative learning
4	TLO 4.1 Describe the use of robots in material handling. TLO 4.2 Explain use of robots in automated assemblies. TLO 4.3 Enlist the steps regarding robot maintenance. TLO 4.4 Compare predictive and preventive maintenance. TLO 4.5 List different safety norms in robot handling. TLO 4.6 Explain the concept of interlocking in robotic systems. TLO 4.7 Suggest the remedies for common troubles encountered in robots	**Unit - IV Robot Applications and Maintenance** 4.1 Robot in material handling - Pick and place robot, robot in palletizing and related operations 4.2 Robot in processing operations - Spot welding, continuous arc welding , spray coating, die- casting, plastic molding, forging operation 4.3 Robot in automated assemblies 4.4 Robot in automated inspections 4.5 Robot maintenance - Need and types of maintenance 4.6 Common troubles and remedies in robot operation 4.7 General safety norms, robot handling aspects and their precautions 4.8 Overview of interlocking robots	Educational Video Video Demonstrations Site/Industry Visit Collaborative learning Demonstration Flipped Classroom
5	TLO 5.1 Interpret the concept of robot intelligence. TLO 5.2 Explain the functionalities of telepresence. TLO 5.3 Explain system integration and network approach. TLO 5.4 Enlist the emerging applications of robots. TLO 5.5 Describe briefly applications of robots like military operations, fire-fighting operations, space operations, etc. TLO 5.6 Describe the working principle and applications of humanoid robots.	**Unit - V Emerging Robotic Technologies** 5.1 Robot intelligence, advanced sensor capabilities (3D Vision), telepresence and related technologies, mechanical design features (direct drive robot, multiple arm coordinate robot), mobility, locomotion and navigation, universal hand, system integration and network 5.2 Emerging applications of robots - Military operations, fire-fighting operations, under sea operations, space operations, humanoid robots, swarm robotics, soft robotics, micro-robots, nano-robots and Cobalt robots	Model Demonstration Educational Video Case Study Collaborative learning Demonstration Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

INDUSTRIAL ROBOTICS AND APPLICATIONS **Course Code : 316343**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify key components of an industrial vision system, such as cameras, lenses, and lighting sources. LLO 1.2 Explain the function of each component in capturing and processing images for robotic applications.	1	*Identification of industrial machine vision components (industrial camera, lens, light source, etc.)	2	CO1
LLO 2.1 Implement an OpenCV-based program to capture and display images from a camera. LLO 2.2 Modify camera settings in order to optimize image capture for different lighting conditions.	2	*Implementation of image display using OpenCV	2	CO1
LLO 3.1 Apply edge detection techniques to highlight object boundaries. LLO 3.2 Analyze the different threshold values that affect the accuracy of edge detection.	3	*Edge detection of an object in an image using OpenCV	2	CO1
LLO 4.1 Use contour detection to identify and classify geometric shapes in an image. LLO 4.2 Apply image thresholding to improve shape detection accuracy.	4	Shape detection of an object in an image using contours	2	CO1
LLO 5.1 Extract object coordinates from an image using bounding boxes and centroid calculation. LLO 5.2 Implement real-time tracking of objects based on their detected position.	5	*Object location detection in an image	2	CO1
LLO 6.1 Implement HSV color filtering to segment objects of a specific color in an image. LLO 6.2 Apply masking techniques to highlight detected color regions.	6	Segmentation using color detection of an object in an image	2	CO1
LLO 7.1 Integrate computer vision data with robotic motion commands for automated control. LLO 7.2 Develop a real-time object recognition and response system for a robotic arm.	7	Vision system interfacing with robot programming	2	CO1
LLO 8.1 Apply image processing techniques to detect manufacturing defects in industrial components. LLO 8.2 Evaluate the effectiveness of vision-based quality control systems in automation.	8	Image processing techniques for industrial applications using OpenCV	2	CO1
LLO 9.1 Execute an assembly language program for inserting a bolt or bearing using an industrial robot. LLO 9.2 Troubleshoot programs to optimize insertion accuracy and efficiency.	9	Insertion program for bolt or bearing	2	CO2
LLO 10.1 Execute an assembly language program for a robot to follow a specific path using precise motion control. LLO 10.2 Optimize the robot's path planning to ensure smooth and accurate movement while avoiding obstacles.	10	Program for specific path movement for a robot	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Develop a robot program for automated palletizing, ensuring efficient object stacking using any assembly language. LLO 11.2 Apply kinematic principles to optimize the robot's pick-and-place movements for palletizing.	11	*Program for palletizing the objects	2	CO2
LLO 12.1 Analyze interrupted welding lines using sensor-based data collection for robotic path adjustments. LLO 12.2 Evaluate the effectiveness of real-time path correction algorithms for maintaining welding precision.	12	*Identification of sensing strategy and robot path for interrupted welding lines	2	CO2
LLO 13.1 Implement a robot painting program that ensures uniform paint application over a surface. LLO 13.2 Design an optimal path planning strategy for robotic arms to cover complex shapes with minimal overspray.	13	Development of robot program for painting operation	2	CO2
LLO 14.1 Develop a robotic spot welding program that ensures accurate positioning and heat application. LLO 14.2 Apply motion control algorithms to synchronize robot movement with welding sequences.	14	*Development of robot program for spot welding operation	2	CO2
LLO 15.1 Set up a ROS 2 environment for configuration on Linux-based system. LLO 15.2 Execute basic Linux commands essential for ROS 2 operation (e.g., sourcing setup files, navigating directories).	15	*Use basic ROS 2 commands and tools	2	CO3
LLO 16.1 Use Linux terminal commands to run and manage ROS 2 nodes . LLO 16.2 Analyze node communication through topics and messages. LLO 16.3 Use Linux-based ROS 2 CLI tools to inspect, debug, and interact with nodes.	16	*Use of ROS 2 commands and CLI tools	2	CO3
LLO 17.1 Install Turtlesim to simulate basic robot movement in ROS 2. LLO 17.2 Verify the execution of Turtlesim by listing active nodes and topics in ROS 2.	17	*Installation of open source ROS simulator - Turtlesim	2	CO3
LLO 18.1 Publish velocity commands to the Turtlesim robot using ROS 2 topics. LLO 18.2 Analyze the effect of different twist message parameters on turtle movement.	18	Turtle movemenr using ROS 2	2	CO3
LLO 19.1 Execute a ROS 2 teleop node to control the turtle's movement using keyboard inputs. LLO 19.2 Demonstrate interactive control of a simulated robot using ROS 2 command-line tools.	19	Control of Turtle using the keyboard	2	CO3
LLO 20.1 Call ROS 2 services to reset and teleport the turtle to a specific position. LLO 20.2 Evaluate the differences between ROS 2 services and topics in handling robot actions.	20	*Use of ROS 2 services to reset and teleport the Turtle	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 21.1 Develop a custom ROS 2 Python node that publishes velocity commands to move the turtle in a circular motion. LLO 21.2 Implement ROS 2 publisher-subscriber communication within a Python script.	21	*Development of a custom ROS 2 python node to move the Turtle in a circle	2	CO3
LLO 22.1 Create a ROS 2 launch file to start multiple nodes simultaneously. LLO 22.2 Evaluate the effectiveness of launch files in managing complex robotic applications in ROS 2.	22	Development of ROS 2 launch file to start multiple nodes	2	CO3
LLO 23.1 Use preventive maintenance techniques to inspect and maintain robotic components, including joints, actuators, and sensors. LLO 23.2 Evaluate the impact of regular maintenance on robot performance, longevity, and failure prevention.	23	*Preventive maintenance techniques for a robot	2	CO4
LLO 24.1 Identify common robot faults such as misalignment, sensor failures, and communication errors. LLO 24.2 Analyze error logs and system diagnostics. LLO 24.3 Troubleshoot robotic malfunctions effectively.	24	*Troubleshooting common robot faults	2	CO4
LLO 25.1 Apply safety inspection protocols to verify emergency stop buttons, interlocks, and sensor-based safety features. LLO 25.2 Evaluate the effectiveness of robotic safety measures in preventing accidents and ensuring compliance with industrial safety standards.	25	Implementation of safety checks in robot operation	2	CO4
LLO 26.1 Analyze the role of AI and machine learning in improving robot intelligence and decision-making. LLO 26.2 Evaluate the differences between AI-powered autonomous robots and traditional pre-programmed robots.	26	Case study on evaluation of robot intelligence in an AI-powered robot	2	CO5
LLO 27.1 Analyze the role of autonomous robots like Mars rovers in space exploration and extraterrestrial research. LLO 27.2 Design a conceptual AI-driven robotic system for future deep-space exploration missions.	27	*Case study on robots in space exploration – Mars rovers & beyond	2	CO5
LLO 28.1 Identify the challenges of deep-sea exploration. LLO 28.2 Analyze the role of sonar, LiDAR, and AI-driven mapping in underwater robotic navigation.	28	*Case study on deep-sea exploration robots for ocean research	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Autonomous turtle navigation with obstacle avoidance in ROS 2.
- Vision-based quality inspection system for industrial components.
- Gesture-controlled robot using OpenCV and ROS 2.
- Smart painting robot for industrial applications using ROS 2.
- Battery performance and power consumption analysis in robots.
- Recalibration and accuracy testing of a robot after a fault.
- Robot safety audit and risk assessment.

Student Activity

- Perform a survey and prepare a detailed report on robots used in manufacturing industries, such as welding, painting, die-casting, etc.
- Prepare a detailed report on the case study for robots used in military operations like logistics, firefighting, surveillance, rescue operations, etc.
- Prepare a detailed report on the case study for robots used in the healthcare sector.
- Prepare a comparative chart on NASA's Perseverance rover and CHANDRAYAN 2 spacecraft (Vikram).

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Light source: Luminous Colour = White Illumination = 40,000 lux Brightness = Continuously Adjustable, (Range:0~100%), Colour Temperature Constant	1,2,3,4,5,6,7,8
2	Focus lens: Focal length = 16mm Aperture = F1.4-F16C Focus Point = 0.3m-Inf	1,2,3,4,5,6,7,8
3	4 axis robotic arm manipulator and programming software Payload - Minimum 500g Maximum reach - 320mm	1,2,3,4,5,6,7,8,9,10,11,12,13,14,23,24,25
4	Vision camera: Effective Pixel = 3 million Hue = Colour Frame Rate/ Resolution =12 @2048x1536	1,2,3,4,5,6,8
5	Any open source software like OpenCV	2,3,4,5,6,7,8

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
6	Color sensor: Input = 20~150mm Detectable = non-glowing object Embedded controllable white LED	5,6,8
7	Open source robot simulation software like VAL/ RT tool box/ RoboDK or any other suitable software	9,10,11,13,14
8	Personal Computer : 8GB RAM, 500 GB HDD, I3 or higher processor Linux operating system like Ubuntu (Windows 10 only, Linux-Ubuntu 18.04 recommended, macOS — Sierra (10.12.x)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Robot Vision System	CO1	14	4	4	8	16
2	II	Robot Languages & Programming	CO2	14	4	6	6	16
3	III	Robot Programming using ROS 2	CO3	10	2	4	6	12
4	IV	Robot Applications and Maintenance	CO4	12	2	6	6	14
5	V	Emerging Robotic Technologies	CO5	10	2	4	6	12
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks.

For formative assessment of laboratory learning 25 marks.
Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	2	3	2	-	2			
CO2	3	3	2	2	2	2	2			
CO3	3	3	2	2	1	2	2			
CO4	3	2	1	1	2	-	2			
CO5	3	2	1	-	2	-	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	S. K. Saha	Introduction to Robotics	McGraw Hill 3rd Edition ISBN: 978-9355326461
2	Mikell P. Groover, Nicholas Odrey, Mitchell Weiss	Industrial Robotics -Technology ,Programming and Applications	McGraw Hill Education 2nd Edition ISBN: 978-1259006210
3	Lentin Joseph	Robot Operating System (ROS) for Absolute Beginners	Apress 1st Edition ISBN: 978-1484234044
4	Ganesh S. Hegde	Industrial Robotics	Laxmi Publications 2nd Edition ISBN: 978-8131805183
5	Ramachandran Nagarajan	Introduction to Industrial Robotics	Pearson Education 1st Edition ISBN: 978-9332544802
6	K. S. Fu, Ralph Gonzalez, C.S.G. Lee	Robotics: Control, Sensing, Vision and Intelligence	McGraw Hill Education 1st Edition ISBN: 978-0070226258

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.ros.org/	Robot Operating System (ROS) official website
2	https://mr-iitkgp.vlabs.ac.in/exp/val-programming/	Robot Teaching Using VAL Programming (Vlabs)
3	https://opencv.org/	OpenCV official website
4	https://docs.ros.org/en/eloquent/Tutorials/Turtlesim/Introducing-Turtlesim.html	Introducing turtlesim and rqt - ROS 2 Documentation: Eloquent documentation

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Programme Name/s	**: Automobile Engineering./ Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Production Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AE/ AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ ME/ MK/ PG/ SE/ TE**
Semester	**: Sixth**
Course Title	**: CAPSTONE PROJECT**
Course Code	**: 316004**

I. RATIONALE

Capstone projects in engineering study are considered important as it allow students to integrate and apply the knowledge and skills acquired throughout their academic program and effectively demonstrating their learning of programme by tackling a real-world problem, ultimately keeping them well prepared for the job market. The capstone project is usually the final assignment and plays a vital role in preparing students for the world of work to its practical applications and ability to help hone students' professional knowledge and skills. Normally, capstone projects are developed in collaboration with industries or businesses, providing students with valuable insights. Capstone projects has been considered as an integral part of diploma curriculum. It helps learners to perform and demonstrate skills gained due to early courses of Diploma study independent. Therefore, this is considered as a course of final year/semester study.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Apply professional skills for solving , executing and demonstrating solutions to real-world problems

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Elaborate the identified field problem from the perspective of project work at institute.
- CO2 - Conduct feasibility & viability analysis (using data collection, experiments, Simulation , Coding) to validate required resources, cost, support of the project work.
- CO3 - Apply the acquired knowledge and skills in providing solutions to the real field/industrial problems.
- CO4 - Present Project and its output/ findings / achievements alongwith its exhibits.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316004	CAPSTONE PROJECT	CPE	INP	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150

V. General guidelines for PROJECT WORK

- The Project- problems must be related to the programme or may be interdisciplinary, based on the industry expected outcomes.
- The individual students have different aptitudes and strengths. Project work, therefore, should match the strengths of students. For this purpose, students should be asked to identify the type of project work they would like to execute.
- Project titles are to be finalized in co-ordination/consultation with the Faculty mentor. However, faculty may form a team of students as per specific roles- Literature survey/data collection, data Analysts, model/prototype developers, testers, Project managers using IoTs ITES and software /application development. Study type project is NOT advisable.
- Project must be assigned to a group of 3-4 students under the guidance of identified faculty mentor.
- Students are required to prepare a prototype/working model/software of the Project and simultaneously prepare a report.
- Students shall Submit One Hard copy and one Soft copy each of Project Report and soft-copy of the project code or the working model.
- Students must maintain a project execution diary having the progress steps and details. The concerned faculty should check the diary on a weekly basis and accordingly interact with students based on the progress shown and keep proper record with feedback if any.
- Project shall address National Thrust area such as Environment, Digitization, Automation, sustainability and similar domains.
- Student shall try to use the national and international standards wherever possible (processes / materials / equipments etc ..)

VI. Project facilitation guidelines:

Once the Project statement has been finalized and allotted to the students, the Faculty Mentor role is very important as guide, motivator, catalyser to promote learning and sustain the interest of the students. At the same time the Faculty Mentor is not expected to guide the students on each step, otherwise it will curb the creativity of the students-group. The Faculty Mentor has to work as a mentor. Following should be kept in mind while facilitating the project at the institute:

1.Project orientation cum -briefing: the project should be relevant to the curriculum of the programme. The project shall be cost effective taking safety aspects, ethical issues, environmental issues and confidentiality as per expectation of industry(if any) into consideration, The work may be industry Sponsored.

2.Information search and data collection: the information and data should be realistic and relevant to the problem /project. Hypothetical data is not to be taken into consideration.

3.Implementation and Monitoring: The project must have important steps /milestones to achieve as per the time frame/action plan prepared by students and faculty. The monitoring mechanism such as daily/weekly dairy (**Format given below)** must be clearly explained and delineated for the students.

VII.Criteria of Assessment /Evaluation of Project work

A. Formative Assessment (FA) criteria

The **Formative Assessment** (FA) of the students for 50 marks is to be done based on following criteria.

Appropriate RUBRICS may be used for assessment

Rubrics for Assessment of the team

Sr.No.	Criteria	Marks
1	Project Selection & Problem definition	05
2	Literature survey and data collection/ Gathering	05
3	Design / concept of project/ Working - Execution of Project	10
4	Stage wise progress as per Action plan/milestone	05
5	Quality Report Writing	05

Rubrics for Individual Assessment

Sr.No.	Criteria	Marks
1	Contribution as a team member	05
2	Depth of Knowledge	10
3	Presentation	05

B. Summative Assessment Criteria

- The summative assessment for 50 marks is to be done and based on following criteria. This assessment shall be done by the faculty mentor and External examiner.

Sr.No.	Criteria	Marks
1	Capstone Project Completion as per plan	10
2	Project related Requirement Analysis & Designing	10
3	Developing a Solution with proper justifications, Teamwork	10
4	Project Report Writing	10
5	Project Presentation	10

(**NOTE :** Team based and Individual performance based summative assessment may include Innovativeness , Technology used , user friendliness , cost effectiveness , society benefits etc..)

SUGGESTED RUBRIC FOR SUMMATIVE ASSESSMENT OF CAPSTONE PROJECT

PROJECT ASSESSMENT				
Project Title:				
Project Assessment Rubric				
Performance	**Excellent**	**Good**	**Fair**	**Poor**
Criteria	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
Capstone Project Completion	Excellent **The project is completed as per tasks described in synopsis.**	Good **The project is completed but require minor modifications.**	Fair **The project is completed but require several modifications.**	Poor **The project is not completed as per tasks described in synopsis.**

Project related Requirement Analysis & Designing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Effectively contributed in requirement analysis and designing.	**Partially Contributed in requirement analysis and designing.**	**Attempted to contribute in requirement analysis and designing**	**No contribution in requirement analysis and designing.**
Developing a Solution with proper justifications , Teamwork	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Developed the critical solution modules with Innovation, optimized design and worked very well with the team.	**Developed some solutions with higher complexity and worked well with the team.**	**Attempted to develop few solutions and worked with the team.**	**No contribution in developing a solution and in the team.**
Project Report Writing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Worked very well to submit an excellent project report .	**Worked well to submit the project report with covering all the aspects of a standard report.**	**Tried to submit the project report but standard of report was not satisfactory.**	**No contribution in project report writing.**
Project Presentation	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Presented the project work flawlessly.	**Presented the project work very nice.**	**Presented the project work not so well.**	**Presentation skill is not up to the mark.**
Project Group Members				
ROLL NUMBER/Enrollment Number				
NAME				
Comments (if any)				

NOTE : " These are suggestive rubrics Faculty mentor and external examiner may frame different rubrics as per Programme need and assigned Project work "

C. Self Learning Assessment

Self Learning Assessment **Max Marks -50**

Sr.No.	Criteria	Max Marks	Marks Obtained
1	Project Selection & Problem definition	10	
2	Literature survey and data collection/ Gathering	05	
3	Design / concept of project/ Working - Execution of Project	15	
4	Stage wise progress as per Action plan/milestone/ psychomotor motor skills acquired	10	
5	Quality Report Writing	10	

VIII. CO-PO Mapping

CO-PO mapping will vary project wise and shall be prepared by concerned faculty for the given project

IX. Typographical instructions/guidelines for Project report writing

Following is the suggestive format for preparing the Project report. Actual report may differ slightly depending upon the nature of industry. The training report may contain the following.

a. The PROJECT report shall be computer typed (English- British) and printed on A4 size paper.
b. Text Font -Times New Roman (TNR), Size-12 point
c. Subsection heading TNR- 12 point bold normal
d. Section heading TNR- 12 capital bold
e. Chapter Name/ Topic Name – TNR- 14 Capital
f. All text should be justified. (Settings in the Paragraph)
g. The report must be typed on one side only with double space with a margin 3.5 cm on the left, 2.5 cm on the top, and 1.25 cm on the right and at bottom.
h. The training report must be hardbound/ Spiralbound with cover page in black colour. The name of the candidate, diploma (department), year of submission, name of the institute shall be printed on the cover [Refer sample sheet (outer cover)]
i. The training report, the title page [Refer sample sheet (inner cover)] should be given first then the Certificate followed by the acknowledgment and then contents with page numbers.

X. Project Report

On completion of the project work, every student will submit a project report which should contain the following:
1. Cover Page (as per annexure 1)
2. Title page (as per annexure 2)
3. Certificate by the Guide (as per annexure 3)
4. Acknowledgment (The candidate may thank all those who helped in the execution of the project.)
5. Abstract (It should be in one page and include the purpose of the study; the methodology used.)
6. Table of Contents (as per general guidelines): Detailed description of the project (This should be split in various chapters/sections with each chapter/section describing a project activity in totality).

Chapter–1 Introduction (background of the Industry or User based Problem/Task)
Chapter–2 Literature Survey (to finalize and define the Problem Statement)
Chapter–3 Scope of the project
Chapter–4 Methodology/Approach, if any
Chapter-5 Details of designs, working and processes
Chapter-6 Results and Applications

7. Conclusion
8. References (The listing of references should be typed 2 spaces below the heading “REFERENCES” in alphabetical order in single spacing left – justified. It should be numbered consecutively (in square [ ] brackets, throughout the text and should be collected together in the reference list at the end of the report. The references should be numbered in the order they are used in the text. The name of the author/authors should be immediately followed by the year and other details). Typical examples of the references are given below:

NOTE:
1. Project report must contain only a relevant and short mention – technology or platform or tools used. It must be more focussed on project work and its implementation
2. Students can add/remove/edit chapter names as per the discussion with their guide

Formats

Project Report

"Project Title----------"

as a partial fulfilment of requirement of the

THIRD YEAR DIPLOMA IN

Submitted by

1)Name Of Student	**Enrollment Number**
2)Name Of Student	**Enrollment Number**
3)Name Of Student	**Enrollment Number**
4)Name Of Student	**Enrollment Number**

Are the bonafide on

FOR THE ACADEMIC YEAR

20-----20---

(H.O.D)

(Principal)

(Internal Guide) **(External Examiner)**

Department Name

(If NBA Accredited mention that)
Institute Name

(An Affiliated Institute of Maharashtra State Board of Technical Education)

Table of Contents

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Note:

***Students can add/remove/edit chapter names as per the discussion with their guide**

Annexure

PROJECT DIARY (Weekly/Daily)

Name of the Student : _____

Name of Guide (Faculty) : _____

Enrollment Number : _____ Semester: _____Project batch Number : _____

WEEK : _____

Date	Activity carried out (Details)	Achievement of mile stone/step as per plan	Remark of Faculty
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			

Dated Signature of Faculty **Dated Signature of HOD**

MSBTE LOGO INST LOGO

Certificate

This is to certify that

Mr./Ms. *bearing examination seat No.* *has*

Satisfactorily completed his/her ***PROJECT*** *entitled*

Along with his/her batchmates in partial fulfillm ent for the

Diploma Course in

< PROGRAMME NAME>

Of the ***Maharashtra State Board of Technical Education*** *at our Polytechnic during the Academic Year20 -20 .*

The Project is completed by a group consisting of Persons under the guidance of the Faculty Guide

Faculty Name and Signature (Internal)	**Faculty Name and Signature (External if applicable)**	**HOD Name and Signature with Department Stamp**
Date and Time		

DRONE TECHNOLOGY **Course Code : 316335**

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electronics & Communication Engg./ Electronics Engineering/ Industrial Electronics/ Electronics & Computer Engg./**
Programme Code	**: AO/ DE/ EJ/ EK/ ET/ EX/ IE/ TE**
Semester	**: Sixth**
Course Title	**: DRONE TECHNOLOGY**
Course Code	**: 316335**

I. RATIONALE

Drones, or UAVs, are transforming industries and are regulated by rules like the DGCA Drone Rules 2021. Emerging technologies like autonomous flight and AI are expanding drone capabilities. This course will provide a comprehensive knowledge of drone technology and its operations. It will prepare students to work in this field.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching-learning experiences: Maintain various components of Drone System.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Classify different types of Drones.
- CO2 - Interpret drone technology along with its rules and regulations.
- CO3 - State function of Drone system and subsystems.
- CO4 - Test the drone system.
- CO5 - Select drone for a given application.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316335	DRONE TECHNOLOGY	DRT	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 2 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe history of Flight and Ancient concepts related to it. TLO 1.2 Describe evolution of UAV technology. TLO 1.3 Explain Drones, types and their applications. TLO 1.4 Explain Drone classification by weight category (as per Drone Rules 2021) . TLO 1.5 Explain terminologies related to Drones . TLO 1.6 Describe Flying area of Drones .	**Unit - I Introduction and Classifications of Unmaned Aerial Vehicle (UAV)/Drones** 1.1 Historical references of ancient flight concepts (IKS) 1.2 Evolution of Drone/UAV technology 1.3 Introduction to Drones : types (fixed,rotary, hybrid) and applications 1.4 Drone classification by weight category (as per Drone Rules 2021) 1.5 Terminologies related to Drones (as per Drone Rules 2021) - UAV (Unmanned Aerial Vehicle), Remote pilot, UAS (Unmanned Aircraft System), RPAS (Remotely Piloted Aircraft System), GCS (Ground Control Station), VLOS (Visual Line of Sight), BVLOS (Beyond Visual Line of Sight), UIN (UAV Identification Number), UAOP (UAV Operations Permit) 1.6 Digital sky platform : Airspace map for zone identification	Lecture Using Chalk-Board Video Demonstrations Model Demonstration
2	TLO 2.1 Describe the operation of basic building blocks of the drone system and subsystem. TLO 2.2 Describe Drone components and its function. TLO 2.3 Explain principles of Flight. TLO 2.4 Explain Drone flying rules, regulations and safety precautions .	**Unit - II Drone Technology - Building blocks, Components, Flight Dynamics, and Regulations.** 2.1 Building blocks of the Drone system and subsystem 2.2 Drone components and its function : frame, motors, propellers, ESC, flight controller, battery, basic Sensors(accelerometer, magnetometer (compass), barometer, GPS),camera, Drone transmitter and receiver, Drone software and firmware 2.3 Principles of flight : lift, thrust, drag, weight, the axis of drone motion (pitch, roll, and yaw), aerodynamic principles that enable flight 2.4 Regulations and safety : Drone flying rules, regulations and their safety precautions (as per Drone rules 2021) governed by DGCA India	Lecture Using Chalk-Board Video Demonstrations Model Demonstration

DRONE TECHNOLOGY **Course Code : 316335**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Describe the working of Drone motors. TLO 3.2 Demonstrate programming for drone flight control using programming ESC. TLO 3.3 Describe the power management used in Drone . TLO 3.4 Explain the power management system in Drone. TLO 3.5 Describe Propellers and it's type . TLO 3.6 Describe frames and it's type . TLO 3.7 Explain the working of other components associated with Drone.	**Unit - III Drone Motors, Power Systems, and other components** 3.1 Motor: Brushless motor , motor specification, thrust-to-weight ratio, KV ratings and motor selection based on application 3.2 Electronic Speed Controllers (ESC): working principle and specification 3.3 Flight controller: Introduction and working principle 3.4 Power Management: batteries, calculation of flying time based on battery capacity ,the power distribution board 3.5 Propellers and it's type 3.6 Frames and it's type 3.7 Camera, gimble and and role of following sensors in the drone (Gyroscope, Accelerometer, Magnetometer (Compass), Barometer, GPS, Temperature Sensor)	Lecture Using Chalk-Board Video Demonstrations Model Demonstration
4	TLO 4.1 Describe selection criteria for different components used in drone. TLO 4.2 Explain assembly and integration system of drone. TLO 4.3 Describe procedure for Drone operation . TLO 4.4 Explain the maintenance process of Drone	**Unit - IV Drone assembly, operation and maintenance** 4.1 Component Selection : Frame, Motor, Propeller, Power distribution board, Battery, Flight controllers, Transmitter and Receiver, Cameras, and Sensors (Accelerometer, Magnetometer (Compass), Barometer) 4.2 Assembly and Integration: Basic wiring and soldering, assembling components into a functional Drone 4.3 Procedure for Drone operation 4.4 Troubleshooting and Maintenance: Diagnosing and fixing common issues (Power Issues, Connectivity Problems, GPS Issues, Motor and ESC Malfunctions, Propeller Problems, Battery Problems, Camera & Gimbal Issue, Firmware or Software Errors), Maintenance (Pre-flight Maintenance, Post-flight Maintenance, Battery Maintenance, Motor and Propeller Maintenance, Firmware and Software Updates, Regular Inspections) and calibration	Lecture Using Chalk-Board Video Demonstrations Model Demonstration
5	TLO 5.1 Explain the application of Drone in various sector. TLO 5.2 Explain Autonomy and AI concept used in the Drone. TLO 5.3 Explain role of the Drone technology in future.	**Unit - V Drone Applications and Future Trends** 5.1 Applications: Drones in agriculture, construction, logistics, military and cinematography 5.2 Basics of autonomous flight : waypoint navigation, sensor fusion, and machine learning for object detection 5.3 Emerging Trends: Drone swarming, Solar-powered drone, Advanced Sensors used in Drones for Imaging Technology	Lecture Using Chalk-Board Video Demonstrations Model Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

DRONE TECHNOLOGY **Course Code : 316335**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Prepare a report/chart on the history of flight and ancient concepts of aerodynamics(IKS) . LLO 1.2 Prepare of a report/chart on the overview of drones, including their history, types, and applications.	1	Preparation of a report/chart on the history of flight and illustrate the evolution timeline of UAV technology till date	2	CO1
LLO 2.1 Explore Digital sky platform.	2	Exploration of Digital sky platform	2	CO1
LLO 3.1 Identify the zones (Red,Yellow,Green) by using Airspace map for any district and area near the airport.	3	* Identification of zones (Red,Yellow,Green) by using Airspace map for any district and area near the airport	2	CO1
LLO 4.1 Prepare a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021.	4	Preparation of a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021	2	CO1
LLO 5.1 Identify the mechanical components in drones, and describe their specifications and functions.	5	Identification of mechanical components in drones, and describe their specifications and functions	2	CO2
LLO 6.1 Identify electrical components in drones, describing their specifications and functions.	6	*Identification of electrical components in drones, describing their specifications and functions	2	CO2
LLO 7.1 Identify electronic components used in drones, describing their specifications and functions.	7	*Identification of electronic components in drones, describing their specifications and functions	2	CO2
LLO 8.1 Prepare a report/chart on DGCA Regulations & Safety Protocols for Drone Operation .	8	Preparation of a report/chart on DGCA Regulations & Safety Protocols for Drone Operation	2	CO2
LLO 9.1 Plot the Speed-Torque Characteristics of a BLDC Motor used in Drone .	9	Plot the speed-torque characteristics of Drone's BLDC motor	2	CO3
LLO 10.1 Inspect battery pack for bulges and leakage.	10	*Inspection of a battery pack for bulges and leakage	2	CO4
LLO 11.1 Calculate the flying time based on battery capacity.	11	*Calculation of the flying time based on battery capacity	2	CO3
LLO 12.1 Assembling of the quadcopter Drone.	12	*Assemble the quadcopter Drone using the given components	2	CO4
LLO 13.1 Configure and operate the Drone transmitter and receiver.	13	Configuration and operation of Drone transmitter and receiver	2	CO4
LLO 14.1 Test the assembled drone. LLO 14.2 Troubleshoot the assembled drone.	14	*Test the assembled drone	2	CO4
LLO 15.1 Prepare a report/chart on application of Drone technology in Agriculture.	15	*Preparation of a report/chart on application of Drone technology in Agriculture	2	CO5
LLO 16.1 Prepare a report/chart on the application of Drone technology in cinematography.	16	Preparation of a report/chart on the application of Drone technology in cinematography	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Explore and make ppt on current drone regulations (DGCA) and summarize the key safety and operational rules.
- Explore Indian Government schemes related to Drone used in various sectors and tabulate it .
- Create a chart that compares different types of drones (fixed-wing, rotary-wing, hybrid). Include details such as their flight mechanism, uses, and advantages/disadvantages.
- Create a comparison table of popular drone software frameworks like ArduPilot, PX4, and ROS. Highlight their features, advantages, and differences in functionality.
- Create an infographic or chart that shows the key components of a drone (motors, ESCs, flight controller, GPS, sensors). Briefly describe each part's role in the flight system.
- Draw a diagram illustrating the principles of drone flight (lift, thrust, drag, weight). Label the forces and explain how they work together in stable flight.
- Make a chart explaining the Drone policy implemented in India for various applications.

Assignment

- Compare different types of quadcopter frames based on their application (racing frames, photography/videography frames, industrial frames, toy drone frames, fpv frames, heavy-lift frames)
- Explain how Electronic Speed Controller (ESC) calibration is essential for ensuring optimal drone performance. In your answer, discuss the role of ESC calibration in motor performance, throttle range, safety, and battery management. Additionally, explain the potential consequences of failing to properly calibrate the ESC in a drone.
- How is drone technology transforming Indian agriculture? Discuss the role of initiatives like the Kisan Drone Scheme and Namo Drone Didi by the Government of India in accelerating this transformation. Highlight the benefits and challenges of using drones for crop monitoring, spraying, and precision farming, and explore how these advancements are shaping the future of farming in India.
- Compare different types of quadcopter propellers based on their application (racing frames, photography/videography frames, industrial frames, toy drone frames, fpv frames, heavy-lift frames)
- Compare the drone regulations in India with those of other countries (any two) around the world and explain how they differ.
- Compare different types of quadcopter motors based on their application (racing frames, photography/videography frames, industrial frames, toy drone frames, fpv frames, heavy-lift frames)
- Comment on the power vs. speed characteristics of the drone based on the thrust-to-weight ratio and KV rating.
- Drone Maintenance for Agricultural Monitoring Fleet Scenario: You are the lead technician responsible for maintaining a fleet of drones used for agricultural monitoring. The drones are equipped with high-resolution cameras, GPS modules, and autonomous flight systems. Your goal is to ensure their continuous operation and minimize downtime due to maintenance issues. Answer the following questions based on your knowledge of drone maintenance, safety procedures, and preventive measures. Question 1: What daily, weekly, and monthly maintenance tasks should be performed to keep the drones in optimal working condition. Question 2: Explain the importance of calibrating the GPS modules regularly. What steps should be taken to calibrate the GPS system in the drones. Question 3: Describe the procedures you would follow to inspect and maintain the drone’s high-resolution cameras and propellers to prevent any operational issues. Question 4: How would you monitor and maintain the health of the drone batteries to ensure long-duration flights in agricultural fields. Question 5: What emergency procedures should be followed if a drone malfunctions during flight, and how would you ensure the safety of crops and equipment in such cases.
- Drones face significant challenges with weight and battery limitations, which affect their flight time, payload capacity, and overall performance. How can the integration of solar power help overcome these issues. Discuss the potential benefits of solar-powered drones.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer system with internet connectivity.	1,2,3,4,8,15,16
2	Any office software and browser	1,2,3,4,8,15,16
3	Quadcopter Drone Kit	5,6,7,9,10,11,13,12,14
4	Tachometer	9
5	Digital Multimeter	9,10,13,12,14

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction and Classifications of Unmaned Aerial Vehicle (UAV)/Drones	CO1	12	4	4	4	12
2	II	Drone Technology - Building blocks, Components, Flight Dynamics, and Regulations.	CO2	12	4	6	6	16
3	III	Drone Motors, Power Systems, and other components	CO3	12	4	6	6	16
4	IV	Drone assembly, operation and maintenance	CO4	14	2	4	10	16
5	V	Drone Applications and Future Trends	CO5	10	2	4	4	10
Grand Total				**60**	**16**	**24**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks. End semester summative assessment of 25 marks for laboratory learning

XI. SUGGESTED COS - POS MATRIX FORM

DRONE TECHNOLOGY **Course Code : 316335**

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	1	1	1	3	1	2			
CO2	2	2	3	3	3	2	3			
CO3	2	2	3	3	3	2	3			
CO4	2	3	3	3	3	2	3			
CO5	2	3	3	3	2	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Ms. Dharna Nar, Dr. Radhika Kotecha	Drone Technology for Beginners: Learn | Build | Fly Drones	Drone School India and Ane Books Pvt Ltd, ISBN : 978-8197222184
2	Aalok Tripathi	DRONE TECHNICIAN THOERY	ARIHANT PUBLICATIONS INDIA LIMITED, ISBN : 978-9364378895
3	Terry Kilby, Belinda Kilby	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Shroff Publishers & Distributors Pvt. Ltd, ISBN : 978-9355428899
4	Garvit Pandya	Basics of Unmanned Aerial Vehicles : Time to start working on Drone Technology	Notion Press Media Pvt Ltd, Chennai, ISBN : 978-1637453865
5	Dr Raja Mogili Amirisetty	THE DRONE LAW IN INDIA	Gogia Law Agenency , ISBN : 978-8193978559
6	David McGriffy	Make: Drones - Teach an Arduino to Fly	Shroff Publishers & Distributors Pvt. Ltd, ISBN : 978-9355425188
7	Mr. I.V.S.Yeswanth & Dr. A.V.S.Sridhar Kumar	Fundamentals of Drone Technology	Authors Click Publishing, ISBN : 978-9366652450

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://digitalsky.dgca.gov.in/airspace-map/#/app	A digital sky airspace map is an interactive, real-time representation of airspace boundaries, flight paths, and aviation regulations, often used for flight planning and navigation
2	https://digitalsky.dgca.gov.in/home	Digital Sky Platform is an online portal by the Indian government for managing and regulating the operations of drones in Indian airspace.
3	https://www.dgca.gov.in/digigov-portal/jsp/dgca/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20Rules%202021.pdf	The Drone Rules, 2021, Unmanned Aircraft System Rules, Government of India in the Ministry of Civil Aviation

DRONE TECHNOLOGY **Course Code : 316335**

Sr.No	Link / Portal	Description

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electronics & Tele-communication Engg./ Electronics & Communication Engg./ Electronics Engineering/ Industrial Electronics**
Programme Code	**: AO/ DE/ EJ/ ET/ EX/ IE**
Semester	**: Sixth**
Course Title	**: VLSI APPLICATIONS**
Course Code	**: 316340**

I. RATIONALE

VLSI (Very-Large-Scale Integration) design equips aspiring engineers with hands-on experience in both front-end and back-end processes. As a rapidly evolving technology in the industry, VLSI offers vast opportunities for innovation. This course provides students with fundamental skills to develop applications in VLSI using VHDL programming. Additionally, it enables them to utilize FPGA and ASIC chips for design and implement various applications.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attend following industry/employer excepted outcome through various teaching learning experiences: Develop VLSI-based electronic circuit/component using VHDL.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret CMOS technology circuits and its applications.
- CO2 - Develop digital circuits on CPLD and FPGA devices.
- CO3 - Use VHDL to develop and test digital circuits.
- CO4 - Develop VHDL program for given application.
- CO5 - Interpret VHDL simulation and synthesis.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316340	VLSI APPLICATIONS	VLS	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe working of MOS transistor as a switch. TLO 1.2 Sketch the given gates using CMOS logic circuits. TLO 1.3 Explain stepwise process of CMOS fabrication. TLO 1.4 Differentiate between the nwell and pwell CMOS. TLO 1.5 Define the given specification/characteristics of CMOS logic family.	**Unit - I Introduction to CMOS Technology** 1.1 MOS Transistor: symbol, characteristics and operation, switch level modes connection, behavior of series & parallel MOS transistor switch, transmission gates and tristate logic 1.2 CMOS fabrication process: Wafer processing, oxidation, epitaxy deposition, ion-implementation, diffusion, metallization, packaging 1.3 Types of CMOS fabrication: nwell, pwell, twin tub process 1.4 Specifications of CMOS logic family: metastability, noise margins, power dissipation, fan-out, skew, figure of merits (Definitions only) and the parameter values 1.5 CMOS circuits for Boolean function	Lecture Using Chalk-Board Presentations Educational Video
2	TLO 2.1 Differentiate between Asynchronous and synchronous logic circuits with the help of suitable examples. TLO 2.2 Explain the Moore and Mealy machine design method with the help of suitable diagram and example. TLO 2.3 Describe the functions of each block of the given type of CPLD, FPGA, ASIC IC. TLO 2.4 Interpret FPGA, CPLA and ASIC parameters.	**Unit - II Advance Programmable Digital Devices (CPLD, FPGA, ASIC)** 2.1 Review of Sequential Logic circuits, comparison of Asynchronous and Synchronous 2.2 Moore and Mealy machine: block diagram, design examples on Moore and Mealy such as counter, sequence detector only 2.3 CPLD: concept, architecture, internal block diagram, applications 2.4 FPGA: concept, block diagram, architecture, applications. differentiate between FPGA and CPLD 2.5 ASIC: concept and design flow	Lecture Using Chalk-Board Presentations Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Differentiate between VHDL and Verilog on the given parameters. TLO 3.2 Optimize VHDL programming steps with its syntax. TLO 3.3 Use basic elements of VHDL programming and develop the simple code for the given function. TLO 3.4 Describe various data types used in VHDL programming with examples. TLO 3.5 Use VHDL operators to develop mathematical expressions.	**Unit - III Introduction to VLSI Design Concepts** 3.1 Hardware Description Languages (HDL): Very High-Speed HDL(VHDL) vs Verilog, and their functionality and comparison 3.2 VHDL: Features, structure and elements of VHDL (entity, architecture, configuration, package, library only definitions) 3.3 Basic Language Elements: Identifiers, VHDL objects: signal, variables and constant (syntax and use) 3.4 VHDL data types: scalar, array, composite, enumerated 3.5 VHDL operators: relational, arithmetic, logical and shift	Lecture Using Chalk-Board Educational Video Presentations
4	TLO 4.1 Compare the VHDL modelling style. TLO 4.2 Develop VHDL program using concurrent statement for the given application. TLO 4.3 Develop VHDL program using sequential statement for given application. TLO 4.4 Implement given combinational and sequential logic circuits using VHDL. TLO 4.5 Develop VHDL test bench code for the given circuit.	**Unit - IV VHDL Programming** 4.1 VHDL Modeling: data flow, behavioral, structural 4.2 Concurrent constructs (when, with) 4.3 Sequential constructs (process, if, case, loop, assert, wait) 4.4 VHDL code for combinational circuits – Logic gates, adder, subtractor, multiplexer, demultiplexer, encoder, decoder, comparator, 4-bit ALU 4.5 VHDL code for Sequential circuits – D, T and JK flip-flop, 4 bit up/down counter, MOD counter, shift registers (4-bit SISO and PIPO) 4.6 Test bench: simple test bench for a combinational circuit (full adder) and sequential logic circuit (D/T flipflop)	Lecture Using Chalk-Board Educational Video Collaborative learning
5	TLO 5.1 Describe the features of the given type of simulator with a suitable example. TLO 5.2 Define the given component in HDL simulation process. TLO 5.3 Prepare flowchart for the HDL design synthesis process. TLO 5.4 Summarize stepwise HDL design flow.	**Unit - V HDL Simulation and Synthesis** 5.1 Types of simulators: event based and cycle based 5.2 Components: Event scheduling, sensitivity list, zero modelling, simulation cycle 5.3 HDL synthesis process: Boolean optimization, flattering, factoring, mapping to gates 5.4 HDL Design flow: RTL simulation, gate-level verification, place and route	Lecture Using Chalk-Board Flipped Classroom Educational Video

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify various blocks of FPGA and CPLD. LLO 1.2 Test the functionality of various pins of FPGA and CPLD.	1	*Identification of internal block and pin configuration of FPGA & CPLD	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Install relevant EDA (such as Xilinx software) tool for VHDL. LLO 2.2 Check the VHDL libraries installed in VHDL environment.	2	*Installation of EDA tool and the relevant libraries for VLSI code development	2	CO3
LLO 3.1 Test the functionality of basic logic gates using VHDL Data flow model. LLO 3.2 Test the functionality of universal logic gates using VHDL Data flow model.	3	*Develop VHDL code for basic and universal gate for data flow model	2	CO3
LLO 4.1 Test the functionality of basic logic gates using VHDL behavioral model. LLO 4.2 Test the functionality of universal logic gate using VHDL behavioral model.	4	Develop VHDL code for basic and universal gate for behavioral model	2	CO3
LLO 5.1 Test the functionality of half and full adder using VHDL code. LLO 5.2 Test the simulated Test bench waveform.	5	*Realize the half and full Adder on FPGA board	2	CO3
LLO 6.1 Test the functionality of 4:1 multiplexer using VHDL code.	6	*Realize the Multiplexer on FPGA board	2	CO3
LLO 7.1 Test the functionality of 1:8 De-multiplexer using VHDL code.	7	Realize the De-multiplexer on FPGA board	2	CO3
LLO 8.1 Interpret the output of 4:2 encoder using VHDL code.	8	Design 4:2 encoder on FPGA board	2	CO3
LLO 9.1 Interpret the output of 3:8 decoder using VHDL code.	9	Design 3:8 decoder on FPGA board	2	CO3
LLO 10.1 Test the functionality of D flipflop using VHDL code. LLO 10.2 Test the functionality of T flipflop using VHDL code.	10	*Realize the D and T flipflop on FPGA board	2	CO3
LLO 11.1 Test the functionality of 2-bit comparator using VHDL code.	11	Design Comparator on FPGA board	2	CO3
LLO 12.1 Interpret the output of Mod-10 Up counter using VHDL code.	12	Design Up Counter on FPGA board	2	CO3
LLO 13.1 Develop VHDL code for 4-bit Up/Down Synchronous counter and test the circuit on FPGA board..	13	Design Synchronous counter on FPGA board	2	CO3
LLO 14.1 Test the functionality of 4-bit binary to gray code converter & Synthesize using FPGA.	14	Design binary to gray code converter circuit using FPGA board	2	CO3
LLO 15.1 Develop VHDL code for 8-bit Digital to analog converter (DAC) & test the circuit on FPGA board	15	*Design digital to analog converter (DAC) using FPGA board	2	CO4
LLO 16.1 Optimize the VHDL code to rotate stepper motor in clockwise direction.	16	*Design stepper motor Controller using FPGA board	2	CO5
LLO 17.1 Develop VHDL code for 4-bit ALU and simulate it using FPGA.	17	Design of 4-bit ALU/ sequence detector using FPGA board	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Develop the flowchart for simulation used in VHDL.
- Write syntax for concurrent and sequential statements.
- Write test bench code of universal shift register using VHDL.
- Describe architecture of CPLD/FPGA with function of each block.
- Develop flow chart of CMOS IC fabrication in p-well and n-well process.

Micro project

- Build a small ASIC system for your Home /Community.
- Develop four-bit addition/subtraction circuit using VHDL code.
- Develop square wave generator system of frequency = 1 Hz/100Hz
- Develop a VLSI based alarm system when a customer enters into the shop through exits door.
- Build a VLSI based system for vehicle security system.
- Design traffic light system using CPLD/FPGA.
- Design Lift controller system using CPLD/FPGA.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	VLSI trainer kit along with DAC/ADC trainer kit.	15
2	VLSI trainer kit along with stepper motor.	16
3	FPGA trainer kit with Accessories	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17
4	JTAG cable, DMM, Bread board.	3,4,5,6,7,8,9,10,11,12,13,14,15,16,17
5	VLSI trainer kit with accessories such as switches,LED,seven segment display etc.	4,5,6,7,8,9,10,11,12,13,14,15
6	Personal computer with latest configuration.	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to CMOS Technology	CO1	12	2	4	8	14
2	II	Advance Programmable Digital Devices (CPLD, FPGA, ASIC)	CO2	10	2	2	6	10
3	III	Introduction to VLSI Design Concepts	CO3	14	4	4	8	16
4	IV	VHDL Programming	CO4	16	4	6	10	20
5	V	HDL Simulation and Synthesis	CO5	8	2	2	6	10
Grand Total				**60**	**14**	**18**	**38**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit test of 30 marks and average of two-unit test will considered for out of 30 marks.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester summative assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	1	1	1	2			
CO2	3	2	1	1	1	1	2			
CO3	3	2	2	2	2	2	3			
CO4	3	3	3	3	2	2	3			
CO5	3	3	3	2	2	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Gaganpreet Kaur	VHDL Basics to programming	Pearson Education India, 2011 ISBN: 9788131732113
2	John M. Yarbrough	Digital Logic: Application and Design	C.L Engineering, ISBN: 978 034066756
3	Willian I. Fletcher	An Engineering approach to digital design	Prentice- Hall of India ISBN: 9780132776998
4	Douglas Perry	VHDL programming by example	Tata McGraw-Hill ISBN: 9780070499447
5	Eugene D. Fabricius	Introduction to VLSI Design	McGraw Hill ISBN:9780070199484
6	Sarkar & Sarkar	VLSI design and EDA tools	Scitech Publications (lndia) Pvt Ltd ISBN: 9788183714976

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://docs.amd.com/v/u/en-US/ug1655-ise-documentation	ISE documentation for version 14.7
2	https://web.eecs.utk.edu/~dbouldin/protected/xilinx-ise-quick-start.pdf	ISE quick start tutorial
3	https://www.allaboutelectronics.org/cmos-logic-gates-explained/	Logic gates implementation using CMOS inverter

VLSI APPLICATIONS **Course Code : 316340**

Sr.No	Link / Portal	Description
4	https://www.geeksforgeeks.org/vhdl-very-high-speed-integrated-circuit-hardware-description-language/	VHDL programming.
5	https://nptel.ac.in/courses/117106092	NPTEL- VLSI Design Course

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

AR & VR **Course Code : 316344**

Programme Name/s : Automation and Robotics
Programme Code : AO
Semester : Sixth
Course Title : AR & VR
Course Code : 316344

I. RATIONALE

Augmented and Virtual Reality technologies are bridging the gap between physical and digital experiences. Hence the integration of Augmented Reality (AR) and Virtual Reality (VR) technologies is revolutionizing industries such as healthcare, gaming, education, manufacturing, and automation. This course provides a fundamental understanding of AR and VR concepts, working principles, applications, and use of AR-VR devices, equipping students with relevant industry-aligned skills.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Use AR and VR devices.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the fundamental concepts of AR and VR technologies.
- CO2 - Analyse sensory perception and cognitive processing in AR and VR.
- CO3 - Examine the functionalities of different AR and VR hardware and software systems.
- CO4 - Implement basic AR and VR interactions using programming and 3D modeling techniques.
- CO5 - Elaborate various applications of AR and VR.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316344	AR & VR	AVA	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 1 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Identify key milestones in the evolution of AR and VR technologies. TLO 1.2 Differentiate types of Extended Reality (XR). TLO 1.3 Ellaborate the components of AR and VR systems. TLO 1.4 Describe terminologies and concepts used in AR, VR.	**Unit - I Introduction to Immersive Technologies** 1.1 Key milestones in the development of AR and VR technologies 1.2 Evolution in AR, VR, MR and XR 1.3 Generalized block diagram of AR, VR system, functions of components: displays, tracking sensors, processor, camera, headsets, input devices 1.4 Terminologies in AR, VR: Field of view, Head Tracking, Frame Rate, Eye tracking, Latency, Marker, Haptics, Collision Detection, Drift, Ambisonics	Teacher Input Demonstration supported by media Educational Videos NPTEL videos
2	TLO 2.1 Define perceptual engineering and its importance in technology fields such as AR, VR and UX design. TLO 2.2 Describe the function of the human sense in perception. TLO 2.3 Implement UX/UI design for immersive experiences using knowledge of selective attention.	**Unit - II Fundamentals of Perceptual Engineering: Sensory Perception and Cognitive Processing** 2.1 Perceptual engineering: Importance in technology (AR, VR, UX design) 2.2 Five primary human senses and their significance in perceptual engineering, role of multimodal perception, structure & function of the human eye and ear, haptic and tactile perception in virtual reality, Importance of sensory feedback, Overview of Cognitive Processing, bottom-up vs top-down processing 2.3 Perception and attention: role of selective attention in human perception, impact on UX/UI design and AR, VR experiences, perceptual learning & adaptation, Neuroplasticity and its applications, case study in perceptual engineering (e.g., adaptive display systems)	Teacher Input Demonstration supported by media Educational Videos NPTEL videos
3	TLO 3.1 Enlist examples of AR and VR devices and write their functions. TLO 3.2 Describe immersive virtual environments using mounted displays (HMDs). TLO 3.3 Implement gesture and voice controls to interact with AR applications. TLO 3.4 Elaborate the concept of haptic feedback in VR for enhancing user interaction. TLO 3.5 Compare of AR, VR software on the basis of features, applications & utility.	**Unit - III Basic Components of AR and VR system** 3.1 AR Devices: Smartphones, smart glasses, AR headsets; VR devices: VR headsets (Oculus, PlayStation VR), motion controllers; cameras and sensors : Google Lens 3.2 Head-mounted displays (HMDs): Virtual world creation, motion tracking in VR, gyroscope & accelerometer – Detection of head movement. Controllers & Hand Tracking – users interaction 3.3 Gesture & Voice Control in AR: Using voice commands and hand gestures, example: google assistant in AR, HoloLens gestures 3.4 Haptic Feedback: VR gloves/controllers, creating a sense of touch, Example: Feeling a virtual ball when catching it in VR 3.5 AR, VR softwares: Unity with XR Interaction toolkit, Google ARCore, OpenXR, Blender	Teacher Input Demonstration supported by media Educational Videos NPTEL videos

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Illustrate the setup process for AR, VR development environments like Unity and Open XR. TLO 4.2 Describe different input methods in AR, VR (gaze, controllers, gestures, voice commands). TLO 4.3 Integrate head tracking, locomotion and object interaction for basic AR, VR interactions. TLO 4.4 Create optimized AR, VR assets using 3D modelling techniques.	**Unit - IV AR, VR interactions and 3D Modelling Techniques** 4.1 Common AR, VR development tools using C#/ Python/ JavaScript, setting up development environments, installing Unity, setting up SDKs: ARCore/ ARKit, basics of open XR for cross-platform VR development 4.2 Programming for basic AR, VR Interactions: input methods: gaze, controllers, gestures, voice commands, implementing hand tracking and motion controllers (e.g., Oculus, etc), Head tracking & locomotion: Implementing teleportation & smooth movement, Object interaction: Picking up, grabbing and throwing objects in VR 4.3 Simple AR Programming: Placing 3D objects in AR: Object anchoring & plane detection, Interactivity: Touch, tap and drag gestures, camera & UI elements: Overlaying AR-based menus, implementing haptic feedback for immersive experiences 4.4 3D Modeling software for AR, VR: 3D Asset Creation using software like Blender, File formats like OBJ, optimizing 3D models, reducing polygon count for real-time performance, applying textures, materials and lighting, implementing level of detail, exporting applications for Web XR	Teacher Input Flipped Classroom Educational Videos NPTEL videos
5	TLO 5.1 Enlist AR and VR applications in different industries. TLO 5.2 Illustrate the benefits of using AR and VR in the enhancement of immersive experiences in gaming. TLO 5.3 Elaborate contribution of AR and VR in healthcare. TLO 5.4 Explain AR and VR in education. TLO 5.5 Describe the role of AR and VR in manufacturing.	**Unit - V AR and VR Applications** 5.1 AR and VR applications 5.2 AR and VR in gaming: VR gaming platforms like Oculus, AR mobile gaming like Pokémon GO, XR gaming experiences 5.3 AR and VR in healthcare: Virtual surgeries and medical simulations, AR-based diagnosis and treatment planning, 5.4 AR and VR in education: Virtual classrooms and VR simulations for vocational training like pilots 5.5 AR and VR in manufacturing: AR for product design and prototyping, VR simulations for industrial training and safety	Teacher Input Demonstration supported by media Educational Videos NPTEL videos

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify components used in AR, VR systems. LLO 1.2 Setup components used in AR, VR systems.	1	Identification of the different components used in AR, VR systems	2	CO1
LLO 2.1 Develop function of human senses (sight, sound) in perception in relevant AR, VR application.	2	Testing of sight, sound perception in relevant AR, VR application	2	CO2
LLO 3.1 Implement immersive experiences (wireframes, mock-ups, and interactive prototypes) in UX/UI design.	3	Immersion Analysis of experiences in UX/UI design	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Implement selective attention techniques (focusing on specific elements while ignoring distractions) in AR, VR.	4	Testing of selective attention in simple AR, VR application	2	CO2
LLO 5.1 Identify components of AR and VR devices. LLO 5.2 Test functionality of components of AR and VR devices.	5	Testing of functionality of AR and VR components	2	CO3
LLO 6.1 Set-up HMD for exploring immersion, realism, and user interaction in virtual environment.	6	Exploration of various experiences in virtual environment using HMD	2	CO3
LLO 7.1 Implement gesture and voice controls in AR, VR application.	7	Performance review of hand gestures and voice commands in AR, VR application	2	CO3 CO4
LLO 8.1 Set-up HMD for exploring immersion, realism, and user interaction in virtual environment. LLO 8.2 Install Unity software. LLO 8.3 Interpret the Unity environment.	8	Installation of Unity software	2	CO3 CO4
LLO 9.1 Implement gesture and voice controls in AR, VR application. LLO 9.2 Develop an application by physical material simulating a 3D sphere using Unity. LLO 9.3 Set properties like friction and bounciness. LLO 9.4 Verify the values of friction and bounciness.	9	Simulation of sphere for friction and bounciness using Unity	2	CO4
LLO 10.1 Setup haptic gloves /controller to enhance user interaction and immersion by haptic feedback.	10	Exploration of enhanced user interaction and immersion in haptic gloves /controller	2	CO4
LLO 11.1 Design primitive shapes/game-objects using Unity. LLO 11.2 Modify the properties of game-objects using the inspector panel (position, rotation, scale). LLO 11.3 Create models of a chair and table using Unity.	11	Modelling simple furniture using primitive shapes with Unity	1	CO4
LLO 12.1 Use input method (gaze controller) in AR, VR application.	12	Operation of gaze-based controller in simple AR, VR application	1	CO4
LLO 13.1 Implement head tracking, locomotion, and object interaction in AR, VR application. LLO 13.2 Incorporate features such as head movement tracking, virtual walking/running, interactions with virtual objects (e.g., picking up and moving objects) in AR, VR application.	13	Testing of movement features and interaction with virtual objects in AR, VR application	2	CO4
LLO 14.1 Create polygon using 3D modelling Blender software. LLO 14.2 Optimize polygon reduction in AR, VR application.	14	Optimization of assets for AR, VR application	2	CO4
LLO 15.1 Develop a game in which triggering of gun destroy the cubes. LLO 15.2 Incorporate display gain of score point on the screen.	15	Exploration of AR, VR experience for a cube shooting game	2	CO4 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 16.1 Create a single player Basketball game in Unity. LLO 16.2 Incorporate basketball court scene and goal count in the game.	16	Exploration of counting of goal in Basketball game	2	CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Analyse how AR and VR have transformed the gaming and entertainment sector with examples of popular applications.
- Conduct a study on emerging trends in AR and VR, including advancements in hardware, AI integration, and metaverse applications.
- Describe the emerging trends in AR and VR, including advancements in hardware, AI integration, and metaverse applications.
- Compare different AR and VR headsets (Oculus Rift, HTC Vive, Microsoft HoloLens, Magic Leap) based on features, performance, and applications.
- Compare Unity, Unreal Engine Godot Engine on the basis of Platform Compatibility, Graphics & Rendering Quality, AR, VR SDK & Framework Support, Device & Hardware Support, Web & Cloud Integration
- Identify business opportunities in AR and VR and analyze successful startups in this domain
- Explain how AR and VR are used in industrial applications like digital twins, remote assistance, and simulation-based training.

Micro project

- Virtual Reality Art Gallery

Create a VR experience where users can explore an art exhibition in a virtual environment.

- VR Physics Lab Simulation

Develop a VR-based physics experiment simulation where users can interact with objects in a virtual lab.

- VR Training Simulator for Industrial Safety

Create a VR environment to simulate industrial safety procedures for workplace training.

- Virtual Reality Meditation & Relaxation App

Develop a VR experience that simulates a peaceful environment for meditation and stress relief.

- AR-Based Language Learning App ,

Develop an AR app that helps users learn new languages by recognizing objects and providing translations.

- VR Sports Training Simulator

Create a VR simulation to train users in sports like football, basketball, or cricket.

- AR Car Dashboard Assistant

Design an AR application that provides real-time dashboard information for cars using a smartphone camera.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Spatial Audio Equipment i) 3D audio headphones (Oculus Earphones/ Valve Index Off-Ear Audio) ii) Binaural microphones (Sennheiser Ambeo /Zoom H3-VR)	1,13,15
2	AR Projection & Display Device: AR Smart Glasses (Vuzix Blade/ Nreal Light)	1,15,16
3	Hardware Components: Tracking & Motion Sensors i) Lighthouse Base Stations (HTC Vive) ii) Inside-out tracking sensors (Quest 2/HoloLens) iii) Leap Motion Controller (for hand tracking) iv) Eye-tracking sensors (Tobii Eye Tracker) v) AR, VR-compatible depth-sensing cameras vi) LiDAR Sensors vii) 360° Cameras for VR content creation(Insta360 Pro/ GoPro Max /Ricoh Theta)	1,7,12,15,8,9
4	Head-Mounted Displays (HMDs) i) VR Headsets: Oculus Quest 2/ HTC Vive /Valve Index /PlayStation VR/ Pimax ii) AR Headsets: Microsoft HoloLens/ Magic Leap	1,7,8,9
5	Controllers & Input Devices i) VR Controllers (Oculus Touch/ Valve Knuckles/ HTC Vive Controllers) ii) Haptic Gloves (HaptX/ Manus VR /Sense Glove) iii) BCI (Brain-Computer Interface) devices like NextMind	1,9
6	i) Locomotion System: Built-in Unity Character Controller ii) XR Toolkit Locomotion System (for teleportation, movement) iii) AR, VR SDKs: ARCore (Android) / ARKit (iOS) iv) SDK, SteamVR SDK, or Windows Mixed Reality SDK v) Hand and Head Tracking SDKs vi) Leap Motion SDK (for hand tracking) vii) Tobii Eye Tracking SDK (for gaze/head tracking)	10,12,13
7	i) Basic Gun Model & Bullet Prefab ii) Cube Objects (to be destroyed) iii) Score UI Element (TextMeshPro or UI Canvas)	15
8	Visual Studio Code / Visual Studio (For C# scripting) – Open source	15,16
9	i) Game Engines & APIs for AR, VR Development ii) Voice Recognition & Command Processing Software iii) CMU Sphinx (PocketSphinx) – Open-source offline speech recognition iv) Unity3D + XR Interaction Toolkit – Best for gesture & voice-based UI	15,16
10	i) Basketball Court Model (3D environment),Basketball Model, Hoop with Collider ii) Required Unity Modules: Physics Engine (Rigidbody, Colliders) (for ball movement and hoop collision), iii) Input System (for controlling player actions)	16

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
11	Unity 3D Suite	2,3,11,15,16
12	Blender software - For 3D modelling	4,14,15,16
13	Open source software for Audio Perception like Audacity, OpenAL	4,15,16
14	AR Device: Smartphone with ARCore/ARKit (for testing AR-based UI) i) UI/UX Design Tools (For Wireframes & Mockups) ii) Leap Motion (for AR, VR simulations & testing iii) Device-Specific SDKs & Tools:SteamVR SDK (for HTC Vive, Valve Index VR testing iv) Testing & Diagnostic Software: OpenXR Tools for Windows Mixed Reality (for AR/VR functionality testing	4,5,6,7,10,13,8,9
15	Computer Workstations Processor: Intel Core i7/i9 / AMD Ryzen 7/9 GPU: NVIDIA RTX 3060 / 3070 / 4070+ (for VR rendering) RAM: 16GB+ (32GB recommended for high-poly assets) Storage: 512GB+ NVMe SSD Monitor: 144Hz+ display (for smooth VR testing)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Immersive Technologies	CO1	8	4	8	0	12
2	II	Fundamentals of Perceptual Engineering: Sensory Perception and Cognitive Processing	CO2	12	2	4	8	14
3	III	Basic Components of AR and VR system	CO3	18	4	4	8	16
4	IV	AR, VR interactions and 3D Modelling Techniques	CO4	16	0	8	8	16
5	V	AR and VR Applications	CO5	10	4	8	0	12
Grand Total				**64**	**14**	**32**	**24**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering 60% weightage to process assessment and 40% weightage to product assessment. Continuous assessment need to be based on process and product related performance indicators.

Summative Assessment (Assessment of Learning)

- End of semester exam based on observations and recording of the particular experiments

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	--	--	--	2	--	2			
CO2	3	1	1	3	1	--	2			
CO3	3	2	2	3	1	--	1			
CO4	1	3	3	3	1	3	1			
CO5	1	--	--	--	3	--	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Paul Mealy	Virtual & Augmented Reality for Dummies	Wiley ISBN: 978-8126577071
2	Erin Pangilinan, Steve Lukas, Vasanth Mohan	Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing (Greyscale Indian Edition)	Shroff/O'Reilly ISBN: 978-9352138104
3	Indika Wijesooriya	Mastering Augmented Reality Development with Unity: Create immersive and engaging AR experiences with Unity	BPB Publications ISBN: 978-9355518330
4	Suman Dutta	Immersive Realm of Extended Reality: Navigating the future of virtual and augmented reality	BPB Publications ISBN: 978-9355517227
5	Jeremy Bailenson	Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do	W. W. Norton & Company ISBN: 978-0393253696
6	M. Claudia, Tom Dieck, Timothy Jung	Augmented Reality and Virtual Reality: The Power of AR and VR for Business	Springer International Publishing ISBN: 978-3030062453

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.opensourceforu.com/2022/03/open-source-platforms-you-can-use-for-ar-and-vr/	Open source Portal
2	https://dev.epicgames.com/documentation/en-us/unreal-engine/samples-and-tutorials-for-unreal-engine	Unreal Engine
3	https://learn.unity.com/	Unity software tutorial
4	https://www.coursera.org/learn/augmented-reality	Corsera free course

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Sr.No	Link / Portal	Description
5	https://www.freecodecamp.org/news/augmented-reality-full-course/	Agumented Reality Course
6	https://ioe.iitm.ac.in/project/virtual-reality-and-haptics/	Agumented Reality Course
7	https://arvr.google.com/	Google AR VR
8	AR, VR Tutorial Videos	Youtube video

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students