Maharashtra State Board Of Technical Education, Mumbai

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

Programme Name	**: Diploma In Mechatronics**		
Programme Code	**: MK**	**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 Practical				Based on Self Learning		Total Marks
						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	AUTOMOTIVE MECHATRONICS	AMK	DSC	316351	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
3	PLC PROGRAMMING AND SCADA	PPS	SEC	316352	-	4	-	4	-	8	4	3	30	70	100	40	25	10	25#	10	-	-	150
4	MICRO-ELECTRO MECHANICAL SYSTEM	MMS	DSC	316353	-	3	-	4	1	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
5	CAPSTONE PROJECT	CPE	INP	316004	-	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150
Elective -II (Any - One)																								
6	COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE	IQA	DSE	316354	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
	MECHATRONICS IN HEALTH SERVICES	MHS	DSE	316355	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
	SMART MANUFACTURING SYSTEMS	SMS	DSE	316356	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
Total					**1**	**18**		**14**	**8**		**20**		**150**	**350**	**500**		**150**		**150**		**150**		**950**

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

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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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 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	**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,	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.
	given situation TLO 1.6 Apply the required managerial skills for a given situation	leadership	
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	**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.
	aspects of an event management		
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

MANAGEMENT **Course Code : 315301**

Sr.No	Link / Portal	Description
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

AUTOMOTIVE MECHATRONICS **Course Code : 316351**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **AUTOMOTIVE MECHATRONICS**
Course Code : **316351**

I. RATIONALE

The modern automotive industry is driven by the integration of sophisticated electronics and control systems. The modern vehicles are no longer purely mechanical entities; they are complex, interconnected systems relying on sophisticated electronics, sensors, actuators, and control algorithms. This course in Automotive Mechatronics is meticulously designed to address this paradigm shift, providing diploma engineers with the essential knowledge and practical skills required to navigate and excel in this dynamic field.

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: Diagnose fault in automotive mechatronic system

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify various automobile systems with their functions and location.
- CO2 - Diagnose performance of given automotive sensors and actuators
- CO3 - Create block diagram of given automotive control system explaining its working and functioning of different components
- CO4 - Perform onboard diagnostics on MPFI and CRDI engine using scan tool and measuring instruments.
- CO5 - Check functionality of vehicle safety device components and advanced driver assistance systems

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											Total Marks
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316351	AUTOMOTIVE MECHATRONICS	AMK	DSC	4	-	2	2	8	4	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
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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 Classify Automobiles on basis of various criteria TLO 1.2 Draw block diagram of general vehicle layout TLO 1.3 List major components of automobile with their location and function TLO 1.4 Sketch block diagram of SI & CI Engine TLO 1.5 Explain working of given power train control system with block diagram TLO 1.6 State necessity, functions and location of given automobile system	**Unit - I Automotive Fundamentals** 1.1 Automobile: Definition, Need of Automobile, Classification of Automobiles. 1.2 Block diagram of general vehicle layout 1.3 Major components of Automobile with their function and location 1.4 Block diagram of Spark Ignition (SI) and Compression Ignition (CI) Engine 1.5 Power train control system: Electronic control system used in Multi-Point Fuel Injection (MPFI) and Common Rail Direct Injection (CRDI) system 1.6 Necessity, functions and locations of following automobile systems. a.Transmission system b.steering system. c.Suspension system. d.Cooling and lubrication system e.Fuel injection and Ignition system. f.Starting and charging system.	Video Demonstrations Presentations Model Demonstration Lecture Using Chalk-Board
2	TLO 2.1 List variables sensed in engine control TLO 2.2 Describe functions of automobile sensors and actuators TLO 2.3 Explain with sketches working and output signals of given automotive sensors TLO 2.4 Explain construction & working of given automotive actuators TLO 2.5 Describe procedure for maintaining given automotive sensors and actuators	**Unit - II Automotive Sensors and Actuators** 2.1 Concepts of an Electronic Engine control system: Inputs to controller, Outputs from controller 2.2 Variable quantity sensed in automotive engine : Air flow rate, speed , pressure, temperature, vibration, concentration of oxygen. 2.3 Sensors in Automotive: Air flow rate sensor, Engine speed sensor, Engine crankshaft angular position sensor, Throttle Position sensor, Manifold Absolute Pressure sensor, Intake Air Temperature sensor, Coolant Temperature sensor, Exhaust gas oxygen sensor, Knock sensor 2.4 Automobile Engine control Actuators:- Fuel injector, Exhaust gas recirculation actuator, Brushless Direct Current (BLDC) Motor	Video Demonstrations Presentations Model Demonstration Lecture Using Chalk-Board Site/Industry Visit
3	TLO 3.1 Explain construction and working	**Unit - III Automotive Motion Control System** 3.1 Cruise control system : Location, Types, Construction &	Video Demonstrations

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.
	of given motion control system TLO 3.2 State advantages and disadvantages of Antilock Braking system (ABS) TLO 3.3 State function of given motion control system TLO 3.4 List types of cruise control system TLO 3.5 Draw the block diagram of given automotive motion control system	working of cruise control system. 3.2 Antilock Braking system (ABS): Function, Construction & working , Advantages & Disadvantages. 3.3 Electronic power steering (EPS) system: Location, function, Construction & working. 3.4 Traction control system (TCS): Function, Construction & working 3.5 Electronic Stability control (ESC): Function, Construction & working 3.6 Integrated Engine control (IEC): Function, Construction & working	Presentations Model Demonstration Lecture Using Chalk-Board
4	TLO 4.1 Explain diagnostics procedure to given component and system TLO 4.2 List types of On-Board Diagnostics (OBD) Scanner available in market TLO 4.3 Explain OBD II procedure TLO 4.4 State procedure for standalone diagnosis of given component TLO 4.5 Describe six step approach in testing of given automotive component with flow chart TLO 4.6 List diagnostics fault codes with meaning TLO 4.7 State function of given measuring instrument for testing	**Unit - IV Diagnostics and Testing** 4.1 Electronic control system diagnostics 4.2 On-Board Diagnostics (OBD) scanner types 4.3 On-Board Diagnostics (OBD II) Procedure of MPFI/ CRDI system 4.4 Standalone diagnosis: Sensors and actuators 4.5 Six step approach for component testing 4.6 Diagnostic Fault codes : Types with their meaning 4.7 Measuring Instruments: Digital multi-meters, Oscilloscope, scan tool, Frequency meters	Video Demonstrations Presentations Model Demonstration Lecture Using Chalk-Board Site/Industry Visit
5	TLO 5.1 Describe the necessity of safety systems in modern vehicles TLO 5.2 Identify the different Advanced Driver Assistance System used in vehicle TLO 5.3 Describe working of given	**Unit - V Safety and Advanced Driver Assistance System** 5.1 Necessity of safety system 5.2 Types of safety-Active and Passive 5.3 Safety and Advanced Driver Assistance System :– Air Bags, Seat Belt, Central Locking, Collapsible Steering, Keyless Entry, Reverse Parking Sensor and Rear View Camera, Active Suspension, Adaptive Cruise Control, Voice Alert System, Automatic Climate Control, General Packet Radio Service (GPRS), Tyre Pressure Warning.	Video Demonstrations Presentations Lecture Using Chalk-Board Model Demonstration Site/Industry Visit

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.
	Advanced Driver Assistance System used in vehicle		

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 automobile systems like (Transmission ,Control ,Suspension ,Electrical and Electronics) LLO 1.2 Draw block diagram of general vehicle layout LLO 1.3 Label the diagram and list major components of automobile	1	*Trace general vehicle layout of given vehicle	2	CO1
LLO 2.1 Select various tools available in laboratory LLO 2.2 Categorize tools available in laboratory LLO 2.3 Use different hand tools and measuring devices for different application	2	Use of different hand tools and measuring devices	2	CO1 CO4
LLO 3.1 Use relevant tools require to dismantle petrol/diesel engine LLO 3.2 Follow safety procedure as per standard LLO 3.3 Inspect condition of components	3	*Dismantling of 4-stroke engine (Petrol/Diesel)	2	CO1
LLO 4.1 Use relevant tools require to assemble petrol/diesel engine LLO 4.2 Follow safety procedure as per standard LLO 4.3 Inspect condition of components LLO 4.4 Reassemble the petrol/diesel engine	4	*Assembling of 4-stroke engine (Petrol/Diesel)	2	CO1
LLO 5.1 Dismantle given clutch LLO 5.2 Identify components of clutch LLO 5.3 Draw any components of the clutch LLO 5.4 Identify fault in clutch. (if any) LLO 5.5 Assemble clutch	5	Dismantling and Assembling of Clutch	2	CO1
LLO 6.1 Identify and locate the various sensors on vehicle engine	6	*Identification of sensors and actuators in the given MPFI/CRDI engine	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.2 Write function of each				
LLO 7.1 Connect the oscilloscope to the oxygen sensor signal wire LLO 7.2 Observe the waveform at idle and while the engine is revved LLO 7.3 Check resistance and voltage output LLO 7.4 Observe sensor performance and relate with engine efficiency and performance	7	*Diagnosis of (waveform, resistance and voltage output) oxygen sensor and throttle position sensor using oscilloscope	2	CO2
LLO 8.1 Make connection of oscilloscope to the given sensor signal wire LLO 8.2 Observe the waveform at idle and while the engine is revved LLO 8.3 Check resistance and voltage output LLO 8.4 Observe sensor performance and relate with engine efficiency and performance	8	Diagnosis of (waveform, resistance and voltage output) Engine Temperature sensor and manifold absolute pressure sensor using oscilloscope	2	CO2
LLO 9.1 Identify Antilock braking system components LLO 9.2 Identify Electronic stability control system components LLO 9.3 List features of ABS and ESC	9	*Identification of various components of ABS and ESC system	2	CO3
LLO 10.1 Identify various components of given motion control system LLO 10.2 List features of motion control system like cruise control system, EPS, TCS, IEC etc. in vehicle	10	Identification of various components of motion control system like cruise control system, EPS, TCS, IEC etc. in vehicle	2	CO3
LLO 11.1 Search information on digital platform/ by market survey LLO 11.2 Report features of various types of OBD scanner	11	*Preparation of report on OBD Scanner types available in market with manufacturer specifications	2	CO4
LLO 12.1 Connect Scan tool to MPFI engine control unit and enter vehicle identification data LLO 12.2 Interpret the trouble code/s LLO 12.3 Inspect relevant transducer and wiring LLO 12.4 Rectify fault and clear diagnostic trouble code	12	On-Board Diagnosis (OBD-II) of MPFI engine using Scan tool	2	CO4
LLO 13.1 Detect fault using scanner LLO 13.2 Replace faulty sensor, actuator or ECU as required LLO 13.3 Perform onboard diagnostics on CRDI engine	13	On-Board Diagnosis (OBD-II) of CRDI engine using Scan tool	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 14.1 Identify types of safety devices used in vehicle LLO 14.2 Check the functionality of the components used in safety devices	14	*Functioning of vehicle Saftey devices components	2	CO5
LLO 15.1 Identify Advanced Driver Assistance Systems LLO 15.2 Check the functionality of Advanced Driver Assistance Systems used in vehicle	15	Demonstration of functional features of Advanced Driver Assistance System used in different vehicles	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

- Collect specifications and features of control system of vehicle, such as: Traction control system, Stability control, Integrated Engine control and prepare report for the same
- Visit modern service station for observing automobile electronics and computer-controlled systems and prepare a report on the same
- Prepare power point presentation or animation for understanding different automotive components and systems
- Observe videos relevant to practical task. Prepare a list of appropriate tool/ equipment Considering its range/ application. For following applications, tools should be listed: i.Diagnostic tools for MPFI engine ii.Diagnostic tools for CRDI engine
- Observe videos to operate various testing equipment's. Prepare a list of appropriate equipment considering its range/applications
- Collect videos relevant to MPFI, CRDI system
- Collect specifications and features of control system of vehicle, such as: ABS, Electronic suspension systems, Electronic power steering system and prepare report for the same

Micro project

- Choose a modern engine and search information on any one system from website. Prepare a report for the same.
- Case study based on Visit to automobile garage to study a faulty system of engine
- Identify a modern technology used in an engine. Collect relevant information on the technology and its features. Compare the same with older/ modern technologies adopted in other vehicles. Refer internet/ reference books/ manufacturer published literature for the same. Prepare a report
- Prepare a detail report on diagnosis of MPFI engine: following steps to be followed: i.Student should visit the shops/ garage for survey. ii.List out steps of diagnosis. iii.Diagnose a system of an engine using scan tool/multimeter/ oscilloscope. iv. Prepare a report

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	General purpose tools (spanner, ring spanner and socket)-6mm to 32mm	1,2,3,4,5
2	Scan tool: Make reputed manufacturers: On Board Diagnosis (OBD), II Generation scan tool, controlled Network area enabled, color display, operating temperature:0 to 50 degree Celsius, Internal storage: 4AAA Batteries, External Power :7 to 18 Volts; generic tools; accessories: extended cable, OBD II cable; relevant optional accessories.	11,12,13
3	Special purpose tools (piston ring expander, piston ring compressor, valve lifter, spark plug remover, torque wrench), torque wrench range -10 Nm to 200 Nm	2
4	Multiport fuel injection system with sensors, actuators and electronic control module, exhaust gas circulation valve and Positive crankcase ventilation valve make reputed manufacturers power 25 KW@ 5000 RPM to 50 KW @ 5000 RPM: Cubic capacity 1000 CC to 2000 CC	6,7,8
5	Automotive Diagnostic Oscilloscope; Type PC Based or hand-held analog channel: 8; Bandwidth :1000 KHz; Input impedance resistance: 1 M?; Input sensitivity :10mV/div to 5 V/div	7,8
6	Digital Multimeter: Make: Reputed manufacturers -Measure Voltage and Current AC and DC, Resistance, Capacitance, diodes, continuity, frequency, Min-Max functions: LCD Display,0 to 500C operation, Temperature, DC voltage-2mV to 1000V alternating current, current: 2 Ma TO 20 A DC, Diode Test, Continuity Test-Audible buzzer, resistance: 200 ohm to 200 Mega ohm	7,8,11,12,13
7	Four-wheeler vehicle make of TATA, Mahindra or alike in good running condition. OR Cut section working model of four-wheeler transmission system showing all the parts	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	Automotive Fundamentals	CO1	12	4	4	6	14
2	II	Automotive Sensors and Actuators	CO2	14	4	4	8	16
3	III	Automotive Motion Control System	CO3	12	2	6	4	12
4	IV	Diagnostics and Testing	CO4	12	2	4	10	16
5	V	Safety and Advanced Driver Assistance System	CO5	10	2	4	6	12
Grand Total				**60**	**14**	**22**	**34**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Class Test, Term work, Self-Learning

Summative Assessment (Assessment of Learning)

- End Semester Examination Theory , End Semester Examination Practical (External)

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	-	-	3	1	1	1			
CO2	3	2	1	2	1	-	2			
CO3	2	-	-	1	-	-	1			
CO4	3	2	2	3	1	2	3			
CO5	3	-	-	-	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	Dr. Kirpal Singh	Automobile Engineering Vol-I & II	Standard Publishers Distributors, New Delhi, 2011, ISBN:978-81-8014-171-3
2	William B. Ribben	Understanding Automotive Electronics	Butterworth-Heinemann, UK, 2017, ISBN 13:978-0128104347
3	A K BABU	Automotive Electrical and Electronics	Khanna Book Publishing Co. Ltd, New Delhi, 2016,ISBN:978-93-82609-69-8
4	Ronald K. Jurgen	Automotive Electronics Handbook	McGraw-Hill Inc.
5	Bosch, Robert	Automotive Handbook	Bentley Publishes, UK, 2014, ISBN:13:978978-1119975564
6	Denton, Tom	Advanced Automotive Fault Diagnosis	Routledge, New York, 2012, ISBN:978-0415725767

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=jAqC0qxIiL8 for MPFI system	MPFI system working

Sr.No	Link / Portal	Description
2	https://www.youtube.com/watch?v=KzF8ieiJ9UY for CRDI system	CRDI system working
3	https://www.youtube.com/watch?v=M9dZUOr6n4g for camshaft and crankshaft sensor testing	How to test camshaft and crankshaft sensor
4	https://www.youtube.com/watch?v= 8q6qZQJQEIU for automotive sensors and actuators	Describe different Automotive sensor and actuators
5	https://www.youtube.com/watch?v=RR8LsMBwL2I for Scan tool video	Scan tool video
6	https://www.youtube.com/watch?v=NUvWnOd5lFw for Common Rail Diesel Injector Working and Common Failure Points	Working of Common Rail Diesel Injector
7	https://www.youtube.com/watch?v=jKtBSFoAYlg- for cruise control system	What is cruise control system
8	https://www.youtube.com/watch?v=oMDqgcm4ZjU - Park assist system	Working of Park assist system
9	https://www.youtube.com/watch?v=lnK00rtWf68 for Throttle Position sensor cleaning	Cleaning process of Throttle position sensor
10	https://www.youtube.com/watch?v=98DXe3uKwfc - Antilock Braking system	How ABS work
11	https://www.youtube.com/watch?v=CYufBm5Bek8 - working of Air bag	Working of Air bag
12	https://www.youtube.com/watch?v=JIa0nsrQXI0 to read car fault codes and to clear them	How to read car fault codes and to clear fault code
13	www.araiindia.com	Website of The Automotive Research Association of India

Note :

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

PLC PROGRAMMING AND SCADA **Course Code : 316352**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **PLC PROGRAMMING AND SCADA**
Course Code : **316352**

I. RATIONALE

Contemplating the growing demand for expertise in Advanced Automation Systems within modern industries, learning about Programmable Logic Controller (PLC) programming and SCADA will equip the students with the ability to design and implement control systems and skills for real-time monitoring and data acquisition. This knowledge is critical for optimizing industrial processes, enhancing productivity, and ensuring safety by designing, programming, and maintaining PLC & SCADA based systems.

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:: Use PLC & SCADA systems for industrial automation.

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 and functions of different elements of PLC.
- CO2 - Execute different PLC ladder programming instructions.
- CO3 - Maintain PLC-based automation systems.
- CO4 - Develop SCADA screen for simple application.
- CO5 - Select advanced automation systems for industry 4.0 compliance.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											Total Marks
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316352	PLC PROGRAMMING AND SCADA	PPS	SEC	4	-	4	-	8	4	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 Explain the significance of industrial automation. TLO 1.2 Classify different types of automation used in mechatronic systems. TLO 1.3 Describe types of controls in industrial automation. TLO 1.4 Explain the function of different elements of PLC with the help of block diagram. TLO 1.5 Describe the concept of sinking and sourcing in PLC. TLO 1.6 Explain the advantages of PLCs in industrial automation.	**Unit - I Basics of PLC** 1.1 Introduction to industrial automation: Need of automation, automation hierarchy, types of automation 1.2 Analog control, Digital control (Supervisory control and Direct digital control) 1.3 Architecture of PLCs: Block diagram, CPU, I/O modules, power supply, memory organization, special I/O modules 1.4 Types of PLCs: Compact and modular PLCs, selection criteria of PLC, concept of redundancy in PLC 1.5 PLC power connection (wiring), concept of sinking and sourcing in PLC 1.6 Advantages of PLCs over traditional/hardwired relay logic	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom
2	TLO 2.1 Describe different programming languages used to program PLC. TLO 2.2 Specify appropriate I/O addressing format for the given PLC. TLO 2.3 Explain use of different PLC programming instructions used to write a simple program for performing a given operation. TLO 2.4 Explain the timer and counter instructions with their status bits and waveforms. TLO 2.5 Describe do's and don'ts in the PLC-PC installation procedure.	**Unit - II PLC Programming** 2.1 PLC programming languages: Functional Block Diagram (FBD), Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming (Introduction only) 2.2 Basics of ladder programming: PLC I/O addressing formats in ladder logic, relay-type instructions, PLC processor scan cycle 2.3 Programming Timer: Addressing a timer block, status bits, ON delay, OFF delay and reset, retentive timer 2.4 Programming Counter: Addressing a counter block, status bits, UP and DOWN counter, UP-DOWN counter 2.5 Advanced PLC programming: PLC arithmetic/ Math instructions, PLC logical instructions, PLC comparison instructions and data handling instruction (Move, Masked Move, Copy, Clear), Analog I/O instructions (Scaling & signal processing) 2.6 Introduction to popular PLC programming software used in industries 2.7 PLC-PC interface, do's and don'ts in PLC	Lecture Using Chalk-Board Presentations Video Demonstrations

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.
		installation	
3	TLO 3.1 Explain basics of Ladder programming for a given Boolean expression. TLO 3.2 Develop Ladder program for simple applications. TLO 3.3 Prepare Ladder program for a given industrial application. TLO 3.4 Describe regular PLC maintenance practices. TLO 3.5 Enlist steps to troubleshoot PLC for a specific application.	**Unit - III PLC Applications and Troubleshooting** 3.1 PLC based simple applications: Ladder programming for latching and seal in circuits, Boolean expressions and logic gates, home automation etc. 3.2 PLC based industrial applications: Motor sequence control, traffic light control, conveyor system, bottle filling plant, car parking, stepper motor control, Elevator control, Electro-hydraulic and electro-pneumatic control, robotic control 3.3 Analog controls: Tank level control, temperature control, pressure control/flow control 3.4 Regular PLC maintenance practices 3.5 Standard steps for PLC troubleshooting	Lecture Using Chalk-Board Presentations Model Demonstration Video Demonstrations Site/Industry Visit
4	TLO 4.1 Explain various benefits and applications of SCADA. TLO 4.2 Enlist different SCADA software. TLO 4.3 Explain the architecture of SCADA with the help of sketch. TLO 4.4 Explain the major features of the given communication protocol used for SCADA. TLO 4.5 List the steps in Interfacing of PLC and SCADA system. TLO 4.6 Describe the need and architecture of OPC. TLO 4.7 State the steps in creating simple SCADA screen for a given application.	**Unit - IV SCADA Fundamentals** 4.1 Supervisory Control and Data Acquisition (SCADA): Introduction, need, benefits and typical applications 4.2 Introduction to popular SCADA software used in industries 4.3 SCADA architecture: Types of SCADA architecture, Master Terminal Unit (MTU), Remote Terminal Unit (RTU) 4.4 Network topologies, RS232, RS422, RS485 standards for data communication, communication protocols (Modbus, Field bus, Profibus, Industrial Ethernet) 4.5 Interfacing SCADA system with PLC: Typical connection diagram 4.6 Object linking and embedding for process control (OPC) - need, architecture 4.7 Developing SCADA screen for simple applications - conveyor system, car washing system, Traffic light system and Hydro-power plant	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom
5	TLO 5.1 Identify the steps in integrating given HMI panel with given PLC. TLO 5.2 AC drives preferred over DC drives in modern automation systems. Justify. TLO 5.3 Draw wiring diagram of VFD to PLC interfacing. TLO 5.4 Explain the architecture of DCS with the help of sketch. TLO 5.5 List various emerging trends in industrial automation.	**Unit - V Advanced Industrial Automation Systems** 5.1 Human-Machine Interface (HMI): Introduction to HMI, Types of HMIs (Touchscreen, Panel-based, PC-based, Steps for integrating PLC with HMI panel 5.2 AC/DC Drives: Fundamentals of Electrical Drives, Applications of VFDs in Mechatronics Systems 5.3 Distributed Control System (DCS): Architecture and Functioning of DCS, DCS-PLC Comparison and Applications, Role of DCS in Process Automation 5.4 Emerging trends in industrial automation: Introduction to Cloud PLC & SCADA, IIOT,	Lecture Using Chalk-Board Presentations Case Study Site/Industry Visit

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.
		Industry 4.0	

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 parts of PLC. LLO 1.2 Connect PLC to PC.	1	*Identification of various parts of PLC available in your laboratory	2	CO1
LLO 2.1 Develop ladder diagram to test the functionality of logic gates. LLO 2.2 Simulate the ladder diagram for logic gates.	2	*Development of ladder diagram for testing functionality of logic gates	2	CO2
LLO 3.1 Develop ladder diagram for seal in circuit. LLO 3.2 Simulate the ladder diagram for seal in circuit.	3	*Simulation of simple seal in circuit using PLC simulator	2	CO2
LLO 4.1 Develop ladder diagram for mathematical instructions. LLO 4.2 Simulate the ladder diagram for mathematical instructions.	4	*Simulation of mathematical instruction using ladder program	2	CO2
LLO 5.1 Develop ladder diagram to operate siren using timer. LLO 5.2 Execute the ladder program to demonstrate on hardware.	5	* Activation of siren using Timer in PLC	2	CO2
LLO 6.1 Develop ladder diagram for up counter. LLO 6.2 Execute the ladder program to demonstrate on hardware.	6	Simulation of up counter for certain number of counts to turn on lamp	2	CO2
LLO 7.1 Develop ladder diagram for up/down counter. LLO 7.2 Simulate the ladder diagram to make lamp ON/OFF.	7	*Development of ladder program for up/down counter to make lamp ON/OFF	2	CO2
LLO 8.1 Develop ladder diagram for pulse counting using limit switch / proximity sensor LLO 8.2 Simulate the ladder diagram for pulse counting using limit switch / proximity sensor	8	*Development of ladder diagram for pulse counting using limit switch / proximity sensor	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.1 Develop ladder diagram for latching circuit. LLO 9.2 Simulate ladder diagram for latching circuit.	9	*Simulation of latching circuit using ladder program	2	CO3
LLO 10.1 Develop ladder diagram for motor sequence control. LLO 10.2 Simulate the ladder diagram for motor sequence control.	10	*Simulation of motor sequence control using ladder diagram	2	CO3
LLO 11.1 Develop ladder diagram for traffic light control. LLO 11.2 Simulate the ladder diagram to demonstrate on hardware.	11	*Implementation of traffic light control using ladder diagram	2	CO3
LLO 12.1 Develop ladder diagram for automated elevator control. LLO 12.2 Simulate the ladder diagram for automated elevator control.	12	Implementation of automated elevator control using ladder diagram	2	CO3
LLO 13.1 Develop ladder diagram for tank level control. LLO 13.2 Simulate the ladder diagram to demonstrate on hardware.	13	*Implementation of tank level control using ladder diagram	2	CO3
LLO 14.1 Develop ladder diagram for conveyor system. LLO 14.2 Simulate the ladder diagram for conveyor system.	14	Implementation of conveyor system using ladder diagram	2	CO3
LLO 15.1 Develop ladder diagram for rotation of stepper motor. LLO 15.2 Simulate the ladder diagram to demonstrate on hardware.	15	*Development of ladder program for rotating stepper motor in forward direction and reverse direction at constant speed	2	CO3
LLO 16.1 Develop ladder diagram for rotation of DC motor. LLO 16.2 Simulate the ladder diagram to demonstrate on hardware.	16	Development of ladder program for ON/OFF control of DC motor in forward and reverse directions	2	CO3
LLO 17.1 Develop ladder diagram for temperature control using any temperature sensor. LLO 17.2 Simulate the ladder diagram to demonstrate on hardware.	17	Development of ladder program for temperature control using any temperature sensor with heater on off	2	CO3
LLO 18.1 Develop ladder diagram for car parking system. LLO 18.2 Simulate the ladder diagram for car parking system.	18	Implementation of car parking system using ladder diagram	2	CO3
LLO 19.1 Develop ladder diagram for bottle filling application. LLO 19.2 Simulate the ladder diagram to demonstrate on hardware.	19	Development of ladder program for bottle filling application	2	CO3
LLO 20.1 Develop ladder diagram for Electro Pneumatic/Hydraulic system. LLO 20.2 Simulate for Electro-	20	Implementation of Electro-Pneumatic/ Hydraulic system using ladder diagram	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
Pneumatic/Hydraulic system.				
LLO 21.1 Develop ladder diagram for object sorting system. LLO 21.2 Simulate the ladder diagram for object sorting system.	21	Development of ladder program for object sorting (Metallic & Nonmetallic) system	2	CO3
LLO 22.1 Study different SCADA software and system in the market. LLO 22.2 Select the suitable SCADA software for given application.	22	*Selecting the suitable SCADA software for given application	2	CO4
LLO 23.1 Use various functions of SCADA simulation editor. LLO 23.2 Write the steps to develop simple object.	23	*Development of SCADA mimic screen/ diagram for START/STOP logic system to turn ON/OFF light after pressing start-stop switch	2	CO4
LLO 24.1 Design alarm annunciation system in SCADA. LLO 24.2 Simulate using SCADA software.	24	Implementation of alarm annunciation using SCADA	2	CO4
LLO 25.1 Design liquid level controller system in SCADA. LLO 25.2 Simulate using SCADA software.	25	Implementation of liquid level controlling in Tank by using SCADA	2	CO4
LLO 26.1 Develop SCADA mimic screen for temperature control. LLO 26.2 Simulate using SCADA software and observe reporting & trending.	26	Development of SCADA mimic screen for temperature control using any temperature sensor and observe reporting & trending in SCADA System	2	CO4
LLO 27.1 Develop SCADA mimic screen for hydro-power plant. LLO 27.2 Simulate using SCADA software.	27	Development of SCADA mimic screen for hydro-power plant	2	CO4
LLO 28.1 Develop HMI screen with simple objects. LLO 28.2 Simulate using HMI software.	28	*Designing a simple HMI screen with labels, buttons, and indicators	2	CO5
LLO 29.1 Develop multiple HMI screen for different process sections.	29	Designing multiple HMI screens for different process sections	2	CO5
LLO 30.1 Identify various Industry 4.0 technologies such as IoT, AI, robotics, and cloud computing used in automation.	30	*Visit to any industry 4.0 compliant automation industry	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

- Automatic mixing system: Implement Automatic product mixing control system using PLC.
- Traffic light control: Prepare PLC based simple traffic light control system.
- Railway gate control using PLC.
- Washing machine control using PLC ladder programming.
- Automatic Street light controller: Prepare a SCADA based system to control the street lights as per the intensity of natural light.
- Home automation: Implement a versatile automation system for home that can automate any three home appliances using SCADA.
- Color sensing and sorting of objects: Develop a HMI screen for sorting of different products based on color.

Student activity

- Prepare a Report on general maintenance and troubleshooting methods of PLC.
- Make a report on market survey of different types of SCADA software.
- Prepare a report on "Industry Website Exploration: Automation Tools".
- Explore any virtual lab on PLC to perform an activity and prepare a report on it.

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	PLC trainer kit (with analog and digital I/Os) along with IEC 1131-3 compatible programming Software	1,2,3,9,4,5,6,7,10,12,11,13,14,15,16,17,18,19,8,20
2	Tank Water Level Kit	13,25
3	Conveyer belt (24 V DC operated) Kit	14,16,19,20
4	Trainer kit for bottle filling plant	14,19
5	Stepper Motor PLC Interfacing Kit	15
6	IEC Standard compatible latest version of SCADA software from any reputed manufacturer like - Ellipse/ Citect/ wonderware - intouch/Json/Wincc/ Cimplicity etc.	22,23,24,25,26,27
7	Min 7’ inch HMI Panel with standard software	28,29
8	Input and output devices for PLC: Lamps, Siren/ Buzzer, DC motors, Proximity sensors, Limit switches, Push buttons, RTD/Thermocouple, solenoid valve,	5,6,7,12,17,18,19,8,20,25,26

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
	hydraulic & pneumatic actuators	
9	Computer System: OS with windows 10 or higher, minimum of 8 GBRAM	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 PLC	CO1	10	4	4	4	12
2	II	PLC Programming	CO2	15	4	8	6	18
3	III	PLC Applications and Troubleshooting	CO3	14	2	4	10	16
4	IV	SCADA Fundamentals	CO4	13	4	6	6	16
5	V	Advanced Industrial Automation Systems	CO5	8	4	2	2	8
Grand Total				**60**	**18**	**24**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-Class Tests of 30 marks each and average of Two-Class Tests out of 30.
- For laboratory learning, maximum 25 marks and minimum 10 marks.

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks. End semester summative assessment is 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	2	-	2	-	-	2			
CO2	3	3	2	3	-	-	2			
CO3	3	2	2	3	2	2	3			
CO4	2	2	3	3	-	-	2			
CO5	2	2	2	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	Petruzella, F.D.	Programmable Logic Controller	Tata-McGraw Hill India, 2010 ISBN: 978-0071067386
2	Bolton, W.	Programmable Logic Controllers	Elsevier Newnes, 2007 ISBN: 978-0750681124
3	John Web, W.; Ronald A. Reis	Programmable Logic Controller	Pearson, 2008 ISBN: 978-0135048818
4	Boyar, S. A.	Supervisory Control and Data Acquisition	ISA Publication, 2009 ISBN: 978-1936007097
5	Manoj, K.S.	Industrial Automation with SCADA Concept, Communication and Security	Notion Press, 2019 ISBN: 978-1684668281

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=MS3qJq2jvu0	This NPTEL lecture discuss about basics of program logic controllers. Various programming techniques and terms used in PLC are discussed in detail.
2	https://instrumentationtools.com/free-allen-bradley-plc-ladder-logic-training-course/	Allen Bradley PLC Ladder Logic Training Course.
3	https://www.youtube.com/watch?v=E2WNPXJf-Kw	PLC Introduction. PLC Basics, Components of PLC, Modular PLC Modules, Input Output.
4	https://www.matrikonopc.com/opc-server/opc-data-access-versions.aspx?	OPC Data Access (OPC DA) Versions & Compatibility.
5	https://rapidscada.org/?	An open source SCADA software.
6	https://ial-coep.vlabs.ac.in/	Virtual Laboratory on automation.
7	https://www.youtube.com/watch?v=jXRksET5vNo	A foundational understanding of DCS, explaining its structure and functionality within industrial settings.
8	https://ied-nitk.vlabs.ac.in/List%20of%20experiments.html	Virtual Industrial Electric Drives Lab
9	https://www.youtube.com/watch?v=jNEDOdttBNo	Learn Industrial Automation- Free Tutorial PLC SCADA VFD HMI DCS PAC Industry4.0 M580 TIA Courses

Note :

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

MICRO-ELECTRO MECHANICAL SYSTEM **Course Code : 316353**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **MICRO-ELECTRO MECHANICAL SYSTEM**
Course Code : **316353**

I. RATIONALE

This course equips mechatronics diploma holders with essential MEMS knowledge and skills for industrial applications. Students will learn to identify materials, components, and packaging, alongside understanding the mechanical and electrical principles behind MEMS. The course also covers standard microfabrication processes and hands-on practice for making measurements of physical quantities using microsensors and microactuators.

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: Integrate Micro-Electro-Mechanical Systems (MEMS) technology into various processes and applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify the types of materials and components and packing processes.
- CO2 - Specify the mechanical and electrical properties and principles implied in the given MEMS.
- CO3 - Explain standard microfabrication processes.
- CO4 - Measure physical quantity using relevant microsensors and microactuators.
- CO5 - Prepare a report on the use of MEMS for a given industrial application.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											Total Marks
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316353	MICRO-ELECTRO MECHANICAL SYSTEM	MMS	DSC	3	-	4	1	8	4	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 Explain the importance and characteristics of MEMS in Mechatronics. TLO 1.2 List different types of elements used in MEMS. TLO 1.3 List different materials used in MEMS. TLO 1.4 List different properties of MEMS materials. TLO 1.5 Differentiate BIOMEMS, RFMEMS, and MOEMS. TLO 1.6 List the applications of MEMS.	**Unit - I Introduction to MEMS** 1.1 Introduction to MEMS: Overview and definition of MEMS, new trends of MEMS used in engineering and science, microscale systems, and intrinsic characteristics of MEMS. 1.2 Advantages & Disadvantages of MEMS. 1.3 Block diagram of MEMS: micro sensors and micro actuators, microelectronics fabrication process. 1.4 Materials for MEMS: silicon, polymers, ceramics, metals. 1.5 Packaging and integration: glass encapsulation, MEMS process integration strategies. 1.6 Definitions of BIOMEMS, RFMEMS, and MOEMS. 1.7 Applications of MEMS.	Lecture Using Chalk-Board Video Demonstrations Presentations
2	TLO 2.1 Explain various electrical concepts implied by MEMS. TLO 2.2 Explain various mechanical concepts implied by MEMS. TLO 2.3 Calculate resistivity of the semiconductor	**Unit - II Electrical & Mechanical properties and principles of MEMS.** 2.1 Electrical concepts of materials (silicon, polymers, ceramics, metals) related to MEMS: semiconductor materials. 2.2 Calculate charge carrier concentration, conductivity, and resistivity of the semiconductor (only simple numerical based on above). 2.3 Mechanical concepts of materials related to MEMS: Crystal planes and orientation, Internal force analysis, mechanical properties of silicon and related thin films. 2.4 Surface preparation, microhardness testing of materials/metals, microscopic study of materials for microstructure and hardness, Effect of surface finish on MEMS fabrication.	Lecture Using Chalk-Board Video Demonstrations Presentations
3	TLO 3.1 Define micromachining. TLO 3.2 Explain surface micromachining processes. TLO 3.3 Explain micromachining processes. TLO 3.4 Explain bulk	**Unit - III MEMS fabrication processes** 3.1 Micromachining – Definition, needs types. 3.2 Surface micromachining: Sacrificial layer processes – steps, MEMS accelerometer, humidity microsensor, micromotors advantages and disadvantages, examples. 3.3 Bulk micromachining: – Advantages and disadvantages, examples (micro nozzle).	Lecture Using Chalk-Board Video Demonstrations 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.
	micromachining. TLO 3.5 Explain etching processes. TLO 3.6 Explain thin film deposition methods.	3.4 Etching: dry etching, plasma etching, wet etching - principle and processes. 3.5 High Aspect-Ratio Processes: LIGA process, Deep Reactive Ion Etching (DRIE). 3.6 Thin film deposition: Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), evaporation, and sputtering.	
4	TLO 4.1 Explain the construction of different Micro-sensors. TLO 4.2 Explain the operation of different Micro-sensors. TLO 4.3 Explain the construction of different Micro-actuators. TLO 4.4 Explain the operation of different Micro-actuators.	**Unit - IV Micro sensors and Micro actuators.** 4.1 Electrostatic sensor, the principle of parallel plate capacitors and its applications. 4.2 Thermal sensor: Fundamentals of thermal transfer, thermal bimorph principle. 4.3 Piezoresistive sensor: Materials, piezo resistivity, Piezoelectric sensor: Materials and Piezoelectric effect. 4.4 Actuation using thermal forces, Actuation using shape memory alloys. 4.5 Actuation using piezoelectric crystals. 4.6 Electrostatic actuation. 4.7 Actuation using electrostatic forces (Comb drive actuators), micromotors and micropumps.	Lecture Using Chalk-Board Video Demonstrations Presentations
5	TLO 5.1 Collect the specification, data sheets, and block diagram of given MEMS applications.	**Unit - V Applications of MEMS.** 5.1 Applications of MEMS - (a) Automobile deployment - Airbag, navigation, tyre pressure, (b) Medical field – Microneedle, blood pressure sensor, micropump,(c) Manufacturing industries – Pressure, humidity, level, temperature, (d) Consumer products – Washing machines, printers.	Lecture Using Chalk-Board Video Demonstrations Presentations

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 the different MEME devices.	1	*Understand the different MEMS devices.	2	CO1
LLO 2.1 Microscopic study of specimen material	2	*Microscopic analysis of Specimen materials.	2	CO2
LLO 3.1 Check the resistivity of given materials. LLO 3.2 Suggest suitable materials for the given MEMS application.	3	*Measure the electrical resistivity of given MEMS materials.	2	CO2
LLO 4.1 Check the Ra value of given materials. LLO 4.2 Suggest suitable materials for the given MEMS application.	4	*Microscopic analysis for surface finish of different materials.	2	CO2

MICRO-ELECTRO MECHANICAL SYSTEM **Course Code : 316353**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Study of surface finish using a microscope.	5	*Microscopic analysis for surface finish of different materials.	2	CO2
LLO 6.1 Test the surface hardness of MEMS material before application.	6	*Microhardness testing of MEMS materials/metals before application.	2	CO2
LLO 7.1 Test the surface hardness of MEMS material after application	7	*Microhardness testing of MEMS materials/metals after application.	2	CO2
LLO 8.1 Select the microsensors for pressure measurement. LLO 8.2 Measure pressure using microsensors.	8	Pressure measurement using microsensors.	4	CO3
LLO 9.1 Select the microsensors for speed measurement. LLO 9.2 Measure speed using microsensors.	9	Speed measurement using microsensors.	4	CO3
LLO 10.1 Select the microsensors for temperature measurement. LLO 10.2 Measure temperature using microsensors.	10	*Temperature measurement using microsensors.	4	CO3
LLO 11.1 Select the microactuator for Mechanical motion measurement. LLO 11.2 Measure mechanical motion using a microactuator.	11	*Mechanical motion measurement. using microactuator – piezoelectric.	4	CO3
LLO 12.1 Select the microactuator for mechanical motion measurement. LLO 12.2 Measure mechanical motion using a microactuator.	12	Mechanical motion measurement. using microactuator – magnetic.	4	CO3
LLO 13.1 Select the microactuator for Mechanical motion measurement. LLO 13.2 Measure Mechanical motion using a microactuator.	13	Mechanical motion measurement. using microactuator – electrostatics.	4	CO3
LLO 14.1 Observe the operation of Surface micromachining. LLO 14.2 Interpret the fabrication process.	14	*Demonstration of surface micromachining. Part - I	2	CO4
LLO 15.1 Observe the operation of Surface micromachining. LLO 15.2 Interpret the fabrication process.	15	Demonstration of surface micromachining. Part - II	2	CO4
LLO 16.1 Observe the operation of bulk micromachining. LLO 16.2 Interpret the fabrication process.	16	Demonstration of bulk micromachining. Part - I	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 17.1 Observe the operation of bulk micromachining. LLO 17.2 Interpret the fabrication process.	17	Demonstration of bulk micromachining. Part - II	2	CO4
LLO 18.1 Search information on the use of MEMS in automobile industries by market survey. LLO 18.2 Prepare a report on the same	18	*Case study on the use of MEMS in Automobile industries. (Specifications, data sheets, block diagram, etc.)- Airbag, navigation, tyre pressure (Any one).	4	CO5
LLO 19.1 Search information on the use of MEMS in the medical field by market survey. LLO 19.2 Prepare a report on the same.	19	*Case study on the use of MEMS in the Medical field. (Specifications, data sheets, block diagram, etc.) Medical field – Microneedle, blood pressure sensor, micropump (Any one).	4	CO5
LLO 20.1 Search information on the use of MEMS in manufacturing industries by market survey. LLO 20.2 Prepare a report on the same.	20	Case study on the use of MEMS in Manufacturing industries. (Specifications, data sheets, block diagram, etc.) - Pressure, humidity, level, temperature (Any one).	4	CO5
LLO 21.1 Search information on the use of MEMS in consumer products by market survey. LLO 21.2 Prepare a report on the same.	21	Case study on the use of MEMS in Consumer products. (Specifications, data sheets, block diagram, etc.)- Washing machines, printers (Any one).	4	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

- Any other relevant assignment given by subject teacher.
- Prepare a detailed report on MEMS application.
- Numerical on the resistivity and conductivity of MEMS materials.
- Collect the information of various microactuators and microsensors used in industries
- Compare the parameters of different semiconductors used in MEMS.
- Collect information about materials used for MEMS with specifications and compare them.

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	Various microsensors and microactuators.	1,8,9,10,11,12,13
2	Experimental setup of temperature measurement using related microsensors.	10
3	Experimental setup of a piezoelectric microactuator for mechanical motion measurement.	11
4	Experimental setup of a magnetic microactuator for mechanical motion measurement.	12
5	Experimental setup of an electrostatic microactuator for mechanical motion measurement.	13
6	Experimental setup of surface roughness tester for surface evaluation.	2,4,5,6,7
7	Experimental setup to measure the resistivity of the given materials.	3
8	Experimental setup of surface hardness testing using microhardness tester.	5
9	Microscope for microstructure analysis.	6
10	Experimental setup of pressure measurement using related microsensors.	8
11	Experimental setup of speed measurement using related microsensors.	9

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 MEMS	CO1	6	2	4	4	10
2	II	Electrical & Mechanical properties and principles of MEMS.	CO2	10	2	6	6	14
3	III	MEMS fabrication processes	CO3	12	4	6	8	18
4	IV	Micro sensors and Micro actuators.	CO4	12	4	6	8	18
5	V	Applications of MEMS.	CO5	5	2	2	6	10
Grand Total				**45**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Formative assessment (Assessment for Learning)
- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks
- For Self-Learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory 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	1	2	1	2			
CO2	3	1	2	2	2	2	3			
CO3	3	2	2	2	2	2	1			
CO4	3	3	3	3	2	2	2			
CO5	3	3	2	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	Dilip kumar Bhattacharya , Brajesh Kumar Kaushik	Microelectromechanical Systems	CENGAGE Publication, New Delhi,2014, ISBN-10. 9788131525883
2	Tai Ran Hsu	MEMS & Micro systems Design and Manufacture	TMH, New Delhi, 2002, ISBN-10. 007048709X
3	Chang Liu	Foundation of MEMS	Pearson education Inc., 2006 ISBN-10. 0132497360
4	Stephen D Senturia	Microsystem design	Springer Publication, 2000. ISBN-10. 0792372468
5	Hans H. Gatzen, Volker Saile, JurgLeuthold	Micro and Nano Fabrication: Tools and Processes	Springer Publication, 2015. ISBN-13. 978-3662508268
6	Marc J. Madou	Fundamentals of Microfabrication and Nanotechnology	3rd Edition, 2011, CRC Press. ISBN 9780849331800
7	M.D. Singh, J.G. Joshi	Mechatronics	Prentice Learning Pvt. Limited New Delhi, 2006. ISBN 9788120329867

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=O5qTDrZIPeI	Fundamentals of MEMS
2	https://www.youtube.com/watch?v=GaGQrP0D6Zw	Materials for MEMS
3	https://www.youtube.com/watch?v=m8kXG5ZERYI	Applications of MEMS
4	https://www.youtube.com/watch?v=jQF4_hO_2qw	Types of MEMS, MEMS process integrations

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Sr.No	Link / Portal	Description
5	https://www.youtube.com/watch?v=1qDfxPW02Pw	Calculation of charge carrier concentration
6	https://www.youtube.com/watch?v=STs55uv389Y	Flexural beam bending
7	https://www.youtube.com/watch?v=lHXZkamSMWw	Surface micromachining, Bulk micromachining
8	https://www.youtube.com/watch?v=9UOiSxFB6aA	Electrostatics sensors
9	https://www.youtube.com/watch?v=_iMHP-gaABk	Piezo electric actuators
10	https://www.mdpi.com/2072-666X/13/5/654	Different case studies in MEMS

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	Good	Fair	Poor
	The project is completed as per tasks described in synopsis.	**The project is completed but require minor modifications.**	**The project is completed but require several modifications.**	**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	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**

Presentation	**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)

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6.	Chapter-6 Results and Applications	
7.	REFERENCES	

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		

COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE **Course Code : 316354**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE**
Course Code : **316354**

I. RATIONALE

This course equips diploma engineers with the essential knowledge and skills for modern inspection and quality assurance integrating computer aided technologies. It covers foundational methodology, advance measurements with CMM's ,machine vision for automated inspection, Quality management principles including auditing, six sigma, and statistical tools for process control

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 computer aided inspection and quality control techniques for assuring quality of products and services.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Select relevant measuring instrument for given situation.
- CO2 - Measure common features using coordinate measuring machine.
- CO3 - Identify various elements of machine vision system in context of inspection.
- CO4 - Prepare a plan for quality audit considering the quality standard for a given simple process
- CO5 - Apply various SQC tools to ensure Quality assurance for a given data

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	
316354	COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE	IQA	DSE	4	-	2	2	8	4	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 working principle of Linear measuring instruments. TLO 1.2 Explain the use of gauges for given job with justification. TLO 1.3 State the advantages and disadvantages of Computer Aided Inspection (CAI) TLO 1.4 Explain method of laser-based inspection . TLO 1.5 Compare traditional inspection with laser-based inspection.	**Unit - I Introduction to Metrology and Computer aided inspection** 1.1 Definition of Metrology, objective and types of metrologies, need of inspection, methods of measurements. 1.2 Linear measuring Instruments: Working principle of Vernier caliper, micrometer, height gauge and depth gauge. 1.3 Gauges: Limit gauges. Taylor's principle of Gauge design, Plug gauges , Ring Gauges, Snap gauges. 1.4 Computer-Aided Inspection (CAI):Introduction, need, advantages and disadvantages. Comparison between Traditional Inspection and Computer-Aided Inspection (CAI). 1.5 Laser Metrology in Computer-Aided Inspection (CAI):Introduction, need, method of laser based inspection, advantages and disadvantages . 1.6 Applications of Laser Metrology in Industries, Aerospace & Automotive: High-accuracy component inspection	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit
2	TLO 2.1 Explain the principle of working of CMM. TLO 2.2 List the components of CMM. TLO 2.3 Explain the types of CMM. TLO 2.4 List the specifications of CMM. TLO 2.5 Explain procedure for Measurement by CMM.	**Unit - II Co-ordinate measuring machine** 2.1 Introduction to Coordinate Measurement Machine (CMM). 2.2 Contact type CMM – Configurations, parts and its features, types of probes, probe compensation and specifications. 2.3 Non-Contact type CMM –Features, probes, specifications. 2.4 Merits and demerits of CMM. 2.5 Applications of CMM for dimensional and form measurements.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study Flipped Classroom
3	TLO 3.1 Select the alignment test for the given machine tool with justification. TLO 3.2 Explain the procedure of flatness testing for the given job.	**Unit - III Introduction to Machine Vision Metrology** 3.1 Machine tool metrology: parallelism, flatness, straightness, squareness, roundness, run out alignment tests of Lathe and machine tools (as per IS standard.) using gauges and measuring devices .	Lecture Using Chalk-Board Presentations Model Demonstration Video

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.
	TLO 3.3 Explain the procedure for measuring complex dimensions of the given job using machine vision . TLO 3.4 Explain the role of AI in machine vision inspection. TLO 3.5 List the components of automated inspection system	3.2 Introduction to Machine Vision Metrology: Machine vision system – Methods for sensing objects. 3.3 Applications of machine vison in metrology. 3.4 AI-Based machine vision techniques. 3.5 Automated Inspection Systems: Computers power automated inspection systems, including machine vision and optical inspection.	Demonstrations Site/Industry Visit Hands-on
4	TLO 4.1 Identify quality characteristics for given product TLO 4.2 Explain the parameters of quality economics TLO 4.3 Explain the general procedure to perform the quality audit for the given problem. TLO 4.4 Explain six sigma methodology and tools for quality imporvement TLO 4.5 describe ISO 14000 for environment management system TLO 4.6 describe ISO9001 as a part of QMS TLO 4.7 Explain quality assurance approach for given example	**Unit - IV Quality Control & Quality Assurance** 4.1 Concept and Meaning of Quality Control and Objectives of qualify control. Quality characteristics. 4.2 Quality of design, Quality of conformance and Quality of Performance, 4.3 Quality Economics: Cost of quality, Value of quality, Economics of quality confirmation, Cost of quality appraisal, prevention, external and internal failure cost. 4.4 Quality Audit: functions, Scope of quality audit practices. Difference between inspection & quality control. Role of Quality Inspector and Auditor. Internal and External Quality Audits, 4.5 Six sigma: Methodology, Statistical meaning, six sigma approaches, Introduction to ISO 9001-2008, ISO 14000 and TS 16949 and its implementation. 4.6 Quality Management Systems (QMS): ISO 9001:2015 and Implementing a QMS in an Organization, Documentation and Standard Operating Procedures (SOPs). QMS software ,document management, audit tracking, and non-conformance report. 4.7 Quality Assurance: Definition , Importance, procedure, techniques , Differences Between QC and QA. 4.8 Role of Quality Inspector and Auditor Internal and External Quality Audits, Compliance and Regulatory Requirements	Lecture Using Chalk-Board Presentations Case Study Video Demonstrations Case Study Site/Industry Visit
5	TLO 5.1 Calculate mean, mode and median for the given sample(s) including the frequency histogram, frequency polygon. TLO 5.2 Draw normal distribution curve after calculating the standard deviation (Sigma), variance, range to determine the process capability. TLO 5.3 Draw the control charts	**Unit - V Statistical Quality Control** 5.1 Basics of Statistical concepts, Meaning and importance of SQC. 5.2 Variable and attribute Measurement. Control charts - inherent and assignable sources of variation. Control charts for variables - x bar and R charts, control charts for attributes p, np, C charts. Statistical Process Control (SPC): SPC software to create control charts. 5.3 Process capability of machine (±3sigma or ±6sigma), Cp and Cpk calculations. 5.4 Different types of sampling plans, - sampling	Lecture Using Chalk-Board Presentations Site/Industry Visit Case Study Video Demonstrations Model Demonstration

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.
	(X and R-bar, P-chart and C-chart) for measured data of the given samples. TLO 5.4 Prepare Single/Double sampling plan for the given Lot size (N), Sample size(n), acceptance number(c)	methods. 5.5 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve. Merits and demerits of acceptance sampling.	

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 Use Vernier caliper, vernier height gauge, micrometer (use both mechanical and digital) to measure dimensions of a given components.	1	*Measurement of Length and Height by using Vernier Calipers and Vernier Height Gauge of a given components.	2	CO1
LLO 2.1 Measure and verify the dimensions and tolerances of workpieces during quality control processes using gauges	2	Inspection using Dial Indicator /Dial Bore Gauge/Snap Gauge for a given component.	2	CO1
LLO 3.1 Use slip gauges combination to set the adjustable snap gauge Go end and No-Go end for a given dimension.	3	*Arrange the adjustable snap gauge Go end and No-Go end for a given dimension.	2	CO1
LLO 4.1 Analyse the application of laser metrology for quality control and dimensional inspection based on given use case	4	*Perform quality control and dimensional inspection by using laser inspection based on given use case	2	CO1
LLO 5.1 Measure the flatness of given flat object using CMM LLO 5.2 Measure the circularity of given cylindrical object using CMM	5	*Measurement of form using CMM	2	CO2
LLO 6.1 Select the type of probe for CMM	6	*List the types of probes for given situtaion	2	CO2
LLO 7.1 Select the appropriate probe and stylus for measurement LLO 7.2 Set up part fixturing to maintain the product orientation LLO 7.3 Align the product coordinate system with the CMM's coordinate system. LLO 7.4 Measure the dimensions using CMM	7	Measurement of product dimension using Coordinate Measuring Machine (CMM) as per standard procedure	2	CO2
LLO 8.1 Identify components of low-cost vision-based automation solutions in the following areas: Inspection (Object recognition and Pose Estimation) Detection (Presence Verification, Counting).	8	*Components identification of low-cost vision-based automation solutions	2	CO3
LLO 9.1 Set up camera ,lens, lighting ,mounting and fixture	9	*Inspect the given componenet using machine vision system .	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.2 Capture image of the given components LLO 9.3 Apply image processing techniques to enhance the image quality. LLO 9.4 Extract features that are essential for measurement of required dimension				
LLO 10.1 Draw relevant control chart by observing the variations in a lot of 20 cylindrical jobs with some nominal outside diameter.	10	Preparation of a relevant control chart by observing the variations in a lot of 20 cylindrical jobs with some nominal outside diameter.	2	CO5
LLO 11.1 Choose a simple process - (e,g ,ordering food online, barrowing a library book) LLO 11.2 Create a flow chart or a process map of the steps involved LLO 11.3 Identify potential points of failure or non compliance that an auditor would examine. LLO 11.4 Prepare a quality audit checklist .	11	*Mapping a process for quality audit,.	2	CO4 CO5
LLO 12.1 Calculate mean, mode and median for the given data. LLO 12.2 Draw frequency histogram, frequency polygon for the given data.	12	Calculation of mean, mode and median using frequency histogram, frequency polygon for the given sample.	2	CO5
LLO 13.1 Draw normal distribution curve for given data LLO 13.2 Calculate standard deviation (Sigma), variance, range for given data LLO 13.3 Determine the process capability for given data	13	Determintion of process capability for ±3Sigma or ±6Sigma .	2	CO5
LLO 14.1 Draw and interpret X bar chart for the given data LLO 14.2 Draw and interpret R chart for the given data	14	*Inspection of given variable data using Control chart	2	CO5
LLO 15.1 Draw P- chart for given data. LLO 15.2 Draw C - chart for given data.	15	*Inspection of given attribute data using control chart chart	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

- Prepare a report to interpret effect of errors on the accuracy of instrument and measurement.
- Visit to any nearby shop or industry and list out different gauges used for inspection along with its purpose.
- Visit to any tool room and prepare a report consisting,
  (i)Different advanced measuring instruments.
  (ii)Different measuring standards and calibration process.
  (iii)Care and maintenance of measuring instruments observed.

- Prepare/Download a specification of followings.
  (i)Measuring tools and equipment in metrology laboratory.
  (ii)Machineries in metrology laboratory.

Micro project

- Prepare a report on Quality Management Systems (QMS) for your institute.
- Comparative study of various linear measuring instruments like steel rule, Inside-outside micrometer, Vernier caliper and Digital caliper with proper justification.
- Comparative study of surface finish of various samples machined by various machining / finishing processes using surface roughness tester.
- Prepare a report on calibration procedure of Vernier Caliper and Micrometer followed by NABL Lab.
- Prepare a visit report on measurement systems used in nearby industries / SME / Workshops / Fabrication shops.

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	Digital/manual Vernier Caliper Range 0-150 mm, L.C. 0.02mm	1
2	Vernier Height Gauge and Depth Gauge (mechanical and digital) 0-300 mm	1
3	Tool Maker’s microscope: Dimensions 152 x 152mm, Stage glass size 96 x 96mm, Feeding range 50 x 50 mm, Maximum height 115 mm x 107 mm, Workpiece 5Kg, Light source: 24V, 2W (special bulb), Continuously adjustable light intensity, green filter.	1
4	Display Wall chart showing X bar Chart and R Chart.	11,12,13,14,15
5	Display Wall chart showing “C Chart”	12,13
6	Spirit Level: Base length: 200 mm + 1 mm, Base width: 20 mm + 0 - 1, Height : 25 + 1 mm, Bubble opening : 50 mm x 8 mm (length x width).	4
7	Gauges - plug (3piece) Grade A/X.	5

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 Metrology and Computer aided inspection	CO1	10	2	4	6	12

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Co-ordinate measuring machine	CO2	10	2	4	4	10
3	III	Introduction to Machine Vision Metrology	CO3	10	2	4	6	12
4	IV	Quality Control & Quality Assurance	CO4	15	4	6	8	18
5	V	Statistical Quality Control	CO5	15	4	6	8	18
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and the average of two-unit tests. For laboratory learning 25 Marks For Self-Learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory 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	-	-	3			
CO2	-	-	-	3	-	-	3			
CO3	-	-	-	3	-	-	3			
CO4	-	-	-	3	-	-	3			
CO5	-	-	-	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	Dr. Parthasarathi, Dr. P. Sreenivas	Metrology, Measurements and Computer Aided Inspection	Scientific International Publishing House ISBN: 9789361320309
2	R.K. Rajput	A Textbook of Measurements & Metrology	S.K. Kataria & Sons ISBN 978-93-5014-230-1
3	K Duraivelu and S Karthikeyan	Engineering Metrology and Measurement	Universities Press ISBN 9789386235527

Sr.No	Author	Title	Publisher with ISBN Number
4	Kulkarni V. A.. Bewoor A. K.	Quality Control	Wiley India Pvt. Ltd, New Delhi, 2012. ISBN: 978-81-265-1907-1
5	Ankita Dadwal	Quality Assurance	PharmaMed Press ISBN-10 : 9395039701
6	Mahajan M	Statistical Quality Control	Dhanpat Rai & Co. ISBN-13 : 978-8177000399
7	M.M.M. SARCAR, K. LALIT NARAYAN,	Computer Aided Design and Manufacturing	PHI Learning, ISBN - 9788120333420
8	Sheila Anand	Guide for Machine Vision in Quality Control	Chapman and Hall, ISBN -978-0815349273

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://elearn.nptel.ac.in/shop/nptel/engineering-metrology/ ?v=c86ee0d9d7ed	Engineering Metrology
2	https://youtu.be/4O6mfoJWJGc?si=AZaSdaunYusJr7on	Learning about CMM and Metrology
3	https://youtu.be/BPQI1xMXC04? si=hq33GQJUtlvywUbD	Basics of CMM (Coordinate Measuring Machine)
4	https://youtu.be/6eGwbxHOa-A?si=oF-upNkZ3K0QfWq4	Visual Inspection for Defect Detection
5	https://youtu.be/uqEXP14i3QQ?si=qprSEsfNniQLhXAw	Smart Factory - Vision based quality inspection
6	https://youtu.be/60Sk-mq3Cr8?si=wZvKfYzD9lkY8O7Z	Improve Production Quality with Visual Inspection AI
7	https://youtu.be/9fqygvj-O2s?si=nhcV7NKn4Mn4nYmc	Computer Aided Quality Control

Note :

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

MECHATRONICS IN HEALTH SERVICES **Course Code : 316355**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **MECHATRONICS IN HEALTH SERVICES**
Course Code : **316355**

I. RATIONALE

Today the healthcare industry increasingly relies on sophisticated mechatronic systems for diagnosis, treatment, monitoring, and rehabilitation. This course is designed to equip diploma students in mechatronics with specialized knowledge and skills to work with medical equipment and devices that incorporate mechatronic principles. The increasing adoption of automation, robotics, and smart systems in healthcare has created a demand for technicians who understand both the technical aspects of mechatronic systems and the specific requirements of the healthcare environment, including safety standards, sterilization protocols and patient considerations.

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: Carry out repair and maintenance of medical equipment.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Use concept of AI, ML and IoT in health care service equipment and devices.
- CO2 - Rectify the faults in given primary health care device/s using troubleshooting chart.
- CO3 - Troubleshoot the given medical imaging machine.
- CO4 - Check the performance of infusion pump and MEMS drug delivery system.
- CO5 - Prepare a plan for use of robot/s in given medical situation.

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	
316355	MECHATRONICS IN HEALTH SERVICES	MHS	DSE	4	-	2	2	8	4	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 Explain the various healthcare systems with its core functions, advantages and disadvantages. TLO 1.2 Interpret various healthcare facilities available in India: its funding, administration and delivery. TLO 1.3 Analyze given case on use of AI and ML in health services. TLO 1.4 Design a simple IoT application for a selected health service.	**Unit - I Introduction to health services** 1.1 Need of health services, Types of healthcare systems: primary, secondary, tertiary and quaternary. 1.2 Categories of healthcare facilities available in India: public and private sectors. 1.3 Role of technology in health services: Artificial Intelligence (AI), Machine Learning (ML) and Internet of Things (IoT).	Lecture Using Chalk-Board Presentations Video Demonstrations
2	TLO 2.1 Illustrate Primary healthcare equipment. TLO 2.2 Explain Heart rate monitoring system. TLO 2.3 Calculate Body mass index. TLO 2.4 Explain functions of pulse oximeter and glucometer. TLO 2.5 Describe function of Blood pressure monitoring system and digital thermometer. TLO 2.6 Interpret troubleshooting chart for identification of fault in give equipment/device.	**Unit - II Primary healthcare equipment** 2.1 Primary healthcare equipment, Heart rate monitoring system: functional block diagram, working principle, advantages and applications. 2.2 Body mass index (BMI) measurement system and pulse oximeter: functional block diagram, working principle, advantages and applications. 2.3 Blood pressure monitoring system, glucometer and digital thermometer: functional block diagram, working principle, advantages and applications.	Lecture Using Chalk-Board Presentations Video Demonstrations
3	TLO 3.1 Describe the physical properties of X-rays. TLO 3.2 Identify and describe the components of the given medical imaging machine (X-ray, CT scan and MRI machines). TLO 3.3 Explain the working principle of medical imaging machine (X-ray, CT scan and MRI machines). TLO 3.4 Describe the steps of installation of X-ray, CT scan and MRI machines. TLO 3.5 Describe with sketches the function of CT scan and MRI machine. TLO 3.6 Interpret troubleshooting chart	**Unit - III Medical Imaging Machines** 3.1 Block diagram of X-ray machine, control circuit for high voltage (KV), current (mA), exposure timer circuit. 3.2 Concept of mobile X-ray technology and dental X-ray machine, risk involved in X-ray machine 3.3 Basic principle of CT scan, block diagram of CT scan machine, parts of CT scan machine, clinical application 3.4 Magnetic resonance imaging(MRI): Principle, block diagram, types of magnets, biological effects of MRI imaging, function and applications of MRI system 3.5 Installation, maintenance and	Lecture Using Chalk-Board Presentations Model Demonstration Video Demonstrations Flipped Classroom Site/Industry Visit

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.
	for identification of fault in give medical imaging machine (X-ray, CT scan and MRI machines).	troubleshooting of X-ray machine, CT scan machine and MRI machine	
4	TLO 4.1 Identify the components of the Drug delivery systems. TLO 4.2 Explain the function of infusion pump. TLO 4.3 Describe with sketches the function of Closed-Loop Control in Infusion System. TLO 4.4 Describe the function of given MEMS Drug delivery device. TLO 4.5 Examine the MEMS device for any visible defect, cracks, consistency and repeatability of actuator motion, and packaging.	**Unit - IV Automated drug delivery systems** 4.1 Major components: Transducers, logic unit and activating mechanisms. 4.2 Syringe pump: Working principle, function, applications. 4.3 Infusion pump: Implantable infusion system, closed-loop control in infusion systems. 4.4 Insulin pumps: Working principle, function, applications. 4.5 MEMS Drug delivery devices: A Miniaturized Wireless Micropump Enabled by Confined Acoustic Streaming	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit
5	TLO 5.1 Describe role of robotics in health science TLO 5.2 Identify Rehabilitation robotics. TLO 5.3 Describe the working of robots used in hospital automation TLO 5.4 Explain concept of AI and robotics in diagnostic	**Unit - V Robotic in health science** 5.1 Role of robotics in health science: Advancements, applications, and future directions 5.2 Rehabilitation robotics- assistive robotics, therapeutic applications 5.3 Hospital automation: Disinfection robot (UV light robot), Pharmacy robot (Automate medication dispensing), Logistic robot (Transport supplies, lab samples). 5.4 AI and robotics in diagnostic: Robot-Assisted imaging Lab automation	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study

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 Enlist health care equipment. LLO 1.2 Give applications of observed health care equipment.	1	* Identification of various Health care equipment available in laboratory	2	CO1
LLO 2.1 Prepare the report on use of AI, ML in health services	2	AI and ML in health service	2	CO1
LLO 3.1 Develop a simple IoT/IoMT application for use in health services	3	*Internet of Things in health services	2	CO1
LLO 4.1 Identify the components of pulse oximeter. LLO 4.2 Compare the result obtained from two different pulse oximeter	4	* Performance of pulse oximeter	2	CO2
LLO 5.1 Identify the components of stadiometer	5	Performance of stadiometer	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.2 Check the performance of stadiometer by taking measurement of weight and height LLO 5.3 Suggest measures for accurate performance				
LLO 6.1 Identify the components of sphygmomanometer LLO 6.2 Check the performance of sphygmomanometer by taking measurement of blood pressure. LLO 6.3 Suggest measures for accurate performance	6	Performance of sphygmomanometer	2	CO2
LLO 7.1 Identify the components of glucometer LLO 7.2 Check the performance of glucometer by taking measurement of sugar level in blood. LLO 7.3 Suggest measures for accurate performance	7	* Performance of glucometer	2	CO2
LLO 8.1 Identify the components of digital thermometer LLO 8.2 Check the performance of digital thermometer by taking temperature reading. LLO 8.3 Suggest measures for accurate performance	8	Performance of digital thermometer	2	CO2
LLO 9.1 Identify the X-ray machine components. LLO 9.2 Carryout routine maintenance as per the operational manual.	9	*Routine maintenance of X-ray machine	2	CO3
LLO 10.1 Identify the faults using troubleshooting chart. LLO 10.2 Suggest measures to rectify the faults	10	X-ray machine - Fault finding and remedial measures	2	CO3
LLO 11.1 Identify the components of CT Scanner machine. LLO 11.2 Carryout routine maintenance as per the operational manual.	11	Routine maintenance of CT Scanner machine	2	CO3
LLO 12.1 Identify the faults using troubleshooting chart. LLO 12.2 Suggest measures to rectify the faults	12	* CT Scanner machine - Fault finding and remedial measures	2	CO3
LLO 13.1 Identify the MRI machine components. LLO 13.2 Carryout routine maintenance as per the operational manual.	13	Routine maintenance of MRI machine	2	CO3
LLO 14.1 Identify the faults using troubleshooting chart. LLO 14.2 Suggest measures to rectify the	14	MRI machine - Fault finding and remedial measures	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
faults				
LLO 15.1 Identify the components of infusion pump LLO 15.2 Carryout routine maintenance as per the operational manual.	15	* Routine maintenance of infusion pump	2	CO4
LLO 16.1 Identify type of robot used in selected situation. LLO 16.2 Develop program for identified situation. LLO 16.3 Execute the program. LLO 16.4 Prepare an action plan for use of robot in selected situation.	16	*Plan for use of robot for any one of given situations 1. Hospital automation 2.Robotics in diagnostic 3. Robotics in surgery	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

- Prepare and present a seminar on importance of health service equipment.
- Prepare a report on a visit to diagnosis center on the basis specifications and type of ECG / CT / MRI machine
- Prepare charts and present a seminar on body mass index variation on four-month duration with a group of four students. (take fifteen days interval)
- Prepare a report on health service center according to national standards.
- Collect the catalogue of modern equipment used in health services
- * Prepare a report on application, integration and limitations of MEMS accelerometers in wearable drug delivery devices for motion monitoring and adaptive drug release. (This Microproject is compulsory and students may choose any one from the above list).

Assignment

- Make power point presentation including videos on heart rate measurement
- Identify the faults in X-ray machine
- Collect information of different standards with specification related to medical imaging equipment.
- Carry out comparative study of conventional health care services and modern health care services
- Collect information of robotic in used in health science

Visit

- Arrange a visit to the general hospital either private or government
- Arrange a visit to the nearby diagnostic center.

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	CT scanner: gantry aperture size (typically 70cm or more), slice acquisition capabilities (ranging from 16 to 640 slices), X-ray tube power (70kW or more), and image processing software	11,12
2	MRI machine: magnet strength (measured in Tesla, with common strengths being 1.5T and 3T), gradient strength and slew rate, radiofrequency system capabilities, and image processing and storage capacity.	13,14
3	Infusion pump: Minimum guaranteed flow rate range of 1-1500 mL/hr in either 0.1 or 1 mL/hr increments.	15
4	Robot offline simulation software	16
5	Computer with internet connectivity: (Minimum Core i5 Processor, 8GB RAM, 500GB HDD)	2,3,16
6	Pulse oximeter: Pulse rate: Range 30-254bpm - Accuracy: ±2% at 30-254bpm	4
7	Stadiometer: 20 - 205 cm, 1 mm / 1/8 inch, 337 x 2165 x 590 mm, 13,3 x 85,2 x 23,2 inch, 2,4 kg, 5,3 lbs	5
8	Sphygmomanometer: Gauge graduated 0 - 300mmHg (min) in 2 (max) mmHg increments, with pressure release valve. Accuracy as per ISO 81060-1: +/- 3mm Hg.	6
9	Glucometer : Hand held meter with LCD display mg/dl Reported result range : 20 - 600 mg/dL	7
10	Digital thermometer: Temperature measurement range 32 – 43 °C (minimum guaranteed)	8
11	X-ray machine: a high-frequency X-ray generator, a power output of 80kW or more, an exposure range of 40-150kV, and a minimum exposure time of 1ms or less.	9,10

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

MECHATRONICS IN HEALTH SERVICES **Course Code : 316355**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to health services	CO1	10	4	4	4	12
2	II	Primary healthcare equipment	CO2	12	4	8	4	16
3	III	Medical Imaging Machines	CO3	16	4	6	8	18
4	IV	Automated drug delivery systems	CO4	10	2	6	4	12
5	V	Robotic in health science	CO5	12	2	6	4	12
Grand Total				**60**	**16**	**30**	**24**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-Class Tests of 30 marks and average of Two-Class Tests out of 30.
- For laboratory learning Maximum 25 Marks and Minimum 10 Marks.
- Self-Learning (Assignment) Question and Answers in class room, Micro Project, Visit report

Summative Assessment (Assessment of Learning)

- End Semester Assessment of 70 marks for theory learning.
- End Semester External Assessment of Maximum 25 Marks and Minimum 10 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	2	1	1	2	-	2	2			
CO2	3	3	-	2	-	2	2			
CO3	2	3	-	2	-	2	2			
CO4	2	1	1	2	-	2	2			
CO5	2	2	1	2	-	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	Khandpur, R. S.	Hand book of biomedical instrumentation	McGraw Hill Education (India) Private Limited, New Delhi,2014 ISBN: 978-9339205430

Sr.No	Author	Title	Publisher with ISBN Number
2	Cromwel, Leslie; Weibell, Fred J; Pfeiffer, Erich A.	Biomedical instrumentation and measurements	Prentice Hall of India Private Limited, New Delhi, 1995, ISBN: 978-8120306530
3	Anandanatarajan, R.	Biomedical instrumentation and measurements	PHI Learning Private Limited, New Delhi, 2015, ISBN: 978-8120352155
4	Azar, Ahmad Taher	Control Systems Design of Bio-Robotics and Bio-Mechatronics with Advanced Applications	Academic Press Inc, 2019, ISBN: 978-0128174630
5	-	Medical Equipment Maintenance Manual	Ministry of Health and Family Welfare, New Delhi October 2010 (http://www.frankshospitalworkshop.com/organisation/biomed_documents/Medical%20Equipment%20Maintenance%20Manual%20-%20Ministry%20of%20Health%20and%20Family%20Welfare,%20New%20Delhi.pdf)

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=230k3sPKYqo	Medical Equipment- Made in India | Umesh Sonar & Ravindra Mahajan Interview | Swayam Talks
2	https://learning.edx.org/course/course-v1:DelftX+SGS1x+1T2025/home	Biomedical Equipment: Repairing and Maintaining Biomedical Devices. EDX course
3	https://youtu.be/QX7Q0a8GxaA?si=WpT8dpxwORLPIi3i	Primary health care throughout our life
4	https://youtu.be/t_eWESXTnic?si=kojUc9hTAnNShOnW	Public Health
5	https://www.foreseemed.com/artificial-intelligence-in-healthcare	Role of AI and ML in health service
6	https://ordr.net/article/iot-healthcare-examples	Role of IoT/IoMT in health service
7	https://www.medicalsearch.com.au/buying-guide/maintenance-and-calibration-of-ecg-machines/f/24930	ECG maintenance and calibration
8	https://www.ncbi.nlm.nih.gov/books/NBK9622/	Blood pressure measurement using sphygmomanometer
9	https://nest360.org/wp-content/uploads/2021/08/Clinical-Job-Aid-Glucometer_Xpress2.pdf	Maintenance of glucometer
10	https://www.youtube.com/watch?v=F7hdNVA2yqU	Production of X Rays animated
11	https://www.medicalsearch.com.au/buying-guide/maintenance-an	Maintenance and Care of X-Ray Machines

Sr.No	Link / Portal	Description
	d-care-of-x-ray-machines/f/25057	
12	https://info.atlantisworldwide.com/blog/top-5-ct-scanner-iss ues-how-to-resolve-them	CT Scanner Issues & How to Resolve Them
13	https://www.youtube.com/watch? v=wMSryzRvC8Y	Computed Tomography | CT Scanners | Biomedical Engineer
14	https://www.blockimaging.com/blog/bid/80499/top-four-mri-sca nner-service-problems-and-solutions	MRI Scanner Service Problems and Solutions
15	https://www.youtube.com/watch? v=nFkBhUYynUw	How does an MRI machine work?
16	https://pmc.ncbi.nlm.nih.gov/articles/ PMC10713785/	medical devices for sustained drug delivery
17	https://spj.science.org/doi/10.34133/research.0314	Miniaturized Wireless Micropump Enabled by Confined Acoustic Streaming
18	https://jai.front-sci.com/index.php/jai/article/ view/1008/82 0	role of robotics in medical science
19	https://nhm.gov.in/New_Updates_2018/ NHM_Components/Health_Sy stem_Stregthening/ Comprehensive_primary_health_care/letter/B MMP_Technical%20Manual.pdf	Biomedical equipment management and maintenance program

Note :

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

SMART MANUFACTURING SYSTEMS **Course Code : 316356**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **SMART MANUFACTURING SYSTEMS**
Course Code : **316356**

I. RATIONALE

This course provides students with the fundamental knowledge and practical skills required to work in modern manufacturing environments that leverage Industry 4.0 technologies such as IoT, AI, Robotics, CAM, CNC, PLC, and Cloud Computing. Course bridges the gap between conventional manufacturing and future-ready digital industries, preparing students for careers in automated production systems, industrial robotics, and smart factories.

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: Plan smart manufacturing systems for various industrial/ field applications using relevant knowledge & skills.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Compare features of traditional manufacturing, smart manufacturing and Industry 4.0.
- CO2 - Apply digital technologies in manufacturing.
- CO3 - Use smart manufacturing control and monitoring systems.
- CO4 - Apply Automation and Robotics in Smart Manufacturing.
- CO5 - Plan smart manufacturing applications in given industry.

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	
316356	SMART MANUFACTURING SYSTEMS	SMS	DSE	4	-	2	2	8	4	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 Explain Traditional Manufacturing system. TLO 1.2 Explain the need of smart manufacturing system. TLO 1.3 State basic principles of smart manufacturing. TLO 1.4 Explain evolution of smart manufacturing systems. TLO 1.5 List Key technologies of Smart manufacturing. TLO 1.6 Compare features of traditional manufacturing and smart manufacturing system.	**Unit - I Introduction to Smart Manufacturing** 1.1 Traditional manufacturing system. Definition, advantages & applications. 1.2 Need of smart manufacturing system. 1.3 Smart Manufacturing-Definition, basic principles, objectives, types & benefits . 1.4 Evolution of smart manufacturing systems. 1.5 Key components and overview of technologies used in Smart Manufacturing (IIoT, AIML, Big data analytics, Automation & Robotics etc.)	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom
2	TLO 2.1 Explain the need of Industry 4.0. TLO 2.2 Explain Various Technologies of Industry 4.0. TLO 2.3 Draw factory layout with IoT. TLO 2.4 Plan for incorporating industry 4.0 for given manufacturing application. TLO 2.5 Identify the challenges of IoT in Manufacturing. TLO 2.6 Explain need of cloud computing in manufacturing. TLO 2.7 State concept of Digital Twin Technology.	**Unit - II Fundamentals of Industry 4.0** 2.1 Industry 4.0- History, Need & importance. 2.2 Introduction to Technologies of Industry 4.0- IoT, AI, cloud computing, big data, robotics, additive manufacturing. 2.3 Basics of IoT- Concept, Connecting devices and machines, layout. 2.4 Industrial Applications-Real-time monitoring, predictive maintenance, optimized supply chains, and enhanced product tracking. 2.5 Benefits & challenges of IoT in Manufacturing. 2.6 Cloud Computing in Manufacturing- Storing and accessing data in the cloud. Cloud-based manufacturing applications. 2.7 Digital Twin Technology- Concept, benefits & applications.	Video Demonstrations Presentations Site/Industry Visit Lecture Using Chalk-Board
3	TLO 3.1 Describe the process of computer aided manufacturing control. TLO 3.2 Explain step by step process of computer aided quality control (CAQC), PLC & SCADA.	**Unit - III Digital Manufacturing Technologies** 3.1 Computer aided manufacturing Control (CAMC): Generate computer program in machining. Interfacing part program to CNC. 3.2 Computerized monitoring & control-Computer aided quality control (CAQC), Programmable logic control (PLC), & SCADA.	Video Demonstrations Presentations Site/Industry Visit Lecture Using Chalk-Board Flipped

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.
	TLO 3.3 Describe applications of AIML in smart Manufacturing. TLO 3.4 List Cybersecurity measures.	3.3 Artificial Intelligence & Machine Learning (AIML)- Concept, data collection, storage & processing. Predictive analysis & machine learning. Applications of AI in manufacturing. 3.4 Cybersecurity-Measures & best practices, cybersecurity for industrial control systems.	Classroom
4	TLO 4.1 Explain given types of automation. TLO 4.2 Suggest the strategies for automation in given situation. TLO 4.3 Explain role of PLM & SCM in smart Manufacturing. TLO 4.4 List applications of robotics in manufacturing. TLO 4.5 State the function of various types of Cobots.	**Unit - IV Factory automation & Robotics in smart manufacturing** 4.1 Automation in Manufacturing Types of automation: Fixed, programmable, and flexible. 4.2 Strategies in automation-Online inspection, online monitoring, automated guided vehicles (AGVs) and conveyor systems. Process control & optimization, control of plant operations & CIM (Computer Integrated Manufacturing). 4.3 Computer Integrated Manufacturing (CIM)-Role of Product Life Cycle Management, Role of Supply Chain Management (SCM) In Smart Manufacturing. 4.4 Robotics in Manufacturing- Material Handling, Processing operations, Automated assemblies & inspections. 4.5 Collaborative Robot (Cobot)-Definition, types-Power & force limiting, safety monitored stop, speed & separation & hand guiding, industrial robot & Cobot.	Video Demonstrations Presentations Site/Industry Visit Case Study Demonstration
5	TLO 5.1 List different areas of applications of Smart manufacturing. TLO 5.2 Explain Sustainability and environmental considerations in Smart Manufacturing. TLO 5.3 List the Challenges in Smart Manufacturing.	**Unit - V Smart Manufacturing-Implementation & Challenges** 5.1 Implementation- Factories and Assembly Line, Food Industry, Medical, Power Plants, Inventory Management & Quality. 5.2 Data Acquisition and Analysis. Sustainability and environmental considerations in Smart Manufacturing. 5.3 Challenges in smart manufacturing.	Video Demonstrations Case Study Site/Industry Visit Lecture Using Chalk-Board

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 Study various manufacturing processes. LLO 1.2 Prepare a manufacturing process report considering traditional manufacturing system.	1	*Report generation of traditional manufacturing systems (Considering any product assembly).	2	CO1
LLO 2.1 Study different network topologies for system communication. LLO 2.2 Built up communication between machines and cloud storage.	2	Communication network between hardware and Cloud storage.	2	CO1 CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Interpret different methods of data analysis. LLO 3.2 Observe remote factory data Using cloud platforms.	3	Visualization of remote factory data Using cloud platforms.	2	CO1 CO2
LLO 4.1 Draw simple 3D model for path simulation. LLO 4.2 Generate and simulate tool paths using CAM software.	4	*Tool path generation and simulation of simple parts.	2	CO1 CO3
LLO 5.1 Study different machining parameters. LLO 5.2 Perform toolpath simulation and analyze machining parameters.	5	*Tool path simulation & analysis of machining parameters.	2	CO1 CO3
LLO 6.1 Develop CNC part programs for turning operations. LLO 6.2 Operate CNC machine for turning operation.	6	*CNC part program for turning operation.	2	CO1 CO3
LLO 7.1 Develop CNC part programs for milling operations. LLO 7.2 Operate CNC machine for milling operation.	7	CNC part program for milling operation.	2	CO3
LLO 8.1 Study different SCADA software and systems in the market. LLO 8.2 Select Suitable SCADA Software for given application.	8	SCADA software for factory operations.	2	CO3
LLO 9.1 Collect machine data for fault prediction. LLO 9.2 Analyze machine data for fault prediction.	9	Machine data collection for fault prediction.	2	CO3
LLO 10.1 Study different types of sensors & actuators used in manufacturing systems. LLO 10.2 Interface proximity sensors and actuators for real-time control with PLC.	10	*Proximity sensors and actuators interface with PLC.	2	CO3
LLO 11.1 Measure part tolerances using Coordinate Measuring Machine (CMM). LLO 11.2 Operate CMM machine for measurement of part tolerance.	11	* CMM for measuring different variables.	2	CO3
LLO 12.1 Study different CIM software for product development. LLO 12.2 Use PLM (Product life cycle Management) software for CIM related to any simple product.	12	PLM software for simple product Manufacturing.	2	CO4
LLO 13.1 Study different CIM software for product development. LLO 13.2 Use Supply Chain Management (SCM) software for CIM related to any simple product.	13	*SCM software for simple product Manufacturing.	2	CO4
LLO 14.1 Study of collaborative robot. LLO 14.2 Analyze different operating	14	Observe actual/Video of collaborative robot.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
parameters of Cobot.				
LLO 15.1 Study industrial robot anatomy. LLO 15.2 Use robots for different Manufacturing processes.	15	*Robots for automated assemblies and inspections.	2	CO4
LLO 16.1 Study of smart manufacturing systems in Industry. LLO 16.2 Analyze different operations in smart manufacturing system.	16	Observe actual/Video of smart manufacturing systems.	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

- Collect information about traditional manufacturing systems & smart manufacturing systems.
- “Smart manufacturing systems are highly efficient than traditional manufacturing systems” Justify.
- Collect an information about cybersecurity for industrial control systems.
- Carry out comprehensive study of technologies used in Smart Manufacturing (IIoT, AIML, Big data analytics, Automation & Robotics etc.)
- Collect information about online inspection, online monitoring, automated guided vehicles (AGVs) and conveyor systems.
- Prepare a report on applications of smart manufacturing systems in various sectors.
- Make power point presentation including videos on AIML, IoT, Cloud computing, Digital twin technology.

Micro project

- Prepare a chart showing basic principles, objectives, types & benefits of Smart Manufacturing.
- Prepare and present a seminar on technologies of Industry 4.0.
- Examine & prepare a report on inspection of parts using CAQC software by CMM/other system.
- Prepare charts on digital twin technology & cloud computing in smart manufacturing.
- Prepare charts on technologies used in Smart Manufacturing systems.
- Prepare a model showing components of smart manufacturing systems.

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	PLC (Min 8 input/output)	10
2	ERP, PLM & SCM software (1+10 user)	12,13
3	Industrial Robot with standalone servo controller as well as compatible PLC interface with following features: 1) Minimum 3 linkages 2) Minimum 6 degree of freedom (6 DoF) 3) Various sensors 4) Compatible Robot vision system for inspection.	14,15
4	Robot offline simulation software-Any suitable freeware	15
5	Computers with internet connectivity (Minimum i7 Core Processor, 8GB RAM, 500GB HDD)	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 Smart Manufacturing	CO1	10	4	4	4	12
2	II	Fundamentals of Industry 4.0	CO2	12	2	8	6	16
3	III	Digital Manufacturing Technologies	CO3	14	2	8	6	16
4	IV	Factory automation & Robotics in smart manufacturing	CO4	14	2	6	8	16
5	V	Smart Manufacturing-Implementation & Challenges	CO5	10	2	4	4	10
Grand Total				**60**	**12**	**30**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks
- For Self Learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester 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	2	-	-	1	2	-	3			
CO2	3	2	2	3	2	2	3			
CO3	2	2	2	3	2	2	3			
CO4	2	2	2	3	2	2	3			
CO5	3	2	2	3	3	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	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress (1 January 2019) ISBN:978-1484249703
2	Dr Shirish Gandhare	Basics and Introduction to Industry 4.0	Notion Press ,ISBN: 9798896730323
3	M. Niranjanamurthy , Sheng-Lung Peng , E. Naresh .	Advances in Industry 4.0: Concepts and Applications (Smart Computing Applications, 5)	De Gruyter ,ISBN:978-3110725360.
4	Domanic T Matt , Vladimir Modrak	Implementing Industry 4.0 in SMEs	Springer Nature Switzerland AG, ISBN: 9783030705183
5	Dr. Shruti Vashist, Dr. Sujata Nayak, Mr. Piyush Mahendru and Dr. Prashant Bhardwaj	Industry 4.0: New age of Robotics, Automation and Communication Engineering	AkiNik Publications, ISBN:978-93-5570-343-9
6	M. Groover	CAD/CAM: Computer-Aided Design and Manufacturing	Pearson Education ,ISBN: 978-8174906700

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=7iWriXyI2cE&t=6s	Introduction to IoT
2	https://www.youtube.com/watch?v=gWu2Jxfae74&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=5	IoT networking
3	https://www.youtube.com/watch?v=KqSqyKwVuA8&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=17	Cyber security
4	https://www.youtube.com/watch?v=eKiepu2D-XQ&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=8	Sustainability in Manufacturing
5	https://www.youtube.com/watch?v=JC3cQ2MB_34	Data Handling
6	https://www.youtube.com/watch?v=zLMgdYI82IE&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=14	Virtual & augmented reality

SMART MANUFACTURING SYSTEMS **Course Code : 316356**

Sr.No	Link / Portal	Description
7	https://www.youtube.com/watch?v=CN1gn4J_Plk	Study of Cobots
8	https://www.youtube.com/watch?v=De8MQWbhu3k&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=11	Smart factories
9	https://www.youtube.com/watch?v=C_dYxnTDlPE&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=50	Applications of smart manufacturing in factories assembly line
10	https://www.youtube.com/watch?v=XLY4M0mm05A&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=51	Applications of smart manufacturing in food industries
11	https://www.youtube.com/watch?v=I59n_ScFIp4&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=54	Applications of smart manufacturing in inventory management
12	https://www.youtube.com/watch?v=Tvj4Hmrzj7w&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=65	Applications of smart manufacturing in Virtual reality lab

Note :

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