Maharashtra State Board Of Technical Education, Mumbai

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

Programme Name	**: Diploma In Automation and Robotics**		
Programme Code	**: AO**	**With Effect From Academic Year**	**: 2023-24**
Duration Of Programme	**: 6 Semester**	**Duration**	**: 16 WEEKS**
Semester	**: Third** **NCrF Entry Level : 3.5**	**Scheme**	**: K**

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme											
						Actual Contact Hrs./Week			Self Learning (Activity/ Assignment /Micro Project)	Notional Learning Hrs /Week		Paper Duration (hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
																	Practical						
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
(All Compulsory)																							
1	DIGITAL TECHNIQUES	DTE	DSC	313303	-	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175
2	CONTROL SYSTEM & COMPONENTS	CSC	DSC	313329	-	4	-	2	-	6	3	3	30	70	100	40	25	10	25@	10	-	-	150
3	MEASUREMENTS & AUTOMATION BASICS	MAB	DSC	313330	-	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175
4	SENSOR TECHNOLOGY	STC	DSC	313331	2	4	-	2	2	8	4	3	30	70	100	40	25	10	-	-	25	10	150
5	ESSENCE OF INDIAN CONSTITUTION	EIC	VEC	313002	-	1	-	-	1	2	1	-	-	-	-	-	-	-	-	-	50	20	50
6	BASIC PYTHON PROGRAMMING	BPP	AEC	313011	-	2	-	2	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50
7	3D MODELLING & SIMULATION	SIM	SEC	313014	-	-	-	4	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50
Total					**2**	**18**	**0**	**16**	**6**		**20**		**120**	**280**	**400**		**150**		**125**		**125**		**800**

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) : 4, Discipline Specific Elective (DSE) : 0, Value Education Course (VEC) : 1, Intern./Apprenti./Project./Community (INP) : 0, AbilityEnhancement Course (AEC) : 1, Skill Enhancement Course (SEC) : 1, GenericElective (GE) : 0

Programme Name/s	**: Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Computer Technology/ Computer Engineering/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electronics & Tele-communication Engg./ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Instrumentation & Control/ Industrial Electronics/ Instrumentation/ Medical Electronics/ Electronics & Computer Engg.**
Programme Code	**: AI/ AN/ AO/ CM/ CO/ CW/ DE/ DS/ EJ/ ET/ EX/ HA/ IC/ IE/ IS/ MU/ TE**
Semester	**: Third**
Course Title	**: DIGITAL TECHNIQUES**
Course Code	**: 313303**

I. RATIONALE

Digitization implies use of digital circuits in most of automation and industrial systems. The knowledge of logic gates, combinational and sequential circuits using discrete gates and digital ICs will enable students to interpret working of digital equipment and test their functionality.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:
Student will able to test the functionality of the digital circuits/system.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Apply number system and codes concept to interprete working of digital systems.
- CO2 - Apply Boolean laws to minimize complex Boolean function.
- CO3 - Develop combinational logic circuits for given applications.
- CO4 - Develop sequential logic circuits using Flip-flops.
- CO5 - Interpret the functions of data converters and memories in digital electronic systems.

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	
313303	DIGITAL TECHNIQUES	DTE	DSC	3	-	2	1	6	3	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
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3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Convert the given number from one number system to another number system. TLO 1.2 Perform arithmetic operations on binary numbers. TLO 1.3 Subtract given binary numbers using 1's and 2's compliment method. TLO 1.4 Convert the given coded number into the other specified code. TLO 1.5 Write the application of the given code. TLO 1.6 Perform BCD addition and subtraction for the given Decimal numbers .	**Unit - I Number Systems** 1.1 Number Systems: Types of Number Systems (Binary, Octal, Decimal, Hexadecimal), conversion of number systems 1.2 Binary Arithemetic: Addition, Subtraction, Multiplication and Division 1.3 Subtraction using 1's and 2's complement method 1.4 Codes: BCD, Gray code, Excess-3 and ASCII code,Code conversions, Applications of codes. 1.5 BCD Arithemetic: BCD Addition, Subtraction using 9's and 10's complement	Lecture Using Chalk-Board

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Define the given characteristics parameters of the digital logic families. TLO 2.2 Draw symbol and truth table of given logic gates. TLO 2.3 Explain the concept of Buffer and Tristate logic . TLO 2.4 Implement basic gates and other gates with the help of universal gate. TLO 2.5 Simplify the given expression using Boolean laws and develop logic circuits .	**Unit - II Logic Gates and Boolean Algebra** 2.1 Logic Families: Characteristics Parameters of logic Families- Noise margin, Power dissipation, Figure of merit ,Fan in, Fan out, Speed of operation, maximum clock frequency supply voltage requirement ,power per gate , Comparison of TTL, CMOS and ECL logic family 2.2 Introduction to positive and negative logic systems, Logic Gates: Symbol ,Truth table of Basic logic gates(AND,OR,NOT),Universal gates(NAND,NOR) and Special purpose gates(EX-OR,EX-NOR) 2.3 Buffer: Tristate logic, Unidirectional and Bidirectional 2.4 Boolean algebra : Laws of Boolean algebra, Duality Theorem ,De-Morgan's theorem	Flipped Classroom Lecture Using Chalk-Board
3	TLO 3.1 Develop logic circuits for standard SOP/POS form of the given logic expression. TLO 3.2 Minimize the given logic expression using K-map (up to 4 variables). TLO 3.3 Design Adder and subtractor using K-map. TLO 3.4 Describe working of specified Encoder and Decoder with help of block diagram and truth table. TLO 3.5 Describe the working of Multiplexer and Demultiplexer.	**Unit - III Combinational Logic Circuits** 3.1 Standard Boolean expression: Sum of products [SOP] and Products of Sum [POS], Min-term and Max-term, SOP-POS form conversion, realisation using NAND/NOR gates 3.2 Boolean Expression reduction using K-map: Minimization of Boolean expressions (upto 4 variables) using SOP and POS form 3.3 Arithemetic circuits : design Half and Full Adder using K-maps, design Half and Full Subtractor using K-maps , n bit adder and n bit subtractor . 3.4 Encoder and Decoder: Functions of Encoder and Decoder, Block Diagram and Truth table, Priority Encoder (4:2, 8:3), BCD to 7 segment Decoder/Driver, Keyboard Encoder / decoder 3.5 Multiplexer and Demultiplexer: Working, Truth table and applications of MUX and DEMUX. MUX tree, DEMUX tree, DEMUX as Decoder	Flipped Classroom Presentations Lecture Using Chalk-Board

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Differentiate between Latch and Flip Flop. TLO 4.2 Explain basic memory cell and use relevant triggering technique for the given digital circuit. TLO 4.3 Describe the truth tables for the given Flip flops, applications of Flip flops. TLO 4.4 Use the given type of flip flop and its excitation table to design specific type of counter. TLO 4.5 Describe the working of specified shift register with the help of timing diagram. TLO 4.6 Design specified modulo-N counter using Flip flops . TLO 4.7 Design Ring /Twisted ring counter using given Flip-Flop.	**Unit - IV Sequential Logic Circuits** 4.1 Difference between Combinational and Sequential Logic circuits, Time independent (un-clocked)and Time dependent (Clocked) logic system , Flips- Flops and Latch, Basic memory cell ,RS-Latch using NAND and NOR, Triggering methods- Edge trigger and Level Trigger 4.2 Flip-Flops: S-R, J-K, T and D, Truth table and logic circuits of each flip-flop, Excitation table, applications 4.3 Race around condition in JK flip-flop, Master- Slave JK Flip Flop 4.4 Shift registers- Serial In Serial Out, Serial In Parallel Out, Parallel In Serial Out ,Parallel In Parallel Out,Bi-directional Shift register, 4-bit Universal Shift register 4.5 Counters- Synchronous and Asynchronous counters, Modulus of counter, Ripple counter, Ring Counter, Twisted Ring Counter, Up – down counter, Decade Counter, MOD-N counter, Timing Diagram	Video Demonstrations Lecture Using Chalk-Board Simulation
5	TLO 5.1 Describe the working of the given type of DAC. TLO 5.2 Calculate the output voltage for the given digital input for specified DAC. TLO 5.3 Describe the working of the given type of ADC. TLO 5.4 Compare working of ROM,EPROM, EEPROM and Flash Memory .	**Unit - V Data Converters and Memories** 5.1 Digital to Analog Data Converter (DAC)- circuit diagram and working of Weighted resistor DAC and R-2R Ladder DAC, DAC Specification/Selection factors 5.2 Analog to Digital Data Converter (ADC) : Block Diagram, Types and Working of Dual Slope ADC, Successive Approximation, Flash Type ADC, ADC selection factors/ specifications 5.3 Memories: Types- Primary memory , Secondary Memory, Organization, Dimension, Memory Bank, Features , Applications: RAM (SRAM, DRAM), Volatile and Non-Volatile, ROM (PROM, EPROM, EEPROM), Flash Memory, Comparison of RAM and ROM,EPROM and Flash Memory, SIMM: Features, SSD memory: Features,	Video Demonstrations 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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Test the functionality of basic gates. LLO 1.2 Test the functionality of special purpose gates.	1	* Test the functionality of AND, OR, NOT, Ex-OR and EX-NOR logic Gates using equivalent 74 series or CMOS Devices [CD] series.	2	CO1 CO2
LLO 2.1 Test the functionality of NAND and NOR gate using breadboard.	2	* Test the functionality of the given Universal Gates using equivalent 74 series /CD series.	2	CO2
LLO 3.1 Test the functionality of the constructed Basic gates using universal gates.	3	* Construct Basic Gates using Universal Gates.	2	CO2
LLO 4.1 Construct Ex-OR, EX-NOR gates using universal gates.	4	Construct Exclusive Gates using Universal Gates.	2	CO2
LLO 5.1 Build the logic circuit on breadboard to verify the De - Morgan's theorems.	5	* Verify De-Morgan's Theorem (1 and 2).	2	CO2
LLO 6.1 Verify the truth table of Half and Full adder circuits for the given input.	6	* Implement 2 input, 3 input Adder Circuit.	2	CO3
LLO 7.1 Verify the truth table of Half and Full subtractor using Boolean expressions.	7	Implement 2 input, 3 input Subtractor Circuit.	2	CO3
LLO 8.1 Construct and test BCD to 7 segment decoder using Digital IC.	8	Test the output of BCD to 7 Segment Decoder using Digital IC for the given inputs.	2	CO3
LLO 9.1 Build/Test 2 or 4 bit Magnitude comparator using Digital IC.	9	Check the output of comparator circuit consisting of Digital IC.	2	CO3
LLO 10.1 Build / test function of MUX Digital IC.	10	* Build and test the functionality of 4:1/8:1 Multiplexer.	2	CO3
LLO 11.1 Build / test function of DEMUX Digital IC.	11	Build and test the functionality of 1:4/1:8 De-Multiplexer.	2	CO3
LLO 12.1 Test functionality of RS flip flop using NAND Gate .	12	Implement and verify the truth table of RS Flip flop.	2	CO4
LLO 13.1 Test functionality of Master Slave (MS) JK flip-flop using Digital IC.	13	Implement and test the functionality of master slave- JK Flip Flop using Digital IC.	2	CO4
LLO 14.1 Test functionality and truth table for D and T Flip flop.	14	Use Digital IC to construct and test the functionality of D and T flip flop.	2	CO4
LLO 15.1 Interpret timing diagram of 4 bit Universal Shift Register.	15	Build 4- bit Universal Shift register and observe the timing diagram.	2	CO4
LLO 16.1 Interpret timing diagram of 4-bit ripple counter using Digital IC.	16	Implement Ripple Counter using Digital IC.	2	CO4
LLO 17.1 Interpret timing diagram of Decade counter (Mod-10).	17	* Implement Decade Counter Using Digital IC.	2	CO4
LLO 18.1 Build R-2R resistive network on breadboard to convert given digital data into analog.	18	* Test the output of given R-2R type Digital to Analog Converter for the given input.	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

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

- Implement 1:8 DEMUX using 1:4 /1:2 DE-MUX.
- Build a circuit to implement 4 Bit adder.
- Build a 4bit parity generator and parity tester.
- Implement 16:1 MUX using 8:1/4:1 MUX.
- Build a circuit to test 7 bit segment display.
- Build a LED display bar.
- Develop a project on Burglar alarm.
- Light Detector circuit using NAND gate.

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.
- 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 Storage Oscilloscope 25MHz/60MHz/70MHz/100MHz Dual Channel, 4 Trace CRT / TFT based X10 magnification 20 nS max sweep rate, Alternate triggering Component tester and with optional features such as Digital Read out, USB interface. Any other Oscilloscope with additional features is also suitable with magnifying probe at least two probes, if possible isolated probe	15,16,17
2	Trainer kit for 4 bit Counter using Flip Flops 4 bit ripple counter synchronous counter IC 7476 based circuit, Input given by switches and output indicated on LED, Facility to select MOD 8 or MOD 16 mode, Built in DC power supply and manual pulser with indicator	16,17
3	Trainer kit IC DAC IC 0800 Trainer based on IC 0800, 8 bit digital input selected by switches and provision for measurement of analog output. Facility to study effect of change in reference voltage, Built in buffer amplifier, Built in DC power supply	18

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
4	Digital multimeter 3.5 digit with R , V, I measurements, diode and BJT testing	All
5	Digital IC Tester Tests a wide range of Analog and Digital ICs such as 74 series /CD series	All
6	Bread Board Development System Bread Board system with DC power output 5V,+/-12V and 0-5V variable , digital voltmeter ,ammeter , LED indicators 8 no , logic input switches 8 no, 7 segment display 2 no, clockgenerator	All
7	Trainer kits for digital ICs Trainer kit should consists of digital ICs for logic gates, flop flop, shift registers, counter alongwith toggle switches for inputs and bi-colourLED at outputs, built in power supply	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	Number Systems	CO1	5	2	4	2	8
2	II	Logic Gates and Boolean Algebra	CO2	8	2	4	6	12
3	III	Combinational Logic Circuits	CO3	12	4	6	8	18
4	IV	Sequential Logic Circuits	CO4	12	4	6	8	18
5	V	Data Converters and Memories	CO5	8	4	6	4	14
Grand Total				**45**	**16**	**26**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

Summative Assessment (Assessment of Learning)

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

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	1	-	-	-	3			
CO2	2	-	2	-	-	-	2			
CO3	3	2	3	2	-	1	2			
CO4	3	2	3	2	-	1	2			
CO5	2	-	2	2	1	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	Jain R.P	Modern Digital Electronics	McGraw-Hill Publishing, New Delhi,2009 ISBN:9780070669116
2	Anand Kumar	Fundamentals of Digital Circuits	PHI learning Private limited, ISBN:978-81-203-5268-1
3	Salivahanan S, Arivazhagan S.	Digital Circuits and Design	Vikas Publishing House, New Delhi,2013 ISBN: 9789325960411
4	Puri.V.K	Digital Electronics	McGraw-Hill Publishing, New Delhi,2016 ISBN:97800746331751
5	Malvino A.P Donald .P. Leach	Digital Principles	McGraw-Hill Education, New Delhi ISBN:9789339203405
6	Anil.K.Maini	Digital Electronics: Principles, Devices and Applications	Wiley India, Delhi, 2007, ISBN:9780470032145
7	Floyd, Thomas	Digital Fundamentals	Pearson Education India, Delhi 2014,ISBN:9780132737968
8	G.K.Kharate	Digital Electronics	Publisher: Oxford University Press, ISBN: 9780198061830

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://studytronics.weebly.com/digital-electronics.html	Basics of Digital Electronics
2	https://www.udemy.com/course/basics-of-digital-techniques/	Introduction To Digital Number System & Logic Gates
3	https://www.geeksforgeeks.org/synchronous-sequential-circuits-in-digital-logic/	Boolean Algebra and Logic Gates, Combinational and Sequential Logic Circuits
4	https://onlinecourses.nptel.ac.in/noc19_ee51/preview	Digital Circuits
5	https://de-iitr.vlabs.ac.in/	Virtual Labs for Digital Systems

Sr.No	Link / Portal	Description
6	https://www.tutorialspoint.com/digital_circuits/digital_circuits_sequential_circuits.htm	Sequential Circuits

Note :

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

Programme Name/s : **Automation and Robotics/ Instrumentation & Control/ Instrumentation**
Programme Code : **AO/ IC/ IS**
Semester : **Third**
Course Title : **CONTROL SYSTEM & COMPONENTS**
Course Code : **313329**

I. RATIONALE

The modern industries are moving towards automation and this course will facilitate the diploma students to acquire knowledge and skill sets to apply the principles of control system to initiate different control actions starting from simple home refrigeration systems to large industrial control systems

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:
Use different types of controllers ensuring the stability of the given control system

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Apply fundamentals of control systems to derive the Transfer Function
- CO2 - Interpret the time response and stability of a given control system
- CO3 - Use relevant controller for controlling a given process system
- CO4 - Use relevant control system component for position control
- CO5 - Choose appropriate actuators for a given application

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313329	CONTROL SYSTEM & COMPONENTS	CSC	DSC	4	-	2	-	6	3	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
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4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
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7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify the given type(s) of control system TLO 1.2 Justify the effect of feedback on control system TLO 1.3 Determine the Transfer Function of the given electrical circuits TLO 1.4 Represent simple physical systems in terms of block diagrams having various inputs and outputs and determine their transfer function TLO 1.5 Determine the poles and zeros of the given Transfer Function	**Unit - I Fundamentals of control systems** 1.1 Control system: definition, Open loop and closed loop, linear and non linear, time variant and time invariant 1.2 Feedbacks and its types: Degenerative and regenerative, effect of feedback on stability 1.3 Transfer function: definition, order of a control system (0, 1, 2), transfer function of simple R-C, L-C and R-L-C circuits 1.4 Block diagram: need and significance, represent sample physical systems in terms of block diagram having various inputs and outputs, reduction rules, simple numerical 1.5 Poles and zeros of a transfer function: pole-zero plot in S-plane	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Collaborative learning Cooperative Learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Represent the given standard test input mathematically and graphically TLO 2.2 Determine the transient and steady state response of the given control system for unit step input TLO 2.3 Determine different time response specifications of a second order system for unit step input TLO 2.4 Determine steady state error for a given control system TLO 2.5 Determine the stability of the given control system using Routh's stability criteria	**Unit - II Time response analysis and Stability** 2.1 Standard test inputs (Step, Ramp, Parabolic and Impulse)-: Laplace transform and graphical representation 2.2 Time domain analysis: Transient and steady state response 2.3 Order of a control system: First order, Standard Transfer Function, Output response analysis for unit step input, Time constant 2.4 Second order control system: Standard Transfer Function, Output response analysis for unit step input, effect of damping (No derivation), Time response specifications- rise time, delay time, peak time, settling time, maximum peak overshoot (no derivation) 2.5 Steady state analysis: Type 0, type 1, type 2 systems, Steady state error and error constants (No derivation) 2.6 Stability: Concept of stability, root location in S-plane, analysis- stable, unstable, critically stable, conditionally stable 2.7 Routh's stability criterion: characteristic equation, method, stable and unstable systems, Range of K for the system to be stable, numerical	Lecture Using Chalk-Board Demonstration Presentations Flipped Classroom Collaborative learning Cooperative Learning
3	TLO 3.1 Describe the function of each block of a given process control system with the help of block diagram TLO 3.2 Explain with sketches the discontinuous control actions used for controlling the given process control system TLO 3.3 Differentiate between the basic continuous control actions in the given process control system TLO 3.4 Select suitable composite continuous control action for controlling the given process control system.	**Unit - III Process Control** 3.1 Process control system: Block diagram, function of each block 3.2 Discontinuous control actions - ON-OFF controller: Operation, definition of differential gap 3.3 Continuous control actions-Proportional, Integral and Derivative: operation, output equations, corresponding transfer function, Response graph 3.4 Composite controllers - PI, PD, PID controllers : operation, output equations, Response graph, comparison, application and selection criteria	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Collaborative learning Cooperative Learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the function of each component of a servo system TLO 4.2 Explain different components of the given DC servo system TLO 4.3 Explain different components of the given AC servo system TLO 4.4 Use stepper motor in a given position control servo system	**Unit - IV Position Control** 4.1 Servo system: concept, generalized block diagram 4.2 DC servo system: functional diagram, potentiometer as error detector, DC servo motor - characteristic, difference from a normal DC motor 4.3 AC servo system: functional diagram, synchro as error detector, AC servo motor-characteristic, difference from a normal 2 phase induction motor 4.4 Stepper motor: Working and applications of Permanent Magnet and variable reluctance stepper motor	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Collaborative learning Cooperative Learning
5	TLO 5.1 Classify various actuators TLO 5.2 Differentiate between different Directional control valves TLO 5.3 Choose the relevant relay for the given application TLO 5.4 Compare electrical, pneumatic and hydraulic actuators	**Unit - V Control System Components** 5.1 Pneumatic and Hydraulic Actuators: Single acting Cylinder, double acting Cylinder 5.2 Directional control valves: Principle, symbol and working of 2/2, 3/2 and 5/2 Directional control valves 5.3 Control Relays - Principle and working of Electro-mechanical relay, Reed relay, Solid state relay, Overload relay and applications 5.4 Comparison between pneumatic, hydraulic and electric actuators	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Collaborative learning Cooperative Learning

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 Install open source software (scilab) LLO 1.2 Use the appropriate software tools to derive the transfer function	1	Open source software (scilab) tools to derive transfer function of a given control system	2	CO1
LLO 2.1 Determine the poles and zeros of a given transfer function LLO 2.2 Use open loop software to determine the poles and zeros of a given transfer function	2	*Open source software to determine the poles and zeros of a given transfer function	2	CO1
LLO 3.1 Plot the response of given R-C circuit (first order system) LLO 3.2 Determine the time constant for given R-C circuit (first order system)	3	*Response of an R-C circuit (first order system) for unit step input	2	CO2
LLO 4.1 Plot the response of a given first order system using open source software tools LLO 4.2 Determine the time constant for given first order system	4	Analysis of the step response of a first order system for various time constants using open-source software	2	CO2
LLO 5.1 Record the behavior of a given control system for various damping factors using open source software	5	*Analysis of unit step time response of a second order system for various damping factors using open-source software	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Determine the stability of a given control system from the pole locations using open source software	6	Determination of stability of a given control system by plotting poles and zeros in s-plane using open source software	2	CO2
LLO 7.1 Plot the steady state response of a given Type 0 control system for unit step input	7	*Steady state response of Type 0 control system for step input	2	CO2
LLO 8.1 Analyze steady state error for different inputs for Type 0 system using open-source software	8	Analysis of steady state error for different inputs for Type 0 system using open-source software	2	CO2
LLO 9.1 Analyze steady state error for different inputs for Type 1 system using open-source software	9	Analysis of steady state error for different inputs for Type 1 system using open-source software	2	CO2
LLO 10.1 Demonstrate the neutral zone of a given ON-OFF controller	10	*Demonstration of neutral zone of a given ON-OFF controller	2	CO3
LLO 11.1 Plot the response of the given Proportional controller LLO 11.2 Demonstrate the Proportional band	11	*Proportional controller to control a given process parameter and demonstrate the proportional band	2	CO3
LLO 12.1 Test the performance of PID controller LLO 12.2 Plot the time response of the PID controller for different values of P, I, D	12	Test the performance of PID controller for different values of P, I, D	2	CO3
LLO 13.1 Plot the response of the potentiometer as an error detector	13	Test the performance of potentiometer as an error detector	2	CO4
LLO 14.1 Plot the response of the synchro as an error detector LLO 14.2 Take safety measures in operating the synchro error detector	14	*Test the performance of synchro as an error detector by practising safety measures	2	CO4
LLO 15.1 Perform experiment to control the angular position using DC Servo system	15	Angular position control using DC Servo system	2	CO4
LLO 16.1 Operate single acting or double acting cylinder using directional control valve	16	*Operation of pneumatic/ hydraulic single acting or double acting cylinder with the help of directional control valve	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

- Not applicable

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.
- 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	Any Open source software like scilab to find out poles, zeros, TF, and time response of the given system (https://www.scilab.org/)	1,2,4,5,6,8,9
2	On-off controller:- Controlled variable- Temperature or Flow or Pressure or Level; Signal Conditioning- OPAMP based signal conditioning with 1-5% accuracy; Control- Relay based; Power requirement- 230V single phase AC	10
3	Proportional and PID controller:- Controlled Variable- Temperature or flow or pressure or level; Input Value- Linear 0-20mA and or 4-20mA, 0-5V and or 1-5V; Output Value- appropriate range to study PID controller response; Display Type- 4.5 digit 7 segment or 16x2 LCD; Set up- Appropriate setup for control of controlled variable; Power requirement- 230V single phase AC	11,12
4	Potentiometer as an error detector:- Potentiometer- 270 to 360 degree rotation with 1 degree resolution; on kit 3½ digit DVM; Test points- Sockets at Different Places; Power Supply- Inbuilt regulated power supply from 220 V, 50 Hz AC supply	13
5	Synchro Transmitter Receiver Kit:- Synchro transmitter-receiver pair with calibrated dials(0-200V AC); Receiver use as control transformer; Built-in balanced demodulator circuit; Panel meter for ac/dc voltages; Locking system for receiver rotor; Power requirement- 230V single phase 50 Hz	14
6	D.C. Position control system:- DC Motor- Geared PM motor 12V/1A (50/60 RPM); Tacho Feedback- Positive/Negative tacho-generator feedback with polarity reverse switch; Tacho Constant- Calibrated tacho constant 0.2 to 1 in steps; Motor Unit- The motor unit housed in a separate cabinet with transparent cover; Interconnection with the main unit- appropriate connector; Built in capture/ display card- optional; Power Requirement: Inbuilt regulated power supply from 220 V, 50 Hz AC supply.	15
7	Electro pneumatic trainer kit:- Air Compressor- 0 to 8/10 bar pressure, 150-180 psi capacity, auto cutoff; Single/ Double acting cylinder- 20mm to 30mm bore, 25 to 75 stroke, pressure 0.5 to 8/10 bar; Directional control valve-3/2 for single acting and 5/2 for double acting, 0-8/10 bar, lever or solenoid operated	16
8	Breadboard, Resistors(10K ohm to 1 M ohm), capacitors(100µF to 1000µF), DC power supply(0-30V, 2 A), Digital Multimeter, Stop Watch	3

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
9	Standard test signal generator kit:- outputs- Step, Ramp, impulse and parabolic signals; Variable DC Voltage : -12V to +12V; Frequency- approx. 50Hz to 5KHz; Power Requirements- DC regulated from 230V single phase AC	7
10	Type 0 system trainer kit:- Input Type- provision to connect external inputs (step, ramp and parabolic); Frequency of operation- approx. 50Hz to 5KHz(may vary for different inputs; Power Requirements- DC regulated from 230V single phase AC	7

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	Fundamentals of control systems	CO1	14	2	6	8	16
2	II	Time response analysis and Stability	CO2	18	4	6	8	18
3	III	Process Control	CO3	8	2	6	4	12
4	IV	Position Control	CO4	10	2	6	4	12
5	V	Control System Components	CO5	10	4	4	4	12
Grand Total				**60**	**14**	**28**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning
- End semester assessment is 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	2	2	2	2			2			

CO2	2	2	2	2			2			
CO3	2	2	2	2		1	2			
CO4	2	2	2	2		1	2			
CO5	2	2	2	2		1	2			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Nagrath I.J, M. Gopal	Control System Engineering	New age International ISBN: 9788122420081
2	Andrew A. Parr	Hydraulics and Pneumatics	Elsevier Science and Technology Books ISBN: 0750644192
3	Johnson C. D.	Process Control Instrumentation Technology	Prentice hall of India ISBN: 978-9332549456
4	Ogata K.	Modern Control Engineering	Pearson India ISBN: 978-9332550162
5	Varmah K.R	Control Systems	Tata McGraw Hill ISBN: 9780070678750
6	Sawhney A.K	A Course in ELECTRICAL AND ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	Dhanpat Rai and Co ISBN: 9788177001006.
7	Manke B. S.	Linear Control Systems with MATLAB Applications	Khanna Publishers ISBN: 978-8174093103
8	S. Hasan Saeed	Automatic Control Systems (With Matlab Programs)	Arihant ISBN: 978-8190691925

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/107/106/107106081/	NPTEL study material for chapter 1,2 and 3
2	www.electrical4u.com/control-engineering	About control of electrical circuits
3	https://www.ni.com/en/shop/labview/pid-theory-explained.html#:~:text=The%20basic%20idea%20behind%20a,components%20to%20compute%20the%20output.	PID controller
4	https://forumautomation.com/t/types-of-directional-control-valve-dcv-based-on-the-fluid-path-control/2645	About Directional control valves
5	https://www.scilab.org/	Free ware open source software to find out poles, zeros, TF, and time response of the given system
6	https://onlinecourses.nptel.ac.in/noc22_ee83/unit?unit=29&lesson=32	NPTEL study material for chapter 1 and 2
7	https://onlinecourses.nptel.ac.in/noc22_ee83/unit?unit=37&lesson=40	NPTEL study material for Time response analysis

Sr.No	Link / Portal	Description

Note :

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

Programme Name/s : **Automation and Robotics**
Programme Code : **AO**
Semester : **Third**
Course Title : **MEASUREMENTS & AUTOMATION BASICS**
Course Code : **313330**

I. RATIONALE

Engineering diploma holders in electronics and allied disciplines are expected to identify and use various measuring instruments in industrial applications. Measurement-based control has always been at the core of industrial automation. This course is designed to give overview of the basics of Industrial measurements and its subsequent requirement in automation

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:
Test various electronic parameters in automation systems.

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 characteristics of measuring instrument.
- CO2 - Use relevant instrument to measure specified parameters.
- CO3 - Maintain signal conditioning and data acquisition systems.
- CO4 - Identify different components of automation system.
- CO5 - Identify different components of robotic system.

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	
313330	MEASUREMENTS & AUTOMATION BASICS	MAB	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175

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

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the concept of measuring instrument and their types. TLO 1.2 Determine static and dynamic characteristics of measuring instruments. TLO 1.3 Identify standards of measurements. TLO 1.4 Identify errors in industrial measurement.	**Unit - I Fundamentals of Electrical and Electronics Measurements** 1.1 Fundamentals of measuring instrument 1.2 Types of measuring instruments: Analog, digital, electrical and electronics 1.3 Compare analog and digital instruments 1.4 Static and dynamic characteristics of instruments 1.5 Calibration(need and methods:direct,indirect)standards of Instrument 1.6 Errors in measurement, types of errors, sources of errors	Lecture Using Chalk-Board Presentations
2	TLO 2.1 Describe the procedure to measure displacement in automation system. TLO 2.2 Describe the use of rotary encoder to measure angle of given rotating device. TLO 2.3 Describe the procedure to measure frequency, period, voltage using DSO. TLO 2.4 Explain the working of function generator and signal generator with block diagram.	**Unit - II Measuring Devices and Instruments** 2.1 Angular and linear displacement using potentiometer 2.2 Rotary encoder: Working principle, specifications, applications 2.3 Digital multi meter: Working principle, specifications, applications 2.4 DSO: Functional block diagram and uses of Digital Storage Oscilloscope 2.5 Signal generator: Basic working principle 2.6 Function generators: Functional block diagram and applications	Lecture Using Chalk-Board Model Demonstration 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.
3	TLO 3.1 Explain the need of signal conditioning in the measurement. TLO 3.2 Differentiate AC and DC signal conditioning circuits. TLO 3.3 Describe function of given block of DAS. TLO 3.4 Differentiate types of DAS system.	**Unit - III Data Acquisition System** 3.1 Signal conditioning: Need, types of signal conditioning (block diagram of AC and DC signal conditioners) 3.2 Filter, isolator, amplifier and converter as a signal conditioner (only function) 3.3 Data Acquisition Systems (DAS): Need, types (single channel, multi-channel and computer based) 3.4 Comparison of types of DAS 3.5 Data loggers: Concept and applications	Lecture Using Chalk-Board Presentations
4	TLO 4.1 Identify the need and benefits of industrial automation. TLO 4.2 List applications of automation system. TLO 4.3 Describe function of components of automation system. TLO 4.4 Identify different types of automation system.	**Unit - IV Basics of Automation System** 4.1 Need and benefits of automation system 4.2 Application areas: Process industries, building, robotics, railways, infrastructure development, aerospace, automobiles electrical distribution, medical, telecommunication etc. 4.3 Automation hierarchy:Basic components and function of each component 4.4 Types of automation system: Fixed, programmable, flexible machine automation, process automation,factory automation 4.5 Different systems used in industrial automation: PLC, HMI, SCADA, DCS, drives	Lecture Using Chalk-Board Video Demonstrations Presentations
5	TLO 5.1 Describe the function of the given element of the robotic systems with the help of sketch. TLO 5.2 Explain with sketches the given degree of freedom for a robot. TLO 5.3 Compare given types of robot on the basis of degree of freedom, construction, end effector used and applications.	**Unit - V Basics of Robotics in Automation System** 5.1 Robotics: Block diagram and function of each component (sensors, drive system, control system, end effectors) 5.2 Construction and degrees of freedom of cylindrical robot 5.3 Construction and degrees of freedom of spherical and cartesian robots	Lecture Using Chalk-Board Presentations Video Demonstrations

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 multimeter to determine accuracy, resolution, precision for specified measured quantity.	1	*Measurement of accuracy, resolution and precision of given measuring device	2	CO1
LLO 2.1 Calibrate given measuring instrument using direct method. LLO 2.2 Calibrate given measuring instrument using indirect method.	2	*Caliberation of given measuring instruments by direct and indirect method	2	CO1
LLO 3.1 Identify use of analog multimeter.	3	Measurement of AC voltage, current and resistance using analog multimeter	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Identify use of digital multimeter.	4	*Measurement of DC voltage, current and resistance using digital multimeter	2	CO2
LLO 5.1 Identify controls of function generator.	5	*Identification of front panel controls of function genrator	2	CO2
LLO 6.1 Use function generator to generate different types of waveforms (sine, square, triangular). LLO 6.2 Measure the frequency and amplitude of the waveform using DSO.	6	*Analysis of different waveforms using function generator and DSO	2	CO2
LLO 7.1 Use DSO to measure amplitude and frequency of the given input signal.	7	*Measurement of amplitude and frequency of input signal using DSO	2	CO2
LLO 8.1 Use potentiometer for linear displacement measurement.	8	*Measurement of linear displacement using potentiometer	2	CO2
LLO 9.1 Use potentiometer for angular displacement measurement.	9	*Measurement of angular displacement using potentiometer	2	CO2
LLO 10.1 Use of rotary encoder for angular displacement measurement.	10	Measurement of angular displacement using rotary encoder	2	CO2
LLO 11.1 Verify concept of data acquisition system.	11	Verification of working of data acquisition system available in laboratory	2	CO3
LLO 12.1 Verify filter as signal conditioner.	12	*Verification of filter as signal conditioning circuits	2	CO3
LLO 13.1 Verify isolator as signal conditioner.	13	Verification of isolator as signal conditioning circuits	2	CO3
LLO 14.1 Verify converter as signal conditioner.	14	Verification of function of converter (ADC/ DAC) as signal conditioning circuits	2	CO3
LLO 15.1 Verify current to voltage conversion operation.	15	Verification of current to voltage convertor as signal cinditioner(4-20mA signal into 0-5 volt)	2	CO3
LLO 16.1 Verify voltage to current conversion operation.	16	Verification of use of voltage to current converter as signal conditioner	2	CO3
LLO 17.1 Identify components of automation system available in laboratory. LLO 17.2 Identify facilities of automation system available in laboratory.	17	*Identification of components and facilities of automation trainer kit available in laboratory	2	CO4
LLO 18.1 Identify various PLC brands used in Industries.	18	*Identification of major industrial PLC available in market which are used for industrial process	2	CO4
LLO 19.1 Inspection of Controls of PLC front panel.	19	*Identification of various parts of front panel of any 3 general purpose PLC	2	CO4
LLO 20.1 Identify various input devices used in Industries. LLO 20.2 Identify various output devices used in Industries.	20	*Identification of various input and output devices used in PLC system available in laboratory	2	CO4
LLO 21.1 Identify software and hardware of automation system using virtual lab.	21	Identification of hardware and software of PLC automation system with virtual lab	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 22.1 Identify components of automation hierarchy.	22	*Identification of flow of automation hierarchy of automation system	2	CO4
LLO 23.1 Inspect use of Human Machine Interface (HMI) in automation system.	23	Verification of use of HMI in automation system	2	CO4
LLO 24.1 Identify components of robotics.	24	*Identification of function of major components of roboticavailable in laboratory	4	CO5
LLO 25.1 Verify Degree of freedom of robotic system.	25	* Verification of number of Degree of freedom for robotic available in laboratory	2	CO5
LLO 26.1 Measure various parameters(Amplitude, time, frequency).	26	Measurement of amplitude,frequency and time of a signal using simulation software	2	CO2
LLO 27.1 Measure voltage resistance and current of a circuit.	27	Measurement of voltage, resistance and current of a circuit using simulation software	2	CO2
LLO 28.1 Measure linear displacement using potentiometer using simulation software.	28	Measurement of linear displacement using potentiometer using simulation software	2	CO2
LLO 29.1 Verify of function of data acquisition system using simulation software.	29	Verification of function of data acquisition system using simulation software	2	CO2

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

- Design practical model for measurement of linear or angular displacement using potentiometer and calculate its sensitivity.
- Build and test I to V converter circuit.
- Design and simulate any one signal conditioning circuit using open source simulating software.

Activity

- Prepare activity report on calibration, its need and procedure for a measuring instrument.
- Market survey of electronic measuring instruments used in laboratory.
- Prepare market survey report of major PLCs used in industry with their specifications.
- Prepare detailed informative chart of static and dynamic characteristics of measuring instrument.

Assignment

- Identify all controls of a DSO available in laboratory and give its specifications as per data sheet.
- Prepare report on a Robotic system with the observations of industrial visit to any industry based on robotic system.

- Identification various automation systems available in day to day life and draw schematic of any system.

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.
- 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 multimeter 0-10A, 0-600V, 0-10 Mega ohm	1,2,4,8,9,15,16
2	Analog multimeter 0-10 A, 0-600 V, 0-10 Mega ohm	1,3
3	Portable data acquisition system: 8 bit ADC/channel 4 analog voltage inputs powered by USB.	11
4	Input and Output devices for PLC: like Lamp, DC Motor, Proximity sensors, Thermocouple/RTD, Red, green, yellow LEDs, Stepper Motor, limit switches, push button	17,18,19,20,21,22,23
5	IEC 1131-3 compatible PLC with programming Software and interfacing hardware, user manual, (complete PLC trainer system) with HMI	17,18,19,20,22,23,21
6	Robotic system: 6 DoF, 8Kg Payload, arm range:930 mm,max speed 10.5 mm/sec.with compatible software	24,25
7	Computer system installed with required simulation software.	26,27,28,29
8	Any open source or online simulation software.	26,27,28,29
9	Function generator: Frequency ranges 0.1Hz to 11Mz,Pulse and ramp, aspect ratio 95:5	5,6,7
10	Digital storage oscilloscope :BW 60 MHz Dual channel	6,7

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	Fundamentals of Electrical and Electronics Measurements	CO1	8	2	2	4	8
2	II	Measuring Devices and Instruments	CO2	13	4	6	6	16
3	III	Data Acquisition System	CO3	14	4	4	8	16
4	IV	Basics of Automation System	CO4	13	4	6	8	18
5	V	Basics of Robotics in Automation System	CO5	12	2	4	6	12
Grand Total				**60**	**16**	**22**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

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

Summative Assessment (Assessment of Learning)

- End semester assessment 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	2	1	1			
CO2	3	2	2	2	2	1	1			
CO3	3	3	3	2	1	1	1			
CO4	3	1	2	1	2	1	1			
CO5	3	1	2	1	2	1	1			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Jadhav, V. R.	Programmable Logic Controller	Khanna publishers, New Delhi, 2017, ISBN: 978-8174092281
2	Madhuchhand A Mitra, Samarjit Sen Gupta	Programmable logic controllers and industrial automation an introduction	Penram international publication, New Delhi, 2015, ISBN: 978-8187972174
3	Kalsi H.S.	Electronics Instrumentation	McGraw Hill, New Delhi, 2010, ISBN:978-0070702066
4	Sawhney A.K.	Electrical and Electronic Measurements and Instrumentation	Dhanpat Rai and Sons, New Delhi, 2005, ISBN: 978-8177000160
5	David A.Bell	Electronic Instrumentation and Measurments	Oxford University,Press New Delhi India 3rd Edition, 2013, ISBN-13 978-0195696141
6	W.Boltan	Mechatronics	Pearson Education, ISBN 978-8131732533

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/tN7iAzVEqa0?feature=shared	NPTEL lecture on measurement
2	https://youtu.be/fg9No42IjnM?feature=shared	How potentiometer works(linear and rotary type potentiometer)
3	https://youtu.be/tw-79FiRYKA?feature=shared	What is industrial automation
4	https://youtu.be/uOtdWHMKhnw?feature=shared	Programmable logic controller basics explained - automation engineering
5	https://youtu.be/E2WNPXJf-Kw?feature=shared	PLC Introduction,PLC basics, Components of PLC,modular PLC, Modules (input Output)
6	https://youtu.be/kujHQgK352o?feature=shared	What is HMI
7	https://youtu.be/uxKyLTMv9js?feature=shared	How to do measurements using digital storage oscilloscope (DSO)

Note :

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

Programme Name/s : **Automation and Robotics**
Programme Code : **AO**
Semester : **Third**
Course Title : **SENSOR TECHNOLOGY**
Course Code : **313331**

I. RATIONALE

Sensor technologies have improved the everyday life of human beings through their applications in almost all fields. Sensor is device that detect changes in the source/environment, collect signals, and accordingly give the reaction. This course will enable the students to understand the principle of various sensors, their construction and applications. This course is a core course that will develop basic skills with regards to electronic sensor based technology used in any robotics and automation industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences:
Use relevant sensors in the electronic sensor-based systems related to Automation, Robotics and IoT.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Interpret various characteristics of sensors.
- CO2 - Develop signal conditioning circuits using relevant analog ICs.
- CO3 - Select appropriate sensor for given application.
- CO4 - Describe the latest trends in the field of sensor.
- CO5 - Develop an application employing various sensor technologies.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313331	SENSOR TECHNOLOGY	STC	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 2 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare transducer, sensor and actuator. TLO 1.2 Classify sensors on basis of various parameters. TLO 1.3 Explain characteristics of sensors. TLO 1.4 Identify the appropriate sensor with reference to given criteria.	**Unit - I Fundamentals of Sensors** 1.1 Transducer, sensor and actuator-definition and its comparison 1.2 Need of sensor, classification of sensors -analog and digital, active and passive, scalar and vector 1.3 Characteristics of sensors : Range, resolution, sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, response time, dead band 1.4 Criteria to choose a sensor: Accuracy, environmental condition, range, calibration, resolution , cost and repeatability	Lecture Using Chalk-Board Video Demonstrations Presentations
2	TLO 2.1 Describe the general structure of measurement system using block diagram. TLO 2.2 Explain the need of signal conditioning in instrumentation system. TLO 2.3 Differentiate the various modes of Op-Amp IC741. TLO 2.4 Explain the working of various applications of Op-Amp using IC741. TLO 2.5 Explain applications of IC555.	**Unit - II Signal Conditioning** 2.1 General structure of measurement system , importance of signal conditioning in instrumentation system. 2.2 Operational Amplifier- IC741 pin diagram, characteristics of Op-Amp IC741, various modes of Op-Amp IC741 2.3 Operational amplifier application using IC741: Amplifiers (inverting and non-inverting), comparator, integrator, differential amplifier and instrumentation amplifier 2.4 Timer IC555-internal diagram, pin diagram, application as astable and monostable multivibrator	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.
3	TLO 3.1 Describe importance of mechanical and electromechanical sensors. TLO 3.2 Explain different types of mechanical sensors. TLO 3.3 Explain different types of electro-mechanical sensors.	**Unit - III Mechanical and Electromechanical Sensors** 3.1 Mechanical and electromechanical sensors: Definition, basic principle and applications 3.2 Mechanical sensors: Pressure sensor- C shape bourdon tube, bellows and diaphragm, Pressure measurement in ancient time (IKS) , flow sensor - rotameter, venturi meter and orifice plate 3.3 Electro-mechanical sensors: Resistive (potentiometric type), strain gauge, inductive sensor-LVDT, capacitive sensors, thermal (RTD-PT100, thermocouple (J,K,R,S,T)), proximity sensors (inductive, optical, capacitive, magnetic, ultrasonic)	Lecture Using Chalk-Board Presentations Video Demonstrations
4	TLO 4.1 Describe stages in the development of sensor technology. TLO 4.2 Describe techniques used in semiconductor sensors and biomedical sensors. TLO 4.3 Describe the operation of smart sensor using its block diagram. TLO 4.4 Compare IR radiation sensors and ultrasonic sensors with respect to technology used and its applications.	**Unit - IV Advance Sensors** 4.1 Development of sensor technology 4.2 Semiconductor sensors: Material and technique, types of semiconductor sensors (thermistor, gas sensor), biomedical sensor: magnetic biosensor 4.3 Smart sensors: Definition, configuration of smart sensor, Microsensors: Micro size microphone, inertial sensor, hall effect sensor 4.4 Colour sensor, IR radiation sensor, thermal detectors, ultrasonic sensors (flow and level sensor), fiberoptic sensors (displacement sensor and humidity sensor)	Lecture Using Chalk-Board Demonstration Video Demonstrations
5	TLO 5.1 Describe working principle of MEMS sensor. TLO 5.2 Explain different MEMS sensors used for speed and pressure measurement. TLO 5.3 Illustrate working of different touch screen sensors.	**Unit - V MEMS (Microelectromechanical Systems) Sensors** 5.1 Microelectromechanical systems: MEMS technology overview and its need, MEMS sensor working principle. 5.2 MEMS accelerometers, MEMS gyroscopes, MEMS pressure sensors, MEMS magnetic field sensors 5.3 Advantages, disadvantages and applications of MEMS sensors 5.4 Touch screen sensors: Resistive, capacitive, infrared and surface acoustic wave (block diagram and its working).	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 Compile a list of transducers,sensors, and actuators available in your institute.	1	*Compilation of a list of transducers, sensors, and actuators available in your institute	2	CO1
LLO 2.1 Determine the gain of the amplifier using IC741.	2	*Gain determination of the Inverting amplifier and Non-Inverting amplifier using IC741	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Build differentiator circuit using IC741. LLO 3.2 Test differentiator circuit using IC741.	3	Performance of differentiator circuit using IC741	2	CO2
LLO 4.1 Build astable multivibrator using IC555 for the given specifications. LLO 4.2 Test astable multivibrator using IC555 for the given specifications.	4	*Performance of astable multivibrator using IC555 for the given specifications	2	CO2
LLO 5.1 Build comparator circuit consist of IC741. LLO 5.2 Test comparator circuit consist of IC741.	5	*Performance of comparator circuit using of IC741	2	CO2
LLO 6.1 Use a bourdon tube pressure gauge to measure pressure.	6	*Measurement of pressure using bourdon tube pressure gauge	2	CO3
LLO 7.1 Use LVDT to measure displacement.	7	*Use LVDT to measure displacement	2	CO3
LLO 8.1 Use strain gauge to measure weights.	8	Measurement of weights using strain gauge	2	CO3
LLO 9.1 Use RTD to measure temperature.	9	Temperature measurement using RTD	2	CO3
LLO 10.1 Measure temperature using a thermo couple.	10	*Temperature measurement using a thermocouple	2	CO4
LLO 11.1 Compile a list of biomedical sensor with their physical picture, function and applications.	11	Compilation list of the biomedical sensors with their physical picture, function, and applications	2	CO4
LLO 12.1 Interface an IR sensor with Arduino Uno using any simulation software.	12	Interface IR sensor with Arduino Uno using simulation software	2	CO4
LLO 13.1 Identify sensors used in given mobile.	13	*Identification of various sensors available in a given smart mobile phone.(using relevant code and mobile applications)	2	CO5
LLO 14.1 Build astable multivibrator using IC555 for the given specifications. LLO 14.2 Test astable multivibrator using IC555 for the given specifications.	14	Performance of monostable multivibrator using IC555 for the given specifications	2	CO2
LLO 15.1 Detect different colours using colour sensor trainer.	15	Detection of different colours using colour sensor	2	CO4
LLO 16.1 Measure speed using proximity sensor.	16	Speed measurement using proximity sensor	2	CO4

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

- Use a fire sensor make a small electronic alarm circuit.
- Make a small circuit using LDR as a sensing device.
- Make a power point presentation describing smart garbage segregation systems using sensors.
- Develop a chart depicting the classification table of various types of sensors.
- Make temperature control circuit using thermistor.
- Develop Schmitt trigger using IC555.
- Using a touch sensor make a small electronic circuit.
- Make a astable multivibrator using IC555.

Assignment

- Describe different sensors used in escalator.
- Explain different sensors used in dish washer system.
- Explain Smart traffic management systems using its block diagram.
- Describe different sensors used in biometric readers.
- Explore any car company's website, record various sensors and their functions used in high-end cars.

Field visit

- Visit any of the Mall/Electronic showroom and record different sensors used there,from entry to exit .

Activity

- Explore Nadi Pariksha Device and make a descriptive report on how this device is correlated with ancient medical parameter sensing (*IKS).
- Simulate the performance of a bio-sensor and record responses for different inputs using V-Lab.

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.
- 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	Models and charts of various sensors and actuators	1
2	Thermocouple Trainer Kit Complete with thermocouple sensor, thermometer, glass beaker , instruction manual,inbuilt regulated power supply ±12 volts DC, null balance and amplification circuit.	10
3	Simulation software any open source software for interfacing Arduino uno or software like Proteus	12

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
4	Computer Processor Intel i5 or equivalent AMD, memory: 8 GB RAM minimum, storage: 500 GB) minimum, with Web camera and mic	12
5	Mobile phone having smart phone characteristics	13
6	Colour Sensor Trainer Advance Technology provides RGB color sensor which is 8051 compatible which can detect different color up to 10 colors,16*2 LCD display to show value of color,on board power supply section with power indicator and test point	15
7	Proximity Sensor Trainer On board proximity sensor, on board DC motor,test points to analyse the signal, variable supply to vary the speed of DC motor ON/OFF switch and LED for power indication.	16
8	CRO Sensitivity in 1, 2, 5 sequence : 5mv/cm to 10 v/m, band width : dc to 15 m hz/, rise time : 24 ns, accuracy : ±3%, max. input voltage dc + ac peak : 400 v, input impedance : 1 m/35 pf	2,3,4,5,14
9	Operational Amplifier Trainer Inbuilt variable/fixed DC regulated power supplies output voltages : 0-5VDC (variable) (2Nos.), +12VDC (fixed) , transistor & components Provided IC : 741, transistor : CL 100 (NPN), resistors, capacitors, power requirement : 230 VAC, 10%, 50Hz	2,3,5
10	Multivibrator using 555 timer trainer kit On board includes: Monostable mutivibrator, astable mutivibrator, bistable mutivibrator circuits Fuse for short circuit protection, instruction manual, connections are brought out through 2mm colored sockets, patch cords 2mm.	4,14
11	Bourdon Pressure Gauge Trainer Parameter Measured: Pressure, type : C type bourdon tube and spring loaded core type LVDT, Measurement Range : 0 to 10 Kg, Operating Voltage : 230V, + 10%, accessories: chamber for pressure developing and releasing, Foot pump to develop pressure in chamber	6,7
12	Strain gauge trainer Parameter measured: Strain in terms of kilograms Wheatstone bridge principle range: 0 – 500 grams, actual strain: by weights placed in a plate fixed on the beam, excitation source: DC regulated source	8
13	RTD trainer kit Digital meters: Voltmeter 200mv, DC power supplies: DC supply IC regulated +12v DC, 150MA, operated on mains power 230v, 50HZ	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	Fundamentals of Sensors	CO1	10	4	4	4	12
2	II	Signal Conditioning	CO2	12	4	6	6	16
3	III	Mechanical and Electromechanical Sensors	CO3	14	4	6	6	16
4	IV	Advance Sensors	CO4	12	4	4	8	16
5	V	MEMS (Microelectromechanical Systems) Sensors	CO5	12	2	4	4	10
Grand Total				**60**	**18**	**24**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

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

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.

End semester summative assessment of 25 marks for laboratory learning

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Patranabis D.	Sensors and Transducers	PHI Learning Private Limited, ISBN: 978-8120321984
2	Gayakwad Ramakant A.	Op-Amps and Linear Integrated Circuits	Pearson Education, ISBN: 978-9332549913
3	Botkar K. R.	Integrated Circuits	Khanna Publishers, ISBN: 81740920801
4	Murty D.V.S	Transducers and Instrumentation	Prentice Hall India Learning Private Limited, ISBN: 978-8120335691
5	Edited by Korvin Jan G. K and Paul Oliver	MEMS: A Practical Guide to Design, Analysis, and Applications	Springer-Verlag GmbH & Co. KG, ISBN : 3540211179

Sr.No	Author	Title	Publisher with ISBN Number
6	Jain V.K.	Internet of Things	Khanna Publisher, ISBN: 8195207529
7	Liptak Bela G.	Process Measurement and Analysis	CRC Press, ISBN: 0849310830

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.farnell.com/datasheets/1504633.pdf	Touch screen sensor design guide.
2	https://www.bosch-mobility.com/en/solutions/electronic-components/mems-sensors/	MEMS sensors information
3	https://nptel.ac.in/courses/117105082	MEMS sensors overview
4	https://sl-coep.vlabs.ac.in/List%20of%20experiments.html	Sensor simulation using virtual lab
5	https://www.bharathuniv.ac.in/page_images/pdf/courseware_eee/Notes/NE3/BEE026%20MEMS.pdf	MEMS sensors introduction
6	https://courses.cs.washington.edu/courses/cse466/15au/pdfs/lectures/MEMS%20Sensors.pdf	MEMS sensors course
7	https://www.classcentral.com/course/youtube-electronics-mems-microsystems-47673	Short duration online course for MEMS sensors
8	https://nptel.ac.in/courses/108108147	Sensors and actuators overview
9	https://nptel.ac.in/courses/117107094	Operational amplifier information

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	**: 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/ Dress Designing & Garment Manufacturing/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Food Technology/ Computer Hardware & Maintenance/ Hotel Management & Catering Technology/ 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/ Textile Technology/ Electronics & Computer Engg./ Travel and Tourism/ Textile Manufactures**
Programme Code	**: AA/ AE/ AI/ AL/ AN/ AO/ AT/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DC/ DD/ DE/ DS/ EE/ EJ/ EP/ ET/ EX/ FC/ HA/ HM/ IC/ IE/ IF/ IH/ IS/ IX/ IZ/ LE/ ME/ MK/ ML/ MU/ PG/ PN/ PO/ SC/ TC/ TE/ TR/ TX**
Semester	**: Third**
Course Title	**: ESSENCE OF INDIAN CONSTITUTION**
Course Code	**: 313002**

I. RATIONALE

This course will focus on the basic structure and operative dimensions of Indian Constitution. It will explore various aspects of the Indian political and legal system from a historical perspective highlighting the various events that led to the making of the Indian Constitution. The Constitution of India is the supreme law of India. The document lays down the framework demarcating the fundamental political code, structure, procedures, powers, and sets out fundamental rights, directive principles, and the duties of citizens. The course on constitution of India highlights key features of Indian Constitution that makes the students a responsible citizen. In this online course, we shall make an effort to understand the history of our constitution, the Constituent Assembly, the drafting of the constitution, the preamble of the constitution that defines the destination that we want to reach through our constitution, the fundamental right constitution guarantees through the great rights revolution, the relationship between fundamental rights and fundamental duties, the futurist goals of the constitution as incorporated in directive principles and the relationship between fundamental rights and directive principles.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry /employer expected outcome – Abide by the Constitution in their personal and professional life.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - List salient features and characteristics of the constitution of India.
- CO2 - Follow fundamental rights and duties as responsible citizen of the country.
- CO3 - Analyze major constitutional amendments in the constitution.
- CO4 - Follow procedure to cast vote using voter-id.

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	
313002	ESSENCE OF INDIAN CONSTITUTION	EIC	VEC	1	-	-	1	2	1	-	-	-	-	-	-	-	-	-	50	20	50

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 meaning of preamble of the constitution. TLO 1.2 Explain the doctrine of basic structure of the constitution. TLO 1.3 List the salient features of constitution. TLO 1.4 List the characteristics of constitution.	**Unit - I Constitution and Preamble** 1.1 Meaning of the constitution of India. 1.2 Historical perspectives of the Constitution of India. 1.3 Salient features and characteristics of the Constitution of India. 1.4 Preamble of the Constitution of India.	Presentations Blogs Hand-outs Modules Flipped classrooms Case studies

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Enlist the fundamental rights. TLO 2.2 . Identify fundamental duties in general and in particular with engineering field. TLO 2.3 Identify situations where directive principles prevail over fundamental rights.	**Unit - II Fundamental Rights and Directive Principles** 2.1 Fundamental Rights under Part-III. 2.2 Fundamental duties and their significance under part-IV-A. 2.3 Relevance of Directive Principles of State Policy under part-IV A.	Presentations Blogs Hand-outs Modules Case Study Flipped Classroom
3	TLO 3.1 Enlist the constitutional amendments. TLO 3.2 Elaborate the elements of Centre-State Relationship TLO 3.3 Analyze the purposes of various amendments.	**Unit - III Governance and Amendments** 3.1 3.1 Amendment procedure of the Constitution and their types - simple and special procedures. 3.2 The Principle of Federalism and its contemporary significance along with special committees that were setup. 3.3 Major Constitutional Amendment procedure - 1st, 7th, 42nd, 44th, 73rd & 74th, 76th, 86th, 52nd & 91st, 102nd	Cases of Federal disputes with relevant Supreme court powers and Judgements Presentations Blogs Hand-outs Problem based learning
4	TLO 4.1 Explain the importance of electoral rights. TLO 4.2 Write the step by step procedure for process of registration TLO 4.3 Explain the significance of Ethical electoral participation TLO 4.4 Explain the steps to motivation and facilitation for electoral participation TLO 4.5 Enlist the features of the voter's guide TLO 4.6 Explain the role of empowered voter TLO 4.7 Write the steps of voting procedure TLO 4.8 Write steps to create voter awareness TLO 4.9 Fill the online voter registration form TLO TLO 4.10 Follow procedure to cast vote using voter-id.	**Unit - IV Electoral Literacy and Voter's Education** 4.1 Electoral rights , Electoral process of registration 4.2 Ethical electoral participation 4.3 Motivation and facilitation for electoral participation 4.4 Voter's guide 4.5 Prospective empowered voter 4.6 Voting procedure 4.7 Voter awareness 4.8 Voter online registration https:/ /www.ceodelhi.gov.in/ELCdetails.aspx	Presentations Hand-outs Modules Blogs Problem based Learning

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

- Outline the procedure to submit application for Voter-id
- Assignments are to be provided by the course teacher in line with the targeted COs.

A1. Prepare an essay on Constitution of India .
A2 Prepare a comparative chart of Unique features of Indian Constitution of India and Constitution of USA

- Assignments are to be provided by the course teacher in line with the targeted COs. A1. Prepare an essay on Constitution of India . A2 Prepare a comparative chart of Unique features of Indian Constitution of India and Constitution of USA A3. Self-learning topics: Parts of the constitution and a brief discussion of each part Right to education and girl enrollment in schools. GER of Girls and Boys. Right to equality. Social Democracy. Women Representation in Parliament and State Assemblies. LGBTQIA+

Micro project

- 1. Organize a workshop-cum discussions for spreading awareness regarding Fundamental Rights of the citizen of the country

2. Prepare elaborations where directive principle of State policy has prevailed over Fundamental rights with relevant Supreme Court Judgements.
3. Organize a debate on 42nd, 97th and 103rd Constitutional Amendment Acts of Constitution of India.

Seminar

- 1 Differences in the ideals of Social democracy and Political democracy.

2 Democracy and Women's Political Participation in India.
3 Khap Panchayat - an unconstitutional institution infringing upon Constitutional ethos.
4 Situations where directive principles prevail over fundamental rights.

Group discussions on current print articles.

-

- Art 356 and its working in Post-Independent India.
- Women's Resrvation in Panchayat leading to Pati Panchayats - Problems and Solutions.
- Adoption of Article 365 in India.
- Need of Amendments in the constitution.
- Is India moving towards a Unitary State Model ?

Activity

- Arrange Mock Parliament debates.

Prepare collage/posters on current constitutional issues.
i. National (Art 352) & State Emergencies (Art 356) declared in India.
ii. Seven fundamental rights.
iii. Land Reforms and its effectiveness - Case study of West-Bengal and Kerala.

Cases: Suggestive cases for usage in teaching:

- A.K. Gopalan Case (1950) :SC contented that there was no violation of Fundamental Rights enshrined in Articles 13, 19, 21 and 22 under the provisions of the Preventive Detention Act, if the detention was as per the procedure established by law. Here, the SC took a narrow view of Article 21.

Shankari Prasad Case (1951) : This case dealt with the amendability of Fundamental Rights (the First Amendment's

validity was challenged). The SC contended that the Parliament's power to amend under Article 368 also includes the power to amend the Fundamental Rights guaranteed in Part III of the Constitution.

Minerva Mills case (1980) :This case again strengthens the Basic Structure doctrine. The judgement struck down 2 changes made to the Constitution by the 42nd Amendment Act 1976, declaring them to violate the basic structure. The judgement makes it clear that the Constitution, and not the Parliament is supreme.

Maneka Gandhi case (1978) :A main issue in this case was whether the right to go abroad is a part of the Right to Personal Liberty under Article 21. The SC held that it is included in the Right to Personal Liberty. The SC also ruled that the mere existence of an enabling law was not enough to restrain personal liberty. Such a law must also be "just, fair and reasonable."

Other cases:

1. Kesavananda Bharati Case (1973) : In this case the Hon. SC laid down a new doctrine of the 'basic structure' (or 'basic features') of the Constitution. It ruled that the constituent power of Parliament under Article 368 does not enable it to alter the 'basic structure' of the Constitution. This means that the Parliament cannot abridge or take away a Fundamental Right that forms a part of the 'basic structure' of the Constitution.
2. Mathura Rape Case(1979) : A tribal woman Mathura (aged 14 to 16 years) was raped in Police Custody. The case raised the questions on the idea of 'Modesty of Woman' and here it was was a tribal woman who succumbs to multiple pattiarchies. Custodial rape was made an offence and was culpable with the detainment of 7 years or more under Section 376 of Indian Penal Code. The weight of proofing the allegations moved from the victim to the offender, once sexual intercourse is established. The publication of the victim's identity was banned and it was also held that rape trials should be conducted under the cameras.
3. Puttswamy vs Union of India (2017) : In this landmark case which was finally pronounced by a 9-judge bench of the Supreme Court on 24th August 2017, upholding the fundamental right to privacy emanating from Article 21. The court stated that Right to Privacy is an inherent and integral part of Part III of the Constitution that guarantees fundamental rights. The conflict in this area mainly arises between an individual's right to privacy and the legitimate aim of the government to implement its policies and a balance needs to be maintained while doing the same.
4. Navtej Singh Johar & Ors. v. Union of India (2018) : Hon. SC Decriminalised all consensual sex among adults, including homosexual sex by scrapping down section 377 of the Indian penal code (IPC). The court ruled that LGBTQ community are equal citizens and underlined that there cannot be discrimination in law based on sexual orientation and gender.
5. Anuradha Bhasin Judgement (2020) : The Supreme Court of India ruled that an indefinite suspension of internet services would be illegal under Indian law and that orders for internet shutdown must satisfy the tests of necessity and proportionality. The Court reiterated that freedom of expression online enjoyed Constitutional protection, but could be restricted in the name of national security. The Court held that though the Government was empowered to impose a complete internet shutdown, any order(s) imposing such restrictions had to be made public and was subject to judicial review.

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.
- 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	Constitution and Preamble	CO1	4	0	0	0	0
2	II	Fundamental Rights and Directive Principles	CO2	4	0	0	0	0
3	III	Governance and Amendments	CO3	4	0	0	0	0
4	IV	Electoral Literacy and Voter's Education	CO4	3	0	0	0	0
Grand Total				**15**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Assignment, Self-learning and Terms work Seminar/Presentation

Summative Assessment (Assessment of 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	1	-	-	-	2	-	-			
CO2	1	-	-	-	2	-	-			
CO3	1	2	-	-	2	-	1			
CO4	-	-	-	1	-	-	-			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	P.M.Bakshi	The Constitution of India	Universal Law Publishing, New Delhi 15th edition, 2018, ISBN: 9386515105 (Check the new edition)
2	D.D.Basu	Introduction to Indian Constitution	Lexis Nexis Publisher, New Delhi, 2015, ISBN:935143446X
3	B. K. Sharma	Introduction to Constitution of India	PHI, New Delhi, 6thedition, 2011, ISBN:8120344197

Sr.No	Author	Title	Publisher with ISBN Number
4	MORE READS :	Oxford Short Introductions - The Indian Constitution by Madhav Khosla. The Indian Constitution: Cornerstone of a Nation by Granville Austin. Working a Democratic Constitution: A History by Garnville Austin Founding Mothers of the Indian Republic: Gender Politics of the Framing of the Constitution by Achyut Chetan. Our Parliament by Subhash C. Kashyap. Our Political System by Subhash C. Kashyap. Our Constitution by Subhash C. Kashyap. Indian Constitutional Law by Rumi Pal.	Extra Read
5	B.L. Fadia	The Constitution of India	Sahitya Bhawan,Agra, 2017, ISBN:8193413768

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	http://www.legislative.gov.in/constitution-of-india	Constitution overview
2	https://en.wikipedia.org/wiki/Constitution_of_India	Parts of constitution
3	https://www.india.gov.in/my-government/constitution-india	Constitution overview
4	https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/	Fundamental rights and duties
5	https://main.sci.gov.in/constitution	Directive principles
6	https://legalaffairs.gov.in/sites/default/files/chapter%203.pdf	Parts of constitution
7	https://www.concourt.am/armenian/legal_resources/world_constitutions/constit/india/india-e.htm	Parts of constitution
8	https://constitutionnet.org/vl/item/basic-structure-indian-constitution	Parts of constitution

Note :

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

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Instrumentation & Control/ Industrial Electronics/ Instrumentation/ Medical Laboratory Technology/ Medical Electronics/**
Programme Code	**: AO/ DE/ EE/ EJ/ EP/ ET/ EX/ IC/ IE/ IS/ ML/ MU**
Semester	**: Third**
Course Title	**: BASIC PYTHON PROGRAMMING**
Course Code	**: 313011**

I. RATIONALE

Electronics based industries needs to deal with creating circuits design, simulation, signal processing and control systems which can be developed using Python. This course deals with the basics of python to enhance the programming skills of diploma students. The course will enable students to write python programs as well as use different python libraries to solve given problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences:
Develop programs using python to solve wide-reaching electronics engineering related problems.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Develop script to demonstrate use of basic building blocks of python.
- CO2 - Implement conditional and looping statements for given problem statement.
- CO3 - Perform operations on sequence structures in python.
- CO4 - Implement basics of object oriented programming concepts.
- CO5 - Create modules and packages for given purpose.

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	
313011	BASIC PYTHON PROGRAMMING	BPP	AEC	2	-	2	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50

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

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the given Keywords and Constants in Python. TLO 1.2 Use indentation, comments in the given program. TLO 1.3 Use different types of operators for writing expressions. TLO 1.4 Write python program using input output statements.	**Unit - I Basic Python's Constructs** 1.1 Introduction to Python- Python as scripting Language, Programming language Vs Scripting Language (C vs Python), Python's Technical Strength, Application in different domains 1.2 Python's building blocks- Identifiers, Keywords, Variables, Constants, Indentation, Comments in python 1.3 Python's Data Types – Numbers, Strings, List, Tuples, Dictionaries, Sets 1.4 Input and Output statements in python 1.5 Operators in Python- Operators as Arithmetic, Assignment, Unary Minus, Relational, Logical, Boolean, Bitwise, Membership, Identity, Operator precedence and Associativity	Presentations Lecture Using Chalk-Board Hands-on
2	TLO 2.1 Develop programs using Conditional Statements. TLO 2.2 Develop programs using Loop statements. TLO 2.3 Use statements to control the loops.	**Unit - II Control Statements in Python** 2.1 Types of Control Statements – Decision making statements, Looping statements 2.2 Decision Making Statements: - if, if….else, else-if ladder ,nested if and switch statement 2.3 Looping statement: - while loop, for loop, nested loop 2.4 Manipulating Loops- use of break, continue and pass statements	Lecture Using Chalk-Board Demonstration Hands-on Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Develop program to manipulate List for given purpose. TLO 3.2 Develop program to manipulate Tuples for given purpose. TLO 3.3 Develop program to manipulate Sets for given purpose. TLO 3.4 Develop program to manipulate Dictionaries for given purpose.	**Unit - III Data Structures in Python** 3.1 List- Defining List, Creating list, Accessing values from list, Updating the elements of a list, Concatenation of two lists, Repeating of Lists, Membership in list, Aliasing and cloning Lists, Methods to process Lists, Nested Lists 3.2 Tuples- Defining Tuple, Creating Tuples, Accessing the Tuple elements, Inserting elements in a Tuple, modifying elements of a Tuple, Deleting elements from a Tuple, Basic operations in Tuples, Functions to process Tuples, Nested Tuples 3.3 Sets- Defining Set, Creating a Set, Accessing elements from set, Add and update Set, Remove an elements from a Set, Built in functions with Set, Set methods to perform mathematical operations, other relevant set methods 3.4 Dictionaries- Defining Dictionary, Creating Dictionary, Accessing elements from Dictionary, Add and update Dictionary, Delete an element from a Dictionary, Built in functions of Dictionary, Methods to perform Dictionary	Demonstration Lecture Using Chalk-Board Hands-on
4	TLO 4.1 Use python built-in functions to perform tasks. TLO 4.2 Develop relevant user defined function for the given purpose. TLO 4.3 Define classes to create and access objects with its methods and attributes.	**Unit - IV Functions with Basic OOP concepts** 4.1 Python Functions- Use of python built in functions (e.g. type/data conversion functions, math and string functions), User defined function- Function definition, function calling, function arguments and parameter passing, Return statement, scope of variables (Global and Local Variables) 4.2 Basic OOP concepts- Introduction to object-oriented programming, Creating classes and objects, Constructors and Destructors in python, Data abstraction and Encapsulation	Demonstration Lecture Using Chalk-Board Hands-on
5	TLO 5.1 Develop a python module in python for given purpose. TLO 5.2 Develop a python package for given purpose. TLO 5.3 Use NumPy for performing mathematical operations on arrays. TLO 5.4 Use matplotlib to create data visualization in python.	**Unit - V Modules and Packages in Python** 5.1 Modules- Writing modules, importing module, python built in modules (Numeric and mathematical module, Functional Programming Module) 5.2 Python packages- Introduction, Writing python packages, using standard packages (NumPy, matplotlib) and user defined package statements	Demonstration Lecture Using Chalk-Board Hands-on

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 Install Python Integrated Development Environment.	1	a) Install and configure Python IDE. b) Write Python program to display message on screen.	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Use operators in Python.	2	*a) Write simple Python program to calculate equivalent registers connected in series and parallel. Accept values of R1, R2 and R3 from the user. *b) Write simple Python program to calculate value of voltage by applying Ohm's law. Accept value of Current(I) and Resistance(R) from the user.	2	CO1
LLO 3.1 Implement two-way branching statement.	3	Write program to check whether entered frequency is radio frequency or audio frequency.	2	CO2
LLO 4.1 Implement multi-way branching statement.	4	*a)Write program to display various radio frequency bands using if..elseif ladder. *b)Write program to display resistor color code using switch statement.	2	CO2
LLO 5.1 Implement control loops for solving iterative problems.	5	*a. Write a simple Python program to demonstrate use of control loops: i) while ii) do while *b. Create a simple program, to demonstrate use of: for loop in Python (e.g.: various pattern building, printing multiplication table, checking palindrome number etc.)	2	CO2
LLO 6.1 Perform basic operations on the Lists.	6	*Write Python program to perform following operations on List: a) Create b) Access c) Update d) Delete elements from list.	2	CO3
LLO 7.1 Execute various tuple operations.	7	Develop Python program to perform following operations on Tuples: a) Create b) Access c) Update d) Delete Tuple elements	2	CO3
LLO 8.1 Implement various set operations.	8	Write Python program to perform following operations on Set: a) Create b) Access c) Update d) Delete Access Set elements	2	CO3
LLO 9.1 Execute various operations on Dictionaries.	9	*Create a program to perform following operations on Dictionaries in Python: a) Create b) Access c) Update d) Delete e) Looping through Dictionary	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Use built-in mathematical functions and string functions in python.	10	a) *Create python program to demonstrate use of math built-in function. b) *Create python program to demonstrate use of string built-in function.	2	CO4
LLO 11.1 Create user defined functions in Python.	11	Write python programs to define function with arguments. a) Calculate factorial of a number b) Swapping of two variables	2	CO4
LLO 12.1 Implement function with default arguments.	12	Write programs to define function with default arguments.	2	CO4
LLO 13.1 Use built-in python mathematical modules.	13	*Create a program to demonstrate use of: Built-in module (e.g. numeric, mathematical functional and programming module) in Python.	2	CO5
LLO 14.1 Write user-defined module in python.	14	Write program to create a user-defined module (e.g.: building calculator) in python.	2	CO5
LLO 15.1 Use python built-in packages.	15	*Develop Python program to demonstrate use of NumPy package for creating, accessing and performing different array operations.	2	CO5
LLO 16.1 Implement user-defined packages in python.	16	Write program to demonstrate the use of user defined packages in Python.	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

- Not Applicable

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.
- 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

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	a) Computer System with all necessary peripherals and internet connectivity. b)Any relevant python IDE like IDLE/PyCharm/VSCode/Jupiter Notebook/Online Python Compiler.	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	Basic Python's Constructs	CO1	4	0	0	0	0
2	II	Control Statements in Python	CO2	4	0	0	0	0
3	III	Data Structures in Python	CO3	10	0	0	0	0
4	IV	Functions with Basic OOP concepts	CO4	6	0	0	0	0
5	V	Modules and Packages in Python	CO5	6	0	0	0	0
Grand Total				**30**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering – 60% weightage to process and – 40% weightage to product.

Summative Assessment (Assessment of Learning)

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

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Giancarlo Zaccone	Natural Computing with Python	BPB, ISBN:9789388511612
2	Martin C. Brown	Python: The Complete Reference	Tata McGraw Hill ISBN: 9789387572942
3	Yashwant Kanetkar	Let Us Python	BPB, ISBN: 978-9391392253
4	Kumar Naveen, Taneja Sheetal.	Python Programming: A modular approach	Pearson, ISBN: 978-9352861293
5	Mark Lutz and David Ascher	Learning Python	O'Reilly, ISBN: 978-1449355739
6	Paul Barry	Head First Python	O'Reilly, ISBN: 978-1449382674
7	John Guttag	Introduction to Computation and Programming Using Python	MIT Press, ISBN: 978-0262529624
8	David Beazley	Python Essential Reference	Addison-Wesley Professional, ISBN: 978-0672329784
9	Dr. R. Nageswara Rao	Core Python Programming	DREAMTECH PRESS, ISBN: 978-9386052308

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.programiz.com/python-programming	Python Programming
2	https://python-iitk.vlabs.ac.in/Introduction.html	Virtual Lab for Python Programming-Basic Constructs in Python
3	https://www.geeksforgeeks.org/python-programming-language/	Python Programming
4	https://intellipaat.com/academy/course/introduction-to-python-programming-free-course/	Online Course-Python Programming
5	https://www.w3schools.com/python/	Python Programming
6	https://www.tutorialspoint.com/python/index.htm	Python Programming
7	https://www.python.org/	Python Programming
8	https://spoken-tutorial.org/tutorial-search/?search_foss=Python+3.4.3&search_language=English	Spoken Tutorial on Python Programming

Note :

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

Programme Name/s : **Automation and Robotics/ Instrumentation & Control/ Instrumentation**
Programme Code : **AO/ IC/ IS**
Semester : **Third**
Course Title : **3D MODELLING & SIMULATION**
Course Code : **313014**

I. RATIONALE

3D simulation is the process of creating a three-dimensional virtual model of a product and testing it in a simulated environment before the final development for identifying potential problems in product design. This course will enable the diploma students to develop skills for comprehensive 3D simulation in-line with the industry demands for addressing real-world design challenges.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:
Graduates of 3D simulation course are expected to Integrate 3D simulation using CAD for creating real world projects.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Use fundamental commands for basic 3D modeling in open source CAD software
- CO2 - Create simple 3D models for a given application
- CO3 - Create assembly of complex 3D structure for a given application
- CO4 - Apply rendering and visually appealing features for a 3D model
- CO5 - Create real-world projects by applying advanced simulation techniques

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	
313014	3D MODELLING & SIMULATION	SIM	SEC	-	-	4	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50

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 Navigate the CAD software interface and locate basic tools. TLO 1.2 Develop a conceptual understanding of 3D simulation. TLO 1.3 Acquire the ability to use fundamental commands in CAD software for sketching, extrusion, and basic 3D modeling.	**Unit - I Introduction to 3D simulation** 1.1 Introduction to CAD software and its applications 1.2 Overview of the CAD software user interface 1.3 Basic sketching and drawing commands 1.4 Extrusion and basic 3D modeling 1.5 Introduction to simulation concepts	Model Demonstration Video Demonstrations Presentations Hands-on
2	TLO 2.1 Apply parametric design principles to create 3D models with adjustable parameters. TLO 2.2 Use assemblies in CAD software, allowing them to design simple automated components. TLO 2.3 Create a hands-on project involving simple 3D designs for a given application.	**Unit - II Creating Simple 3D Models** 2.1 Advanced sketching and parametric design 2.2 Constraints and relationships in CAD software 2.3 Creating simple assemblies for automation 2.4 Introduction to mechanical joints 2.5 Hands-on Project: Designing a basic automated component	Video Demonstrations Presentations Hands-on Model Demonstration Collaborative learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Apply commands in CAD software. TLO 3.2 Explore techniques for incorporating electronic components into 3D designs. TLO 3.3 Develop in creating complex assemblies in CAD software, considering interconnections and joints in automation.	**Unit - III Assembly of complex 3D structures** 3.1 Advanced 3D modeling Techniques 3.2 Incorporating electronics into 3D Designs 3.3 Advanced assembly techniques in CAD software 3.4 Interconnecting components 3.5 Complex structures and mechanisms	Model Demonstration Video Demonstrations Presentations Hands-on Collaborative learning
4	TLO 4.1 Apply the basics of rendering and visualization in CAD software. TLO 4.2 Apply materials to 3D models and understanding their impact on rendering .	**Unit - IV Rendering and Visualization** 4.1 Introduction to Rendering and Visualization 4.2 Applying materials to 3D models 4.3 Enhancing aesthetics in 3D model 4.4 Rendering realistic 3D model visualizations	Model Demonstration Video Demonstrations Presentations Hands-on Collaborative learning
5	TLO 5.1 Apply dynamic simulation techniques in CAD. TLO 5.2 Simulate structural integrity of components for various stress conditions. TLO 5.3 Apply their skills to a real-world simulation project.	**Unit - V Advanced Simulation Techniques** 5.1 Dynamic simulation principles 5.2 Simulating designed 3D model in CAD software 5.3 Stress analysis and structural Integrity 5.4 Real-world simulation project 5.5 Integration of Design, Rendering, and Dynamic Simulation	Model Demonstration Video Demonstrations Presentations Hands-on Collaborative learning

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 Installing properly the open source CAD software.	1	*Installation of open source CAD software (Fusion 360/ any other).	2	CO1
LLO 2.1 Explore User Interface. LLO 2.2 Explore key features of the software.	2	*Explore the user interface, key tools and features of CAD software.	2	CO1
LLO 3.1 Creating 2D shape according to the given dimensions.	3	*Creation of a given 2D shape using basic sketching tools.	2	CO1
LLO 4.1 Create, save, and export project files in CAD software.	4	*Creation of a basic 3D object from the given 2D object using extrude function.	2	CO1
LLO 5.1 Creating a new project. LLO 5.2 Upload and export project files in CAD software.	5	Design a new project, upload and export the same.	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Creating technical layout as per design specifications. LLO 6.2 Creating a document of the layout.	6	*Creation of a technical layout and document for a given 3D model.	2	CO1
LLO 7.1 Developing proficiency in exploring the utilization of CAD cloud-based collaboration features. LLO 7.2 Enabling effective team collaboration on cloud.	7	CAD cloud-based collaboration features.	2	CO1
LLO 8.1 Importing the given image. LLO 8.2 Creating a parametric design.	8	*Creation of a parametric design of a given image.	2	CO2
LLO 9.1 Designing an assembly of a 3D object. LLO 9.2 -Applying constraints for movement for a given 3D object.	9	Design an assembly with appropriate constraints for movement of a given 3D object.	2	CO2
LLO 10.1 Designing simple automated components. LLO 10.2 Applying parametric principles to the component.	10	Design a simple automated component using parametric principles.	2	CO2
LLO 11.1 Applying CAD animation tools. LLO 11.2 Creating simple animation.	11	*Creation of a simple animation of an given object using CAD animation tools.	2	CO2
LLO 12.1 Collaborate with a peer on an assembly project using cloud-based features.	12	*Collaboration using cloud-based features.	2	CO2
LLO 13.1 Explore shortcut and commands for 2D sketch. LLO 13.2 Apply the shortcut and commands to create a 2D sketch.	13	Creation of 2D sketch using shortcut and commands.	2	CO2
LLO 14.1 Explore shortcut and commands for 3D model. LLO 14.2 Apply the shortcut and commands to create a 3D model.	14	*Creation of 3D models using shortcut and commands.	2	CO2
LLO 15.1 Explore the difference between components and bodies. LLO 15.2 Create components for a given assembly.	15	Creation of components for a given assembly.	2	CO3
LLO 16.1 Demonstrate the ability to create assemblies with multiple components and joints.	16	*Demonstration of assembling of joints and components for a given 3D object.	2	CO3
LLO 17.1 Explore the features of CAD simulation function. LLO 17.2 Create a basic circuit.	17	Creation of a basic electronic circuits using CAD simulation function (Amplifier/ any other).	2	CO3
LLO 18.1 Apply design principles. LLO 18.2 Optimize mechanical parts for manufacturing.	18	*Application of design principles for optimizing a simple mechanical part.	2	CO3
LLO 19.1 Integrate various mechanical components.	19	Integrating mechanical components by using CAD software.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 20.1 Explore the features of mesh. LLO 20.2 Create a mesh body using 3D body.	20	Conversion of a given 3D body to a mesh body.	2	CO3
LLO 21.1 Create a given mesh body to 3D body.	21	Conversion of a given mesh body to a 3D body.	2	CO3
LLO 22.1 Develop a motion study of a assembly. LLO 22.2 Simulating its movement under different conditions.	22	*Conduction of a motion study for the given assembly.	2	CO3
LLO 23.1 Explore basic rendering concepts. LLO 23.2 Apply rendering function.	23	*Application of render function to a given simple 3D model.	2	CO4
LLO 24.1 Explore advanced rendering concepts. LLO 24.2 Apply advanced rendering function.	24	Application of render function to a complex 3D model.	2	CO4
LLO 25.1 Analyze different types of materials. LLO 25.2 Apply appropriate materials to enhance the aesthetics.	25	*Enhancement of aesthetics of a given model using various materials.	2	CO4
LLO 26.1 Explore different lighting effects. LLO 26.2 Apply appropriate lighting effects to enhance the visualizations.	26	Enhancement of visualizations of a given model by incorporating different lighting effects.	2	CO4
LLO 27.1 Perform stress analysis on components, ensuring structural integrity. LLO 27.2 Observe stress analysis.	27	*Stress analysis on a given object in 3D model.	2	CO5
LLO 28.1 Perform electronic cooling on components in 3D model. LLO 28.2 Observe electronic cooling.	28	*Electronic cooling on electronic devices in 3D model.	4	CO5
LLO 29.1 Apply simulation tools to a real-world project.	29	Develop real-world projects by applying simulation tools.	2	CO1 CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

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

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

Micro project

- Not Applicable

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.
- 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	Appropriate software suitable for process automation drawings like AutoDesk Inventor, FreeCAD, SolidWorks, AutoDesk Fusion 360 etc.	All
2	Personal Computer : 8GB RAM, 500 GB HDD, I3 or higher processor	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table) : NOT APPLICABLE

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For formative assessment of laboratory learning 25 marks.

Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester 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	2	1	1	2	1	1	2			
CO2	2	2	2	2	1	1	2			
CO3	2	2	2	2	1	1	2			
CO4	2	2	2	2	1	1	2			

CO5	2	3	3	3	1	1	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	Cameron Coward	A Beginner's Guide to 3D Modeling: A Guide to Autodesk Fusion 360	No Starch Press- 2019 (ISBN: 978-1593279264)
2	Randy H. Shih	Parametric Modeling with Autodesk Fusion 360	SDC Publications- 2023 (ISBN: 978-1-63057-610-3)
3	Paul J. Schilling, Randy H. Shih	Parametric Modeling with SOLIDWORKS	SDC Publications- 2024 (ISBN: 978-1-63057-626-4)
4	Daniel T. Banach, Shawna Lockhart, Sheila Markazi	Autodesk Inventor 2024 Essentials Plus	SDC Publications- 2024 (ISBN: 978-1-63057-589-2)
5	Kelly L. Murdock	Autodesk 3ds Max 2024 Basics Guide	SDC Publications- 2024 (ISBN: 978-1-63057-614-1)

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://help.autodesk.com/view/fusion360/ENU/courses/	Self-paced learning for Fusion
2	https://www.youtube.com/@adskFusion/featured	Autodesk Fusion 360
3	https://www.youtube.com/playlist?list=PLrOFa8sDv6jcp8E3ayUFZ4iNI8uuPjXHe	SolidWorks Tutorials for Beginners
4	https://www.youtube.com/@FreeCADAcademy	Study FreeCAD software
5	https://www.youtube.com/playlist?list=PLkMYhICFMsGYkVrkVbX4xngskLzxTBStJ	AutoDesk Inventor Complete Learning Tutorials. Starting from Beginners level
6	https://www.youtube.com/playlist?list=PLrZ2zKOtC_-DR2ZkMaK3YthYLErPxCnT-	Learn Autodesk Fusion 360 in 30 Days for Complete Beginners

Note :

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