CONTROL SYSTEM & COMPONENTS **Course Code : 313329**

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
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 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
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	**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.
	TLO 3.4 Select suitable composite continuous control action for controlling the given process control system.		
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.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	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
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

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Sr.No	Author	Title	Publisher with ISBN Number
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

Note :

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