GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM

COURSE TITLE: CONTROL INSTRUMENTATION SYSTEM

(Code: 3341701)

Diploma Programmes in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	4th semester

1. RATIONALE

In the present industrial scenario, it is desired that instrumentation diploma engineers be able to identify, classify, troubleshoot and maintain the different Control Instrumentation Systems. They are required to implement the planned Plant Control Instrumentation Systems. Therefore, this course has been designed so that students may learn to build, test and wire the different types of Control Instrumentation Systems for Process Application.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency

- learn to types of control system, modes of control action, response of control system and stability of control system for Process Application

3. Course Outcomes:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

I. Identify different types of control system

II. Determine transfer functions of simple systems by various methods

III. Determine stability of control systems using frequency response analysis (Bode plot/Polar plot/ Nyquist criteria).

IV. Use stability criteria (Routh, Hurwitz criteria) for system stability determination.

V. Analysis of simple system by time response method (up to second order & step input only)

VI. Interpret modes of control action.

4. Teaching and Examination Scheme

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	4	7	70	30	40	60	200

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit **ESE** - End Semester Examination; **PA** - Progressive Assessment**.**

5. COURSE DETAILS

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit – I INTRODUCTION TO CONTROL SYSTEMS	1a. Define: Plant, Process, System, Control system, Servo system, Open loop control system, closed loop control system. 1b. Classify types of control system. 1c. Explain open loop control system with block diagram and example. 1d. Explain closed loop with block diagram and example. 1e. Compare open loop and closed loop system. 1f. Define transfer function. 1g. Derive Transfer Function for simple one tank and two tank level system. 1h. Obtain mathematical model of simple mechanical and electrical system. 1i. Compare differential equations for the mechanical translational system, mechanical rotational system and series/parallel electrical system and prepare table for analogous quantities in force- torque and voltage/current analogy. 1j. Define block diagram. 1k. List rules for block diagram reduction. 1l. Derive T.F. of a single loop closed loop control system. 1m. State Mason's gain formula.	1.1. Control System. 1.2. Open Loop and Closed Loop Control System 1.3. Transfer function 1.4. Mathematical model of simple mechanical and electrical control system and analogy. 1.5. Block diagram Algebra. 1.6. Signal Flow Graph.

Unit	Major Learning Outcomes	Topics and Sub-topics
	1n. Derive transfer function from given simple signal flow graph.	
Unit – II **TIME RESPONSE ANALYSIS OF CONTROL SYSTEM.**	2a. List and draw Standard test signals. 2b. Explain Standard test signals with their equations. 2c. Define time response, transient response, steady state response. 2d. Define Characteristic equation, Order of the system and Type of the system. 2e. Explain time response of 1 st order system with unit step input. 2f. Explain time response of 2 nd order system with unit step input. 2g. Draw time response of second order system with unit step input and define following terms- delay time $t_{d,}$ rise time $t_{r,}$ peak time $t_{p,}$ maximum overshoot Mp, settling time ts.. 2h. Describe steady state error and error constant of control system for step, ramp, parabolic input and type-0, 1, 2 systems.	2.1. Standard test signals. 2.2. Time response. 2.3. Time Response of first order system to step input. 2.4. Time Response of second order system to step input. 2.5. Time Response specifications of the second order system. 2.6. Steady-state errors and error constants
Unit – III **CONCEPT OF STABILITY**	3a. Describe concept of stability. 3b. Classify Control system stability according to location of the roots of characteristic equation (poles of the system). 3c. State necessary conditions for stability. 3d. State Routh-Hurwitz Criteria for stability. 3e. Determine stability of given characteristic equation using Routh-Hurwitz Criteria. 3f. Describe concept of root locus in brief	3.1. Stability 3.2. Routh-Hurwitz Criteria for stability. 3.3. Introduction to Root Locus Concept.

Unit	Major Learning Outcomes	Topics and Sub-topics
	3g. State the rules for construction of Root Locus.	
Unit – IV **FREQUENCY RESPONSE ANALYSIS**	4a. Describe concept of Polar plot in brief. 4b. Describe concept of Bode plot in brief. 4c. Define gain margin and phase margin. 4d. State Nyquist stability statement. 4e. Describe concept of Nyquist stability criteria in brief.	4.1. Polar plot 4.2. Bode plot 4.3. Gain Margin & Phase Margin 4.4. Nyquist Stability Criterion.
Unit – V **MODE OF CONTROL ACTION**	5a. Define Process terminologies 5b. Classify modes of control action. 5c. Explain two positions, Multi position, P, I, D and composite mode control action. 5d. Sketch output for various modes of control action for step changes only. 5e. Compare various modes of control action. 5f. Define feed forward, cascaded control, Spilt range control and Ratio control system.	5.1. Process terminologies: process equation, process load, process lag, self regulation, measurement lag, control lag, transportation lag, dead time, cycling 5.2. Discontinuous and continuous modes control action 5.3. Concept of Two position ,Multi position control action 5.4. Concept of P, I, D, P+I, P+D, P+I+D mode of control action. 5.5. Introduction to feed forward, cascaded, Spilt range, Ratio control system.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**INTRODUCTION TO CONTROL SYSTEMS**	**12**	**7**	**10**	**4**	**21**
II	**TIME RESPONSE ANALYSIS OF CONTROL SYSTEM**	**10**	**6**	**6**	**2**	**14**
III	**CONCEPT OF STABILITY**	**06**	**4**	**08**	**2**	**14**
IV	**FREQUENCY RESPONSE ANALYSIS**	**06**	**4**	**4**	**2**	**10**
V	**MODE OF CONTROL ACTION**	**08**	**2**	**4**	**5**	**11**
	Total	**42**	**23**	**32**	**15**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills **(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain*

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	Identify various control parameters viz. set point, controlling variable, actuating signal, controlled variable, manipulated variable etc. in a given control loop.	02
2	I	Identify various blocks of a given open loop system.	02
3	I	Identify various blocks of a given closed loop system	02
4	I	Convert an open loop system in to a closed loop and observe the difference in output using control simulator.	02
5	I	Obtain mathematical model for a single tank system and compare the same with control simulator derived.	02
6	I	Obtain mathematical model for two non-interacting tank system and compare it with control simulator derived.	02
7	I	Obtain mathematical model for two interacting tank system and compare it with control simulator derived.	02
8	I	Obtain transfer function of given electrical systems.	02
9	I	Obtain transfer function of given mechanical systems.	02

10	I	Obtain equivalent voltage analogous system (series electrical system) from given mechanical translational motion system (mass-spring-dashpot).	02
11	I	Obtain equivalent current analogous system (parallel electrical system) from a given mechanical translational motion (mass-spring-dashpot) system.	02
12	I	Obtain equivalent voltage analogous system (series electrical system) from given mechanical rotational motion system.	02
13	I	Obtain equivalent current analogous system (parallel electrical system) from given mechanical rotational motion system.	02
14	I	Derive transfer function for a given block diagram using control simulator.	02
15	I	Derive transfer function using signal flow graph with control simulator.	02
16	II	Observe output of first order system with control simulator. Compare it with theoretical output and find out reasons if there is any difference.	02
17	II	Observe output of second order system with control simulator. Compare it with theoretical output and find out reasons if there is any difference.	02
18	II	Compare various parameters of time response and frequency response for given system using control simulator.	02
19	II	Calculate Kp, Kv, Ka error constant for a given type -0 system .	02
20	II	Calculate Kp, Kv, Ka error constant for a given type -1 system..	02
21	II	Calculate Kp, Kv, Ka error constant for a given type -2 system.	02
22	II	Calculate t_d, t_r, t_p, M_p, t_s, e_{ss} for a given second order system.	02
23	III	Find out roots of a given transfer function and decide stability.	02
24	III	Determine stability for various system using Hurwitz criteria.	02
25	III	Determine stability for various system using Routh criteria.	02
26	IV	Obtain root locus for a given system using control simulator.	02
27	IV	Obtain bode plots for a given system using control simulator and calculate gain margin and phase margin.	02
28	IV	Observe the effect of increasing and decreasing gain margin and phase margin for given system using control simulator.	02
29	IV	Obtain nyquist plot for a given system using control simulator.	02
30	IV	Obtain polar plot for a given system using control simulator.	02
Total			**60**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

- Do analysis of First & Second Order Control System using various free control simulators.
- Develop simple program for different control actions.
- Use Internet Surfing relevant to Automation & Control Systems.
- Prepare Presentation on given topics.

9. SPECIAL INSTRUCTIONAL STRATEGIES

i. Visit to Industries.

ii. Use Free Simulators Software for teaching / learning activities.

iii. Show Video/Animation Films relevant to Automation & Control System.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Control Systems Engineering	Nagrath & Gopal	New Age International
2.	Linear Control System	B.S.Manke	Khanna publication
3.	Feed back Control Systems	Dr. S D. Bhide & Barapte	Tech max Publication
4.	Control Systems Engineering	S.K. Bhattcharya	Pearson Education
5.	Process Control Instrumentation Technology	C.D. Johnson	PHI
6.	Automatic Control system	Syed Hasan Saeed	S.K. Kataria &Sons

B) List of Major Equipment/ Instrument with Broad Specifications

- Process Control Trainer
- Process control simulator

B) List of Software/Learning Websites:

MATLAb,
Labview

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S. Z. Shyara**, Sr. Lecturer, IC, A.V.P.T.I. Rajkot
- **Prof. R. J. Dhruv** , Sr. Lecturer, IC, A.V.P.T.I., Rajkot
- **Prof. N. B. Mehta**, Sr. Lecturer, IC, GP, AHMEDABAD
- **Prof. R. P. Raiyani**, I/C Head, Christ Polytechnic Institute Rajkot

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering.
- **Prof. (Mrs.) Susan S. Mathew**, Associate Professor, Department of Electrical and Electronics Engineering.