GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)

Semester- IV

Course Title: Instrumentation Simulation & Practices

(Course Code: 4341704)

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

1. RATIONALE

In the present industrial scenario, diploma engineering students should be able to understand, simulate, and analyze the prevalent Process Control Systems in the industry. They are required to foresee the effects of changes in the various process parameters on the system behavior before actual implementation of the Plant Control System. Therefore, this course has been designed so that students can familiarize themselves with various simulation software tools to build and simulate the different types of Control Systems for Process Application.

2. COMPETENCY ('Program Outcome' according to NBA Terminology)

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:

- **Analyze the different types of Instrumentation and Control systems behavior for process application using simulation software.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

I. CO1: Recognize appropriate instrumentation simulating and analyzing software.
II. CO2: Simulate the circuit using simulation software used in Instrumentation.
III. CO3: Use virtual instrumentation simulation software to test different systems.
IV. CO4: Generate the output plot relevant to input for different process control loops using appropriate simulation software.
V. CO5: Simulate different control actions using appropriate simulation software.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
0	0	4	2	0	0	25*	25	50

(*): For this practical only course, 25 marks under the practical CA have two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15 marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

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

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	To Study the function and Importance of simulating software in instrumentation and control engineering.	1	2
2	Perform Installation of simulation software in a given system and familiarize with features/specifications of simulation software.	1	2
3	Perform basic commands in the given simulation software.	1	2
4	Verify Kirchhoff's Voltage Law (KVL) and analyze the input-output for a given circuit using simulation software.	1	2
5	Verify Kirchhoff's Current Law and analyze the input-output for a given circuit using simulation software.	1	2
6	Simulate rectifier circuit and analyze its input-output the using simulation software.	1	2
7	Simulate a circuit to demonstrate the use of semiconductor devices and analyze its input-output plot using simulation software.	1	2
8	Simulate a circuit to demonstrate the use of optoelectronic devices and analyze its input-output plot using simulation software.	1	2
9	Simulate an analog AC (Alternative Current) circuit and analyze its input-output plot using simulation software.	1	2
10	Simulate an analog DC (Direct Current) circuit and analyze its input-output plot using simulation software.	1	2
11	Simulate a given digital circuit and analyze its input-output plot using simulation software.	1	2
12	Simulate a circuit to demonstrate the use of relay and analyze its input-output plot using simulation software.	1	2
13	Simulate and analyze the input-output for basic instruments viz indicators, recorders (Cathode Ray Oscilloscope (CRO), Multimeter, Function generator, Signal generator, Voltage source, Current source) using simulation software.	1	4
14	Simulate a circuit to perform mathematical operations like addition, subtraction, Integration, and Differentiation using an Operational Amplifier (Op-Amp), then analyzes its input-output plot using simulation software.	1	4

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
15	Simulate an instrumentation amplifier circuit and analyze its input-output plot using simulation software.	1	2
16	Simulate a circuit to demonstrate the function of the Stepper Motor and analyze its input-output plot using simulation software.	1	2
17	Simulate level measurement and analyze its input-output plot using simulation software.	1	2
18	Simulate flow measurement and analyze its input-output plot using simulation software.	1	2
19	Simulate temperature measurement and analyze its input-output plot using simulation software.	1	2
20	Simulate pressure measurement and analyze its input-output plot using simulation software.	1	2
21	Simulate relative humidity measurement and analyze its input-output plot using simulation software.	1	2
22	Simulate relative distance measurement and analyze its input-output plot using simulation software.	1	2
23	Simulate light Intensity measurement and analyze its input-output plot using simulation software.	1	2
24	Simulate soil moisture measurement and analyze its input-output plot using simulation software.	1	2
25	Simulate the level control system and analyze the input-output plot of the system for step input using simulation software.	1	2
26	Simulate a simple feedback control loop for a given process parameter and analyze the input-output plot by varying set-point in simulation software.	1	4
27	Simulate On-Off control action on temperature control system and analyze its input-output plot for step input using simulation software.	1	2
28	Simulate On-Off control action on level control system and analyze its input-output plot for step input using simulation software.	1	2
29	Simulate P-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot by varying Kp of P-control action using simulation software.	1	2

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
30	Simulate I-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot by varying Ki of I-control action using simulation software.	1	2
31	Simulate P+I-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot by varying Kp and Ki of P+I-control action using simulation software.	1	2
32	Simulate P+D-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot by varying Kp and Kd of P+D-control action using simulation software.	1	2
33	Simulate P+I+D-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot by varying Kp, Ki, and Kd of P+I+D-control action using simulation software.	1	4
34	Simulate tuning of P+I+D-control action on a given system for a given step/ramp input and set point, then analyze the input-output plot using simulation software.	1	4
35	Simulate a simple feed-forward loop for a given process parameter and analyze the input-output plot by varying set point in simulation software.	1	2
36	Simulate FOPDT (First Order Plus Dead Time) model and analyze the input-output plot for step input in simulation software.	1	2

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry-relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above-listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Understanding of the problem.	20
2	Approach of solving a problem.	20

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
3	Preparation of Algorithms.	10
4	Efficiency of the code.	20
5	Overall observations from the Simulation.	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

i. Computer with basic configuration with windows or Unix OS.
ii. Simulation Software/ Tools like. MATLAB, LABVIEW, VLAB, ORCAD, myopenlab, PARTSIM, easyeda, tinkercad, PSPICE, PROTEUS, QUCSSTUDIO, Octave, and Scilab.

S. No.	Equipment Name	Pro No.
1	Computer (Latest version)	01 to 36

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical appliances.
c) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of Revised Bloom's taxonomy in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
Unit – 1	1a.	Explain the importance of Virtual Instrumentation.	1.1.1	Virtual Instrumentation for Test, Control, and Design.

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
Simulation	1b.	Explain the utilization of Block diagrams in Virtual Instrumentation.	1.2.2	Utilization of Block diagram in Virtual Instrumentation.
	1c.	Explain simulation steps using programming in simulation software.	1.3.1	Writing script for programming.
			1.3.2	Debugging the script for programming.
			1.3.3	Programming using blocks.
			1.3.4	Modeling and Simulation
	1d	Explain steps to create Graph and Chart in simulation software.	1.4.2	Chart
			1.4.3	X-Y Graph

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	**Simulation**	**Not Applicable**				

***Legends:** R = Remember; U = Understand; A = Apply and above levels (Bloom's revised 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.*

10. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Students may be asked to collect photographs using the internet which is relevant to field application of various topics and have to prepare learning materials using it.
ii. Teachers guided self-learning activities through internet/ lab based mini projects, industrial visit etc.
iii. Students activities like: course/ topic based seminars, Internet based assignments.
iv. Students should deliver a seminar in groups on Simulation software.
v. Visit library and collect information from various magazines on recent developments in simulation software used in Instrumentation & control engineering and its applications and then make report of that.

vi. Students can join various channels / pages of simulation software used in Instrumentation & control engineering on social media and conduct group discussion on learned topics.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Use Free Simulators Software for teaching / learning activities.
ii. Show Video/ Animation Films relevant to Process Automation and Control System.
iii. Internet-based home assignments.
iv. Mini project.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that he/she contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a. Study of First and Second Order Control System using various simulation software.
b. Develop a simple simulated instrumentation and process control system for different control actions strategies.
c. Develop a simple simulation to check input and output for different types of sensor using various simulation software.
d. Develop a simple simulation to check input and output for different types of analog and digital circuits using various simulation software.
e. Prepare Presentation on given topics.

13. SUGGESTED LEARNING RESOURCES

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Sr. No.	Title of Books	Author	Publication

1	Process Control: Modeling, Design, and Simulation, Prentice Hall PTR, 2002.	B. WayneBequette	Publisher : Prentice Hall India Learning Private Limited, ISBN-10 8120322657, ISBN-13 8120322653-978 :
2	Circuit Analysis with Multisim	David Baez-Lopez and Felix Guerrero-Castro	Publisher : Morgan & Claypool, ISBN : 10- 1608457567, ISBN : 13-160845756-978 .
3	A Guide to MATLAB: For Beginners and Experienced Users	Ronald L. Lipsman, Jonathan Rosenberg	Publisher :Cambridge University Press.
4	Getting Started with Matlab 7: A Quick Introduction For Scientists And Engineers	Rudra Pratap	Publisher : Oxford University press.
5	LabVIEW 7 Express Student Edition	Robert Bishop	Publisher : PHI Learning, New Delhi
6	LabVIEW™ Basics II Course Manual PDF	Worldwide TechnIcal Support and Product Information ni.com	Publisher : National Instruments Corporate.
7	Instrumentation Control, Data Acquisition and Processing with MATLAB	Fornetti Francesco	Publisher : Explore RF Ltd, ISBN-10 : 0957663501, ISBN-13 : 978-0957663503.
8	LabVIEW based Advanced Instrumentation Systems	S. Sumathi	Publisher : Springer, ISBN-10 : 3540485007, ISBN-13 : 978-3540485001.
9	Virtual Instrumentation using LABVIEW	Sanjay Gupta	Publisher : McGraw Hill Education, ISBN-10 : 0070700281, ISBN-13 : 978-0070700284.
10	Instrumentation Design Studies	Ernest Doebelin	Publisher : CRC Press, ISBN-10 : 1439819483, ISBN-13 : 978-1439819487.
11	System Simulation Techniques with MATLAB and Simulink	D Xue (Dingyü Xue)	Publisher : John Wiley & Sons Inc, ISBN-10 : 1118647920, ISBN-13 : 978-1118647929.
12	MATLAB Control Systems Engineering	Cesar Lopez	ASIN : 1484202902 Publisher : Apress, ISBN-10 : 9781484202906, ISBN-13 : 978-1484202906.

13	Getting Started with Simulink	Luca Zamboni	Publisher : Packt Publishing , ISBN-10 : 178217138X, ISBN-13 : 978-1782171386.
14	Introduction to Multisim Schematic Capture and SPICE Simulation	Janell Rodriguez and Erik Luther	Publisher : CNX
15	Complete PCB Design Using OrCAD Capture and PCB Editor	Kraig Mitzner	Publisher : Newnes (Butterworth-Heinemann Ltd), ISBN-10 : 0750689714, ISBN-13 : 978-0750689717.
16	VIRTUAL INSTRUMENTATION USING LabVIEW	Jovitha Jerome	Publisher:PHI Learning Private Limited, ISBN-978-81-203-4030-5.
17	Arduino-based embedded systems : interfacing, simulation, and LabVIEWGUI	Rajesh Singh, Anita Gehlot, Bhupendra Singh and Sushabhan Choudhury	Publisher: Taylor & Francis, CRC Press, Identifiers: LCCN 2017029926 ISBN 9781138060784 (hardback : alk. paper) ISBN 9781315162881 (ebook)

14. List of Software/Learning Websites

A. www.nptel.com
B. https://www.vlab.co.in/
C. https://www.scilab.org/
D. https://dwsim.org/
E. https://matlab.mathworks.com/
F. https://www.multisim.com/
G. https://octave.org/
H. https://www.orcad.com/
I. http://www.scicos.org/
J. http://qucsstudio.de/
K. https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html
L. https://www.tango-controls.org/
M. https://www.ni.com/en-in/shop/labview/select-edition/labview-community-edition.html
N. https://www.myopenlab.org/inicio/descargar-myopenlab/
O. https://www.coursera.org/
P. http://www.edx.org/
Q. https://www.simscale.com/
R. https://openmodelica.org/
S. https://www.vlab.co.in/broad-area-electronics-and-communications
T. https://www.vlab.co.in/broad-area-electrical-engineering
U. https://wokwi.com/projects/new/arduino-uno

V. https://www.tinkercad.com/things/dEOWWJatCtv-arduino-simulator
W. https://www.circuitlab.com/accounts/login/?next=/workbench/
X. https://easyeda.com/editor
Y. https://www.partsim.com/
Z. https://www.simulator.io/
AA. https://www.falstad.com/circuit/

15. PO-COMPETENCY-CO MAPPING

Semester IV	Instrumentation Simulation & Practices (Course Code: 4341704)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**"Simulate different types of Instrumentation and Control Systems for process application and analyze system behavior."**						
CO1: Recognize an appropriate instrumentation simulating and analyzing software.	2	1	1	2	1	1	3
CO2: Simulate the circuit using simulation software used in Instrumentation.	1	1	2	1	1	1	3
CO3: Use virtual instrumentation simulation software to test different systems.	3	2	2	2	1	2	2
CO4: Generate the output plot relevant to input for different process control loops using appropriate simulation software.	3	2	2	1	1	1	2
CO5: Simulate different control actions using an appropriate simulation software.	3	2	2	1	1	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the irrelevant correlation of each competency, CO, with PO/ PSO*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

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Prof. U. P. Soni, IC Engineering, Government Polytechnic, Ahmedabad.

Prof. M P Girnari, IC Engineering, AVPTI, Rajkot.