TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

CONTROL SYSTEM LABORATORY

by

Surya Darma, M.Si

Undergraduate Program in Physics
Faculty of Mathematics and Natural Sciences
Universitas Indonesia
Depok
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UNIVERSITAS INDONESIA
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
PHYSICS UNDERGRADUATE STUDY PROGRAM

TEACHING INSTRUCTIONAL DESIGN

Course Name	Control System Laboratory	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
Course Code	SCPH603715	1	Electronics 2	-	-
Relation to Curriculum	-				
Semester	6				
Lecturer(s)	Surya Darma, M.Si				
Course Description	After finishing this course, students taking the concentration of Instrumentational Physics in the 7th term is able to explain the principals of a control system, select and chose the transfer function and the control system for specific applications, and is able to design a control system for a certain proces. The instructional language used in this course will be the Indonesian language.				

Program Learning Outcome (PLO)	
Sub-PLO 1	To measure electrical and magnetic physical units.

Sub-PLO 2	To process the data made from experiments and produce a final measurement.
Sub-PLO 3	To apply advanced electronics concepts in an embedded system environment.
Sub-PLO 4	Applying concepts in Physics in botch society and livelihood.
Sub-PLO 5	Applying the concepts thought form system and instrumentational physics.
Course Learning Outcome (CLO)	
CLO	Students are able to analyze (C4) concepts used in embedded systems and operation systems as well as apply (P4) the Assembly and C programming language in a day-to-day basis to solve problems (A5). (ELO(s) 3, 5, 6, 8)
Sub-CLO	
Sub-CLO 1	Able to explain the basic principles of Control Systems. (C2)
Sub-CLO 2	Able to determine and select the transfer function and control system of certain applications. (C3)
Sub-CLO 3	Able to design a control system for a certain process. (C4)

Study Materials	• Introduction to Labview • State Variables • Time Response • PID (Proportional, Integral and Differential) • PID Tuning • Controlling an Inverted Pendulum • HVAC (Heating, Ventilation and Air Conditioning) • Capita Selecta
Reading List	• National Instruments Corporation, LabVIEW Fundamentals, ni.com, 2005 • Sulaymon Eshkabilov, Beginning MATLAB and Simulink: From Novice to Professional, Apress, Fargo, USA, 2019 • Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017. • Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. • Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017. • Quanser, QNET DC Motor Trainer, QNET Rotary Pendulum Trainer, QNET Heating and Ventilation Trainer, 2011.

Teaching Plan

Week	Sub-CLO	Study Materials [with reference]	Teaching Method [with est. time]	Learning Experiences (*O-E-F)	Sub-CLO Achievement Indicator		Sub-CLO Weight on Course (%)
					General	Specific	
1	2	Introduction to LabVIEW and MATLAB a. Introduction to LabVIEW b. Introduction to MATLAB [Reference] 1. National Instruments Corporation, LabVIEW Fundamentals, ni.com, 2005 2. Sulaymon Eshkabilov, Beginning MATLAB and Simulink: From Novice to Professional, Apress, Fargo, USA, 2019 3. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017. 4. Golnaraghi, Farid., and Kuo, Benjamin	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (60%) Feedback: Question and answer	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%

		C., Automatic Control System, 10th ed. McGraw Hill Education., 2017.		with the lecturer (30%)			
2	2	State Variables a. Introduction to the variables in a control system b. Signal-Flow graphs and Block Diagram Models c. Time Response and Condition Transition Matrix d. Techniques for Linearizing Systems [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017. 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017.	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (60%) Feedback: Question and answer with the lecturer (30%)	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%
3	2	Times Response Towards Various Standard Signals and Response System Control Towards Various Standard Signals a. Signal Testing for Time Response and Control Systems b. Steady State Errors c. Transient Response for a Prototype	Laboratory work, simulations, creating a report [Estimated time]	Orientation: Introduction to this week's topic (10%) Exercise:	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%

		Controlling the speed and position of a DC Motor [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017. 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017.	200 minutes	Listen to lecture (60%) Feedback: Question and answer with the lecturer (30%)			
4	2	PID (Proportional, Integral and Differential) and determining the PID Parameters (Trial and Error) a. Operational Systems b. Performance Criterions for a Closed System c. Model-Based Design Methods d. Controller Tuning Relations [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. 3. Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (50%) Feedback: Question and answer with the lecturer (40%)	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%

		and Control, 4th ed., John Wiley & Son., 2017.					
5	Mid Term Exam Presenting a proposal that is required to do the final project						
6	2	Determining the parameters for a PID using the Direct Synthesis and Ziegler Nichols Reaction Curve Method and applying it towards a DC motor a. Standard Model for a Transfer Function b. Applying the PID c. Direct Synthesis d. Ziegler Nichols Reaction Curve e. Techniques for data processing [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. 3. Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (50%) Feedback: Question and answer with the lecturer (40%)	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%
7	2	Controlling an Inverted Pendulum a. Force Analysis and System Equations b. State Space c. Transfer Functions	Laboratory work, simulations,	Orientation: Introduction to this	Able to report the result of the experiment and	Able to apply what has been learned throughout the module in a final	12%

		d. Controlling an Inverted Pendulum [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. 3. Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017.	creating a report [Estimated time] 200 minutes	week's topic (10%) Exercise: Listen to lecture (50%) Feedback: Question and answer with the lecturer (40%)	simulate it in a report based on the rules that apply	simulation using the specific sensor.	
8	2	HVAC (Heating, Ventilation and Air Conditioning) a. Process Control b. Motion Control c. Task Based Control d. HVAC Control [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. 3. Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (50%) Feedback: Question and answer	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%

		and Control, 4th ed., John Wiley & Son., 2017. 4. Quanser, QNET DC Motor Trainer, QNET Rotary Pendulum Trainer, QNET Heating and Ventilation Trainer, 2011.		with the lecturer (40%)			
9	2	Capita Selecta a. VTOL Control b. Mechatronics Sensor and Control c. EMG Signal Processing (Myoelectric Control) [Reference] 1. Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017 2. Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. 3. Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017. 4. Quanser, QNET DC Motor Trainer, QNET Rotary Pendulum Trainer, QNET Heating and Ventilation Trainer, 2011.	Laboratory work, simulations, creating a report [Estimated time] 200 minutes	Orientation: Introduction to this week's topic (10%) Exercise: Listen to lecture (50%) Feedback: Question and answer with the lecturer (40%)	Able to report the result of the experiment and simulate it in a report based on the rules that apply	Able to apply what has been learned throughout the module in a final simulation using the specific sensor.	12%
10	Final Exam Presenting the final project made after the mid term exam						

Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
1	Evaluation of sub-CLO 1	1	Doing assignments in EMAS	• MATLAB • Labview • Mathematical System Models • Transfer Functions • Simple Control Systems	Individual Tasks on EMAS	40 minutes	Assignment Sheet on EMAS
2	Home Group Discussion	2	Discussion in Ms. Teams	State Variables • Introduction to variables in a system • Signal-Flow graph and Block Diagram Models • Time Response and Condition Transition Matrix • Techniques on Linearizing a system	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results
2	Simulation	2	Doing simulations on state variables that is allowed	Creating a mathematical model, transfer function, determining the variables and response of a system designed using linearization techniques.	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link

3	Home Group Discussion	2	Discussion in Ms. Teams	System Response Towards Various Standard Signals and Control Techniques on Response Systems towards Varoius Standard Signals • Signal testing for Time Response form a Control System • Steady State Errors • Transient Response from a Prototype • Speed Control and Position Control on a DC Motor	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results
3	Simulation	2	Doing simulations on open and closed loop control systems in one of the allowed simulators	Response time of every open and closed control systems.	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link
4	Home Group Discussion	2	Discussion in Ms. Teams	PID (Proportional, Integral, and Derivative) and determining the PID Parameters (Trial and Error) • Operational Principles • Performance Criterions for a Closed System • Model-Based Design Methods	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results

				• Controller Tuning Relations			
4	Simulation	2	Doing simulations on complex closed loop systems in one of the allowed simulators	Characteristics of a PI, PD and PID system and determining its parameters	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link
4	Presentation and Focus Group Discussion	2	Presentation and Discussion on MsTeams	PD, PI and PID Control Systems	Group Presentation, Synchronus on MsTeams	60 minutes	Rubric Scoresheet
5	Mid Term Exam	1,2,3	Presenting the progress that has been made on the final project	Includes all models designed based on the transfer function and early simulations			
6	Home Group Discussion	2	Discussion in Ms. Teams	PID (Proportional, Integral, and Derivative) and determining the PID Parameters (Direct Synthesis) • Standard Transfer Function Model • Application of the PID • Direct Synthesis • Ziegler Nichols Reaction Curve • Techniques on Data Processing	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results

6	Simulation	2	Doing simulations on PID Tuning using the Direct Synthesis and Ziegler Nichols Reaction Curve emthods in one of the allowed simulators	Characteristics of a PID system while tuning it using the Direct Synthesis and Ziegler Nichols Reaction Curve Method	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link
6	Presentation and Focus Group Discussion	2	Presentation and Discussion on MsTeams	Characteristics of the PID and applying the Direct Synthesis and Ziegler Nichols Reaction Curve Method	Group Presentation, Synchronus on MsTeams	60 minutes	Rubric Scoresheet
7	Home Group Discussion	2	Discussion in Ms. Teams	Contorl on an Inverted Pendulum • Force Analysis and System Equations • State Space • Transfer Functions Control of an Inverted Pendulum	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results
7	Simulation	2	Doing simulations on an inverted pendulum in one of the allowed simulators	Characteristics on controlling the Inverted Pendulum	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link

7	Presentation and Focus Group Discussion	2	Presentation and Discussion on MsTeams	Characteristics on controlling the Inverted Pendulum	Group Presentation, Synchronus on MsTeams	60 minutes	Rubric Scoresheet
8	Home Group Discussion	2	Discussion in Ms. Teams	HVAC (Heating, Ventilation and Air Conditioning) • Process Control • Motion Control • Task Based Control • HVAC Control	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results
8	Simulation	2	Doing simulations on the process, motion and is tas-based on an HVAC control in one of the allowed simulators	Characteristics on a HVAC Control System	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link
8	Presentation and Focus Group Discussion	2	Presentation and Discussion on MsTeams	Characteristics on a HVAC Control System	Group Presentation, Synchronus on MsTeams	60 minutes	Rubric Scoresheet
9	Home Group Discussion	2	Discussion in Ms. Teams	Capita Selecta • VTOL Control • Mecharonics Sensor and Control • EMG Signal Processing	Group Discussion, Synchronus on MsTeams	60 minutes (outside of class)	Video recording or discussion results

9	Simulation	2	Doing simulations on motion based control on a VTOL / Mechatronic or a Myoelectric System in one of the allowed simulators	Characteristics of a Control System (VTOL, Mechatronics Systems or Myoelectric)	Making a video on the simulation	120 minutes	Uploading the video on EMAS / Youtube and report the link
9	Presentation and Focus Group Discussion	2	Presentation and Discussion on MsTeams	Characteristics of a Control System (VTOL, Mechatronics Systems or Myoelectric)	Group Presentation, Synchronus on MsTeams	60 minutes	Rubric Scoresheet
10	Evaluation of sub-CLO 2	2	Answering Questions in EMAS	• State Variables • Time Response Towards various Standard Signals • Controlling Techniques of a Response System towards Various Standard Signals • PID (Proportional, Integral, Derivative) • Determining the PID Parameters • DC Motor • Control of an Inverted Pendulum	Individual Tasks on EMAS	100 minutes	Assignment Sheet on EMAS

				• HVAC (Heating, Ventilation and Air Conditioning)			
10	Final Exam	1,2,3	Presenting the final result of the group project that has been accepted after the proposal	Involves all control systems that is used throughout the course and other hardware	Group Task on EMAS	100 minutes	Video uploaded on EMAS and submitting the rubric answersheet

Assessment Criteria

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Discussion	2	Discussion Rubric	7x	20%
Presentations and QnA	2, 3	Presentation Rubric	7x	10%
Sub-CLO Evaluation Assignments	1, 2	Multiple Choice Questions / Short Fill-in Questions on EMAS	2x	20%
Laboratory Work	2	Simulations and Reports	8x	30%
Mid Term Exam	1, 2, 3	Presentation on MsTeams	1x	10%
Final Term Exam	1,2,,3	Presentation on MsTeams	1x	10%
Total				**100**

Conversion of the students final score

Score	Grade	Equivalent
85—200	A	4,00
80—<85	A-	3,70
75—<80	B+	3,30
70—<75	B	3,00
65—<70	B-	2,70
60—<65	C+	2,30
55—<60	C	2,00
40—<55	D	1,00
<40	E	0,00

Rubric(s)

A. Criterions for answering the Essai Questions (Simulations, Mid Term Exam and Final Exam)

Grade	Quality of Answer
100	All answers are precise, every definition and main components are fulfilled
76-99	Most answers are precise, the definition and main components are mostly fulfilled
51-75	Only a few answers are precise, most definitions and main components are less complete
26-50	If the student is able to fulfill between 55% and 59% of the rules that apply in creating a report.
<25	If the student is able to fulfill between 50% and 54% of the rules that apply in creating a report.

B. Criterions for the Group Presentation

No	Category	4	3	2	1
1	Group Cooperation	The partner cooperates throughout the experiment while accepting a specific task and is responsible towards it.	The partner cooperates throughout the experiment while accepting a specific task but is not very responsible towards it.	The partner is less likely to cooperate throughout the experiment even though he/she still accepts a certain specific task but is not very responsible	The partner rarely cooperates, does not want to accept a certain task.
2	Mastery of the material	Understands and masters the course's materials and presents it without text	Does not fully understand the materials in the course but presents without using text	Does not fully understand the materials in the course while using texts during the presentation	Does not understand the materials
3	Presentation Delivery	The partner in the course is able to give an explanation that is specific and easy to understand while using helping instruments to explain the concepts easily.	The partner in the course is able to give specific and some are easy to understand explanations while using helping instruments to explain the concepts.	The partner in the course is not able to give a precise and specific explanation towards the concept. Rarely uses instruments to explain the concept.	The explanation given by the partner is not specific and hard to understand while infrequently using instruments to explain the concept.

C. Rubric for Group Discussion

No	Kategori	4	3	2	1
1	Involvement of each member	The partner actively gives feedback while appreciating other people's opinion.	Most of the time, the partner gives feedback while appreciating other people's opinion.	The partner infrequently gives feedback while most of the times appreciates other people's opinion.	The partner rarely gives feedback while also rarely appreciates other people's opinion.
2	Result of Discussion	Able to answer all questions precisely	Most of the questions asked are answered precisely	Only a small part of the questions is answered precisely	Is not able to answer any questions whatsoever
3	Reference Usage	Uses the correct reference in answering the questions	Most of the answers uses a good reference as a base for the answer	Only a small part of the answers uses a good reference as a base for the answer	Does not use any reference to answer the questions