

ASSESSMENT REPORT

**ROY G. PERRY COLLEGE OF ENGINEERING
CHEMICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**

ASSESSMENT REPORT COVER PAGE

**CHEG 4033-Y03: PROCESS DYNAMICS AND
CONTROLS**

FALL 2020 SEMESTER

NAME OF INSTRUCTOR: DR. SHEENA M. REEVES

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Detailed Course Syllabus
(Distributed to Students at the beginning of the Semester)

Course Description in ABET Format

CHEG 4033-Y03: Process Dynamics and Controls

1.	Course number and name:	CHEG 4033-Y03: Process Dynamics and Controls
2.	Credits and contact hours:	3 credit hours; 3 contact hours
3.	Instructor's or course coordinator's name:	Dr. Sheena M. Reeves
4.	Text book: Title:	N/A
	Author:	
	Publisher, Year & Edition:	
	a. Other Supplemental material	1. "Process Dynamic and Control," Seborg, D. E., Edgard, T. F., and Mellicamp, D. A., 2nd edition, John Wiley and Sons. 2. "Process Control: Designing Processes and Control Systems for Dynamic Performance," T. E. Marlin, 2nd edition, McGraw Hill.
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	Dynamic response and control of chemical process equipment such as reactors, heat exchangers, distillation columns. Use is made of fundamental techniques of servomechanism theory such as block diagrams, transfer functions, and frequency response, stability analysis and control loop design. Unsteady state modeling and computer simulation of simple control systems.
	b. Prerequisites/Co-requisites	Senior standing in the Chemical Engineering major. CHEG 3063 and MATH 4173
	c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6.	Specific goals for the course	Students will be able to :
	a. specific outcomes of instruction	1. identify control elements and apply mathematics in controls calculations 2. determine the level of stability using mathematical techniques 3. utilize Matlab, Excel, or ASPEN in controls calculations and simulations 4. model controls for modern chemical engineering processes 5. show a level of comprehension of advanced control strategies
	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.	This course addresses: Outcome 1 Ability to identify, formulate, and solve complex engineering problems (CEP) by applying principles of engineering, science, and mathematics. Outcome 2 Ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor.

7	Brief list of topics to be covered	Introduction to Process Controls	(4)
		Mathematical Modeling	(6)
		Transfer Functions	(4)
		Block Diagrams	(6)
		First Order Systems	(3)
		Second Order Systems/Damping	(3)
		Feedback Controls/PID	(3)
		Feedback Controls	(4)
		Stability and Tuning Parameters	(4)
		Advanced Controls Systems	(3)
		Control Scheme Interpretation	(5)

Additional Course Syllabus Information

Dr. Sheena Reeves, Associate Professor

Email: smreeves@pvamu.edu

Office: Virtual Meetings

Phone: 936-261-9413

Meeting Time: TR 10:10 a.m. – 11:30 a.m.

Location: Zoom Platform

ABET OUTCOMES

Two major course outcomes will be assessed in this course using a number of performance criteria. The Course outcomes and their performance criteria are detailed below:

Course Outcome 1: This outcome is the same as program outcome 1. Students will have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

The three performance criteria used to assess this outcome are:

1. Identify control elements and apply mathematics in controls calculations.
 - a. Apply linearization and other mathematical techniques.
 - b. Derive Laplace transforms and inverse Laplace transforms.
 - c. Understand the different variables associated with process controls.
 - d. Derive transfer functions for the process, disturbance, sensor, controller, and control element.
 - e. Determine initial and final values and/or poles and zeroes.
2. Determine the level of stability using mathematical techniques.
 - a. Calculate steady state gain, proportional band, and the time constant using analytical or graphical methods.
 - b. Perform a Routh array analysis.
 - c. Determine poles and damping level using analytical equations or graphs.
 - d. Determine the value of the damping coefficient, process gain, and time constant given a second order equation.
 - e. Estimate the settling time, overshoot, or decay ratio given a diagram or the damping coefficient.
 - f. Using the damping coefficient, determine the stability of the response.
3. The ability to utilize software such as Matlab, Excel, and ASPEN to solve control problems.
 - a. Create a dynamic system using ASPEN/CHEMCAD.
 - b. Perform a Routh array analysis in Matlab.
 - c. Find LaPlace transforms and inverse LaPlace transforms using Matlab commands.
 - d. Find poles and zeros using Matlab.
 - e. Determining the correct response function for a given input.
 - f. Determine the dampening of a response based on Matlab plots.

Course Outcome 2: This outcome is the same as program outcome 2. Students will have an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

The two performance criteria used to assess this outcome are:

1. The ability to model controls for modern chemical engineering processes.

- a. Select the location of the controller, valve, and sensor based on input and set point.
 - b. Design a control system given a brief scenario.
 - c. Identify controllers, valves, instruments, and piping on a P&ID.
 - d. Create a basic block diagram, complex block diagram, or equivalent block diagram given a scenario.
 - e. Determine the stability of a system.
 - f. Perform mass and energy balances on dynamic systems.
 - g. Determine the overall transfer function using block diagram algebra.
 - h. Move the takeoff point or summation point in a Block diagram and provide the equivalent diagram.
2. Show a level of comprehension of advanced control strategies.
- a. Discuss the objectives and importance of process controls including topics such as damping and stability.
 - b. Distinguish between feedback and feed-forward controls and open/closed loop controls.
 - c. Differentiate between positive and negative feedback.
 - d. Discuss the operation of different control instruments.
 - e. Depict the different types of controllers and discuss advantages and disadvantages of controllers and valves.
 - f. Choose the optimum controller gain and time constant given response information.
 - g. Discuss the advantages and disadvantages of feedback, feedforward, open loop, and closed loop controls.

Major Course Requirements

Method of Determining Final Course Grade

Course Grade Requirement	Value	Total
1. Exams (3)	150 pts	450 pts
2. Online Quiz (4)	25 pts	100 pts
3. Homework Assignments (4)	30 pts	120 pts
4. Simulation Assignment (1)	150 pts	150 pts
5. Online Discussions (3)	10 pts	30pts
6. Final Exam (1)	150 pts	150 pts
Total:		1000 pts

Course Grade Requirement Table

Grading Criteria and Conversion:

A = 900 - 1000

B = 800 - 899

C = 670 - 799

D = 550 - 669

F = 549 and below

A signifies that the student has mastered the subject matter and understands all concepts covered.

B signifies that the student has a good understanding of the subject matter with few exceptions.

C signifies that the student has an adequate understanding of the material and can follow most concepts.

D signifies that the student does not understand important class concepts needed to be successful in future courses.

F signifies that the student has missed significant assignments or does not understand several concepts.

Detailed Description of Major Assignments:

Assignment Title or Grade Requirement	Description
1. Exams	An exam will occur once a month and cover lectures, handouts, and online materials.
2. Online Quiz	The quiz will cover material that is covered online.
3. Homework	Homework assignments will reiterate material covered during the lecture and should serve as practice for the exam.

4. Simulation	A major simulation project will cover the dynamics of a system.
5. Final Exam	The final exam is comprehensive and will test the student's overall grasps of the expected outcomes of the course.

Detailed Description of Major Assignments Table

Course Procedures or Additional Instructor Policies

Taskstream

Taskstream is a tool that Prairie View A&M University uses for assessment purposes. One of your assignments may be required to be submitted as an "artifact," an item of coursework that serves as evidence that course objectives are met. If applicable, more information will be provided during the semester by your department, but for general information, you can visit Taskstream via the link in eCourses.

Tests & Testing Policy

All tests are closed book and closed notes. **NO MAKE-UP EXAMS WILL BE GIVEN.** A missed exam due to an excusable absence will not be added into the students Test Average; instead, only two tests will count for that student. **NO EXCEPTIONS!** No electronic device will be allowed including iPads and eReaders. No graphing or programmable calculators are allowed for any test or quiz. Students must purchase a small scientific calculator to use on exams. A cell phone cannot be used as a replacement for a graphing calculator on an exam. Doing so will result in a severe penalty of the student's grade. No bathroom breaks are allowed during a test or a quiz. If a student leaves the room during this time, their exam/quiz will be collected and considered finished by the student. Any act of cheating will result in a grade of zero for that student, and the student will be referred to the department head. Such meetings must take place within a week of the violation.

Homework Policy & Guidelines

Process controls involves the usage of computer software. Several individual and group assignments will be given throughout the semester. Specific homework assignments will be given throughout the semester as the instructor examines the specific need of the class. Students must submit these assignments during a given time frame. If a student chooses to disobey the university's honor code and copy the solution manual instead of submitting the student's own independent work, the student will receive a grade of zero on the assignment and will be referred to the department head. Such meetings must take place within a week of the infraction. Homework is due at the beginning of the class period. **Late homework assignments will NOT be accepted!**

Class Activities And Participation Grades

Students are expected to attend class on a regular basis and are expected to participate in classroom discussions. A student who fails to attend class is risking a poor mark in this area. There are zero opportunities to makeup a class activity. Students must submit these assignments during a given time frame.

Book Policy

The textbook for this course is **RECOMMENDED**. Many studies have proven that students without textbooks either eventually fail the course or perform poorly. Books can be purchased or rented online.

Final Exam Procedures

The comprehensive final exam is closed book and will occur in Zoom. All students are required to take the final exam. No exemptions are given. It is the student's responsibility to arrive on time for the exam with all of the needed materials.

End of Semester Course Assessment Report

This summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department. **You cannot use any number of your choice**
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

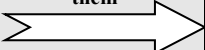
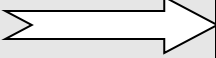
5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 4033-Y03: PROCESS DYNAMICS AND CONTROL
FALL 2020 SEMESTER

Report Prepared by: Dr. Sheena M. Reeves

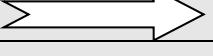
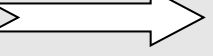
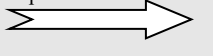
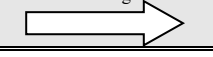
Report Date: December 16, 2020

Semester	Analysis Type	Number of Students	Sub-Outcome 1.1 Identify control elements and apply mathematics in controls calculations.				Sub-Outcome 1.2 Determine the level of stability using mathematical techniques.				Sub-Outcome 1.3 The ability to utilize software such as Matlab, Excel, and ASPEN to solve control problems.				Outcome 1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.”			
			Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2020	Direct	15	75	70	82.3	73.3	75	70	70.6	46.7	75	70	71.7	46.7	75	70	74.9	53.3
Fall 2019	Direct	23	75	70	77.1	60.9	75	70	75.7	73.9	75	70	80.6	69.6	75	70	75.8	60.9
Fall 2018	Direct	24	75	70	72.2	54.2	75	70	N/A	N/A	75	70	80.6	66.7	75	70	75.8	66.7
Implementation Summary	Items implemented from previous report or after meeting previous instructor		Students were given more opportunities to discuss control scenarios for understanding.				Routh analysis was taught with an in class activity to boost understanding.				Students were provided access to software using the mydesktop.pvamu.edu website. Students were given sample videos and a document to review for the project.				All of the implementation summary for the sub-outcomes were implemented for this outcome.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		Overall, the students made small mathematical errors or simply forgot the terminology covered at the beginning of the semester.				The students had issues with simple algebra and/or fractions for some calculations that prevented them from determining parameters.				Students waited until their Senior Design project was completed to attempt this assignment; therefore, several did not finish the control portion of the project.				Major problems were inability to identify constraints, establish milestones, tracking progress on Gantt chart. Also students lacked ability to gather relevant information, and cite references. Inability to do analysis on software			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		The instructor should provide a more detailed final exam review for students. The major issue with this course is the final exam is always on the first day of finals and the students do not have much time to prepare. This semester, the review was provide as soon as the final exam schedule was released by the university. Perhaps, more advance knowledge by the university could have given the students more time to prepare.				The instructor should include these parameters in a series of concept quizzes at the beginning of the semester.				The instructor should include deadlines for different parts of the project throughout the semester.				All of the plans suggested for the sub-outcomes will address the problems encountered for this outcome..			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Student performance greatly improved in this area due to a change in the delivery of the exam.				Students performed below the expected average for this measurement.				Students performed significantly worse in this outcome. Using the software in the online platform was often a hindrance for the students.				Students performance was slightly below the expected average from previous year.			
Were Expectations Met?	 		YES				NO				NO				NO			

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 4033-Y03: PROCESS DYNAMICS AND CONTROL
FALL 2020 SEMESTER

Report Prepared by: Dr. Sheena M. Reeves

Report Date: December 16, 2020

Semester	Analysis Type	Number of Students	Sub-outcome Outcome 2.1				Sub-outcome Outcome 2.2				Outcome 2			
			The ability to model controls for modern chemical engineering processes.				Show a level of comprehension of advanced control strategies.				An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor.			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2020	Direct	15	75	70	72.0	66.7	75	70	76.8	60	75	70	74.4	60.0
Fall 2019	Direct	23	75	70	72.4	56.5	75	70	82.3	78.3	75	70	77.4	60.9
Fall 2018	Direct		75	70			75	70			75	70		
Implementation Summary	Items implemented from previous report or after meeting previous instructor 		Much focus was placed on overall, component, and energy balances.				This activity was not implement for Fall 2020. Will review for 2021; however, it was not an issue in Fall 2020.				This semester, emphasis was placed on reviewing material and energy balance equations. This area remains at a deficit for CHEG students.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		Students still have poor comprehension of how balance equations are derived.				Students had trouble distinguishing between the logic of process control and the logic of normal process flow. The students often confused the concepts of controls. Students also do not under the term "variable."				Perceived problems were as listed for the sub-outcomes			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		As a department, CHEG has implemented changes to the curriculum order to combat this issue as it is a foundational one. The instructor will continue current efforts to enhance the performance of the students.				The instructor should discuss what a variable is with the students to gauge their level of understanding. The instructor should create short concept quizzes that explain the parts of a control system.				The following is recommended for implementation. Concept quizzes in CANVAS for major course concepts.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Student performance was slightly below the expected value; however, the percentage of students meeting the expected value increased.				Student performance was significantly lower than the previous year.				Student performance was slightly lower than expected value; however, the values were similar to the previous year.			
Were Expectations Met?	Class Average $\geq 75\%$ and $\geq 70\%$ of Students Performed at or Above Expected Average 		NO				NO				NO			

**Grade Sheet Showing
Student and Class Performance in Outcomes
The computed semester average in each outcome
as stated in the Assessment report are
highlighted in boldface**

Grade Sheet Showing Student and Class Performance in Course Outcomes
CHEG 4033-Y03: Process Dynamics and Controls, Fall 2020 Semester

OUTCOME				Outcome 1.2					Outcome 1.3		
MEASURE	FE	Total	Percent	E2	H2	H4	Total	Percent	ASP	TOTAL	PERCENT
POINTS	100	100	100	50	30	30	110	100	100	100	100
GRADES	75	75	75	25	27	27	79	72	63	63	63
	67	67	67	40	27	22	89	81	76	76	76
	84	84	84	37	27	19	83	75	56	56	56
	88	88	88	8	DNP	30	38	48	40	40	40
	77	77	77	9	27	19	55	50	85	85	85
	100	100	100	50	27	27	104	95	65	65	65
	91	91	91	5	27	19	51	46	93	93	93
	69	69	69	1	27	19	47	43	56	56	56
	84	84	84	11	27	19	57	52	71	71	71
	64	64	64	26	DNP	25	51	64	52	52	52
	90	90	90	50	27	30	107	97	67	67	67
	95	95	95	46	27	30	103	94	102	102	102
	89	89	89	41	27	20	88	80	89	89	89
	66	66	66	24	27	26	77	70	86	86	86
	95	95	95	45	27	30	102	93	75	75	75
AVERAGE	82.3	82.3	82.3	27.9	27.0	24.1	75.4	70.6	71.7	71.7	71.7
STDEV	11.8	11.8	11.8	17.5	0.0	4.7	23.7	19.4	17.1	17.1	17.1
EXPECTED	75	75	75	37.5	22.5	22.5	82.5	75	75	75	75
% ABOVE EXPECTED			73.3					46.7			46.7

Grade Sheet Showing Student and Class Performance in Course Outcomes
CHEG 4033-Y03: Process Dynamics and Controls, Fall 2020 Semester

	Outcome 2						
OUTCOME	Outcome 2.1			Outcome 2.2			
MEASURE	E2	TOTAL	PERCENT	Q2	E3	TOTAL	PERCENT
POINTS	50	50	100	25	80	105	100
GRADES	48	48	96	25	66	91	87
	38	38	76	25	51	76	72
	40	40	80	25	69	94	90
	22	22	44	25	42	67	64
	10	10	20	25	55	80	76
	40	40	80	25	55	80	76
	35	35	70	25	76	101	96
	44	44	88	25	58	83	79
	50	50	100	20	62	82	78
	40	40	80	25	46	71	68
	15	15	30	25	39	64	61
	48	48	96	25	47	72	69
	50	50	100	25	68	93	89
	40	40	80	25	71	96	91
	20	20	40	25	34	59	56
AVERAGE	36.0	36.0	72.0	24.7	55.9	80.6	76.8
STDEV	13.0	13.0	26.1	1.3	12.7	12.6	12.0
EXPECTED	37.5	37.5	75	18.75	60	78.75	75
% ABOVE EXPECTED			66.7				60.0

Class Performance in Course Outcomes AVERAGE SUMMARIES
CHEG 4033-Y03: Process Dynamics and Controls, Fall 2020 Semester

OUTCOME	Outcome 1				Outcome 2		
SUB-OUTCOME	1.1	1.2	1.3	Average	2.1	2.2	Average
AVERAGES	75	72	63	70	96	87	91
	67	81	76	75	76	72	74
	84	75	56	72	80	90	85
	88	48	40	59	44	64	54
	77	50	85	71	20	76	48
	100	95	65	87	80	76	78
	91	46	93	77	70	96	83
	69	43	56	56	88	79	84
	84	52	71	69	100	78	89
	64	64	52	60	80	68	74
	90	97	67	85	30	61	45
	95	94	102	97	96	69	82
	89	80	89	86	100	89	94
	66	70	86	74	80	91	86
	95	93	75	88	40	56	48
AVERAGE	82.3	70.6	71.7	74.9	72.0	76.8	74.4
STDEV	11.8	19.4	17.1	11.8	26.1	12.0	16.9
EXPECTED	75	75	75	75	75	75	75
% ABOVE EXPECTED	73.3	46.7	46.7	53.3	66.7	60.0	60.0

**OUTCOME SPECIFIC ASSIGNMENTS
USED TO ASSESS OUTCOMES**

ASSIGNMENTS FOR OUTCOME 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematics.

DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 4033-P03: Process Dynamics and Controls
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR FALL 2020 SEMESTER

ABET OUTCOME 1: Show an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
ABET OUTCOME 2: Show an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Name: JOEL KAKONA

Title of Assignment: Exam 2 Date: 10/22/2020

Competency Area	Max for this Assignment	Your Score
1.2.e. Estimate the settling time, overshoot, or decay ratio given a diagram or the damping coefficient. 1.2.c. Determine poles and damping level using analytical equations or graphs. 1.2.d. Determine the value of the damping coefficient, process gain, and time constant given a second order equation. 1.2.f. Using the damping coefficient, determine the stability of the response.	50	46 -4
2.2.b. Distinguish between feedback and feed-forward controls and open/closed loop controls. 2.2.a. Discuss the objectives and importance of process controls including topics such as damping and stability. 2.2.g. Discuss the advantages and disadvantages of feedback, feedforward, open loop, and closed loop controls.	50	40 -10
2.1.d. Create a basic block diagram, complex block diagram, or equivalent block diagram given a scenario. 2.1.g. Determine the overall transfer function using block diagram algebra. 2.1.h. Move the takeoff point or summation point in a Block diagram and provide the equivalent diagram.	50	48 -2
TOTAL	150	134

**Only scientific calculators allowed. No graphing calculators or books.*

$$\frac{\sqrt{1-\zeta^2}}{\tau}$$

$$\frac{5\tau}{\zeta}$$

$$e^{-\frac{\zeta T}{2\tau}} = e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}}$$

$$e^{-\frac{\zeta}{\tau}T} = e^{-\frac{2\pi\zeta}{\sqrt{1-\zeta^2}}}$$

$$\frac{1}{4}T$$

$$\frac{\sqrt{1-\zeta^2}}{\zeta}$$

Problem #1: Two first order mixing tanks are placed in series. The overall transfer function for the process is second order and takes the following form. Given this information, determine expressions/values for the process gain, time constant, and damping coefficient.

$$G(s) = \frac{K_1 K_2}{(\tau_1 s + 1)(\tau_1 s + 1)}$$

$$G(s) = \frac{K_1 K_2}{\tau_1^2 s^2 + 2\tau_1 s + 1}$$

$$G(s) = \frac{K_1 K_2}{\tau_1^2 s^2 + 2\tau_1 s + 1}$$

process gain: $K_p = K_1 K_2$

time constant: $\tau_1^2 = 1$

$\tau_1 = \sqrt{1} = 1$

damping coefficient: $2\tau_1\zeta = 1$

$\zeta = \frac{1}{2\tau_1}$

$\zeta = \frac{1}{2} = 0.5$

Problem #2: The following equation was used to describe before-tax earnings of a petroleum company each month.

$$2 \frac{d^2 y}{dt^2} + 1.414 \frac{dy}{dt} + y(t) = 5u(t)$$

a. Calculate the damping coefficient and time constant. Show all work for full credit.

damping coefficient: $2\tau_1\zeta = 1.414$

$\zeta = \frac{1.414}{2\tau_1}$

$\zeta = \frac{1.414}{2\sqrt{2}}$

$\zeta = \frac{1}{2} = 0.5$

Time Constant: $\tau^2 = 2$

$\tau = \sqrt{2}$

b. Calculate the decay ratio and overshoot. Show all work for full credit.

Decay ratio: $= e^{-\frac{2\pi\zeta}{\sqrt{1-\zeta^2}}}$

$= e^{-\frac{2 \times \pi \times 0.5}{\sqrt{1-(0.5)^2}}}$

$= 0.026$ ✓

overshoot: $= e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}}$

$= e^{-\frac{\pi \times 0.5}{\sqrt{1-(0.5)^2}}}$

$= 0.16$

c. What type of damping is occurring? underdamped

d. Is this system stable, unstable, or metastable? stable

ASSIGNMENTS FOR OUTCOME 2

An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor.

DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 4033-P03: Process Dynamics and Controls
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR FALL 2020 SEMESTER

ABET OUTCOME 1: Show an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

ABET OUTCOME 2: Show an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Name: Vance Allison

Title of Assignment: Exam 2 Date: 10/22/2020

Competency Area	Max for this Assignment	Your Score
1.2.e. Estimate the settling time, overshoot, or decay ratio given a diagram or the damping coefficient. 1.2.c. Determine poles and damping level using analytical equations or graphs. 1.2.d. Determine the value of the damping coefficient, process gain, and time constant given a second order equation. 1.2.f. Using the damping coefficient, determine the stability of the response.	50	25
2.2.b. Distinguish between feedback and feed-forward controls and open/closed loop controls. 2.2.a. Discuss the objectives and importance of process controls including topics such as damping and stability. 2.2.g. Discuss the advantages and disadvantages of feedback, feedforward, open loop, and closed loop controls.	50	40
2.1.d. Create a basic block diagram, complex block diagram, or equivalent block diagram given a scenario. 2.1.g. Determine the overall transfer function using block diagram algebra. 2.1.h. Move the takeoff point or summation point in a Block diagram and provide the equivalent diagram.	50	48
TOTAL	150	113

**Only scientific calculators allowed. No graphing calculators or books.*

$$\text{Decay} = \frac{\sqrt{1-\zeta^2}}{\tau}$$

$$\frac{5\tau}{\zeta}$$

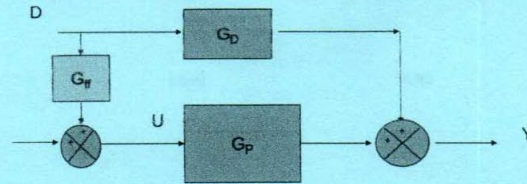
$$e^{\frac{\zeta T}{2\tau}} = e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}}$$

$$e^{-\frac{\zeta}{\tau}T} = e^{-\frac{2\pi\zeta}{\sqrt{1-\zeta^2}}}$$

$$\frac{1}{4}T$$

$$\text{Overshoot} = \frac{\sqrt{1-\zeta^2}}{\zeta}$$

Problem #3: Answer the following set of conceptual questions about process controls.



a. Does the above image show feedforward or feedback control? Feed forward

b. What type of control loop is considered stable? Open loop

c. What type of control loop detects error? Closed loop

d. Name one disadvantage of feedback control.

Perfect error detection is impossible

★ e. Name one advantage of feedforward control.

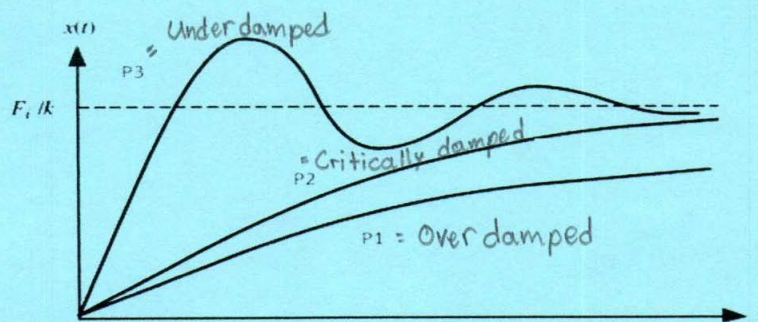
Error is independent -5

f. Name 2 times when you should use feedforward control.

When error detection is insufficient +
-5

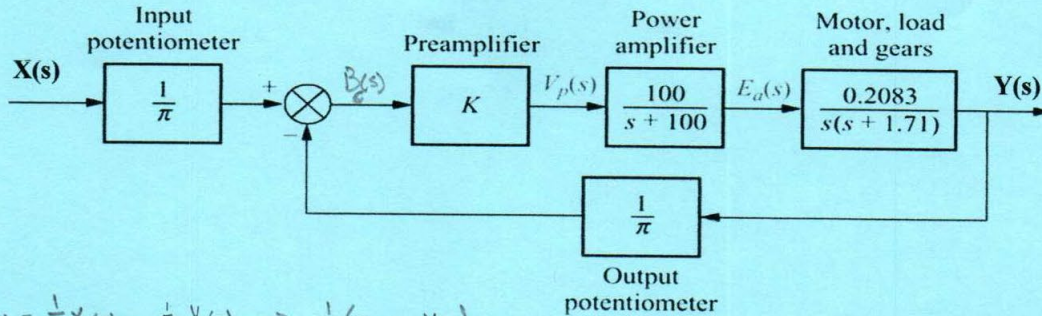
★ g. What type of damping should a chemical engineering never use? + Undamped

h. On the image below, label the types of damping seen in curves P1, P2, and P3.



$P_1 = \text{Overdamped}$
 $P_2 = \text{Critically damped}$
 $P_3 = \text{Underdamped}$

Problem #4: Determine the overall transfer function $G(s)$ using block diagram algebra and provide an equivalent block diagram. Simplify and show all work for full credit.



$$B_e(s) = \frac{1}{\pi} X(s) - \frac{1}{\pi} Y(s) \rightarrow \frac{1}{\pi} (X(s) - Y(s))$$

$$V_p(s) = K \cdot \frac{1}{\pi} (X(s) - Y(s))$$

$$E_a(s) = \frac{100}{s+100} \cdot K \cdot \frac{1}{\pi} (X(s) - Y(s)) = \frac{100K}{\pi(s+100)} (X(s) - Y(s))$$

$$Y(s) = \frac{0.2083}{s(s+1.71)} \cdot \frac{100K}{\pi(s+100)} (X(s) - Y(s))$$

$$Y(s) = \frac{0.2083}{s(s+1.71)} \cdot \left[\frac{100K}{\pi(s+100)} X(s) - \frac{100K}{\pi(s+100)} Y(s) \right] = \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} X(s) - \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} Y(s)$$

-2 Math Error

$$Y(s) + \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} Y(s) = \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} X(s)$$

$$Y(s) \left[1 + \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} \right] = \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} X(s)$$

$$\frac{\text{Output}}{\text{Input}} = G(s) = \frac{Y(s)}{X(s)} = \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} \cdot \left[1 + \frac{(s^2+1.71s)(\pi s+100\pi)}{28.3K} \right]$$

$$= \frac{28.3K}{(s^2+1.71s)(\pi s+100\pi)} \rightarrow \frac{28.3K}{\pi s^3 + 100\pi s^2 + 1.71\pi s^2 + 171\pi s}$$

$$= \frac{28.3K}{\pi s^3 + 101.71\pi s^2 + 171\pi s} \rightarrow \frac{28.3K}{\pi s (s^2 + 101.71s + 171)}$$

Equivalent
Block
Diagram

