Philadelphia University

Faculty of Engineering & Technology

Department of Mechatronics Engineering

Second Semester 2024/2025

Course Information

Course Title:	Mechatronics Systems Modeling and Simulation (640722)
Prerequisite:	None
Credit Hours:	3 credit hours (16 weeks per semester, approximately 45 contact hours)
Textbook:	System Dynamics for Engineering Students: Concepts and Applications, by Nicolae Lobontiu. Elsevier Publication 2010.
References:	- Modeling and Analysis of Dynamic Systems", Ramin S. Esfandiari, Bei Lu- 3rd Edition-CRC Press, 2018 - George Pelz. Mechatronic Systems: modeling and simulation with HDLs. Chapter 2 Wiley 2003 - Devdas Shetty and Richard A Kolk. Mechatronics System Design, 2nd edition. Chapter 2. Cengage, Learning 2011 - Rolf Isermann "Mechatronics Design Approach" Chapter 2 in Mechatronics Handbook edited by Bishop -*"System Dynamics"*, Katsuhiko Ogata, 4th Edition, Pearson Prentice Hall, 2004. - Guide to Modeling and Simulation of Systems of Systems (Simulation Foundations, Methods and Applications) by Bernard P. Zeigler and Hassam S. S2012 Edition - System design, modeling and simulation, Claudius Ptolemaeus, Editor, 2014. - System Identification: Theory for the User by Lennart Ljung 2nd Edition - Modern Control Engineering by Ogata, 2010 - System Identification: An Introduction, by Keesman, Karel J. - System Dynamics: Modeling and Simulation of Mechatronic Systems 5th Edition, by Dean C. Karnopp , Donald L. Margolis, Ronald C. Rosenberg, 2019. - System Dynamics", Palm III, William, 2nd Edition, McGraw-Hill Science, 2009 - Introduction to Physical Systems Modelling with Bond Graphs Jaan F. Broenink / University of Twente - Netherlands
Website:	**http://www.philadelphia.edu.jo/academics/malkhawaldeh/**
Course Description:	Based on the knowledge of the undergraduate level students get the necessary skills in analytical and computational methods in modeling and simulation to work in a scientific environment and solve engineering problems in research and development projects. This course covers three main areas: modelling, simulation, and identification. It presents several modelling methodologies that can be used for mechatronics systems.This will cover mathematical and graph models. Software tools, such as

	MATLAB / Simulink and / or LABVIEW, will be used to simulate the systems and analyze the responses. Also, an introduction to analog simulation methods and system identification will be provided as well.
Instructors:	Dr. Mustafa Awwad Al-Khawaldeh
Course Coordinator:	Dr. Mustafa Awwad Al-Khawaldeh
Technology Requirements:	• Personal computer, laptop, or mobile phone. • Internet Connection. • Access to Philadelphia University E-Learning Portal (MS Teams and Moodle)
Learning Style:	(F2F; Blended; or Online): **Blended**
Communication:	• Announcement: the announcements will be posted in MS Teams or Moodle on a regular basis. • Email. • MS Teams or Moodle chats.
Course Objectives:	The main objective of this course is: o Understand the hardware and software design requirements of distributed and embedded real-time systems. o Design and implementation of real-time algorithms for mechatronics systems o Study stability of embedded real-time systems.

Course Learning Outcomes (CLO) and Relation to ABET Student Outcomes		
CLOs	**Outcomes**	**ABET PLOs**
K1,	Understand analytical and computational principles in modeling and simulation field.	1
K2	Obtain a mathematical model of different physical systems (mechanical, fluid, thermal and electrical).	1
K3	Analyze the transient-response of second-order systems	6
S2	Study new technologies in modeling mechatronics systems.	7
C3	Have the ability to design and implement real-time embedded systems.	3

Grading Policy and Assessment Instruments					
Graded Item	**Marks**	**Topic (s)**	**CLO(s)**	**Learning Portal** (Teams/ Moodle/ F2F/ Others)	**Week**
Assignment 1	10	Mathematical Modeling of Electromechanical Systems,	1-2	Moodle	4
Assignment 2	10	Transient-Response Analysis of Second-Order Systems Using MATLAB	1-2	Moodle	12
Quiz 1	10	Mathematical Modeling of Liquid-Level Systems	1-4	F2F	6
Mid Exam	30%	Weeks 1-8	1,2,3	F2F	8
Final Exam	40%	Week 1-15	1-4	F2F	16
Total Marks	**100%**				

Notes:	• Two written exams will be given. • Copying homework is forbidden, any student caught copying the homework or any part of the homework will receive zero marks for that homework. • Project: Students will be divided into groups of five students, and each group will present a project that deals with a proposal for entrepreneurial work according to what the student achieved during the semester. Each group's report will be discussed during the lectures and before the end of the semester. • Assignment: A number of assignments will be given through the e-learning platform (Moodle). Each student must submit at least four assignments during the semester and before the due date. • The final exam will cover all the class material.

Course Content: Learning Resources/ References/ Activities/ Assessment Methods

Week	Lecture	Topic	CLOs	Learning Resources/ References/ Activities (Learning & Teaching Methods)	Learning Style (F2F, Synchronous, Asynchronous)	Assessment Method
1	L1	Mechatronics Design Process	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Review: 1. Modeling and Simulation Principles, system dynamics	1	Recorded video + Moodle	Asynchronous	
2	L1	Laplace Transform ,Inverse Laplace Transformation	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Solving linear differential equations, Solving time-invariant differential equations	1	Recorded video + Moodle	Asynchronous	
3	L1	Modeling of mechanical systems: Rotational motion and translational motion	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Translational-rotational motion, an energy method for deriving equations of motion	1	Recorded video + Moodle	Asynchronous	Assign
4	L1	Modeling of electrical systems	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Mathematical modeling of operational-amplifier systems	1	Recorded video + Moodle	Asynchronous	
5	L1	Mathematical modeling of electromechanical Systems: Armature current control of dc servomotors.	2	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Mathematical modeling of electromechanical Systems: Field current control of dc servomotors.	2	Recorded video + Moodle	Asynchronous	Assign
6	L1	Transfer-function approach to modeling dynamic systems	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Block diagrams of dynamic systems	1	Recorded video + Moodle	Asynchronous	
7	L1	Mathematical modeling of fluid Systems	3	Lecture Notes + Moodle + Teams	Synchronous	Selection of Projects
	L2	Mathematical modeling of liquid-level systems	3	Recorded video + Moodle	Asynchronous	
8	L1	Mathematical modeling of a thermal systems.	2	Lecture Notes + Moodle + Teams	Synchronous	Mid Exam
	L2	Mathematical modeling of a pneumatic system.	2	Recorded video + Moodle	Asynchronous	
9	L1	Analogous systems: electrical ,mechanical, thermal, pneumatic and liquid-level systems	2	Lecture Notes + Moodle + Teams	Synchronous	Project (Phase1)
	L2	Mechanical-electrical analogies systems: Force-Voltage Analogy Force-current analogy	2	Recorded video + Moodle	Asynchronous	
10	L1	Nonlinear systems	4	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Linearization of nonlinear Systems	2	Recorded video + Moodle	Asynchronous	

11	**L1**	State-Space approach	1	Lecture Notes + Moodle + Teams	Synchronous	Assign
	L2	State-Space Approach to modeling dynamic Systems	1	Recorded video + Moodle	Asynchronous	
12	**L1**	Time-Domain Analysis of Dynamic Systems Using MATLAB	1	Lecture Notes + Moodle + Teams	Synchronous	Project (Phase2)
	L2	Transient-Response Analysis of Second-Order Systems Using MATLAB	1	Recorded video + Moodle	Asynchronous	
13	**L1**	Introduction to System Identification	1	Lecture Notes + Moodle + Teams	Synchronous	
	L2	Model Parameterization and Prediction, Nonparametric Identification	1	Recorded video + Moodle	Asynchronous	
14	**L1**	Higher-order mathematical models	3	Lecture Notes + Moodle + Teams	Synchronous	Project (Phase3)
	L2	Example: Example: 3rd order model	1-4	Recorded video + Moodle	Asynchronous	
15	**L1**	Modeling with Bond Graphs	1-4	PP presentation + Moodle	Synchronous	Project Presentation
	L2	Bond Graph examples: Mass-Spring-damper ,RLC Circuit and hoisting device	1-4	Recorded video + Moodle	Asynchronous	Project Presentation
16	**L1**	Case Study: Hard Drives	1-4		F2F	
	L2	Final exam				Final Exam

Notes:
For Blended and F2F Courses: L1 & L2 each 1 hour.
For Online Course: L1 and L2 each 1.5 hours.

Credit Hours Distribution Report	
Learning Style	**Credit Hours**
F2F	3
Synchronous	23
Asynchronous	22
Total	48

Academic Honesty/ Student Conduct	○ As a student at Philadelphia University, you are expected to follow the university regulations and guidelines for academic honesty/student conduct found in student handbook. ○ This means that you should not cheat, plagiarize and let another student use your account in LMS learning portals.
Attendance Policy	Absence from classes and/or tutorials shall not exceed 15%. Students who exceed the 15% limit without a medical or emergency excuse, acceptable to and approved by the Dean of the relevant college/faculty, shall not be allowed to take the final examination and shall receive a mark of zero for the course. If the excuse is approved by the Dean, the student shall be considered to have withdrawn from the course.

February 2024