

MECH 469/529

Modelling of Dynamic Systems

3 Credits, Second Term, 2021/22

Course Web Site: UBC Canvas. The class lectures are simultaneously taught via Zoom (hybrid). The Zoom recordings are posted on Canvas.

Material Posted on Canvas: Course syllabus, exam requirements, lecture ppt notes, lecture recordings, homework assignments (not graded) and solutions, in-class examples and solutions, past exams and solutions, etc.

Zoon link:

<https://ubc.zoom.us/j/67828558769?pwd=WWZvc0tGek1qL0VaK1JtUUtNYUxwZz09>

Meeting ID: 678 2855 8769; Passcode: 955778

The course will be taught via Zoom (not in-person) at least until February 17th.

Class Times and Location: Tuesdays and Thursdays, 5:00 to 6:30 pm, FORW 303

Instructor

Dr. Clarence W. de Silva, Professor

e-mail: desilva@mech.ubc.ca

Office Hours: Please email me with your issue, I will arrange a personal meeting if I cannot address your question fully via email

Teaching Assistant: Mr. Jing Wang

e-mail: jing@ece.ubc.ca

Office Hours (Possibly after February 17th): Monday 14:00 PM – 15:00 PM Kaiser 4060

Prerequisites

MECH 529 is suitable for both Master's and Doctoral students. MECH 469 is intended for 3rd and 4th year undergraduate students. The course is presented for both graduates and undergraduates, jointly. There are no specific prerequisites. The students who have already taken introductory courses in circuit analysis, dynamics, fluid mechanics, and thermodynamics (or energy conversion) will be at an advantage, however.

Introduction

The course deals with the methodology of understanding and modeling a physical engineering system. The primary emphasis will be on the engineering problem of modeling rather than the applied mathematics of response analysis (and simulation) once a model is available.

The students will learn to understand and develop models in four physical domains (mechanical, thermal, fluid and electrical) in a unified, integrated manner, and systematic manner, to yield a “unique” model. For example, identification of lumped elements such as sources, capacitors, inductors, and resistors in the four types of physical systems will be studied. Analogies among the four physical domains (mechanical, thermal, fluid and electrical) will be presented in terms of these basic lumped elements and in terms of the

system variables. Concepts of through- and across- variables will be introduced. Multi-domain (multi-physics or mixed) systems, which consist of two or more of the four basic system types will be considered as well.

Tools of modeling and model-representation such as linear graphs (LGs) and block diagrams will be discussed. Important considerations of input, output, causality, and system order will be examined. Thevenin and Norton equivalent circuits and their application in mechanical (and fluid and thermal) systems using linear graphs will be studied, in both time domain and frequency domain. In particular, the concept and use of transfer function linear graphs (TF LGs)

Learning Objectives

By the end of this course, the students will be able to:

- Understand the formal meanings of a dynamic system, control system, mechatronic system, and multi-domain (or multi-physics or mixed) system
- Recognize different types of models (e.g., physical, analytical, computer, experimental) and their importance, usage, comparative advantages and disadvantages
- Understand the concepts of through-variable, across-variable, and their importance in recognizing the analogy among different physical domains, and in the development of a “unique” state-space model.
- Recognize similarities and analogies among mechanical, electrical, fluid, and thermal systems (physical domains)
- Understand the “mechatronic” approach or “integrated” approach to modelling a multi-domain (mixed) system, where all physical domains in the system are treated simultaneously (concurrently)
- Understand the “unified” approach to modelling a multi-domain (mixed) system, where similar (analogous) methods are used to model the different domains
- Understand the key steps of using a unified and integrated approach for modelling an engineering dynamic system, in a “systematic” manner, leading to a “unique” model
- Apply in a systematic manner, the developed (unified and integrated) approach to model an engineering dynamic system of various physical domains; in particular, to develop a unique state-space model
- Understand and apply a graphical approach (linear graph) for modelling an engineering dynamic system; in particular, to develop a unique state-space model
- Understand the concepts of generalized impedance, equivalent circuits, and circuit reduction of electrical systems and apply them to mechanical, fluid, and thermal systems
- Learn the model development in the frequency domain, specifically using transfer function linear graphs (TF LGs).

Textbook

De Silva, C.W., *Modeling of Dynamic Systems*, Taylor & Francis/CRC Press, Boca Raton, FL, 2018. (The E-book is available from the UBC library, at: <https://doi-org.ezproxy.library.ubc.ca/10.1201/9781315154824>)

MECH 469/529 COURSE LAYOUT

Week	Starts	Topic	Read from Textbook
1	Jan 11	Introduction	Chapter 1
2	Jan 18	Model Types, Analogies	Chapter 2
3	Jan 25	Electrical Systems	Chapter 2
4	Feb 01	Fluid Systems	Chapter 2
5	Feb 08	Thermal Systems	Chapter 2
6	Feb 15	Analytical/State-space Models	Chapter 3
7	Feb 22	Reading Break	
8	Mar 01	Model Linearization	Chapter 4
9	Mar 08	Linear Graphs	Chapter 5
10	Mar 15 Tuesday, March 15:	State Models from Linear Graphs Intermediate Exam, probably during class or take-home	Chapter 5
11	Mar 22	Transfer Function Models	Chapter 6
12	Mar 29	Thevenin/Norton Equivalent Circuits and Linear Graph Reduction	Chapter 7
13	Apr 05 Thursday, April 07:	Review Final-take home, April 07 (Canvas)	
	Thursday, April 14:	Final Exam (pdf) Due via email by 5:00 pm Thursday, April 14	

Examinations:

March 15, 2021 (Tuesday): Intermediate Examination (During Class or Take-home)

April 07, 2021 (Thursday): Final Take-home Exam given out in **Canvas**

April 14, 2021 (Thursday): Final Take-home Exam (pdf) Due **via email by 5:00 p.m.**

Grade Composition

Intermediate examination (in class)	40%
Homework Assignments	0%
Final take-home (take-home) examination	<u>60%</u>
Total	100%

Important Notes:

- 1. The course will be taught on-line at least until February 07. If this is further extended, the students will be notified.**
- 2. If more than half the class of students participate in the lectures on line, the mid-term exam on March 15 will be a take-home exam.**
- 3. There will not be any penalty for not participating in the lectures on line.**
- 4. If you feel unwell, please do not participate in in-person classes (if held).**

Departmental Policies for This Course:

Passing Requirement: *Students will pass this course based on their overall course mark (mid-term exam, and final exam). Note: The "examination grade" combines the scores from the mid-term exam and the final-exam.*

Live Lecture Recordings: *Live (synchronous) lectures will be recorded and posted on Canvas, for use by students enrolled in this course, but these recordings will not be used beyond the current section of the course. Please be aware that student participation, such as when asking questions in class, will be captured as well in these Zoom recordings.*

Academic Integrity: *In this course you are asked to agree to an academic integrity statement as part of testing or other assessment activities. As a student in a professional program, doing your part to adhere to course rules and upholding the academic integrity of your educational experience is in your best interest. Every effort will be made to ensure that assessment is fair for all students in the course. You can do your part by following the rules set out by your course instructor, and seeking assistance or clarification if you have any questions.*

Faculty/UBC policy available at
<http://calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0>].