MECH 469/529

Modelling of Dynamic Systems

3 Credits, Second Term, 2019/20
Tuesdays and Thursdays in Room DMP 301
5:00 to 6:30pm

Course Web Site: http://ial.mech.ubc.ca/ (**Courses → MECH 469/529**)

Instructor

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Prerequisites

This graduate course is suitable for both Master's and Doctoral students. There are no specific prerequisites. But, students who have already taken introductory courses in circuit analysis, dynamics, fluid mechanics, and thermodynamics (or energy conversion) will be at an advantage.

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, even though the latter aspects will also be covered in the course.

The students will learn to understand and model mechanical, thermal, fluid and electrical systems in a systematic and unified/integrated manner. For example, identification of lumped elements such as sources, capacitors, inductors, and resistors in different types of physical systems will be studied. Analogies among the four main types of systems (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, and flow and effort variables will be introduced. Multi-domain (or mixed) systems, which consist of two or more of the basic system types will be considered as well.

Tools of modeling and model-representation such as linear graphs 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. A brief overview of response analysis will be given.

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 (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, flow variable, and effort variable, and their relationship to state variables
- Recognize similarities and analogies among mechanical, electrical, fluid, and thermal systems
- Understand the "mechatronic" approach or "integrated" approach to modelling a multi-domain (mixed) system
- 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 development of a unified, integrated, and systematic approach for modelling an engineering dynamic system
- Apply in a systematic manner, the developed (unified and integrated) approach to model an engineering dynamic system; in particular, to develop a state-space model
- Understand and apply a graphical approach (linear graph or bond graph) for modelling an engineering dynamic system; in particular, to develop a state-space model
- Understand the concepts of impedance, equivalent circuits, and circuit reduction of electrical systems and apply them to mechanical, fluid, and thermal systems
- Understand common approaches of computer simulation
- Apply a common tool of computer simulation to an engineering dynamic system.

Textbook

De Silva, C.W., *Modeling of Dynamic Systems*, Taylor & Francis/CRC Press, Boca Raton, FL, 2018. (An E-book may be available as well)

MECH 529 COURSE LAYOUT

Week	Starts	Topic	Read from Textbook
1	Jan 07	Introduction	Chapter 1
2	Jan 14	Model Types, Analogies	Chapter 2
3	Jan 21	Electrical Systems	Chapter 2
4	Jan 28	Fluid Systems	Chapter 2
5	Feb 04	Thermal Systems	Chapter 2
6	Feb 11	Analytical/State-space Models	Chapter 3
7	Feb 18	Reading Break	
8	Feb 25	Model Linearization	Chapter 4
9	Mar 03	Linear Graphs	Chapter 5
10	Mar 10 **Tuesday, March 10:**	State Models from Linear Graphs **Intermediate Exam (in class)**	Chapter 5
11	Mar 17	Transfer Function Models	Chapter 6
12	Mar 24	Thevenin/Norton Equivalent Circuits and Linear Graph Reduction	Chapter 7
13	Mar 31	Simulation Block Diagrams	Chapter 8
14	Apr 07 **Tuesday, April 07:** **Tuesday, April 14:**	Response Analysis and Simulation Advanced Topics; Modeling Applications **Final Take-home Question Paper Given Out in Class** **Final Take-home Exam Due by 4:00 pm at TA's office**	Chapter 9

Examinations:

March 10, 2020 (Tuesday): Intermediate Examination (In Class)
April 07, 2020 (Tuesday): Final Take-home Exam given out in class
April 14, 2020 (Tuesday): Final Take-home Exam Due in TA's Office, by 4:00 p.m.

Grade Composition

Intermediate examination	40%
Attendance	10%
Final take-home examination	50%
Total	**100%**