a place of mind

MECH366 : Modeling of Mechatronic Systems

L1 : Introduction

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Remark before starting …

- No need to take notes in this course!
  - All the lecture slides will be posted on Canvas.
  - You may want to write down additional information that I present in the lecture on the slides.
- Just listen to me carefully!
- Ask me any question at any time!
- Today's outline
  - General information
  - Course introduction

Instructor and TAs

- Instructor : *Dr. Ryozo Nagamune*
  - Associate Professor at MECH Department
  - Email: nagamune@mech.ubc.ca
  - Office hours: Drop-in or By-appointment
  - Office: Kaiser Building 3104
  - Research interest: Control theory and applications
    e.g. wind turbine, solar thermal system, engine system
- TAs for laboratory exercises
  - *Mohammadreza Rostam:* reza.rostam@mech.ubc.ca
  - *Amir Chizfahm:* amir.chizfahm@alumni.ubc.ca

Course information

- Canvas **canvas.ubc.ca.**
  - All information on this course (including lecture slides and homework) will be posted.
- Email will be sent to you if necessary.
- Required textbook: None
- Optional textbook
  - Chapters 1-4 of the book “Modeling and Control of Engineering Systems”, CRC Press, 2009, written by Prof. C. W. de Silva

Main components of the course and grading scheme

- Lectures (21 times)
  - Time: Mon/Fri 3-3:50pm
  - Room: CEME 1215
- Homework assignments (almost weekly, **10%**)
  - **Late hand-in will NOT be accepted.**
  - **No plagiarism! (Do NOT copy and paste other's work.)**
- Labs (**10%**)
- Project (**20%**)
- Midterm (on October 11, Friday, 3-3:50pm) (**20%**)
- Final (Exam period in December) (**40%**)

Labs

- See the files:
  - *MECH366_LabGroups_1920_v1.pdf*
  - *MECH366_LabSchedule_1920_v1.pdf*
- Water tank & DC motor
- Labs begin on September 20 (Friday).
- Room: Kaiser 1160 (near Starbucks)
- Lab manuals will be posted on Canvas.
- Ask TAs for help during the lab.
- Attendance to lab sessions is compulsory.

Project

Project group	Lab group
G1	A1, A2, A3
G2	A4, A5, A6
G3	B1, B2, B3
G4	B4, B5, B6

- Each lab group is required to make a dynamic model of a **real physical** mechatronic system.
- Each project group can share a physical system and data for modeling and model validation, but the model needs to be developed by each lab group.
- Schedule
  - Sep 13 (Fri): Meeting for project topic discussion at Kaiser 1160. (**G1**: 10am, **G2**: 11am, **G3**: 1pm, **G4**: 2pm)
  - Nov 29 (Fri): Presentation, followed by report in Dec.

Project: Tip on system selection

- It is better not to build some mechatronic system from scratch, but to just use some completed one. (This is a modeling course, not a mechatronics system design course.)
- You need actuators and sensors in your system.
- You can find and use the existing modeling method found in the literature for your mechatronic system. But parameters need to be determined to match experimental data.
- If necessary, I will ask MECH for financial support.

Exams

- Policies: Closed-book, one-page letter-size (both sides) hand-written cheat-sheet, no calculator
- Alternative exams can be arranged for medical reasons proven by a doctor's note.
- For other (academic, personal) reasons, you should talk with the instructor before the exam date.

Remark: To pass the course, students MUST not only take both midterm and final exams, but also complete all labs and project.

Introduction of MECH366

- Course title: “Modeling of Mechatronic Systems”
- Natural questions
  - What is “Mechatronic Systems”?
  - What is “Model”?
  - What is “Modeling”?

Mechatronic systems

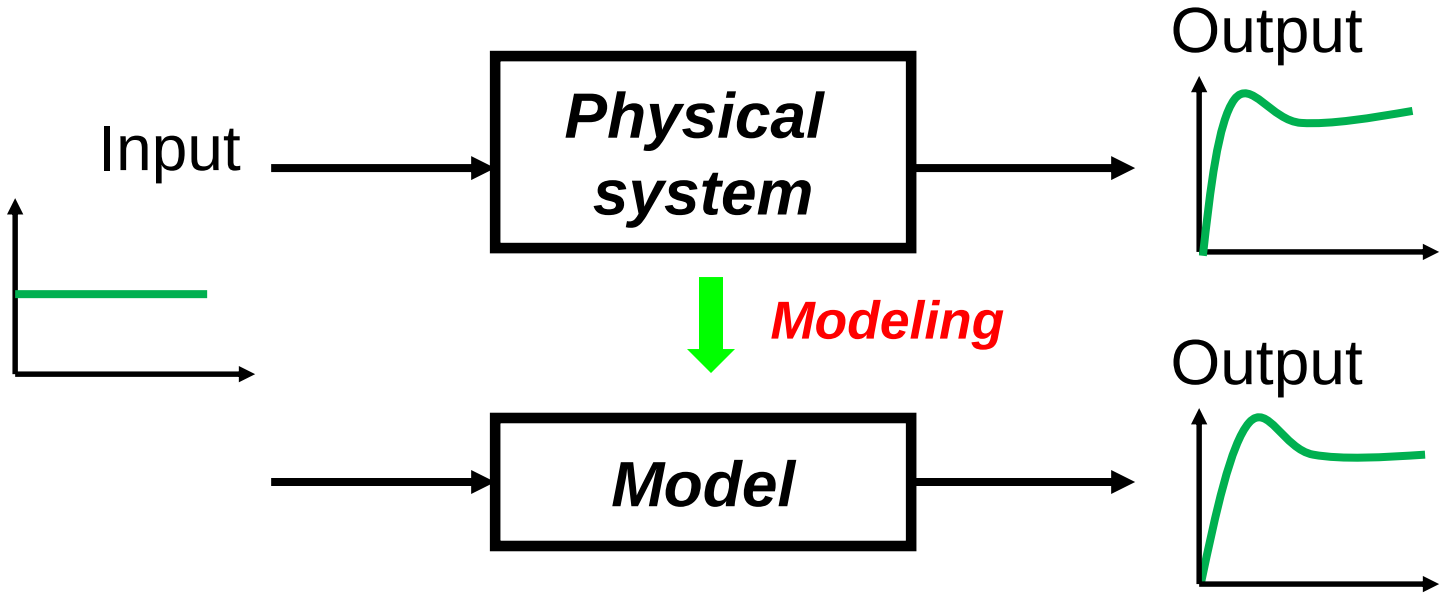
- In Mechatronics option, you are learning how to integrate core subjects and concepts.

Subject	Course #	Subject	Course #
Electrical circuit	MECH2	**Dynamics**	MECH2
Software design	CPEN333	**Mechanical design**	MECH328, 45X
Mechanics	MECH360	**Electronics**	ELEC302
Sensors & Actuators	MECH420	**Instrumentation**	MECH421
Classical control	MECH467	**Modern control**	MECH468

- Modeling (MECH366) provides a foundation for all these subjects and concepts in mechatronics.

Model and modeling

- **Model**: Representation of input-output (signal) relationship of a system
- **Modeling**: Process to derive models



Remarks on models

- No model exactly represents a physical system. There is always a modeling error, or inaccuracy.

$$\text{Math model} \neq \text{Physical system}$$
$$\text{Math model} \approx \text{Physical system}$$

- Do not confuse models with physical systems!
- Goal of modeling: Construct a math model:
  - close enough to a physical system, and yet
  - simple enough to be studied analytically.
- Modeling is an important but difficult task.

Why is modeling important/difficult? (i.e. Why does this course matter?)

- Modeling is important!
  - Models are useful!
    - Prediction of system responses for excitation inputs
    - Analysis of system properties (Fast/slow? Oscillatory?)
    - Controller design
    - Mechanical design (hardware/component selections)
    - Simulation
  - All these go wrong if models are inaccurate.
- Modeling is difficult!
  - Complexity and accuracy are in trade-off relationship.
  - You cannot know if your modeling is successful until the final mechatronic system works.

Examples of systems which are difficult to model

- Human brain
- Fluid turbulence
- Stock market
- Epidemiology
- Climate change

To model these complex systems, data-driven modeling approach (machine learning, system identification) is very popular in this `Big-Data' era.

Goals of this course (This will be shown again at the last class.)

- Acquire basic techniques for *modeling of mechatronic systems* (as the course title says!)
- You will learn:
  - Modeling of mechanical, electrical, thermal, fluid systems
  - Analogies between different domains
  - Linear graph
  - State-space modeling, linearization
  - Transfer function modeling, block diagram
  - Step response analysis
  - Frequency response analysis, Bode diagram
  - Stability

Summary

- Course introduction
- Today's key messages
  - Models play an important role in mechatronic systems design and implementation.
  - However, modeling is not an easy task.
- "Homework"
  - Think about physical systems for the project available for you. Discuss people around you.