Describe and formulate a model of a practical system. Develop (and show to the readers) an in-depth understanding of the system based on knowledge from the class.

- The modeling and analysis exercise contains the following parts
  - one simulation package with corresponding written documentation: 70%
  - one 10min presentation of the documentation in week 4-5: 30%
- This is an individual exercise. You will be randomly assigned to one topic listed below. You can discuss among the class. But everyone must carry out analysis and submit his/her own modeling and analysis report.
- Topics for spring 2020:
  - **Bicycle**: Astrom, K., Klein, R., Lennartsson, a. (2005). Bicycle dynamics and control: adapted bicycles for education and research, IEEE Control Systems Magazine, 25(4), 26 - 47. https://dx.doi.org/10.1109/mcs.2005.1499389
  - **Vehicle steering**: Chap 3.4, Example 3.11 of [Astrom and Murray](http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Version_3.0j)
  - **Vectored thrust aircraft**: Chap 3.4, Example 3.12 and Problem 9.11 of [Astrom and Murray](http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Version_3.0j)
  - **Insulin-glucose dynamics in drug administration**: Chap 4.6 and Exercise 4.9 of [Astrom and Murray](http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Version_3.0j)
  - **Predator–Prey models**: Example 3.4 and Chap 4.7 of [Astrom and Murray](http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Version_3.0j)
  - **Atomic force microscopy**:
    - G. Schitter et al. High performance feedback for fast scanning atomic force microscopes. Review of Scientific Instruments, 72(8):3320–3327, 2001.
    - Chap 4.5 + Ex 9.17 of [Astrom and Murray](http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Version_3.0j)

Develop and simulate the analytic model. Organize and present your modeling and analysis. A sample template for the report is provided on the next page

The presentation and report must include at least the following parts:

1. **title and author information**
2. **problem formulation**:
   (a) **physics**: What is the underlying physics? Use your own language and walk through the main dynamics based on first principles.
      i. *In your report*, do NOT directly list the model and cite a reference. Use data, e.g., tables and illustrations (drawings, pictures, and videos) to demonstrate and support your claims and logic.

   ii. *In your presentation*, provide the main steps of the modeling, considering the 10min presentation limit.

(b) **description of the plant to be controlled**: What are the input and output? What is the model of the plant?

3. **analysis**:

   (a) Start with analyzing the model. Underneath the mathematical equations, how does the plant "look like" to you? Provide your engineering evaluations of model characteristics (e.g., linearization, pole-zero characteristics, fundamental limitations of controls, etc). Evaluate the achievable performance.

   (b) Build the model in Matlab Simulink and/or Simscape. Simulate and analyze the system. Discuss if the results match with your analytic evaluation. Your simulation and report should be comprehensive and documentable, similar to the following examples:

      i. Pendulum on a cart: http://ctms.engin.umich.edu/CTMS/index.php?example=InvertedPendulum&section=SystemModeling

      ii. Suspension system: http://ctms.engin.umich.edu/CTMS/index.php?example=Suspension&section=SystemModeling

      iii. Ball-beam: http://ctms.engin.umich.edu/CTMS/index.php?example=BallBeam&section=SimulinkModeling

4. **references**

Modeling, simulation, and analysis of [xx]

Author

Date

This template is built with LaTeX and LyX. See https://www.lyx.org/Download for installation details.

1 Problem formulation

1.1 Physics

1.2 Description of the plant to be controlled

2 Analysis

2.1 Model linearization (if needed)

2.2 Modal analysis

2.3 Simulation

Your simulation efforts should be readable and documentable. Do NOT submit a simulink model without explaining the intermediate building and analysis steps. Use the following as a reference:

1. Pendulum on a cart: http://ctms.engin.umich.edu/CTMS/index.php?example=InvertedPendulum&section=SystemModeling
2. Suspension system: http://ctms.engin.umich.edu/CTMS/index.php?example=Suspension&section=SystemModeling
3. Ball-beam: http://ctms.engin.umich.edu/CTMS/index.php?example=BallBeam&section=SimulinkModeling