# Course Project Part 1: Controller design in simulation

**Issued 3/24/'23**
**Due 04/13/'23**

**Background:** In this class we are learning about different nonlinear controllers. This course project will allow you to implement and test some of these controllers on physical hardware. You will first design candidate controllers for the ball and beam system [1] in MATLAB. In Part 2 of this project, later in the semester, you will test, and debug, theses controller on hardware to evaluate their performance.

## Directions

- Form groups of 3-4 people to wok together on this project
- The code and instructions for developing your proposed controllers can be downloaded from `https://github.com/HybridRobotics/ball-and-beam-project`.
- The above repo contains a file, *EE_222_Course_Project.pdf*, that has detailed information about the model for the ball and beam system as well as instructions on how to implement and test your proposed controller in MATLAB.
- The following are required deliverables (due on 04/14/'23)
    1. Two different proposed controllers implemented and tested in simulation
    2. An observer implemented for performing state-estimation
    3. A brief report (3-4 pages) describing the proposed controllers and observer and some commentary on their relative performance in simulation. Please cite any papers/work that was used in controller/observer design.
    4. Each group member should upload a folder containing the above report as well as the MATLAB files for the developed controllers and observer.

## Additional Remarks

- Please do not implement an MPC controller. These may not work on hardware because of software interface limitations.
- As is noted in *EE_222_Course_Project.pdf*, the model you will use in simulation will almost have modeling errors and forces that are not modeled/consider (e.g. friction). There are also other factors that will impact the performance of your controller, e.g. measurement noise. These factors will become more apparent as we test your proposed controllers but should also be considered in controller/observer design.

[1] `https://www.quanser.com/products/ball-and-beam/`

- The system may not have a well defined relative degree for parts of the state-space. Therefore, some adjustments may be required to use feedback linearization on this system [2]

[2]Hauser, John, Shankar Sastry, and Petar Kokotovic. "Nonlinear control via approximate input-output linearization: The ball and beam example." IEEE transactions on automatic control 37.3 (1992): 392-398.