Projects may be done individually or in teams of at most 2 people.

Project Description: Due electronically by 5pm on Friday, February 24th, 2023. We will have project discussion meetings during class time on March 6th and 8th to discuss your project description. For teams of 2, only one project description should be submitted with both team member names.

Project Presentation: Everyone (individually or as a team of 2) will present their project in class during the weeks of April 17 through April 26. These presentations will be roughly 15-20 minutes in length and should present each aspect of the project as described below.

Final Project Report: Due electronically (by 5pm on Friday, May 5th, 2023. Please submit your complete report along with your code and any other supporting documents in a **single pdf format**.

Guidelines for designing your project

To encourage the important connection between research, industry application, and classroom education, you are free to design a project based on your own research or interests that fits into the scope of the topics discussed in the class. However, you are responsible for obtaining a problem formulation that clearly fits this scope; we will discuss your idea in a project discussion meeting.

In particular, you are responsible for developing a model that must feature:

- Discrete-time dynamics,
- Represented in state space form with a clearly defined state and control input,
- Explicit incorporation of stochastic disturbances,
- An additive cost function that captures the desired objective of the system,
- Operation over multiple stages (either finite or infinite horizon).

You should include a discussion of your model and formulation, including any assumptions and simplifications you had to make along the way, how to obtain data to quantify the probability distributions of stochastic disturbances, etc. For the purposes of this project, it is perfectly acceptable to make somewhat unrealistic (in the context of your application domain) simplifying assumptions if necessary in order to fit our scope. For example, you may assume that the full state is available for feedback, even though it may be an important and non-trivial requirement in practice to design a state estimator from noisy measurements. Note that many systems can be cast in our implementable framework via space discretization (for low dimensional continuous space models) or linearization (for high dimensional continuous space models with nonlinear dynamics).

With your model in hand, you must apply the dynamic programming methods discussed in class to design a state feedback (or state and disturbance feedback) control policy and compute the associated optimal cost function. You are responsible for formulating a compelling scenario, defining appropriate initial conditions, etc. You should produce plots and visualizations that demonstrate and quantify the performance of your closed-loop system, such as computing or estimating the probabilities of desired or undesired outcomes.

In addition, you must also compare your basic design with one or more alternatives, such as an open-loop controller or one based on approximate dynamic programming methods, such as model predictive control. Again, you should produce plots and visualizations that quantitatively compare alternatives.

The main body of your final report should roughly take the form of an American Control Conference (ACC) paper, which is limited to 6 pages. You should use the LaTex or MS Word templates provided here: http://css.paperplaza.net/conferences/support/page.php
You are free to structure and format the report as you see fit, but as a rough guide it should contain the following sections:

- Introduction, describing the context, a brief literature review, and some discussion of related optimal control and dynamic programming approaches to the problem (if any)
- Model and Problem Formulation, describing in detail the model in our format described above, along with a discussion of simplifying assumptions and limitations.
- Feedback Control Design, describing the application of dynamic programming and approximate dynamic programming methods discussed in class. This section can draw heavily from class notes, but should demonstrate your own understanding.
- Numerical Experiments, describing your simulation studies and including plots and visualizations.
- Conclusions, summarizing what you learned during the project and an outlook for what might be done next, how simplifying assumptions could be removed, how the approach could be generalized, etc.
- Appendices with code, lengthy derivations, or other material relevant to the project but not ideally suited for the main text.

Project Description (Due by 5pm on Friday, Feb. 24th, 2023)

With this end goal in mind, your project description should be a short (no more than one page) typed description of the system you wish to control, the inputs, states, and stochastic disturbances your model will consider, the primary control objective(s), and the types of results you might expect to find from your numerical experiments/simulations.