

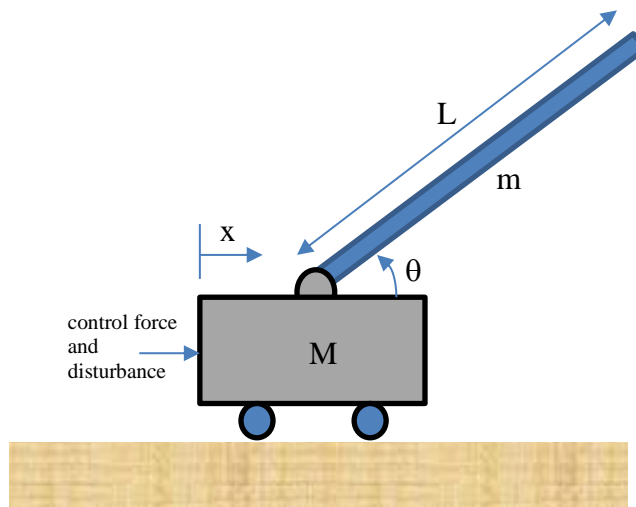
**Department of Mechanical Engineering**  
**ME 577: Advanced Linear Control**

**Control Design Project**

**Spring 2025**

**Due: Sunday April 27, 2025**

**Problem Statement:** The object of this project is to design two controllers for an inverted pendulum using LQR and Pole Placement methods. The inverted pendulum schematics is shown in the figure bellow.



**Deliverables:** A written report of the project, MATLAB codes, and Simulink block diagrams.

**Report:** Final report must include the following items:

1. **An introduction:** Provide an introduction of for the project. This includes doing some research and finding the available research that has been performed out there. Include them in the introduction and explain briefly what methods they have used to model and should come up with a design for the model of the inverted pendulum and then design a controller. This is a solved problem (do not invent the wheel again). Search for inverted pendulum model and controllers, provide an introduction for your project and include references (two pages).

2. **Dynamic model:** Establish the dynamic model of the inverted pendulum system using energy or Newton method, include diagrams. Then, provide the state space equations of the system.
3. **Controllers:** Design the two controllers to keep the inverted pendulum upward. Include your controller block diagrams and design steps in the report. Use ITAE or other optimization methods for pole placement.
4. **Numerical Simulations and Discussion:** Use Simulink to plot the response of controlled and uncontrolled system to small amplitude impulse, and periodic disturbances. Use the following values:  $m=0.35\text{Kg}$  (mass of the bar),  $M=2.2\text{Kg}$  (mass of the cart),  $L=1.3\text{m}$  (length of the bar),  $B=0.25\text{ N/m-s}$  (cart wheels friction coefficient).  
Discuss the results that you have received based on various disturbances. Compare the results of two controllers for each disturbance, and any advantages or disadvantages of the controllers based on performances.
5. **Conclusion:** Write a conclusion about the overall report and important outcomes of this research.

**Appendix:** Add the MATLAB codes you have written and Simulink diagrams here. Explain briefly about each one, or have comments in the codes and diagrams.

Please provide a quality report. It is better if you can type the report. Try not to write a very long (over 20 pages) or very short (under 4 pages) report. Work together as a team, I will ask you individually how much each person has contributed once the project is finished, and submit the Student Evaluation Form together with your final project report. (The same final report will be uploaded by each member from the same group, while the Student Evaluation Form will be uploaded separately.)