# Inverted pendulum on a cart

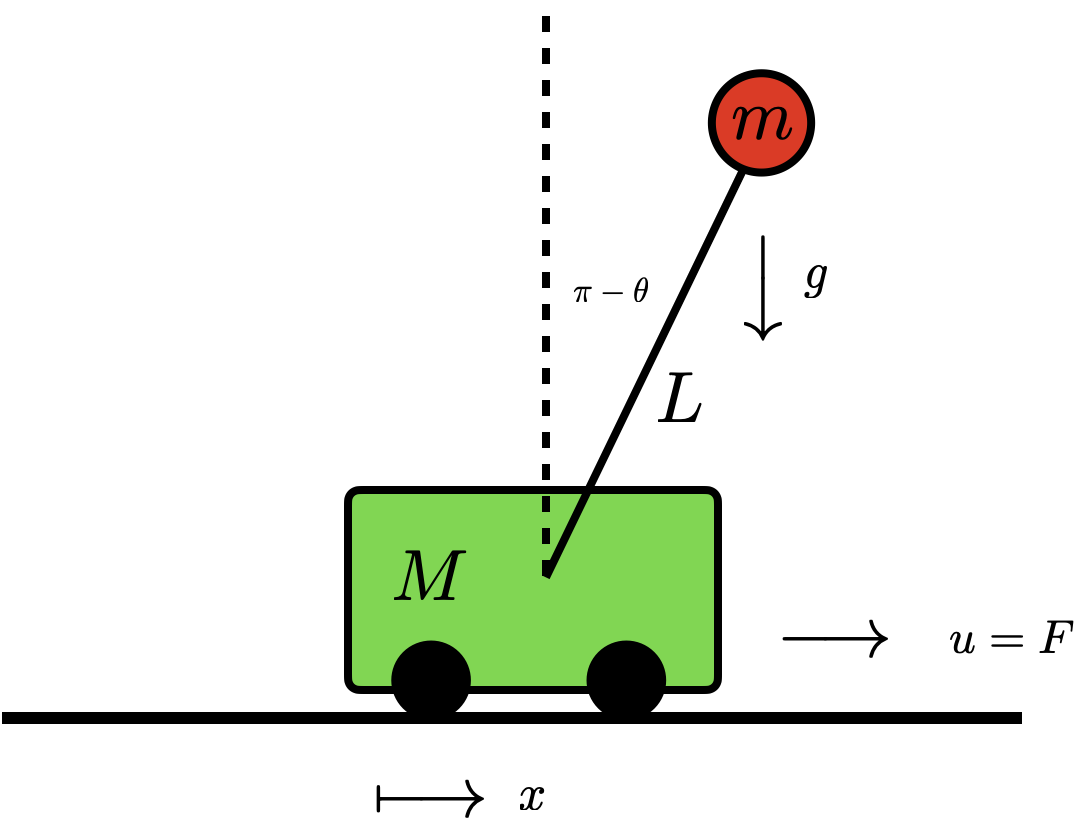


Figure 1. Schematic of inverted pendulum on a cart.

The inverted pendulum on a moving cart system shown in figure 1 is used in multiple applications as moving heavy objects, robot manipulators just to name a few. The only deriving force for this system is the force affecting the cart. There are two fixed points, corresponding to either the pendulum down (stable) or pendulum up (unstable) configuration; in both cases the angular and linear velocity of the pendulum are zeros. The **goal** is to derive the pendulum to the unstable configuration. To do so you must:

1. Derive the full nonlinear dynamics of the system.
2. Linearize the equations around the unstable fixed point (pendulum up configuration i.e., ).
3. Either use Laplace domain or the time domain to analyze the system response by analyzing the:
   1. Force free motion (i.e., only excite the system by different initial conditions).
   2. The step/ramp/parabolic response of the system under different initial conditions.
4. Use any of the proposed controllers to derive the pendulum to the unstable configuration:
   1. LQR
   2. MPC
   3. PID along with genetic algorithms to tune the PID gains.

# Project

1. System Modeling:
   * Develop a mathematical model of the system using first principles.
2. Controller Design:
   * Choose a control strategy from the proposed schemes.
   * Design the controller gains based on the system model and desired performance criteria, such as stability and response time.
3. Software implementation:
   * Use MATLAB to simulate the system and to implement the control algorithm in simulation.
4. Documentation and Presentation:
   * Document your work in a report summarizing the project, including the system modelling, controller design, and results analysis.
   * Make a presentation to discuss the project and present the results to the class.