Problem Statement and Goals
Inverted Pendulum Simulator

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April 19, 2023

Table 1: Revision History

Date	Developer(s)	Change
January 20, 2023	Mina Mahdipour	First version of document
January 25, 2023	Mina Mahdipour	Changes in problem and input-output sections
April 14, 2023	Mina Mahdipour	Updating all documents

1 Problem Statement

An inverted pendulum is a pendulum upside down with its pivot point under its center of mass. It is unstable and without additional help and by any small disturbances will fall over. To stay upright, it needs a controller to keep its center of mass above its pivot point even when disturbances occur. The objective of the control system is to balance the inverted pendulum by applying a force to the place that the pendulum is attached to.
Inverted Pendulums are everywhere, from the human posture system, and Segway, to the launching of a rocket.

1.1 Problem

Simulating the system of an unstable pole mounted on a cart, which can move horizontally, is the main problem of this project. There are two degrees of freedom in this problem, the horizontal movement of cart and the pendulum rotation angle with vertical axis. Therefore, there are two equations of motion, one for each. Solving these equations describe the motion of the cart and the pendulum and help to understand the system in different positions and time.

1.2 Inputs and Outputs

The inputs of the system will be the cart and pendulum specifications such as the mass of cart, the mass of the pendulum, pendulum length, the inertia of the pendulum, the coefficient of friction of the cart, and also an external force to the cart which can be a function of time and the initial condition of the system. The outputs are the angular position of the pendulum and the horizontal position of the cart.

1.3 Stakeholders

As the inverted pendulum is widely used as a benchmark for testing control strategies and algorithms, and it can be used in different applications, the potential stakeholders could be all the related industries using this system.
This project is the first step to creating a stable system, therefore, it can be extended to design a control system in a way that stabilizes the inverted pendulum. On the other hand, it is a classic problem in dynamics and control theory, so the final system can be used in high schools as educational material.

1.4 Environment

There is no limitation on this system and the final software will be compatible with different operating systems such as Windows, MacOS, and Linux.

2 Goals

1. Designing software that simulates the behavior of the system.
2. Showing the effects of the different parameter values on the system behavior.

3 Stretch Goals

1. Visualizing the problem with an interactive graphic design.
2. Designing a system that can control and stabilize the pendulum.
3. Simulating double inverted pendulum problem.