**AI Programming (IT-3105) Spring 2025 lab report**

Project 1 - A General Purpose JAX-based Controller

**Group**: 11

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**Introduction**

In this project, we built a general-purpose PID controller that could simulate different controllable systems and apply two types of PID controllers: the traditional three-parameter model and a neural-network-based version.

For each controller and controlled system, our program used Python’s JAX module to compute gradients and update the controller parameters using a basic gradient descent or ascent algorithm.

This report presents performance measures as illustrations and details the parameters used for different plants and controllers. It also includes a brief mathematical description of the third plant."

Suppose we have a pendulum with an electric motor at its base. The electric motor delivers energy;   
We assume each timestep is 1.0 seconds.

Voltage is a constant controlled by a hyperparameter.

The current is controlled by the controller.

This leaves us with the control signal

The goal is to simulate a perpetual motion machine using the controller to control the amperage at each timestep.

The system loses energy mostly due to air resistance. The following will be a mathematical description of how much energy the pendulum loses at every timestep.

To overcome the air resistance, we measure by the rate of the work done

If we knew the speed, we could just use the time delta to find energy needed, however we must make estimations.

At the bottom of the pendulum the potential energy is 0 and the kinetic energy is at its peak. We can calculate V max from this.

We can use this to find the

A pendulum is a harmonic oscillator and its position over time is described by if its angle is below 30 degrees:

Since cos starts at 0, we don’t care about any shifts when finding the average speed over ¼ of an oscillation.

Given we start from the start of an oscillation the average speed of ¼ would be equal to the average speed of the whole oscillation.

Solving this we get

Plugging this into the formula for air resistance we get

This means we lose P energy every second, and since we assume delta t = 1.

If we put this in the bigger picture, we can also add the controller input and disturbance:

The final equation for the new total energy will be: