Practical 2

CSE Spring 2023

1. Run the mass-spring-damper model (`python3 task1.py`).
   (a) Familiarize yourself with the controls.
   (b) Plot several curves with roughly the same starting position, but different stiffnesses onto the top plot simultaneously. How does changing the stiffness affect the period of the system?
   (c) Repeat the experiment with stiffness of about 3, but varying damping ratio. Test damping ratios of 0.05, 0.1, 0.2, 0.4, 0.5. How does the damping ratio affect the period of the system?
   (d) Plot the system with constant stiffness, but using three different damping ratios: critically damped, slightly overdamped and significantly overdamped. How does this affect the time that it takes to reach the steady state?

2. Run the pendulum model (`python3 task2.py`). You'll also notice that it comes with a controller file (`pendulum_controller.py`) that you can use to generate torque at the red cross mark.
   (a) Without modifying the pendulum controller, play around with the system.
      i. How does changing the gravity affect the frequency of oscillations?
      ii. How does changing the friction affect the frequency of oscillations?
      iii. Try to balance the pendulum upside down. (The pendulum does not have to stay balanced.)
   (b) Use the file `pendulum_controller.py` to provide constant torque to the system. You can reload the code without restarting the simulator using the pink button.
      i. Experiment with different constant inputs, including negative ones. How does this affect the locations of the two equilibrium points of the pendulum?
      ii. What happens when the torque gets too big?
      iii. Keeping the torque at a constant value, modify the gravity and friction settings. What happens to the equilibrium points of the pendulum?
      iv. What kind of input is this similar to?
   (c) Set gravity and friction to approximately 1. Use the file `pendulum_controller.py` to provide different sinusoidal inputs to the system: use the function `math.sin(n*time)`, where `n` is given different values ranging from 0.25 to 5. Set the starting position of the pendulum to be roughly the same for all the experiments and plot them on the same graph. How does the frequency of the input oscillation affect the output (i.e. the motion of the pendulum)?
   (d) Write a controller that would balance the pendulum upside down.
   (e) Modify your controller such that it would be limited to a maximum torque of 1. Does it still work? Can it get the pendulum to stand upside down from any starting position with gravity set to 9.8? Try to modify the controller such that it would be able to handle a wide range of situations even if the maximum output torque is limited. (This would realistically happen when the motor is not infinitely powerful.)