ETF Controls (1-A)

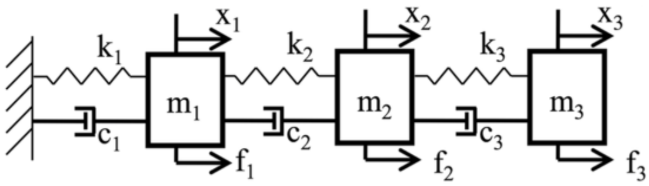
(You need to do boring stuff before you can do cool stuff 🙂)

Assignment 1:
Modeling and Response Analysis of a Spring-Mass-Damper Three-Cart System

Introduction:
Welcome to the intriguing world of multi-cart systems! In this assignment, we will explore the dynamics and response of a three-cart system. The system consists of three carts connected by springs and dampers, forming a three-degree-of-freedom (3-DOF) model. Your task is to model the system, derive its dynamic equations, and generate response plots that illustrate the system's behavior under specific conditions. Let's dive in and uncover the fascinating dynamics of the three-cart system!

Task 1: Modeling the Three-Cart System:

Consider the following 3DOF spring-mass-damper system with external forces $f_1(t)$, $f_2(t)$, and $f_3(t)$.



System Description:
- The three-cart system is described above, including the arrangement of the carts and the connections between them.

Variables and Parameters:
- Define the necessary variables and parameters required for modeling the system. -
- Here f1, f2, and f3 are the force applied on the respective block and are the control inputs to the system.

Derivation of Dynamic Equations:
- Apply Newton's second law of motion to derive the dynamic equations for each cart in the system.
- Consider the forces from the springs, dampers, and any external inputs.
- Present the step-by-step derivation process, including any assumptions made.
- Simplify the equations while retaining the essential terms and variables.

Task 2: Response Analysis of the Three-Cart System:

Simulation Setup:

- Set up the initial conditions and parameters for the simulation of the three-cart system.
- Specify the masses, spring constants, damper coefficients, and other relevant parameters.

Numerical Integration:

- Select an appropriate numerical integration method, such as Euler's or a more advanced solver.
- Implement the derived dynamic equations in Python or C++ to integrate and numerically simulate the system's behavior.

Response Plots:

- Generate response plots (Step and Sinusoidal) that illustrate the behavior of the three-cart system under specific conditions.
- Include plots of cart positions, velocities, and accelerations over time.
- Explore different scenarios by varying initial conditions or system parameters and observe the corresponding response plots.

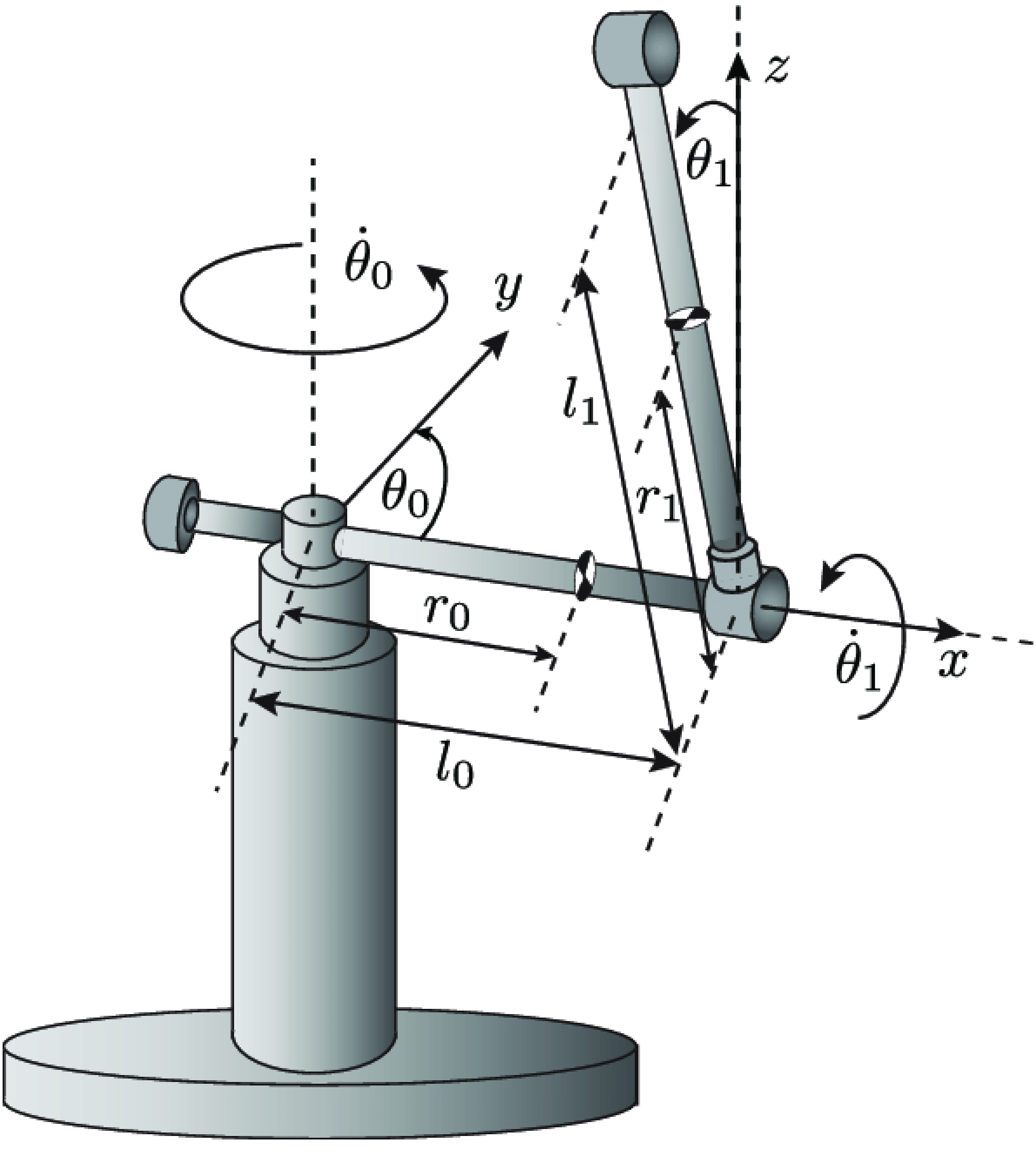
Deliverables:

The assignment should include the following deliverables:

- Derivation of the dynamic equations governing the system, explaining the steps and assumptions made.
- The simulation section showcases the implementation of the dynamic equations and the numerical integration method.
- Response plots illustrate the system's behavior under different scenarios.
- **(Optional)** Analysis and interpretation of the response plots, explaining the observed behavior in terms of the system's dynamics.
- **(Optional)** Conclusion summarizing the key findings, insights gained from the response analysis, and potential future extensions or improvements.

Enjoy exploring the dynamic responses of the three-cart system and uncovering its intriguing behavior!

Assignment 2:
The Furuta Pendulum: Derivation & Simulation



Introduction:
Welcome to the fascinating world of the Furuta Pendulum! Get ready for an exciting adventure into the realm of rotational inverted pendulums. The Furuta Pendulum, invented by Katsuhisa Furuta and his colleagues at the Tokyo Institute of Technology in 1992, is a complex nonlinear oscillator that has captivated the minds of control system theorists. In this assignment, we will derive the dynamic equation governing the Furuta Pendulum and simulate its behavior using **Python or C++ programming**.

Task 1: Derivation of the Dynamic Equation:

System Description:
- Understand the components of the Furuta Pendulum system, comprising a driven arm rotating in the horizontal plane and a pendulum free to rotate in the vertical plane.
- Identify the forces at play, including gravitational, Coriolis, and centripetal forces.

Variables and Parameters:
- Define the variables and parameters for the dynamic equation derivation, explaining their meaning and units.

Derivation:
- Utilize Newtonian mechanics and Lagrangian dynamics principles to derive the equations of motion for the Furuta Pendulum.
- Account for the effects of gravitational, Coriolis, and centripetal forces.
- Present a step-by-step derivation process, highlighting any assumptions made.
- Simplify the derived equations while retaining essential terms and variables.

Task 2: Simulation of the Furuta Pendulum:

Programming Language Selection:
- Choose Python or C++ as the programming language for simulating the Furuta Pendulum.
- Mention any relevant libraries or frameworks necessary for the simulation in the comments.

Implementation:
- Implement the derived dynamic equation into code, considering suitable integration methods.

Simulation Setup:
- Define the initial conditions for the simulation, such as initial angles and angular velocities of the arm and pendulum.

Simulation Loop:
- Set up a simulation loop that iterates through time, updating the system state at each time step based on the dynamic equation.

Deliverables:
The assignment should include the following deliverables:
- Introduction to the Furuta Pendulum, highlighting its significance in control system theory and the pioneering work of Katsuhisa Furuta and his colleagues.
- Derivation of the Furuta Pendulum's dynamic equation clearly explains the steps and assumptions made.
- Simulation section, specifying the chosen programming language and relevant implementation details.

- **(Optional)** Results and analysis of the simulation, including visualizations and explanations of the observed behavior.
- **(Optional)** Conclusion summarizing the key findings, challenges encountered during the derivation and simulation, and potential future extensions or improvements.