Assignment # 03 (CLO3)

**Design of a PID control system for a Toy Train System**

**(To be submitted by 16th May 2023)**

***General Information:***

Consider a toy train consisting of an engine and a car. Assuming that the train only travels in one dimension (along the track), we want to apply control to the train so that it starts and comes to rest smoothly, and so that it can track a constant speed command with minimal error in steady state.

The mass of the engine and the car will be represented by $M_1$ and $M_2$, respectively. Furthermore, the engine and car are connected via a coupling with stiffness $k$. In other words, the coupling is modeled as a spring with a spring constant $k$. The force $F$ represents the force generated between the wheels of the engine and the track, while $\mu$ represents the coefficient of rolling friction.

A picture containing screenshot

Description automatically generated

Figure-1

A picture containing screenshot, diagram, line, plot

Description automatically generated Figure-2 Free Body diagram of entire system

***Requirements:***

1. Construct the mathematical model of the provided system in the forms of equations of motion and find transfer function between engine’s speed and input force.

**In MATLAB: [submit proper Simulink files, codes and response plots]**

1. Construct the Simulink model for given system such that.

* $M_1$ = 1 kg
* $M_2$ = 0.5 kg
* $k$ = 1 N/sec
* $F$ = 1 N
* $\mu$ = 0.02 sec/m
* $g$ = 9.8 m/s^2

1. Plot the system’s response (x1\_dot) for square wave input with frequency set to 0.001. You may leave the Units as the default Hertz. Also enter "-1" into the Amplitude field (positive amplitude steps negative before stepping positive).
2. Now Introduce a Cascaded PID controller and construct a unity feedback system. Plot the system’s response for (x1\_dot) for same input.
3. Adjust the PID controller’s gain to get smallest possible error and fastest transient response. Re-plot the system’s response for (x1\_dot).

**References: Norman S. Nise**, “Control Systems Engineering,” 5th Edition, John Wiley & Sons, 2008

**Note:** please use standard A-4 size paper for the assignment and leave reasonable margins on the top, bottom, left & right.