ME 417 - Homework #1

Control of Mechanical Systems - Summer 2020

Homework Due: Sun, 18 Oct 2020 23:59

Complete the following problems and submit a hard copy of your solutions. You are encouraged to work together to discuss the problems but submitted work **MUST** be your own. This is an **individually** submitted assignment.

Problem 1

System Modeling (25pts)

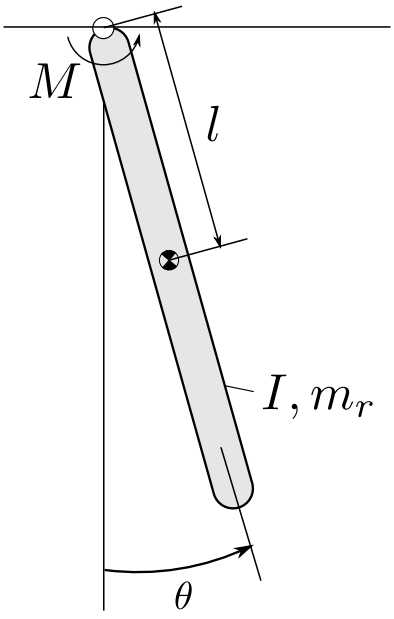
Given the following system

a. Derive the equations of motion for the system

b. Find the transfer function that relates M to $\dot{\theta}$

c. Find the pole locations of the transfer function derived in part (b)

Given: $l = 1m$, $m_r = 2.5kg$



Problem 2

System Modeling (25pts)

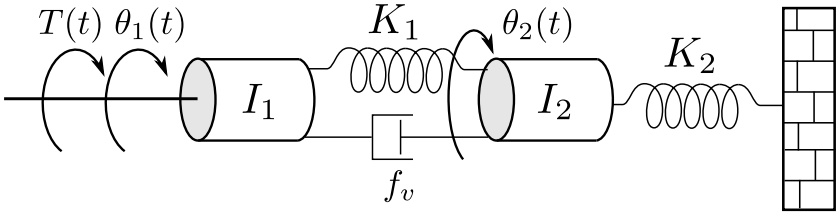
Given the following system

a. Derive the equations of motion for the system

b. Find the transfer function that relates T to θ_2

c. Find the steady state value of θ_2 given a step-input $T(t) = 2$

Given: $I_1 = 0.5kg \cdot m^2$, $I_2 = 0.25kg \cdot m^2$, $K_1 = 200N/m$, $K_2 = 300N/m$, $f_v = 50N \cdot s/m$



Problem 3

System Modeling (25pts)

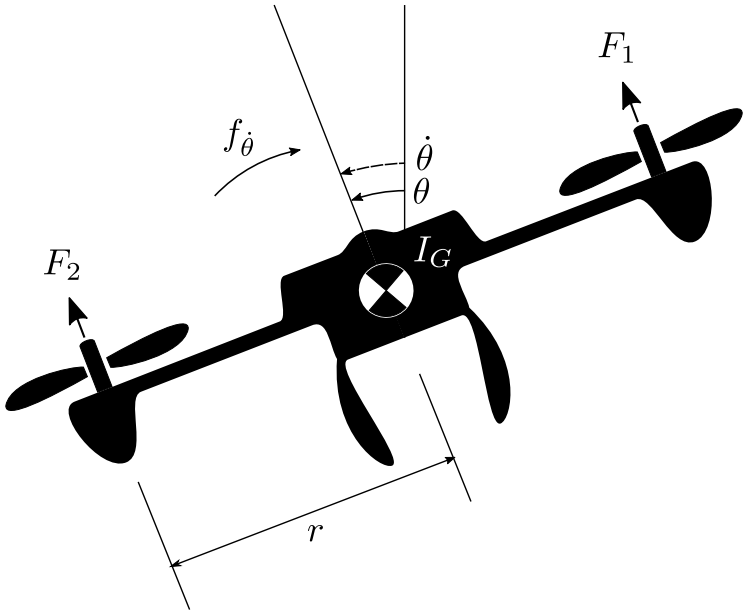
Consider a simplified quadrotor pitch control model. The Thrust F is a function of the rotor's speed $F = k_T\omega^2$, where k_T is the thrust constant

a. Derive the equation of motion for the system governing the pitch angle dynamics only

b. Find the transfer function that relates $\Delta F = F_1 - F_2$ to $\dot{\theta}$

c. Find the steady state value of $\dot{\theta}$ given a step-input $\omega_1 = 250rad/s, \omega_2 = 150rad/s$

Given: $I_G = 0.5kg \cdot m^2$, $K_T = 0.15kg \cdot m$, $r = 30.0cm$, $f_v = 0.25N \cdot s$



Problem 4

Transfer Function Components (25pts)

For each of the following 3rd order systems, perform a partial fraction expansion, then cancel the third pole term if it is real magnitude is five times or higher than the real magnitude of the other two poles

a. $G(s) = \dfrac{10}{(s+1)\,(s^2+2s+2)}$

b. $G(s) = \dfrac{23}{(s+2)\,(s+3)\,(s+20)}$

c. $G(s) = \dfrac{2}{(s+10)\,(s^2+6s+8)}$

d. $G(s) = \dfrac{1}{(s+40)\,(s^2+2s+100)}$

e. $G(s) = \dfrac{5}{(s+10)\,(s^2+8s+20)}$