MAE3134: Homework 1

Due date: 6 February 2018

Problem 1. A block with mass 500 g oscillates at the end of a linear spring with a spring constant of $7.5\,\mathrm{N\,m^{-1}}$. You can assume this is a top-down view and the block is sliding on a frictionless surface, i.e. gravity is not a factor in this problem.

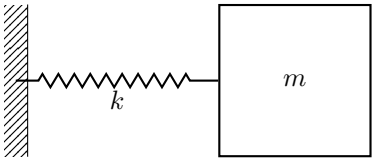

Figure 1: Mechanical System

(a) What is the equation of motion governing the motion of the block?

Problem 2. Find the equations of motion for the model given in Fig. 2.

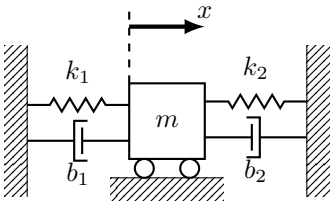

Figure 2: Mechanical System

Problem 3. George Washington University is attempting to launch its first satellite into orbit, GWSAT. In order to control the orientation of the spacecraft, attitude control thrusters are mounted to control the rotational motion about the pitch axis. The thrusters are fired in pairs to produce positive and negative torques as required, i.e. B and D and A and C are fired together to produce positive and negative torques, respectively. Develop the equations of motion that relates the pitch motion of the spacecraft, θ, to the thruster force inputs. The spacecraft is modeled as a constant density cube with sides of length L and a total mass of m.

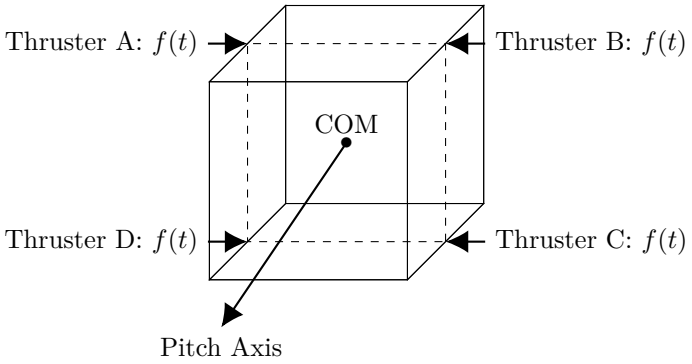

Figure 3: GWSAT Model

Problem 4. In order to communicate with the forthcoming GWSAT, a ground station and movable antenna will be required at GWU. Consider the model shown in Fig. 4. A torque motor drives the antenna shown below about the vertical axis (perpendicular to the horizon) to control the azimuth pointing direction of the antenna. The torque generated by the motor is $T(t)$ and the total moment of inertia of the antenna and platform about the vertical axis is J and the damping coefficient is b. Determine the equations of motion that describes the azimuth motion ϕ of the antenna.

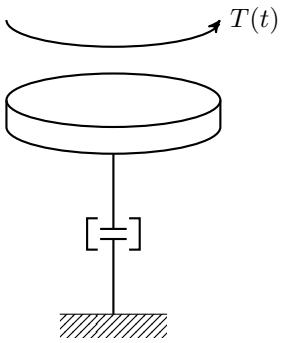

Figure 4: Antenna Model

Problem 5. Find the equations of motion for the electrical circuit in Fig. 5.

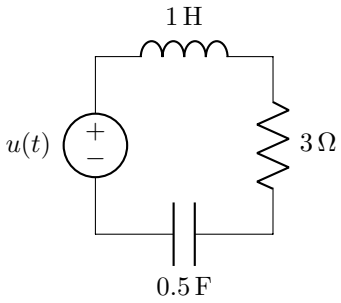

Figure 5: Electrical System

Problem 6. Compute the Laplace transform for the following functions. Show your work including all of the steps in your solution, i.e. you CANNOT simply use a transformation from a table but should derive it yourself by taking the integral.

(a) $e^{4t} + 5$

(b) $\cos(2t) + 7\sin(2t)$

(c) $e^{-2t}\cos(3t) + 5e^{-2t}\sin(3t)$

(d) $10 + 5t + t^2 - 4t^3$

(e) $e^{3t}\left(t^2 + 4t + 2\right)$

(f) $6e^{5t}\cos(2t) - e^{7t}$