The University of Texas at Austin
Department of Electrical and Computer Engineering

EE362K: Introduction to Automatic Control – Fall, 2017

Problem Set 1

Recommended Reading: Chapters 1 & 2 of Murray

1. Complete the exercises in Sections 1 & 2 of the posted MATLAB review or another good online tutorial such as http://www.math.utah.edu/lab/ms/matlab/matlab.html. If you find a great tutorial, please share. We will use MATLAB throughout the class. *You do not need to turn in your answers*, but submit a signed statement that asserts you completed these exercises on your own or completed an equivalent activity.

2. (vision tracking control) *Good news! This is an assignment you can do while resting on your couch or bed and staring at a ceiling fan.* Find a ceiling fan with multiple speeds. Starting with the lowest speed, attempt to track one blade with your vision and repeat for each speed available on the fan (try to find a fan with at least three speeds). For speeds where you can track a single blade, estimate the ***angular*** frequency of the fan by counting revolutions and using a timer. Based on this experiment, for what frequency range can you assert with some confidence that you can track the motion of an oscillating object. Suggest (but do not perform) an experiment and set up that would give you a more precise answer.

3. Identify five feedback systems (not mentioned in class) that you encounter in your everyday environment. For each system, identify the sensing mechanism, the actuation mechanism, and the control law.

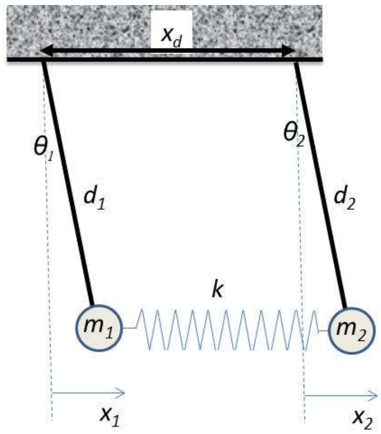
4. Rewrite the following 3 sets of ODEs in state-space form. The only output of interest in each case is y or y_1.

$$\dddot{y} + 7\ddot{y} - 5y = 2$$

$$\begin{aligned} -0.5\ddot{y}_1 + \dot{y}_1 + y_1 &= -11 \\ 0.5\ddot{y}_2 - \dot{y}_2 + 2y_1 &= 2 \\ \dot{y}_3 + y_3 + y_1 &= 5 \end{aligned}$$

$$\begin{aligned} 2\dddot{y}_1 - 4\ddot{y}_1 + y_2 + 2\dot{y}_1 &= -10 \\ \ddot{y}_2 + \dot{y}_1 + 5\ddot{y}_1 + y_1 &= -2 \end{aligned}$$

5. Below is the derivation of the dynamic model for a double pendulum system. Verify the derivation is correct and determine what assumptions were necessary to arrive at the given equations of motion. Then, convert the given equations to state-space form.



$$\sum F_{1,i} = F_{gravity,1} + F_{friction,1} + F_{spring,1} = m_1 a_1$$
$$\sum F_{2,i} = F_{gravity,2} + F_{friction,2} + F_{spring,2} = m_2 a_2$$

If we make a few assumptions, the equations of motion are:

$$m_1 d_1 \ddot{\theta}_1 + g m_1 \theta_1 + k(d_1\theta_1 - d_2\theta_2) = 0$$
$$m_2 d_2 \ddot{\theta}_2 + g m_2 \theta_2 + k(d_2\theta_2 - d_1\theta_1) = 0$$

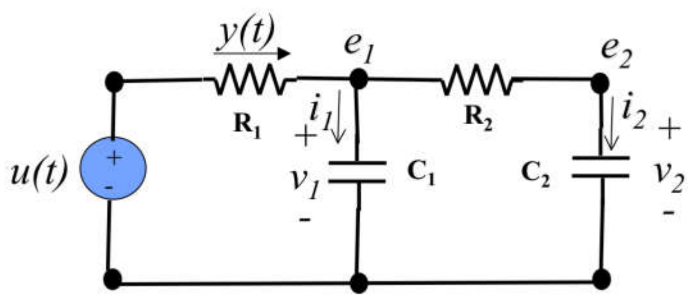
$m_1 = m_2 = 2.7$ kg; $d_1 = d_2 = 0.45$ meters
$b_1 = b_2 = 0.05$ Nms; $x_d = 0.65$ meters
$k = 13$ N/m; Gravity, $g = 9.81$ m/s^2

6. Convert the following differential equations into state-space form assuming the measure signals are $\left[x_1, \dot{x}_2, u_1(t)\right]$ ($\dot{z} = \mathbf{A}z + \mathbf{B}u$, $y = \mathbf{C}z + \mathbf{D}u$).

$$2\dddot{x}_1 - 4x_1 + 2x_2 - \dot{x}_2 = 5u_1(t)$$
$$2\ddot{x}_2 - 2x_2 - \dot{x}_2 + \ddot{x}_1 + 5x_1 = u_1(t) - u_2(t)$$

7. For the matrix $\mathbf{A}$ found in problem 6, use MATLAB to determine its determinant, eigenvalues and eigenvectors of the matrix. To learn more, type 'help eig' or 'help det' at the MATLAB command line.

8. Find the state space model for the following circuit.



Assume the input is the voltage *u(t)* and the output of interest is voltage across R_2. How does the state-space model change if we are instead select the current through R_1 as the output?