



Faculty of Engineering and Technology
Department of Mechanical and Mechatronics Engineering
First Examination – Summer 2018

ENME 438: Control Theory

Date of Examination: 18/7/2018

Instructor: Sima Rishmawi

Student ID: _____

Time duration: 90 minutes

Total Marks: 100

This exam contains 4 pages (including this cover page) and 3 problems. Check to see if any pages are missing. Enter your Student ID number on the top of this page, and on the Answer Booklet.

You may *not* use your books, notes, or any other reference on this exam, except for a one-sided A4 cheat sheet (to be handed in with your exam). You can use your own calculator only. Borrowing calculators is not allowed.

You are required to hand in the exam paper with your answer booklet. Failure to do so, will cause you to fail the exam.

Do not write in the table to the right.

Problem	Points	Score
1	40	
2	30	
3	30	
Total:	100	

1) Fill in the boxes with the suitable answers:

1. A control system has Laplace Domain Transfer Function: $G(s) = \frac{3s+1}{(s+1)(s+2)}$
What is the system's Unit Impulse Response?

2. The Transfer Functions corresponding to each of the following differential equations are:

$$5\dot{y} + 12y = 2u(t)$$

$$\frac{d^3y}{dt^3} + 5\frac{d^2y}{dt^2} + 40\frac{dy}{dt} + y = \frac{d^2u}{dt^2} + 2\frac{du}{dt} + 3u$$

3. The differential equations corresponding to each of the following Transfer Functions are:

$$\frac{Y(s)}{U(s)} = \frac{1}{s+2}$$

$$\frac{Y(s)}{U(s)} = \frac{3s+1}{s^2+9}$$

4. For the non-linear function shown below, answer the following two questions:

$$f(x, u) = \dot{x} = 3x^3 + 5u$$

If at equilibrium ($\dot{x} = 0$) $x_o = 1$, then $u_o =$

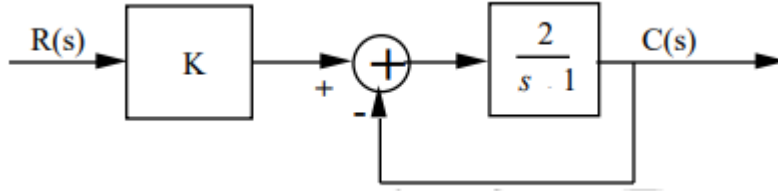
The linearized function about (x_o, u_o) is:

$$\text{Hint: } f(x, u) = f(x_o, u_o) + \left. \frac{\partial f}{\partial x} \right|_{x_o, u_o} (x - x_o) + \left. \frac{\partial f}{\partial u} \right|_{x_o, u_o} (u - u_o)$$

5. When transforming the following Transfer Function to a State Space Representation, then the matrix A will be:

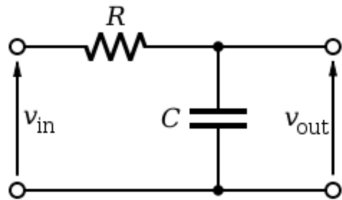
$$G(s) = \frac{8s+10}{2s^5+18s^4+26s^3+8s}$$

6.



The Transfer Function $\frac{C(s)}{R(s)}$ is:

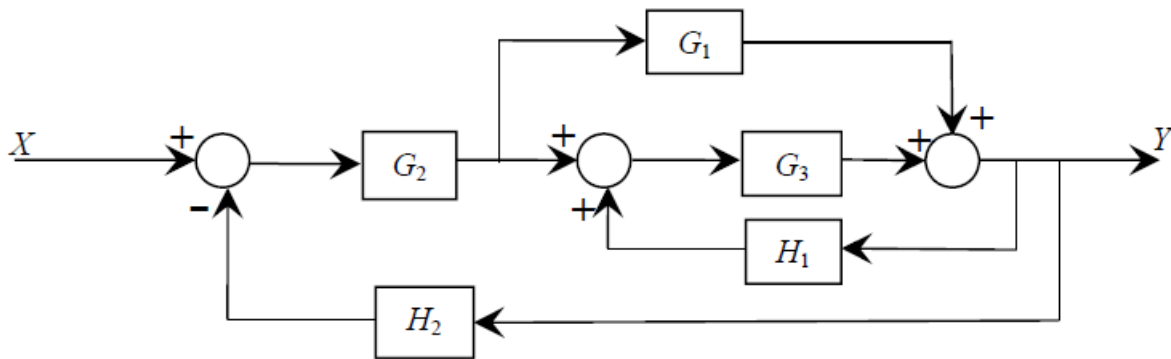
7.



The Transfer Function $\frac{V_o}{V_{in}}$ is:

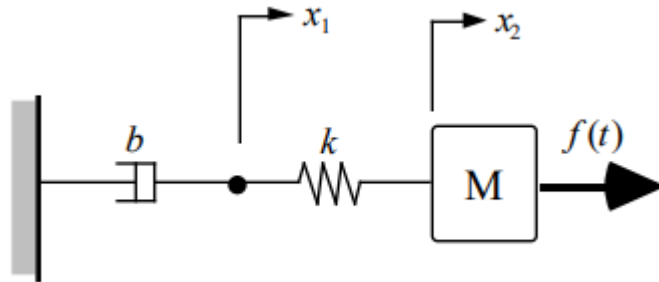
40 marks

2) Using block diagram algebra, reduce the block diagram shown in the figure below to find the transfer function $T(s) = \frac{Y(s)}{R(s)}$. Show all the steps in detail.



30 marks

3) For the vibratory system shown in the figure,



- Derive the differential equations needed to model the mechanical system's response to the force $f(t)$. Assume x_1 and x_2 are measured from the equilibrium position, and the point at x_1 is massless.
- Give the Transfer Function $\frac{X_2(s)}{F(t)}$
- Write the state space equations needed to model the system where $f(t)$ is the input of the system and $x_1(t)$ and $x_2(t)$ are the outputs.
- Draw the electric circuit that is analogous to this mechanical system. Label all voltages, and currents. Express electric passive elements in terms of b , k , and m .

30 marks