H. S.

Carleton UNIVERSITY

FINAL
EXAMINATION
Fall 2020

DURATION: 3 HOURS **No. Of Students: 200**

Department Name & Course Number: **Systems and Computer Engineering**
SYSC 3600B

Course Instructor (s): H. Schwartz

AUTHORIZED MEMORANDA

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has ___6_____pages + cover page = __7_ pages in all

This examination question paper may not be taken from the examination room.

In addition to this question paper, students require: an examination booklet no
Scantron Sheet no

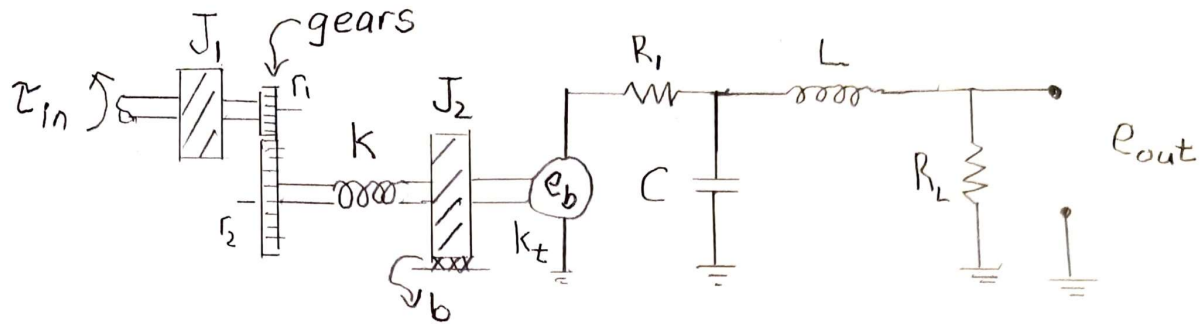
Name: _____

Student Number: _____

Question	Value	Score
1	25	
2	25	
3	25	
4	25	
Total	100	

Question 1 (25 marks)

Model the following dynamic system using energy state variable form. Clearly define the energy storage devices and the associated state variables. Clearly explain in **writing (written sentences)** every equation that you write. I want to understand why you wrote each equation in your own words. Do not draw the simulation diagram. Pretend that **you are teaching me how to do the question**.



Question 2 (25 marks)

A dynamic system has the following transfer function. Find the **unit step** response.

$$H(s) = \frac{100(s^2 + 10s + 41)}{(s + 6)(s^2 + 4s + 5)}$$

Show and explain how one uses graphical methods to compute the partial fraction expansion. Only graphical methods will be accepted. Write the solution only in the form shown in class. Take a picture showing a single example of how to use a ruler to determine a magnitude in the computation of the residue and another picture of a protractor showing your angle for a phasor. Insert your pictures into your solution. I will need to be able to read the scale on your ruler and protractor.

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Question 3 (25 marks)

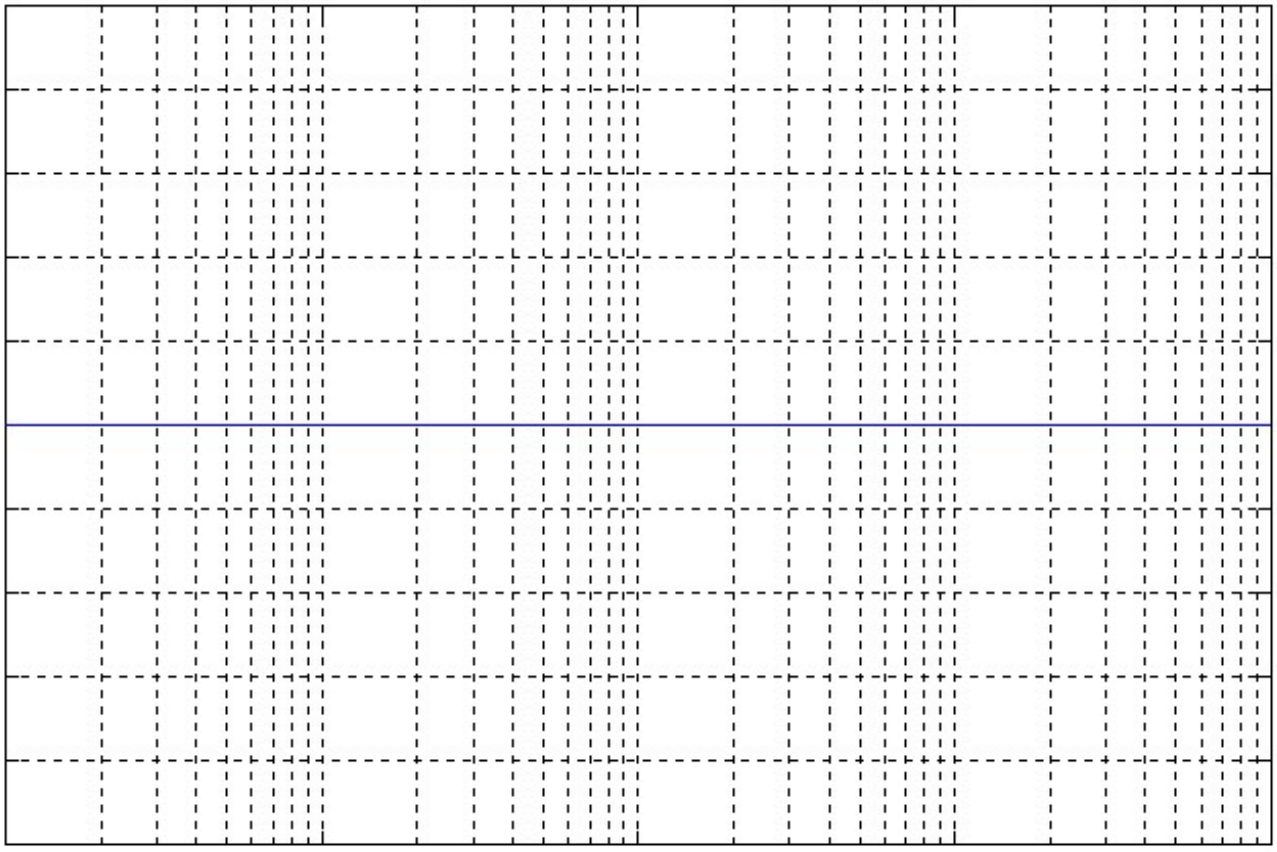
You are given the following transfer function,

$$H(s) = \frac{10(s^2 + 0.8s + 25)}{(s+1)(s^2 + 0.3s + 900)}$$

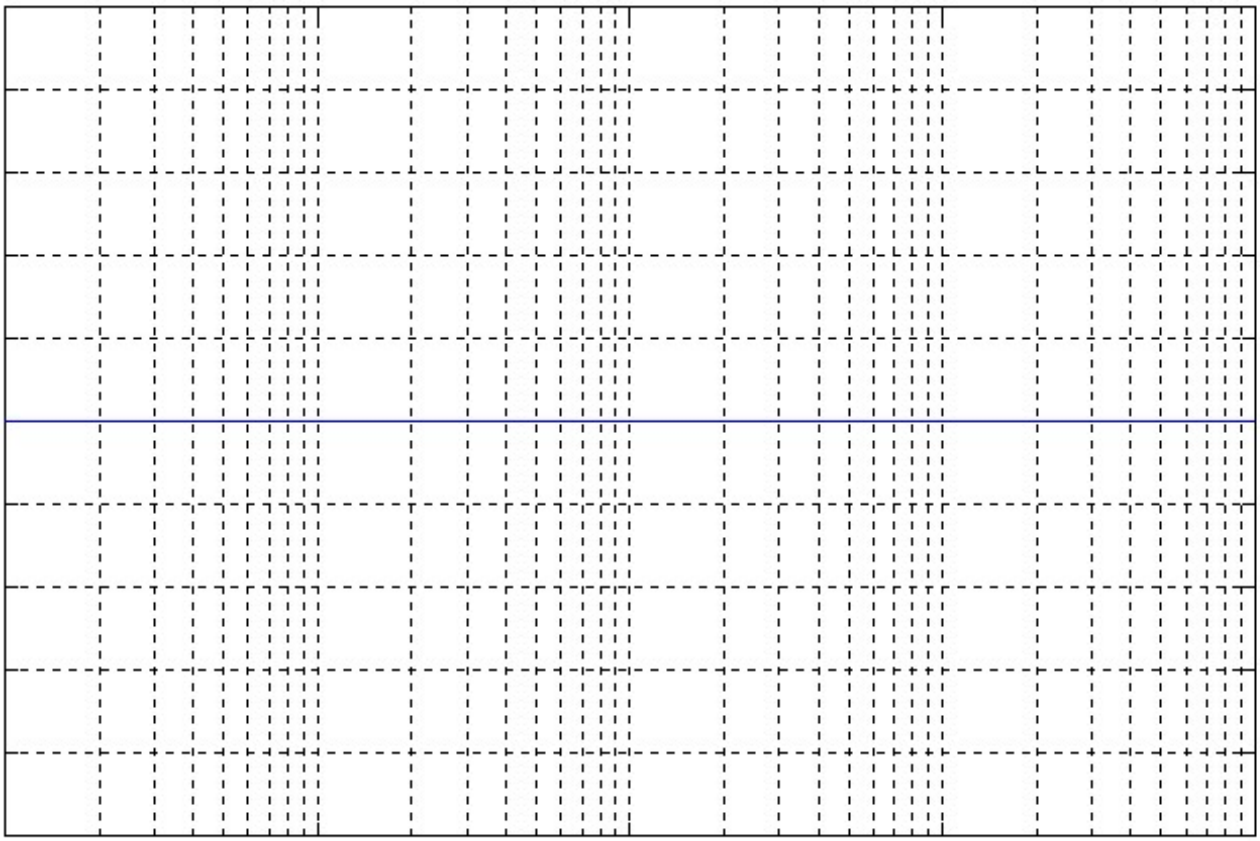
a) Plot the bode diagram clearly showing the slopes of the asymptotes and the height of any peaks. Compute the exact phase and magnitude at the frequencies ω = 5 r/s, ω = 30 r/s**. Illustrate using graphical techniques your computation of the phase and magnitude.** Graphical technique should not be to scale. Make an accurate plot of the bode diagram on the enclosed graph paper. Specifically plot the points at ω = 5 r/s and ω = 30 r/s and clearly mark these points on your Bode plot. Explain in **your own written words (in sentences)** why your results make sense with regard to the heights of peaks and asymptotes. The written explanation is **the most important** part of the question. **You are teaching me how to draw this Bode diagram as shown in class. A sketch of the Matlab solution will result in a very poor grade.**

b) The input to the system is x(t) = 10sin(100t), what is the output, y(t) in steady state? Roughly sketch both the input and the output on the same graph and clearly explain how you scale the time and magnitude axes. Explain your sketch based on the bode diagram.

Question 3 work space…



Question 3 work space



Question 4 (25 marks)

You are required to build a controller for the motor control system shown below. It is assumed the motor is a first order dynamic system. You do an experiment on the motor and you set $V_{in} = 1.0$ volt and you get the response shown in the figure 2 below. The tachometer measures the rotor angular velocity in rad/sec.

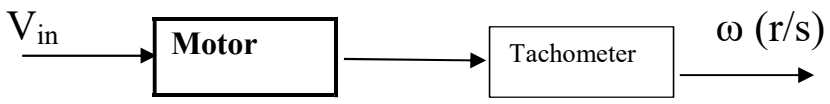


Figure 1: The motor that is tested, results are shown below.

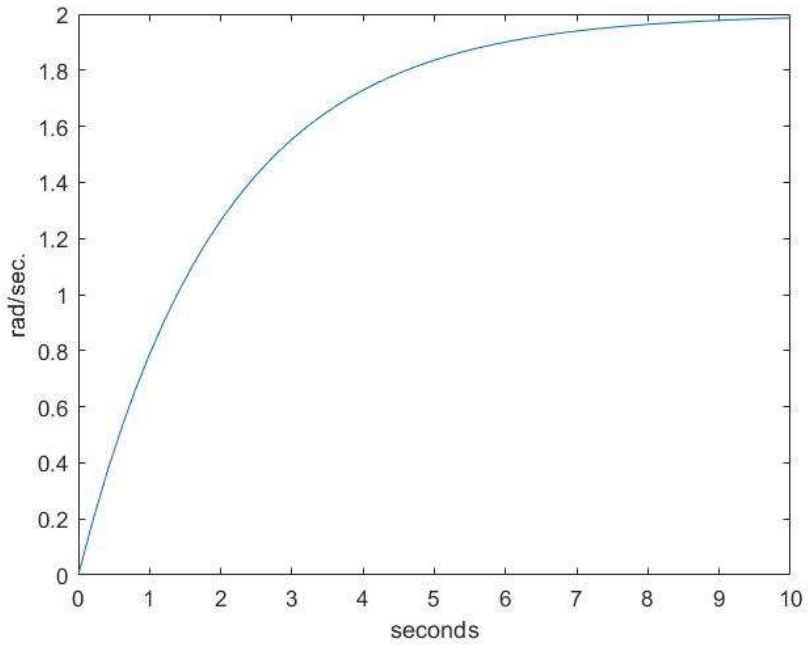


Figure 2: The result of a unit step input signal. The output is angular velocity.

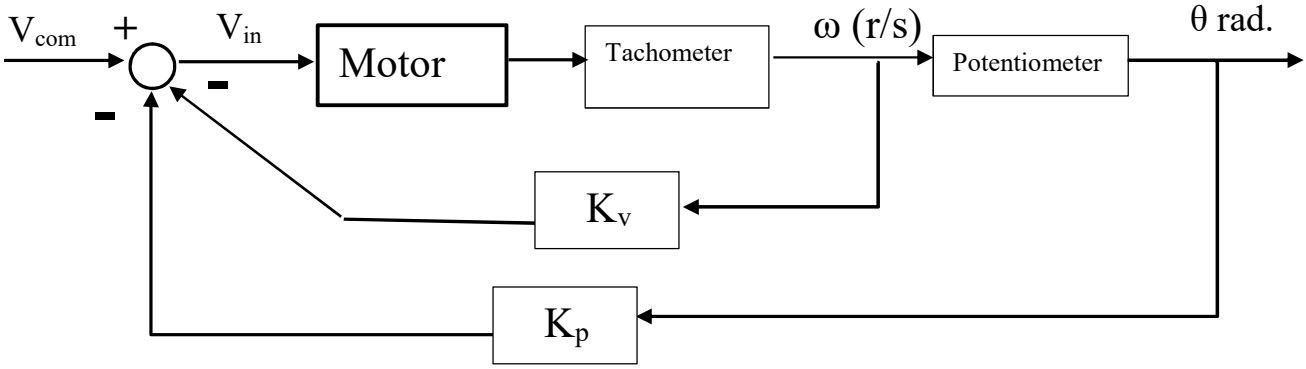


Figure 3: The structure of the position controller.

Question 4) Continued

a) Find the transfer function for the motor itself, $H(s) = \frac{\omega(s)}{V_{in}(s)}$, from figure 1, and the graph in figure 2. What is the time constant? **Explain your answer in written sentences.**

b) From figure 3, what is the closed loop transfer function, $H(s) = \frac{\theta(s)}{V_{com}(s)}$.

c) Design the gains K_v and K_p, such that the motor has a settling time or time constant of approximately 0.5 seconds and very little or no overshoot. **I want a detailed explanation of your design in written sentences.** There is not a single correct answer.