BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Department of Mechanical and Mechatronics Engineering
Second Examination – Fall 2016

ENME 438: Control Theory — Student ID: ____________________
Date of Examination: 18/12/2016 — Time duration: 90 minutes
Instructor: Eng. Sima Rishmawi — Total Marks: 100

This exam contains 4 pages (including this cover page) and 5 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.

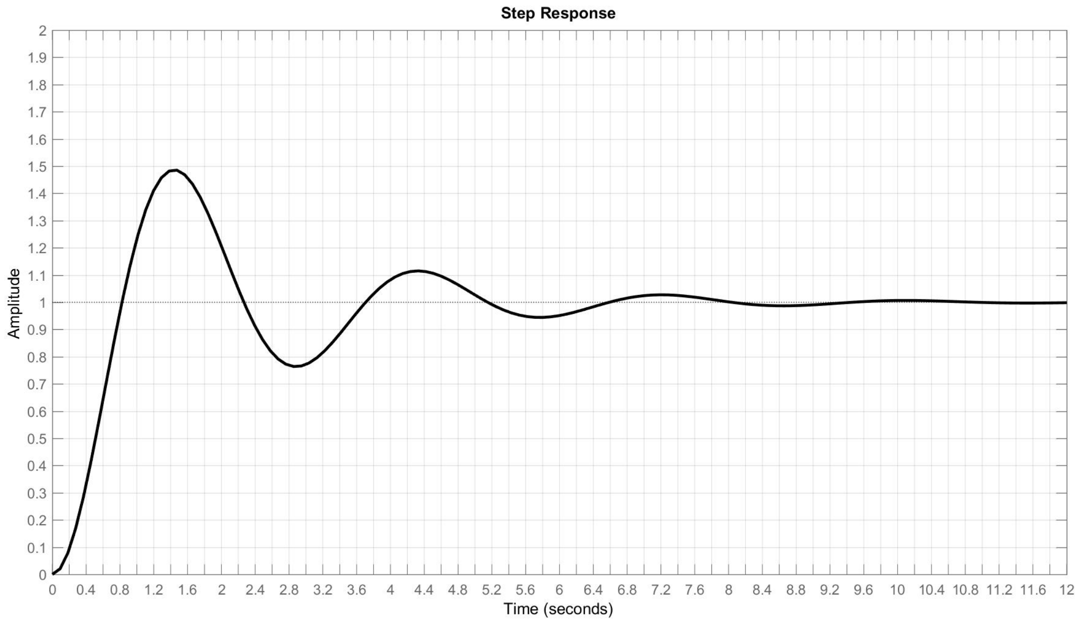
You may *not* use your books, notes, or any other reference on this exam, except for a two-sided A4 cheat sheet (to be handed in with your exam). You can use your own calculator only. Borrowing calculators is not allowed.

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

You are required to show your work on each problem on this exam. The following rules apply:

- **If you use a "certain principle" you must indicate this** and explain why the principle may be applied.
- **Organize your work**, in a reasonably neat and coherent way. Work scattered all over the page without a clear ordering will receive very little credit.
- **Mysterious or unsupported answers will not receive full credit**. A correct answer, unsupported by calculations, explanation, or algebraic work will receive no credit; an incorrect answer supported by substantially correct calculations and explanations might still receive partial credit.

1) A spring-mass-damper system has the following displacement response for a unit step force applied to the mass. Use the graph to find the following parameters. Explain how you found/calculated each parameter:



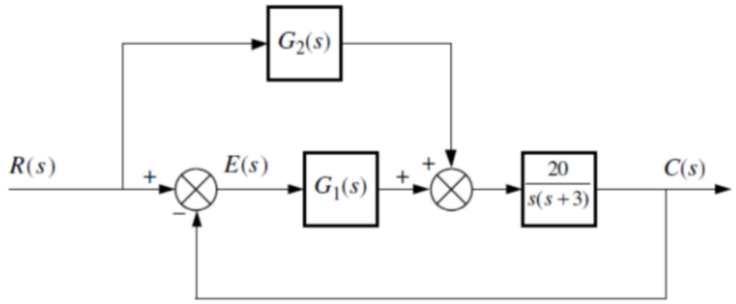
1. Peak Time
2. Rise Time
3. Percentage Overshoot
4. Settling Time
5. Natural Frequency and Damping Ratio of the system
6. Transfer Function

20 marks

2) What are the restrictions on the type of the feedforward transfer function $G_2(s)$ in the system shown in the figure to obtain zero steady-state error for a step input if:

1. $G_1(s)$ is a Type 0 transfer function
2. $G_1(s)$ is a Type 1 transfer function
3. $G_1(s)$ is a Type 2 transfer function

20 marks



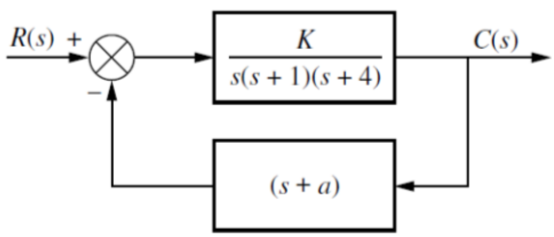
3) A unity feedback system has the following open-loop transfer function:

$$G(s) = \frac{K(s+7)}{s(s+5)(s+8)(s+12)} \tag{1}$$

1. Find the value of K that will yield a steady-state error of 10% for an input of $0.1tu(t)$.
2. Find the minimum possible steady-state error for the same input, knowing that the minimum possible steady-state error occurs with the maximum allowable K before instability.

20 marks

4) Given the system shown in the figure below, find the sensitivity of the steady-state error to parameter a. Assume a step input.



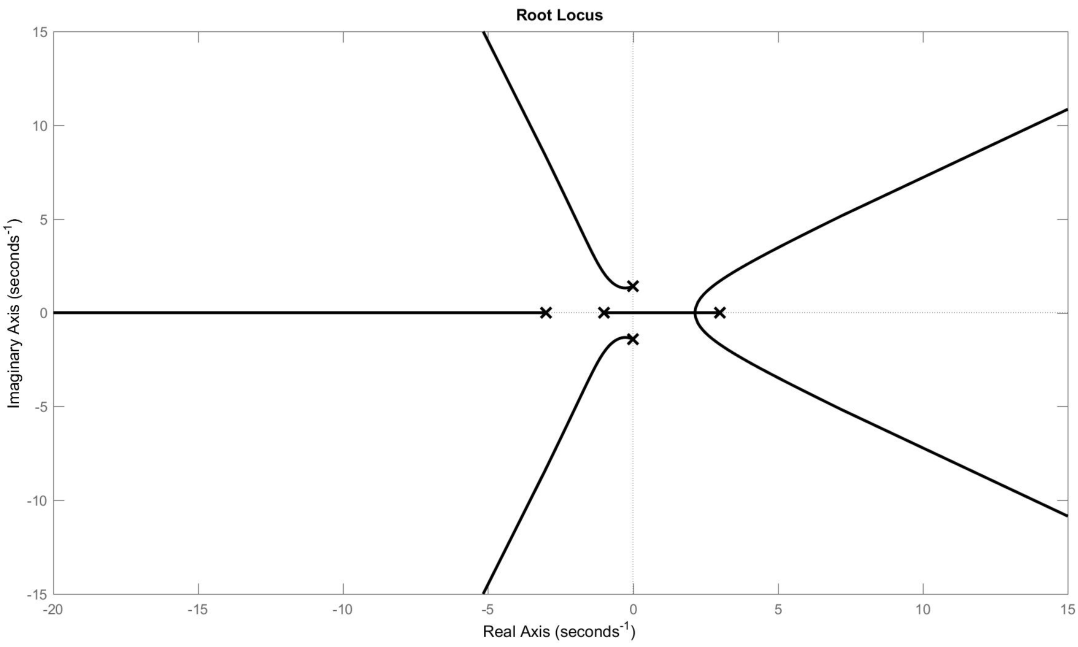
20 marks

5) Given the following closed-loop transfer function, use the Routh-Hurwitz Criterion to prove that the closed-loop poles are located as shown in the following root locus graph. Also, using the root locus, is it possible to find a value of the gain K that will stabilize this system? Why, or why not?

$$T(s) = \frac{18}{s^5 + s^4 - 7s^3 - 7s^2 - 18s - 18} \tag{2}$$

20 marks

Question 5 continues on the next page...


Root Locus
15
10
5
0
-5
-10
-15
Imaginary Axis (seconds^{-1})
-20
-15
-10
-5
0
5
10
15
Real Axis (seconds^{-1})