BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Department of Mechanical and Mechatronics Engineering
Final Examination – Spring 2017

ENME 438: Control Theory
Date of Examination: 4/6/2017
Instructor: Eng. Sima Rishmawi

Student ID: ____________________
Time duration: 2 hours 30 minutes
Total Marks: 100

This exam contains 9 pages (including this cover page) and 4 problems. Check to see if any pages are missing. Enter your Student ID number on the top of this page, and at the bottom of every page, in case the pages become separated.

You may *not* use your books, notes, or any other reference on this exam, except for a three-sided A4 cheat sheet. You can use your own calculator only. Borrowing calculators is not allowed.

The following rules apply:

- **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.
- If you need more space, use the back of the pages; clearly indicate when you have done this.

Problem	Points	Score
1	15	
2	15	
3	30	
4	40	
Total:	100	

Do not write in the table to the right.

1) A feedback control system has a closed loop transfer function with the following characteristic equation:

$$s^6 + 2s^5 + 12s^4 + 4s^3 + 21s^2 + 2s + 10$$

Is this system stable? Why? Why not?

15 marks

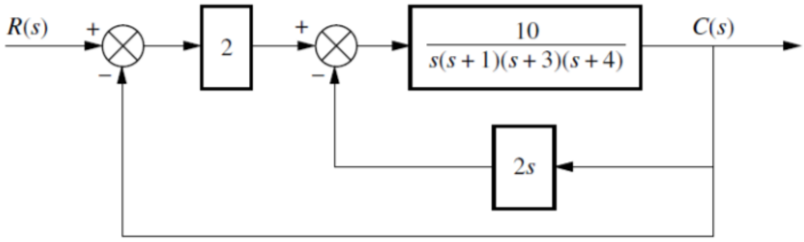
2) Given the system in the figure, calculate the following:

(a) The closed loop transfer function.

(b) The system type

(c) The steady state error for an input of $5u(t)$.

(d) The steady state error for an input of $5tu(t)$.



15 marks

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

$$G(s) = \frac{K}{s(s+1)(s^2+4s+13)}$$

Sketch the root locus for this system. Calculate the following parameters (if needed) in order to create the sketch:

(a) Open loop zeros and poles.

(b) Angles of asymptotes.

(c) Asymptotes intersection point with the real axis.

(d) Angles of arrival and departure.

(e) $j\omega$-intercept.

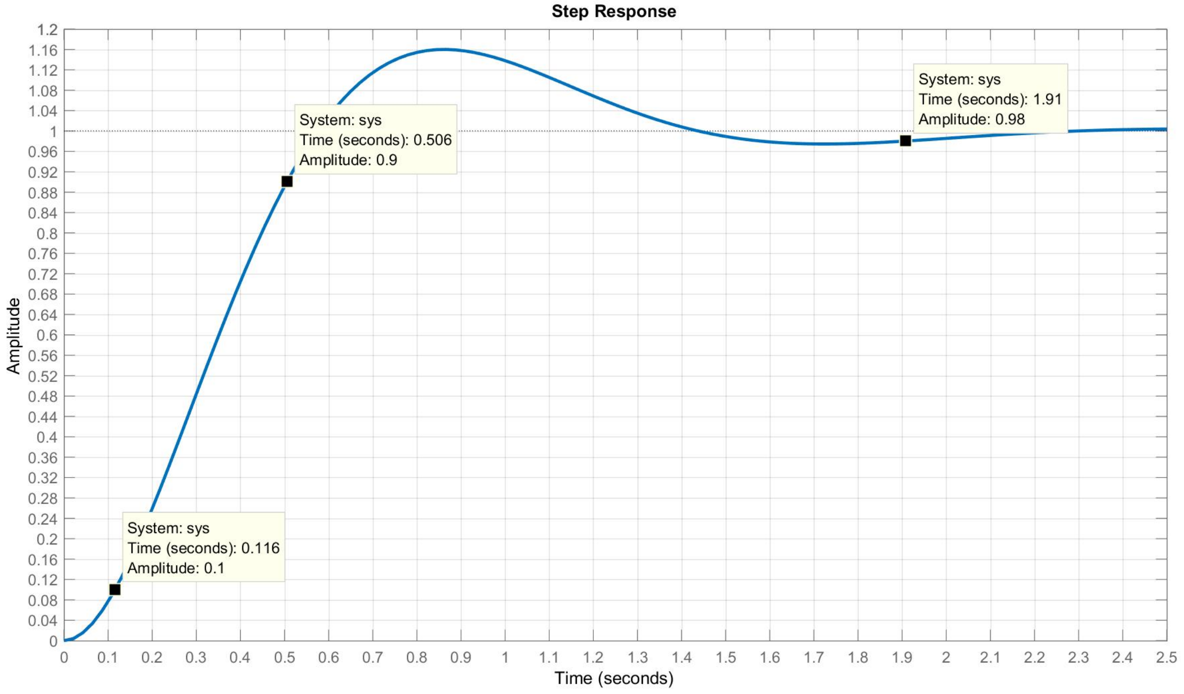
Hint: A break-away point is found at $s = -0.467$.

30 marks

Question 3 continues on the next page...

4) The figure shows the desired response for a position control system that has an open loop transfer function of:

$$G(s) = \frac{10}{s(s+1)(s+10)}$$



(a) Use the figure to find the desired percent overshoot $\%OS$, and desired rise time T_r.

(b) Design a lead compensator that achieves the desired specifications in (a). It should be of the form:

$$G_c(s) = K\frac{(s+1)}{(s+\alpha)}$$

Hint: - Find the desired poles - Check if second order system approximation can be applied - Check if desired poles lie on the root locus - Add required pole and zero - Find the value of K.

(c) Design a lag compensator that keeps the steady state error for a unit ramp input within 2%.
Hint: - Find the current steady state error - Choose the location of the pole - Calculate the location of the zero to achieve the required steady state error.

(d) Write the transfer function of the whole controller.

40 marks

Question 4 continues on the next page...

Question 4 continues on the next page...

Question 4 continues on the next page...