ELEC 312-01
Systems I
TEST 2

Tuesday, April 19, 2010 **Name:** $\underbrace{\hspace{8cm}}$

By writing my name, I understand that I am bound by The Citadel Honor Code.

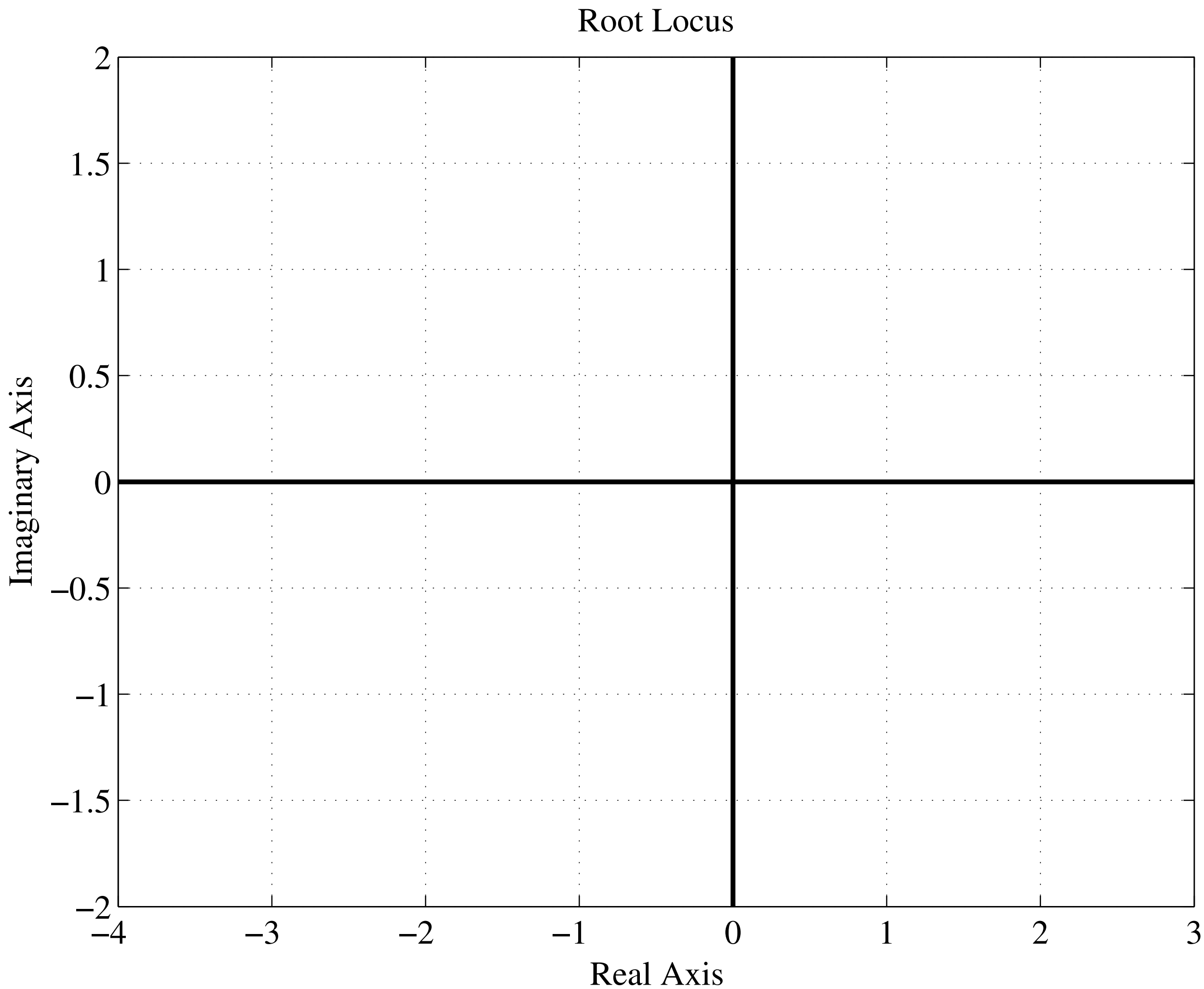
Read all of the following information before starting the test:

- Show all work, clearly and in order, if you want to get full credit. I reserve the right to take off points if I cannot see how you arrived at your answer (even if your final answer is correct).
- Justify your answers algebraically whenever possible to ensure full credit. When you do use your calculator, explain all relevant mathematics.
- **Box, circle, or otherwise indicate your final answers.**
- This test has 2 problems and is worth 50 points, plus some extra credit at the end.
- Check to ensure that you have all pages. It is your responsibility to make sure that you have all of the pages!
- If you remove the staple, you must re-staple your pages IN ORDER. Failure to do so will result in a deduction of 5 points from your final score.
- Good luck!

1. Consider a unity-feedback control system with the feedforward transfer function given by

$$G(s) = \frac{K(s+1)}{s(s-2)}.$$

You may use the grid below to sketch your root locus as you determine your answers for each root locus rule. However, you will only be graded on your answers below.



(a) (1 point) (**Circle the correct answer.**) The system has
   A. 1 closed-loop pole.
   B. 2 closed-loop poles.
   C. 3 closed-loop poles.
   D. 4 closed-loop poles.

(b) (1 point) (**Circle the correct answer.**) The root locus plot contains
   A. 1 branch.
   B. 2 branches.
   C. 3 branches.
   D. 4 branches.

(c) (1 point) (**Circle the correct answer.**) The root locus plot contains

A. 1 asymptote.
B. 2 asymptotes.
C. 3 asymptotes.
D. 4 asymptotes.

(d) (1 point) (**Circle the correct answer.**) The angle(s) for the asymptote(s) is/are

A. $\pm 45°, \pm 135°$.
B. $\pm 60°, 180°$.
C. $\pm 90°$.
D. $180°$.

(e) (2 points) Determine the real-axis intercept for the asymptote(s).

(f) (2 points) Determine the interval(s) on the real axis where the root locus exists.

(g) (3 points) Determine the breakaway (not break-in) point.

(h) (3 points) Determine the break-in (not breakaway) point.

(i) (3 points) Determine the gain K at the breakaway (not break-in) point.

(j) (3 points) Determine the gain K at the break-in (not breakaway) point.

(k) (3 points) Determine the imaginary-axis crossings.

(l) (3 points) Determine the gain K at all imaginary-axis crossings.

(m) (3 points) Give the range of positive gain K to ensure system stability.

2. Consider a unity-feedback control system with the feedforward transfer function given by

$$G(s) = \frac{K(s+1)}{s(s-2)}.$$

where $K = 6$. Note that when $K = 6$, the closed-loop poles are $s = -2 \pm j\sqrt{2}$.

(a) (3 points) Determine the damping ratio.

(b) (3 points) Determine the natural frequency.

(c) (2 points) Estimate the rise time for the unit-step response.

(d) (2 points) Estimate the settling time for the unit-step response.

(e) (2 points) Determine the peak time for the unit-step response.

(f) (2 points) Determine the percent overshoot for the unit-step response.

(g) (1 point) (**Circle the correct answer.**) The system is

A. Type 0.
B. Type 1.
C. Type 2.
D. None of the above.

(h) (3 points) Determine the appropriate static error constant.

(i) (3 points) Determine the appropriate steady-state error.

Bonus Question (5 Extra Credit Points):

Consider a unity-feedback control system with the feedforward transfer function given by

$$G(s) = \frac{K(s+1)}{s(s-2)}.$$

Design a PD compensator so that the dominant closed-loop poles are at $s = -1 \pm j$.