University of Notre Dame
Aerospace and Mechanical Engineering

AME 30315: Differential Equations, Vibrations and Controls II
Second Exam

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NAME: _____
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- Do not start or turn the page until instructed to do so.
- You have 50 minutes to complete this exam.
- You may consult the course text and three pages of written notes.
- You may **not** use a calculator or other electronic device.
- There are three problems.
- Some of your answers will require approximations. Whenever you use an approximation you must clearly show it.
- Your grade on this exam will constitute 25% of your total grade for the course. *Show your work* if you want to receive partial credit for any problem.
- Answer each question in the space provided on each page. If you need more space, use the back of the pages or use additional sheets of paper as necessary.

When men are most sure and arrogant they are commonly most mistaken, giving views to passion without that proper deliberation which alone can secure them from the grossest absurdities.
–David Hume

1. Using the graph paper attached to the end of this exam, sketch the root locus plot for

$$G(s) = \frac{10}{s\left(s^2 + 8s + 20\right)}.$$

Partial credit will primarily be based upon computations for the various steps in the plotting method. (30 points)

2. Consider the system from Problem 1 under unity feedback, *i.e.,* if $G(s)$ is substituted into Figure 9.104 in the course text. 15 points each:

   (a) Use the Routh array to determine the values of k for which the system will be stable.

   (b) Verify this answer by using the root locus plot from Problem 1 to determine the k values for which the system is stable.

3. Consider

$$G(s) = \frac{1}{s^2 + 4s + 3}.$$

10 points each:

(a) Sketch the root locus for this transfer function.

(b) Indicate the section of the root locus for which the system under unity feedback will have a overshoot of less than 5% if the input is a step.

(c) Indicate the sections of the root locus for which the system will have a rise time of approximately 1 second if the input is a step.

(d) Will it be possible to have an overshoot less than 5% and a rise time less than 1 second?