Name _____ Section _____

ES205
Examination III
May 14, 1999

Problem	Score
1	/30
2	/30
3	/40
Total	/100

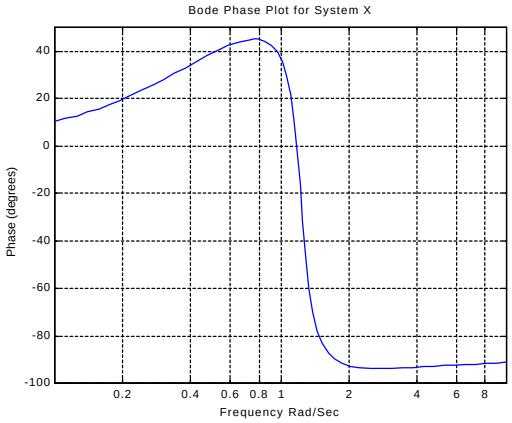
Show all work for credit
AND
Turn in your signed help sheet

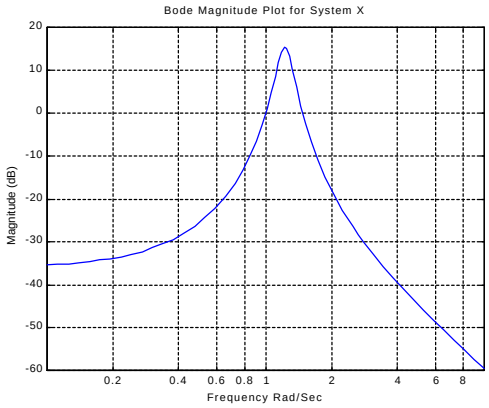
Name _____ 30 pts

ES205 Examination III **Problem 1** May 14, 1999

Problem 1

1.1 Frequency response plots for a physical system were determined experimentally and are shown below. Assuming this system was forced with f(t) = 10cos(0.2t), what would the steady state response be? (3pts)

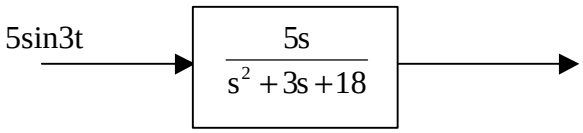




1.2 Draw a block diagram for the system described by the equation below: (3pts)

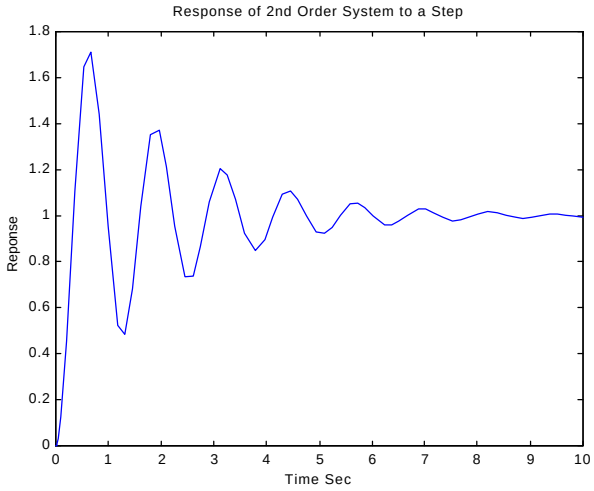
$$\dot{h} + 2\sqrt{h} = 10$$

1.3 Determine the steady state response, y_{ss}, for the system shown below using the transfer function approach. (3pts)



1.4 The response of a second order system to a step, f(t) = 10u(t), is shown below. The system shown may be described as follows: (2pts)

a) undamped b) underdamped c) critically damped d) overdamped e) none of these



1.5 If the system shown in problem 1.4 is excited with a step, f(t) = 6u(t), what is the steady state response of the system? (2pts)

1.6 A mechanical system which has a natural frequency ω_n and a damping ratio ζ is subjected to a forced excitation frequency ω. At steady state, the system will vibrate at (2pts)

a) ω_n b) ω_d c) $\omega_n\sqrt{1-\zeta^2}$ d) ω e) none of the above

1.7-1.10

Given a system that is described by the following differential equation:

$\ddot{x} + 2\dot{x} + 4x = f(t)$ where f(t) is a unit step, determine the following values:

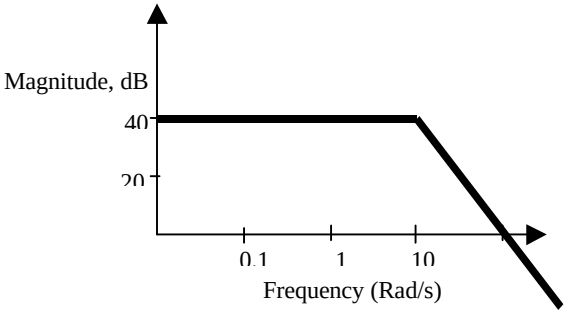
1.7 the maximum % overshoot (3pts)

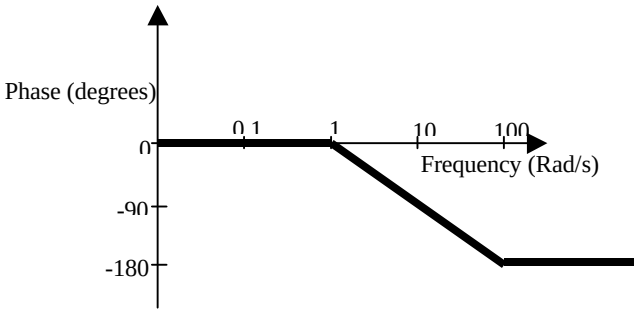
1.8 the time to the first peak, t_p. (3pts)

1.9 the 2% settling time (3pts)

1.10 If the input to the system is 4u(t), where u(t) is the unit step, what is the steady state response of the system? (3pts)

1.11 What transfer function would yield the following frequency response plot? (3pts)



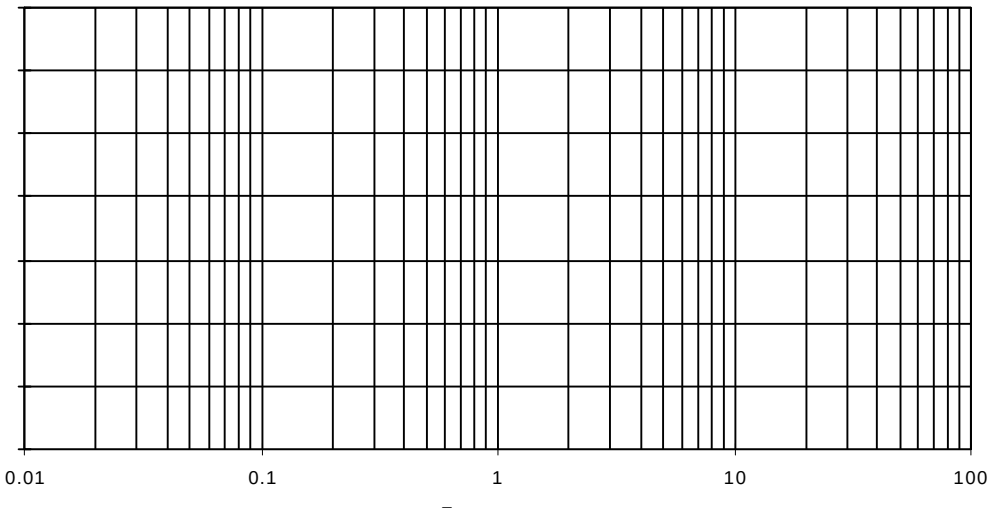


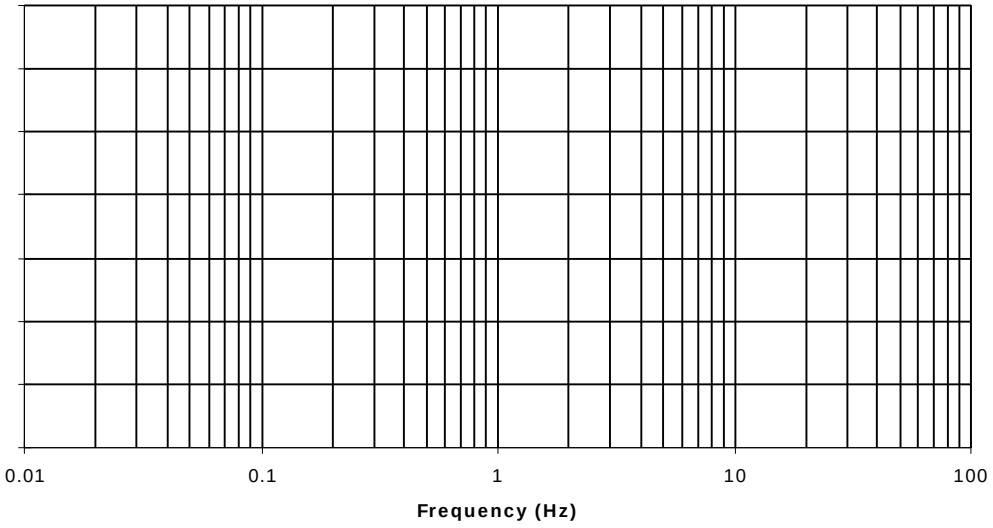
Name _____ 30 pts

ES205 Examination III **Problem 2** May 14, 1999

Sketch the straight line asymptotic frequency response plots for the following transfer function. Use the semilog paper given below for this purpose. Show all work.

$$\frac{25.3s}{(s+10)(s^2+4.2s+0.8)}$$





Name _____ 40 pts

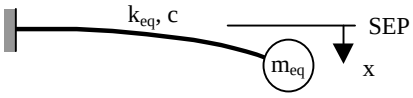
ES205 Examination III **Problem 3** May 14, 1999

You have been hired to determine the dynamic characteristics of the tail rotor of a helicopter. You have only limited equipment so you perform two tests:

1) A static deflection test where you apply a known force and measure the displacement,
2) A free response test where you give the rotor an initial displacement and measure the displacement of the end of the rotor as a function of time.

The force-deflection curve and the free response curve are shown below. For convenience, the displacement is shown along the x-axis for the force-deflection curve and the least squares curve fit is shown on the figure. Assume for parts a), b) and c) the root of the tail is fixed so that the equation of motion for a single degree of freedom model of the tail is given by

$$m_{eq}\ddot{x} + c\dot{x} + k_{eq}x = f(t)$$



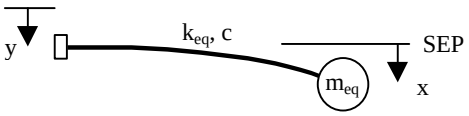
Determine:

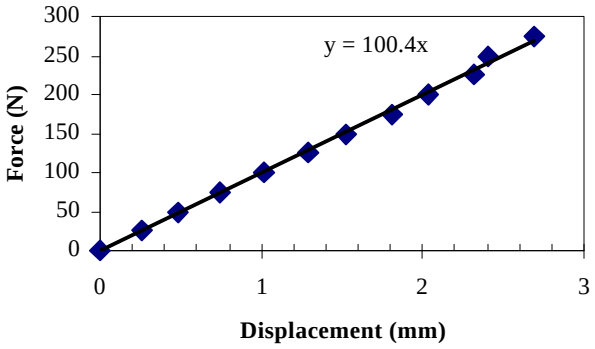
a) The spring constant, damping and equivalent mass of the tail of the helicopter (20 pts) Note: If you are unable to answer part a), assume values for the remainder of the problem.

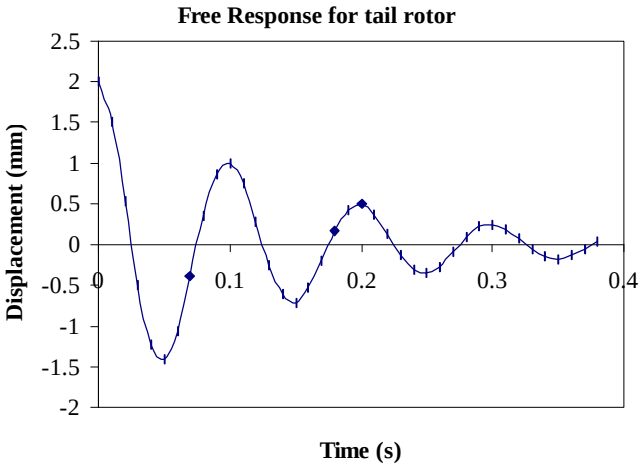
b) Determine the steady state response of the tail assuming that the force applied to the tip of the tail is f(t)=50sin100t N when it is operating. (10 pts)

c) At approximately what forcing frequency would you expect the tail to have a maximum displacement. (5 pts)

c) Determine the steady state response assuming the root of the tail is not fixed, but rather has a prescribed displacement of y(t) = 2 sin100t mm. Use the spring constant, damping and equivalent mass found in part a). (5 pts)







Continue your work on the next page if necessary