Name _____ Section _____

EM406
Examination I
September 23, 2003

Problem	Score
1a	/20
1b	/25
1c	/20
1d	/25
2	/10
Total	/100

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

Name _____ 90 pts

EM406 Examination I **Problem 1** September 23, 2003

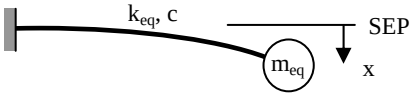
Problem 1a (20 pts)

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.

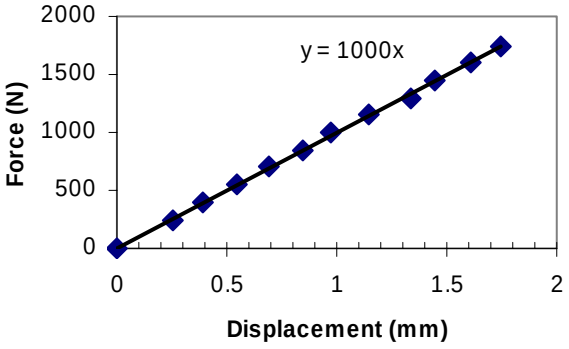
The force-deflection curve and the free response curve are shown below. For convenience, the displacement is shown along the x-axis for the force-deflection curve and the least squares curve fit is shown on the figure. Assume the root of the tail is fixed so that the equation of motion for a single degree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

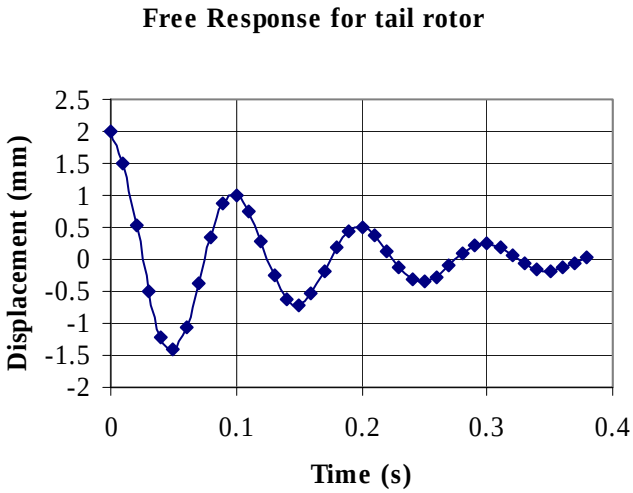
$$m_{eq}\ddot{x} + c\dot{x} + k_{eq}x = f(t)$$



Determine:

a) The spring constant, damping and equivalent mass of the tail of the helicopter





For the remainder of this problem parts b), c) and d) assume the following:

- the natural frequency of the tail rotor is 50 rad/s (not the correct answer)
- the spring constant is $1.5x10^6$ N/m (not correct)
- the damping ratio is 0.05 (not correct).

Problem 1b (25 pts)

Determine the steady state response, x(t), of the tail assuming that the force applied to the tip of the tail is f(t)=5000sin100t N when it is operating. (15 pts)

What is the magnitude of the force transmitted to the root? (5pts)

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

Problem 1c (20 pts)

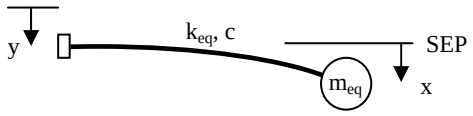
Assuming the forced input described in part b), that is, f(t)=5000sin100t, comes from the fact that the tail rotor is unbalanced, determine the magnitude of the unbalance (the unbalance is defined to be the unbalanced mass, *m* times the eccentricity, *e*). (10 points).

What would magnitude of the tip displacement be if it was possible for the tail rotor to rotate 50% faster? (10pts)

Problem 1d (25 pts)

Assume that the tail rotor is no longer rotating, but the helicopter is being towed over a rough road, that is, the root of the tail is not fixed, but has a prescribed displacement of y(t) = 2 sin60t mm. Determine

a) the equation of motion (show all work for full credit)
b) the magnitude of the steady state response of the tail.



Name _____ 10 pts

EM406 Examination I **Problem 4** September 23, 2003

All that you have left from a vibration study is the scrap of paper shown below. The system was a direct forced excited, spring-mass system.

Estimate the peak steady state response amplitude of the system? An answer that's within 5% is good enough.