ME 328 – Machine Design
Exam 2– Closed book, closed notes, NO calculator
March 13, 2019
Possible points 60pts (plus 2 pts extra credit)

This exam is MY work, and my work ONLY:

Signature:

Print name:

For full credit, you must show units at every step and show variable form of equations before inserting values. Values must <u>include units at every step</u>. If it is not possible to answer the question based upon the information given, briefly explain what information would be needed, make an assumption about that information, and proceed.

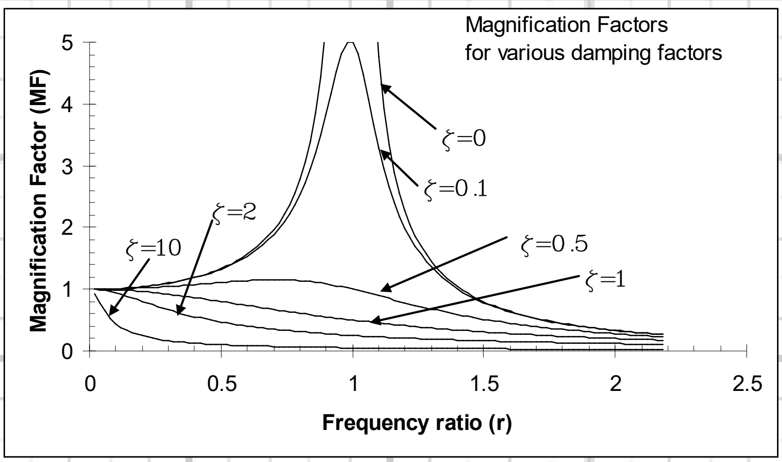
Some equations and graphs:

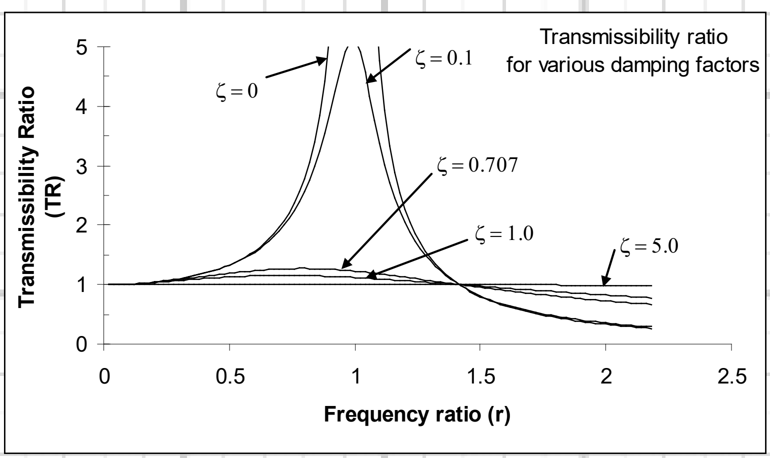
F=ma, KE = ½ mv^2, PE = mgh, $E=mc^2$, $C=\pi D$, $A=\pi D^2/4$, $I=1/12\ bh^3$, $J=\pi D^4/32$

$\delta_{max} = \delta_{st} K$ P = WK $K=\{ 1 + (1+ 2h/\delta_{st})^{1/2}\}$

$m\ddot{x} = -kx - c\dot{x} + P(t)$; $P(t) = P_0 \sin(\omega_f t)$; $c_c = 2m\omega_n$; $\zeta = c/c_c$; $\omega_n = (k/m)^{1/2}$

$$MF = \frac{X}{X_o} = \frac{1}{\sqrt{(1-r^2)^2+(2\zeta r)^2}} \; ; \; TR = \frac{F_T}{P_o} = \frac{\sqrt{1+(2\zeta r)^2}}{\sqrt{(1-r^2)^2+(2\zeta r)^2}} \; ; \; P = T_1\omega_1 = T_2\omega_2$$

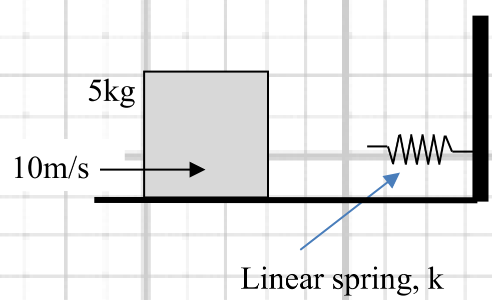


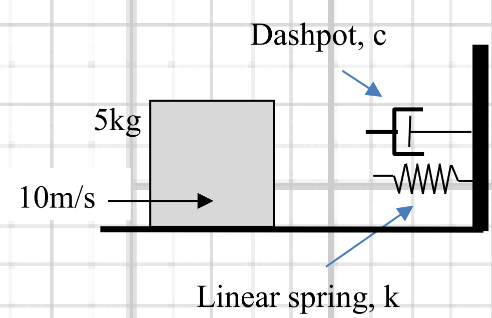


1. (10pts) A 5kg mass is moving without friction at 10m/s as shown below. It strikes a linear elastic spring with spring constant 'k' and comes to rest in a distance of 50mm. We then modify the same system (same mass, same velocity, same spring, no friction) by introducing a dashpot with damping factor of 'c.' The moving mass contacts the spring and dashpot simultaneously and is brought to rest at some distance.

   a) With the dashpot, will the stopping distance be less than, greater than, or the same as the system with the spring alone; or is it not possible to say with the information given? Briefly explain.

   b) With the dashpot, will the maximum force of impact be less than, greater than, or the same as the system with the spring alone; or is it not possible to say with the information given? Briefly explain.



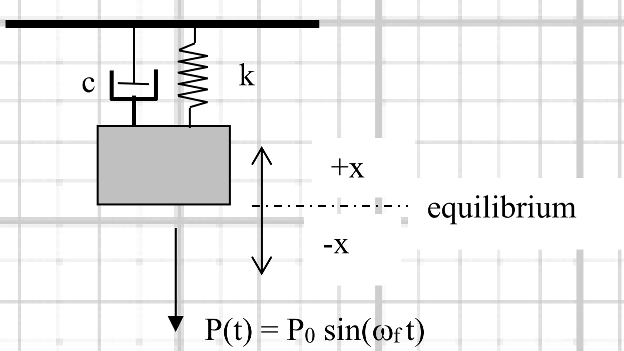


2) (15pts) Given the mass, spring, dashpot system shown below with a harmonic force, P(t), applied to the mass. The magnitude (amplitude) of the displacement of the mass from equilibrium (X) is 10mm and the mass oscillates up and down at a frequency of 100rad/sec. The system is critically damped (ζ=1) and the magnification factor is 0.5 (MF=0.5). Then the dashpot is replaced with a new dashpot and the system becomes over-damped ($\zeta > 1$). Answer the following assuming all other parameters remain the same including the mass and spring:

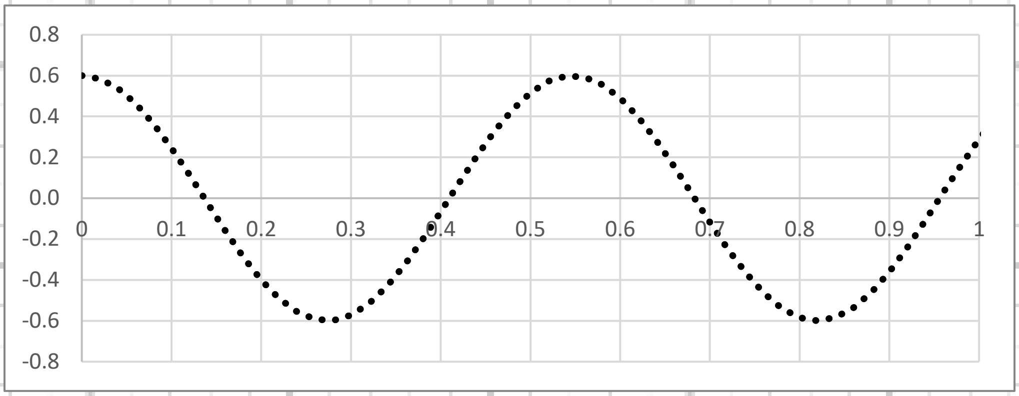
a) How would the new dashpot affect the static displacement X_0: increase it, decrease it, or have no effect on it? Briefly explain/justify your answer.

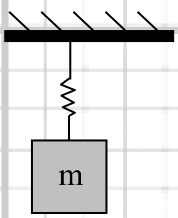
b) How would the new dashpot affect the actual displacement amplitude (X): increase it, decrease it, or have no effect on it? Briefly explain/justify your answer.

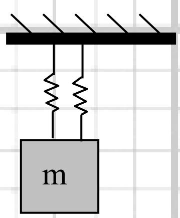
c) How would the new dashpot affect the oscillation frequency? Would it be less than 100rad/sec, greater than 100rad/sec, or remain at 100rad/sec? Briefly explain/justify your answer.



3. (10 pts) Given a mass-spring system (without damping) that has a displacement as shown in the graph with the dashed line. An additional spring is then added to the system, doubling the spring stiffness. How would the system respond differently? Briefly discuss and show graphically on the graph below.



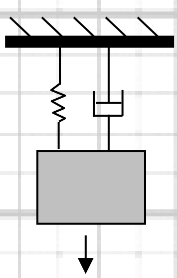




Original Twice the stiffness

4. (5 pts) Draw a complete and appropriate free body diagram and kinetic diagram for the mass-spring-dashpot system with a harmonic force, P(t), applied to the mass.

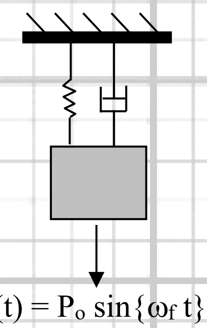
FBD: Kinetic Diagram:



$P(t) = P_0 \sin(\omega_f t)$

5. (20pts) Given the mass-spring-dashpot system, with a harmonic force, P(t), applied to the mass as shown below. Characteristics of the system are: k=500N/m, m=5kg, c=20N-sec/m (c=20kg/sec), P_0=100N, and ω_f=50rad/sec. Briefly, justify your answers and/or show your work.

5.a) What is the frequency ratio, r?



5.b) Is the system under-damped, critically damped, or over damped?
(Hint, first determine damping factor, ζ)

5.c) Will the amplitude (magnitude) of the mass's displacement (X) be equal to, greater than, less than 0.2m; or cannot determine with the information given even with a calculator? Briefly explain and/or show appropriate work.

Extra credit (2 pts): a) what is a 'fairing'? b) what is a 'pillow block'?