1. (*Note: This problem also serves as a post-test for* Damped harmonic motion: Energy loss and the quality factor.)  
  
A mass *m* = 400 g is connected to a spring with spring constant *k* = 1.6 N/m. The oscillator is subject to a retarding force proportional to the velocity of the oscillator, with damping constant ** = 0.6 s-1.

A. Write down the differential equation of motion for the damped oscillator, using the numerical values of given parameters *(m, k, )* as appropriate. (*Note:* Do **not** bother to solve the equation.)

B. Determine the angular frequency of the damped oscillator. Show all work.

C. Determine the ratio of the amplitudes of two successive maxima of the damped oscillator. Show all work.

D. Determine the angular frequency of an external driving force required for the (damped) oscillator to achieve resonance. Show all work.

2. (*Note: This problem also serves as a post-test for* Phase space diagrams: Simple harmonic motion.)  
  
A student performs an experiment in which a damped oscillator is driven by a sinusoidal driving force at each of three different driving frequencies (one at a time). The student records the steady-state motion of the oscillator in the three cases in the form of phase space plots, shown as I, II, and III below.

A. Rank the three phase space plots according to *driving frequency,* from largest to smallest. Explain how you determined your ranking.



For parts B and C below, suppose that one of the three plots represents the oscillator driven at (amplitude) resonance. Suppose also that the *undamped* frequency of the oscillator were equal to *o* = 2.5 s-1.

B. Which plot (I, II, or III) would represent the oscillator being driven at resonance? Explain.

C. Using the plot you selected in part B (representing the oscillator at resonance), calculate:

i. the damping constant ** of the oscillator. Show all work.

ii. the phase difference ** with which the oscillator lags behind the driving force. Show all work.