Questions 3.10, 3.16, C3.1 from the textbook. Additional questions below:

## 1. A mass *m* = 750 g is connected to a spring with spring constant *k* = 1.5 N/m. At *t* = 0 the mass is set into simple harmonic motion (no damping) with the initial conditions represented by the point *P* in the phase space diagram at right.



a. Using the given information, sketch an *accurate* phase space plot for the oscillator. Explain your reasoning and show all work.

b. On the phase space trajectory you have drawn, label the point *Q* that represents the position and velocity of the oscillator *one-quarter period after t* *= 0.* Explain your reasoning.

## 2. Consider the phase space plots *(A, B,* and *C)* shown below.

### Could all three plots correspond to the same simple harmonic oscillator (*i.e.,* same mass and same spring constant)? Explain why or why not.



### Which pair of plots could be used to show the effect of keeping the *total energy* *constant* but *increasing the spring constant?* Clearly indicate which plot would correspond to the larger spring constant. Explain *without* performing any calculations.

### Which other pair of plots could be used to show the effect of keeping the *total energy constant* but *decreasing the mass?* Clearly indicate which plot would correspond to the smaller mass. Explain *without* performing any calculations.

## 3. Consider again phase space **trajectory B** shown in problem 2. Suppose that each unit along the horizontal axis corresponded to 10 cm and that each unit along the vertical axis corresponds to 10 cm/s. Using *m* = 400 g, determine the following quantities for the oscillator represented by trajectory B. Explain your reasoning and show all work.

(i) angular frequency, (ii) period, (iii) total energy, (iv) spring constant

## 4. The phase space trajectory of an undamped oscillator is shown below right. In the diagram, each division along the position axis corresponds to 0.1 m; along the velocity axis, 0.10 m/s.

### What is the angular frequency *o* of the undamped oscillator? Explain how you can tell.



A retarding force is now applied to the oscillator for which the damping constant is equal to ** = 0.069*o.*

### By what factor does the amplitude change after a single oscillation? Show all work.

### On the basis of your results above, carefully sketch the phase space plot for the first cycle of the motion of the damped oscillator, starting at point *P.*

## 5. Two simple harmonic oscillators (1 and 2) move with equal amplitudes and equal frequencies, as illustrated in the *x vs. t* graph provided.



### What is the phase difference between the motions of oscillator 1 and oscillator 2? (Express your answer as a number of degrees not larger than 180°, or as a number of radians not larger than .) Explain how you determined your answer.

### Is oscillator 2 *ahead of* or *behind* oscillator 1 by the amount you specified in part a above? Explain how you can tell.