1. A mass *m* = 400 g is connected to a spring with spring constant *k* = 1.6 N/m. The mass is set into simple harmonic motion (no damping) with initial conditions corresponding to point *P* (*i.e.,* *xo* = 0.2 m, = 0.3 m/s) in the phase space diagram at right.



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

2. (*Note: This problem also serves as a post-test for* Phase space diagrams: Damped harmonic motion.)  
  
The diagrams at right can be used to represent one full period of motion for several different types of oscillators.



For each case below, identify which diagram could be used to represent that situation. If more than one diagram could apply in a particular case, **specify them all.** If none of the diagrams apply, state so explicitly. Explain how you decided your answer in each case.

a. the phase space diagram *(*vs. *x)* for the motion of an ideal 1-D oscillator (no damping)

b. the phase space diagram *(*vs. *x)* for the motion of an underdamped 1-D oscillator

c. the phase space diagram *(*vs. *x)* for the steady state motion of a driven, damped 1-D oscillator

3. The phase space diagram at right represents the evolution of a (mechanical) simple harmonic oscillator. The mass of the oscillator is 250 g.



A. Use the phase space diagram to determine each of the following quantities. *Show all work.*

• angular frequency:

• period:

• total energy:

• spring constant:



B. A *single* change is made to the oscillator apparatus, resulting in the new phase space trajectory shown at right. (The original trajectory is shown as a dashed curve.) It is known, however, that the total energy of the oscillator is *unchanged* from before.

i. Is it possible that the spring constant has changed? If so, is it larger or smaller, and why? If not, explain why not.

ii. Is it possible that the mass has changed (instead of the spring constant)? If so, is it larger or smaller, and why? If not, explain why not.

4. The dashed curve in the phase space diagram below right represents the motion of an 1-D oscillator. A *single* (unknown) change is made to the setup, resulting in the new phase space trajectory shown as the solid curve at right.

A. Did the frequency of the oscillator *increase, decrease,* or *remain the same* as a result of the change? Explain how you can tell.



B. Assuming that the mass of the oscillator remained the same for both the original and new trajectories, which of the following statements are true? Specify **all** that apply, and explain how you can tell.

i. The total energy of the oscillator increased. iv. The spring constant increased.

ii. The total energy of the oscillator decreased. v. The spring constant decreased.

iii. The total energy of the oscillator remained the same. vi. The spring constant remained the same.

5. A 300-g block is placed on a level, frictionless surface and attached to an ideal spring. The phase space diagram at right represents the motion of the oscillator.



The point labeled *O* represents the initial conditions of the oscillator (at *t* = 0). Three other points are unlabeled.

A. On the diagram, label the remaining points *1, 2,* and *3,* in the order in which they occur during the subsequent motion of the oscillator.

B. Use the given information to fully express the position of the oscillator as a function of time, **using the form *x(t)* = *A* sin*(t* + *)****.* (That is, determine *A, ,* and ** as indicated.) Show all work.

C. Suppose that the above experiment were repeated exactly as before, with the same initial conditions as before, except that the spring constant of the spring is reduced by a factor of 2.



In the space at right, ***accurately*** sketch the phase space trajectory of the oscillator for this new case. Draw the trajectory *to scale* with the previous one (shown as a dashed line). Explain your reasoning or show all work.