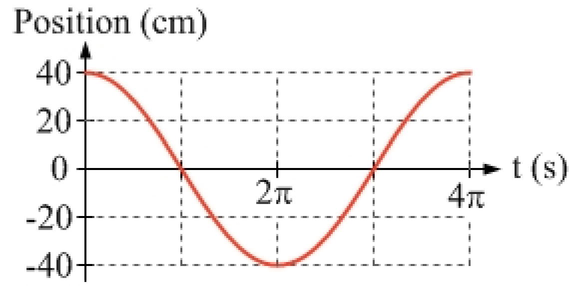
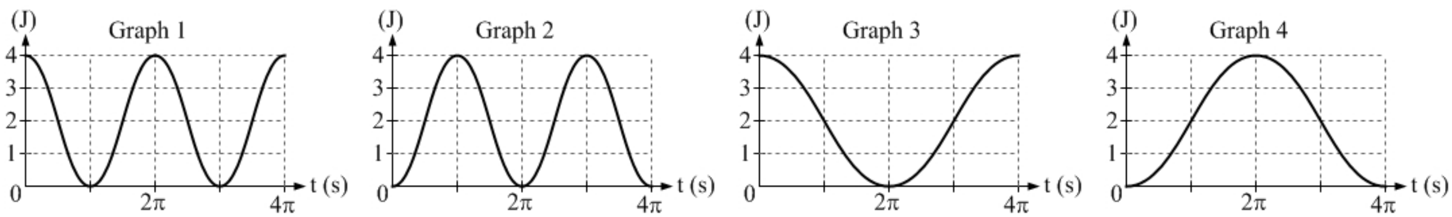
**PROBLEM 1 – 15 points**




A block attached to a horizontal spring is displaced from the spring's equilibrium position and released from rest. The graph at right shows the block's position as a function of time for one complete oscillation as it oscillates on a frictionless surface.

[3 points] (a) Find ω, the angular frequency, for this system.

Now consider these graphs.




[2 points] (b) Which graph represents the graph of the elastic potential energy as a function of time for this system?

[ ] Graph 1 [ ] Graph 2 [ ] Graph 3 [ ] Graph 4

[2 points] (c) Which graph represents the graph of the block's kinetic energy as a function of time for this system?

[ ] Graph 1 [ ] Graph 2 [ ] Graph 3 [ ] Graph 4

Now, the **mass** of the block is **increased by a factor of 4**, and the block is released from rest from the same position as the original block.

[2 points] (d) Compared to the original system, the amplitude of the new oscillations will be…

[ ] larger [ ] unchanged [ ] smaller

[2 points] (e) Compared to the original system, the new system's angular frequency will be…

[ ] larger [ ] unchanged [ ] smaller

[2 points] (f) Compared to the original block, the new block's maximum kinetic energy will be…

[ ] larger [ ] unchanged [ ] smaller

**PROBLEM 2 – 10 points**

You have two identical springs and two identical blocks. You attach each block to a spring so you have two spring-block systems, and you set the blocks up to oscillate simultaneously on a frictionless horizontal surface. You pull the blocks so they stretch their respective springs, releasing them both from rest simultaneously. However, when you release the blocks one of them (we'll call this system 1) is displaced a distance *A* from equilibrium and the other (we'll call this system 2) is displaced 2*A* from equilibrium.

[2 points] (a) If the block in system 1 reaches a maximum speed *v* in its oscillations, what is the maximum speed reached by the block in system 2?

[ ] $\frac{v}{2}$ [ ] $v$ [ ] $\sqrt{2}\,v$ [ ] $2v$ [ ] $4v$

[2 points] (b) If the block in system 1 experiences oscillations with a period $T$, what is the period of the oscillations experienced by the block in system 2?

[ ] $\frac{T}{2}$ [ ] $T$ [ ] $\sqrt{2}\,T$ [ ] $2T$ [ ] $4T$

[2 points] (c) If the maximum force experienced by the block in system 1 is $F_{\max}$, what is the maximum force experienced by the block in system 2?

[ ] $\frac{F_{\max}}{2}$ [ ] $F_{\max}$ [ ] $\sqrt{2}\,F_{\max}$ [ ] $2F_{\max}$ [ ] $4F_{\max}$

[2 points] (d) If the potential energy stored in the spring in system 1 is $U_i$ when the block is first released from rest, what is the potential energy initially stored in the spring in system 2?

[ ] $\frac{U_i}{2}$ [ ] $U_i$ [ ] $\sqrt{2}\,U_i$ [ ] $2U_i$ [ ] $4U_i$

[2 points] (e) At a particular instant, some time after being released, the block in system 1 is 20 cm from its equilibrium position. How far from equilibrium is the block in system 2 at that same instant?

[ ]10 cm [ ] 20 cm [ ] 40 cm

[ ] there is not enough information to answer this question

**PROBLEM 3 – 15 points**

You have a mass on a vertical spring, and a simple pendulum that undergoes small-amplitude oscillations. At this location on Earth they both oscillate with a period of exactly 1.00 seconds. Now you take them to Planet Zorg where the value of g is exactly 4 times smaller than g at this location on Earth.

[3 points] (a) What is the period when the mass on the vertical spring oscillates on Zorg?

[3 points] (b) What is the period of small-amplitude oscillations for the simple pendulum on Zorg?

[4 points] (c) If you give the pendulum the same angular displacement from equilibrium on Earth and on Zorg and release it from rest in both cases, how will the speed of the pendulum bob at its lowest point compare on the two planets?

[5 points] (d) The simple pendulum can be used in various ways to determine the local value of $g$. Can the mass on the vertical spring be used to measure $g$? If so, describe one way to do it.