Problem Set 8: Oscillations

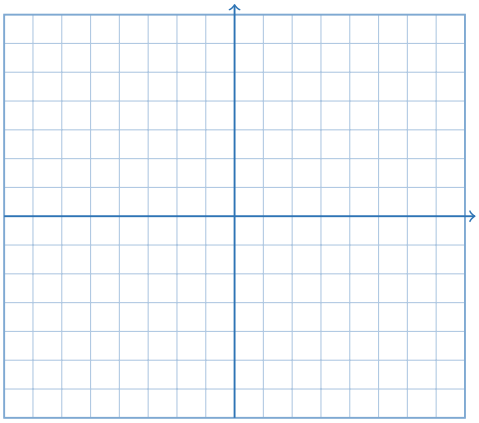
Name: _____ **Date:** _____

Topics 7.1 through 7.4. Take $g = 9.80665$ m/s^2. Out of 100 points.

Equations: $F_s = -kx$ $a = -\dfrac{k}{m}x$ $T = \dfrac{1}{f}$ $T_s = 2\pi\sqrt{m/k}$ $T_p = 2\pi\sqrt{L/g}$ $k = \dfrac{mg}{x}$ $x = A\cos\dfrac{2\pi t}{T}$ $v_{\max} = \dfrac{2\pi A}{T}$ $a_{\max} = \dfrac{4\pi^2 A}{T^2}$

$U_s = \frac{1}{2}kx^2$ $E = K + U_s = \frac{1}{2}kA^2$ $v_{\max} = A\sqrt{k/m}$ $v = \sqrt{\dfrac{k}{m}(A^2 - x^2)}$

1. A glider of mass 0.600 kg rides on a level air track and is attached to a spring of spring constant 15.0 N/m. **[20 pts]** The glider is pulled 0.180 m from the equilibrium position and released from rest. (7.1)



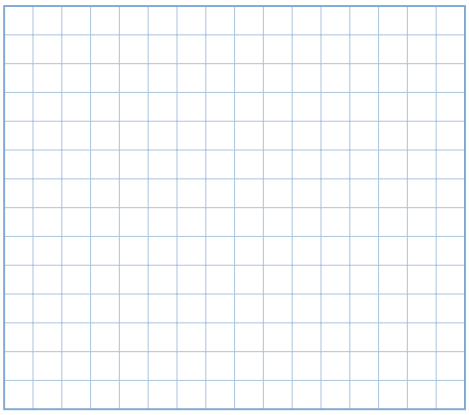
(a) Find the magnitude of the force the spring exerts on the glider at the instant of release. **[5 pts]**

(b) Find the magnitude of the acceleration of the glider at that instant. **[5 pts]**

(c) On the grid, to a stated scale, sketch the acceleration of the glider against its displacement from equilibrium, from -0.180 m to $+0.180$ m. **[5 pts]**

(d) A second glider on the same spring has an acceleration of magnitude 3.00 m/s^2 at a displacement of 0.180 m. Find the mass of the second glider, and state the one position at which the acceleration of either glider is zero. **[5 pts]**

2. A block of mass 0.250 kg hangs at rest from a vertical spring and holds the spring 0.0640 m below its natural length. (7.2) **[20 pts]**



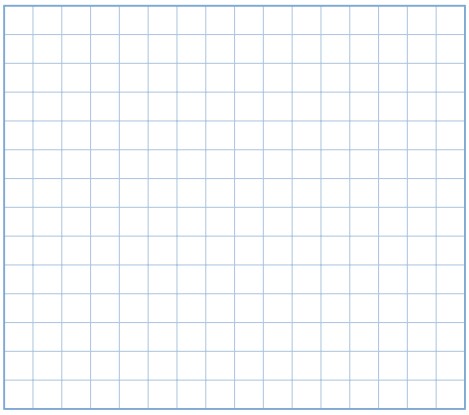
(a) Find the spring constant. **[5 pts]**

(b) Find the period of the block when it oscillates about its hanging equilibrium position. **[5 pts]**

(c) On the grid, to a stated scale, sketch the period of a block on this spring against the mass of the block, from 0 to 1.00 kg. **[5 pts]**

(d) The block is replaced by one of mass 1.00 kg, and the single spring is replaced by two springs of this same spring constant side by side, both pulling the same way. Find the new period, and explain why the period changed by the factor you found and not by a factor of four. **[5 pts]**

3. A pendulum hung in a stairwell is a small dense bob of mass 0.350 kg on a light string 2.40 m long. Treat it as a simple pendulum. (7.2b) **[20 pts]**



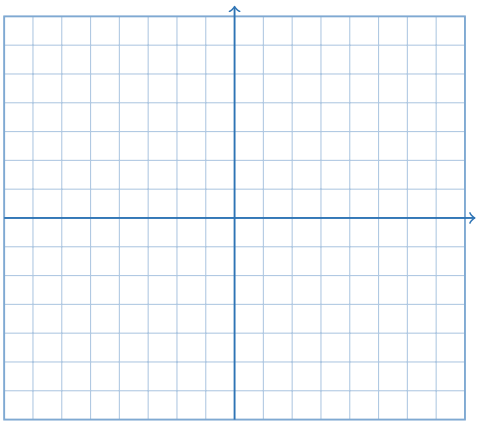
(a) Find the period of the pendulum for small swings. **[5 pts]**

(b) The string makes an angle of 7.00 degrees with the vertical. Find the magnitude of the restoring force on the bob along the arc. **[5 pts]**

(c) On the grid, to a stated scale, sketch the square of the period against the length of the pendulum, from 0 to 2.40 m. **[5 pts]**

(d) The same pendulum is taken to the Moon, where $g = 1.62$ m/s^2. Find its period there, and explain why the mass of the bob appears in your answer to part (b) and in neither period. **[5 pts]**

4. A cart on a horizontal spring is released from rest at a displacement of $+0.150$ m from equilibrium at $t = 0$, and it first returns to that same position 0.800 s later. (7.3) **[20 pts]**



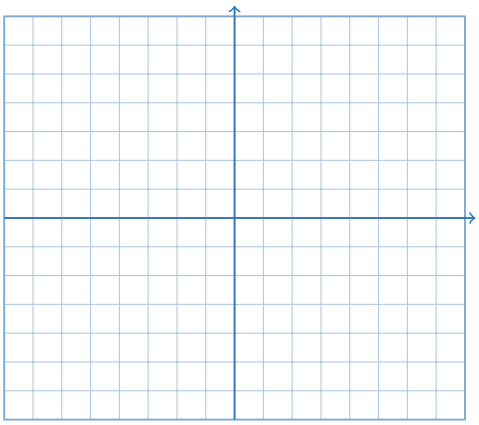
(a) Give the amplitude, the period and the frequency of the motion, and write the displacement of the cart as a function of time. **[5 pts]**

(b) Find the greatest speed of the cart and the greatest magnitude of its acceleration. **[5 pts]**

(c) On the grid, to a stated scale, sketch the displacement of the cart and the velocity of the cart against time for one full period. **[5 pts]**

(d) Find the displacement and the velocity of the cart at $t = 0.100$ s, and state whether the speed of the cart is increasing or decreasing at that instant. **[5 pts]**

5. A cart of mass 0.800 kg on a level track is attached to a spring of spring constant 20.0 N/m and oscillates with an amplitude of 0.250 m. (7.4) **[20 pts]**



(a) Find the total mechanical energy of the cart and the spring. **[5 pts]**

(b) Find the greatest speed of the cart. **[5 pts]**

(c) On the grid, to a stated scale, sketch the elastic potential energy, the kinetic energy and the total energy against the displacement of the cart, from -0.250 m to $+0.250$ m, and mark the displacement at which the first two are equal. **[5 pts]**

(d) The cart is momentarily at rest at $x = +0.250$ m when a lump of clay of mass 0.400 kg is dropped onto it and sticks. Find the new period and the new greatest speed, and state which of the total energy, the amplitude, the period and the greatest speed changed. **[5 pts]**