Assignment VII, HONS 157 (Honors Physics I)
Fall 2015
Due 10/16/15 at start of class

1. Let a particle of mass m move in the presence of a 1-dimensional potential energy function of the form $U(x) = \frac{1}{2}kx^2$ with k some constant.

   a) If the system has total energy E, what is the largest value of x that the mass can take on?

   b) Let the answer to part (a) be represented as X. What is the particle's speed when it is at position αX with $0 \leq \alpha \leq 1$, and the total energy in the system is still E?

   c) What is the force on the particle when it is at $-3X/5$?

   d) Evaluate your answers to parts (a-c) if $m = 2$ kg, $k = 7$ kg/s^2, $E = 8$ J, and $\alpha = 0.3$.

   e) Evaluate your answers to parts (a-c) if $m = 1500$ kg, $k = 1000$ kg/s^2, $E = 13200$ J, and $\alpha = 0.7$.

2. A block of mass m is dropped from height H onto a spring with spring constant k. (You may assume the block starts interacting with the spring at floor-level, so the height of the spring is not a consideration).

   a) Find the maximum distance the spring is compressed.

   b) Evaluate your answer to part (a) if $m = 3$ kg, $H = 72$ cm, and $k = 3100$ kg/s^2.

3. (This is a slightly modified version of a problem in your textbook. I just changed the numbers, but you may want to look at figure 8-52 in your text to help visualize what is going on). A 4.2 kg block is accelerated from rest by a compressed spring of spring constant 732 N/m. The block leaves the spring at the spring's relaxed length and then travels over a horizontal floor with a coefficient of kinetic friction $\mu_k = 0.17$. The frictional force stops the block in distance $D = 11.2$ m.

   a) What is the increase in the thermal energy of the block-floor system?

   b) What is the maximum kinetic energy of the block?

   c) What is the original compression distance of the spring?

   d) What was the initial velocity of the block right after breaking contact with the spring?

   d) What is the velocity of the block when it has traveled $D/2 = 5.6$ m from the spring?

4. Let a particle of mass m move in the presence of a 1-dimensional potential energy function of the form $U(x) = \alpha x \exp[-\lambda x]$ with α, and λ constants.

   a) What units must α have?

   b) What units must λ have?

   c) Where is the largest potential energy located? We will call this position X.

   d) What is the value of the largest potential energy?

   e) If the particle has velocity $v_\circ$ at the position found in part (c), what would its speed be at $2X$? (This will be a little ugly).

   f) If the particle has velocity $v_\circ$ at the position found in part (c), what would its speed be as $x \to \infty$?

   g) Evaluate your answers to parts (d-f) if $m = 2$ kg, $\alpha = 3$ (in proper SI units, but I can't give them to you because that's the answer to part (a), $\lambda = 2$ (in proper SI units, but I can't give them to you because that's the answer to part (b), and $v_\circ = 0.1$ m/s?

   h) Evaluate your answers to parts (d-f) if $m = 7$ kg, $\alpha = 3100$ (in proper SI units, but I can't give them to you because that's the answer to part (a), $\lambda = 210$ (in proper SI units, but I can't give them to you because that's the answer to part (b), and $v_\circ = 0.1$ m/s?

5. A block with mass M is released from height h above the level portion of the track shown below. The track is rough between points A and B, but elsewhere all surfaces are frictionless. As the block traverses the distance d between points A and B it loses mechanical energy E_1 ($E_1 < Mgh$). The spring constant of the spring affixed to the wall is k.

   a) Find the speed of the block at point A the first instant it passes through point A.

   b) Find the speed of the block at point B the first instant it passes through point B.

   c) What is the maximum compression of the spring during the motion of the block?

   d) What is the coefficient of kinetic friction between the block and the rough portion of the track?

   e) Assuming $E_1 < \frac{Mgh}{2}$, how high would the block reach on the first "return trip" up the triangular wedge?