Problem Set 3

Instructions:

1. Answer all questions below. Show your work for full credit.
2. The two problems are due at the start of class on 14 Feb 2014
3. The next two problems are due at the start of class on 17 Feb 2014
4. The remaining problems are due by the end of the day on 19 Feb 2014
5. You may collaborate, but everyone must turn in their own work.

Daily problems due 14 Feb 2014

1. A luge and its rider, with a total mass of 85 kg, emerge from a downhill track onto a horizontal straight track with an initial speed of 37 m/s. If a force slows them to a stop at a constant rate of $2.0\,\mathrm{m/s^2}$, **(a)** what magnitude F is required for the force, **(b)** what distance d do they travel while slowing, and **(c)** what work W is done on them by the force? What are **(d)** F, **(e)** d, and **(f)** W if they, instead, slow at $4.0\,\mathrm{m/s^2}$?

2. A 0.250 kg block of cheese lies on the floor of a 900 kg elevator cab that is being pulled upward by a cable through distance $d_1 = 2.40\,\mathrm{m}$ and then through a distance $d_2 = 10.5\,\mathrm{m}$. **(a)** Through d_1, if the normal force on the block from the floor has a constant magnitude $F_n = 3.00\,\mathrm{N}$, how much work is done on the cab by the force from the cable? **(b)** Through d_2, if the work done on the cab by the (constant) force from the cable is 92.61 kJ, what is the magnitude of F_n?

Daily problems due 17 Feb 2014

3. A block of mass $m = 2.0\,\mathrm{kg}$ is dropped from height 40 cm onto a spring of constant $k = 1960\,\mathrm{N/m}$. Find the maximum distance the spring is compressed.

4. The block in the figure below lies horizontally on a frictionless surface, and the spring constant is 50 N/m. Initially, the spring is at its relaxed length and the block is stationary at position $x = 0$. Then an applied force with a constant magnitude of 3.0 N pulls the block in the positive direction of the x axis, stretching the spring until the block stops. When that stopping point is reached, what are **(a)** the position of the block, **(b)** the work that has been done on the block by the applied force, and **(c)** the work that has been done on the block by the spring force? During the block's displacement, what are **(d)** the block's position when its kinetic energy is maximum, and **(e)** the value of that maximum kinetic energy.

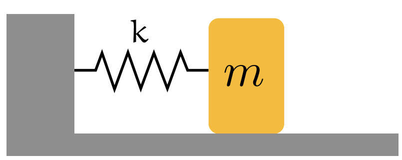
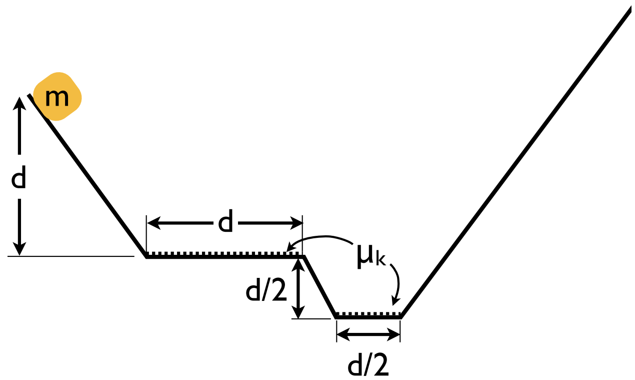


Figure 1: *A mass connected to a spring lies on a horizontal frictionless surface.*

The problems below are due by the end of the day on 17 Feb 2014.

5. A block of mass m is released from rest at a height $d = 40\,\mathrm{cm}$ and slides down a frictionless ramp and onto a first plateau, which has length d and where the coefficient of kinetic friction is $\mu_k = 0.5$. If the block is still moving, it then slides down a second frictionless ramp through height $d/2$ and onto a lower plateau, which has length $d/2$ and where the coefficient of kinetic friction is again $\mu_k = 0.5$. If the block is still moving, it then slides up a frictionless ramp.

Where is the *final* stopping point of the block? If it is on a plateau, state which one and give the distance L from the *left* edge of that plateau. If the block reaches the ramp, give the height H above the lower plateau where it momentarily stops.



6. The figure below shows a cord attached to a cart that can slide across a frictionless horizontal rail aligned along an x axis. The left end of the cord is pulled over a pulley, of negligible mass and friction and at cord height $h = 1.20\,\mathrm{m}$, so the cart slides from $x_1 = 3.00\,\mathrm{m}$ to $x_2 = 1.00\,\mathrm{m}$. During the move, the tension in the cord is a constant 25.0 N. What is the change in the kinetic energy of the cart during the move? *Hint: One method is just to find* $\int \vec{\mathbf{T}} \cdot dx$ *over the cart's motion. A second and shorter method is to recognize how much work is done in creating the initial and final situations.*

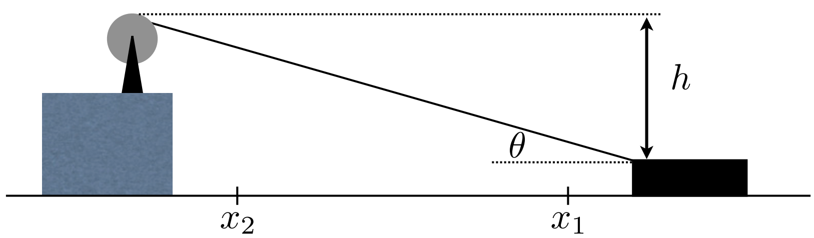


Figure 2: *A cart is pulled along a surface by a cord connected to a pulley.*

7. A funny car accelerates from rest through a measured track distance in time T with the engine operating at a constant power P. If the track crew can increase the engine power by a differential amount dP, what is the change in time required for the run?

8. A phenomenological expression for the potential energy of a bond as a function of spacing is given by

$$U(r) = \frac{A}{r^n} - \frac{B}{r^m} \tag{1}$$

For a stable bond, $m < n$. Show that the molecule will break up when the atoms are pulled apart to a distance

$$r_b = \left(\frac{n+1}{m+1}\right)^{1/(n-m)} r_o \tag{2}$$

where r_o is the equilibrium spacing between the atoms. Be sure to note your criteria for breaking used to derive the above result.

9. In the figure below, a small block of mass $m = 0.032$ kg can slide along the frictionless loop-the-loop, with loop radius $R = 12$ cm. The block is released from rest at a point P, at height $h = 5.0R$ above the bottom of the loop. How much work does the gravitational force do on the block as the block travels from point P to **(a)** point Q and **(b)** the top of the loop? If the gravitational potential energy of the block-Earth system is taken to be zero at the bottom of the loop, what is that potential energy when the block is **(c)** at point P, **(d)** at point Q, and **(e)** at the top of the loop? **(f)** If, instead of merely being released, the block is given some initial speed downward along the track, do the answers to (a) through (e) increase, decrease, or remain the same?

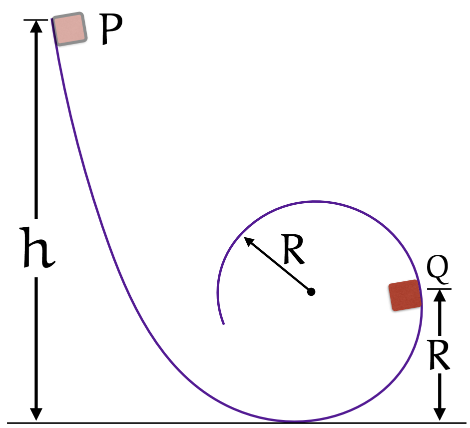


Figure 3: *A block slides along a loop-the-loop.*

10. An 8.00 kg stone sits on top of a spring which is resting on the ground. The spring is compressed 10.0 cm by the stone sitting on it. **(a)** What is the spring constant k? **(b)** The stone is pushed down an additional 30.0 cm and released. What is the elastic potential energy of the compressed spring just before the release? **(c)** What is the change in the gravitational potential energy of the stone-Earth system when the stone moves from the release point to its maximum height? **(d)** What is that maximum height, measured from the release point?