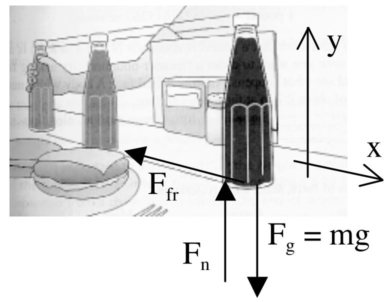
Name:____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A fellow diner at the dorms shoves a 0.450kg bottle of ketchup along the table toward you. As the bottle leaves her hand, it is moving at 2.80m/s. It slides 1.00m before coming to rest in front of you. (a)Draw and name all the forces that act on the bottle while it is in motion. (b)Find their magnitudes.



The weight is given by the mass/weight rule,
$F_g = mg = (0.450)(9.80) \Rightarrow \boxed{F_g = 4.41N}$.

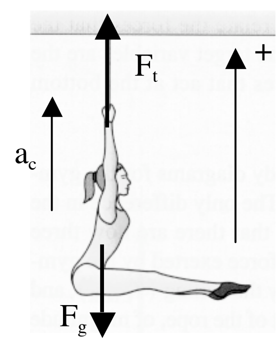
Applying the Second Law to the y-direction, $\Sigma F_y = ma_y \Rightarrow F_n - F_g = 0 \Rightarrow F_n = F_g \Rightarrow \boxed{F_n = 4.41N}$.
Applying the Second Law to the x-direction, $\Sigma F_x = ma_x \Rightarrow F_{fr} = -ma$.

The acceleration can be found using the kinematic equation without the time,

$$v^2 = v_o^2 + 2a(x - x_o) \Rightarrow 0 = v_o^2 + 2ax \Rightarrow a = -\frac{v_o^2}{2x} = -\frac{(2.80)^2}{2(1.00)} \Rightarrow a = -3.92 m/s^2$$

So the frictional force is, $F_{fr} = -ma = -(0.450)(-3.92) \Rightarrow \boxed{F_{fr} = 1.76N}$.

2. A 35.0kg gymnast swings at the end of a 3.70m rope at a speed of 2.50m/s. Find the tension in the rope as she swings through the vertical.



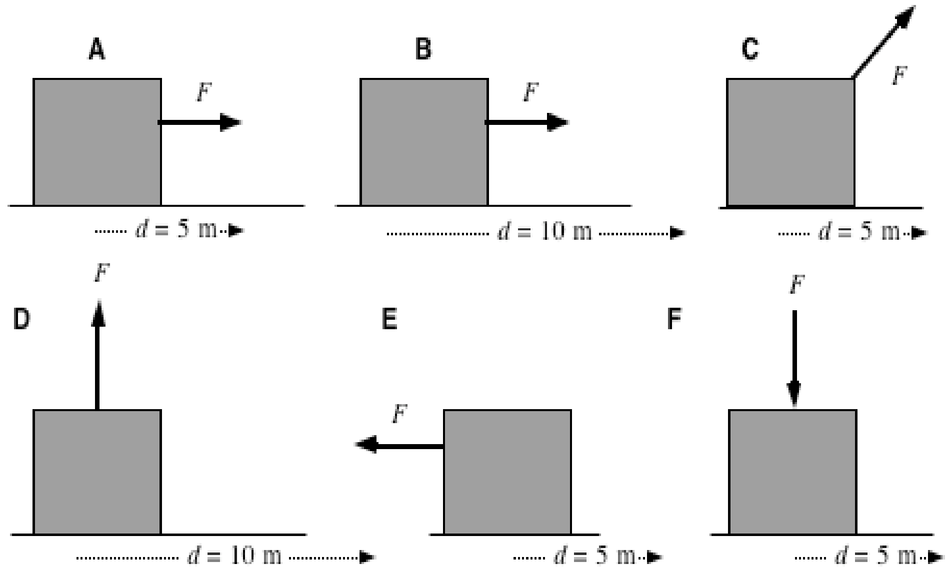
Applying the Second Law, $\Sigma F = ma \Rightarrow F_t - F_g = ma_c$.

Using the mass/weight rule and the centripetal acceleration,

$$F_t - mg = m\frac{v^2}{r} \Rightarrow F_t = m\frac{v^2}{r} + mg = (35.0)\frac{(2.50)^2}{3.70} + (35.0)(9.80)$$

The result is, $\boxed{F_t = 402N}$.

3. In the figures below, identical boxes of mass 10 kg are moving at the same initial velocity to the right on a flat surface. The same magnitude force, F, is applied to each box for the distance, d, indicated in the figures. Rank these situations in order of the work done on the box by F while the box moves the indicated distance to the right. Carefully explain your reasoning.

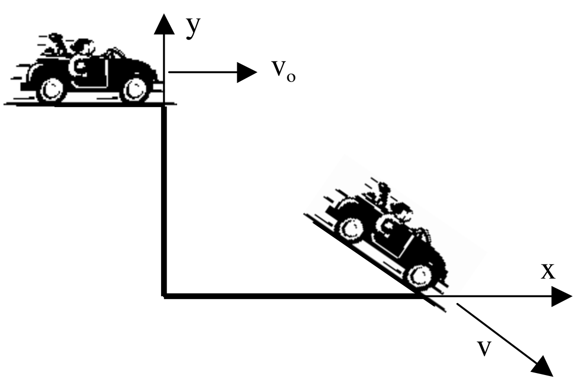


Work is the product of force and the distance. Only the component of the force along the distance counts.

Positive work is done in A and B. Since the distance in B is larger the work done is the largest.

In C positive work is done, but less than B since the force is at an angle. D and F do no work because the force is perpendicular to the motion and E does negative work. In summary, $\boxed{B>A>C>D=F>E}$.

4. A chase scene in a movie shows a car skidding over level ground at 40.0km/h when it comes upon a 10.0m high cliff. Find the speed of the car just before it hits the ground below the cliff.



Initially there is both kinetic and potential energy,

$$K_o = \tfrac{1}{2}mv_o^2 \quad \text{and} \quad U_o = mgh.$$

Just before reaching the ground, the potential energy is zero and the kinetic energy is larger,

$$K = \tfrac{1}{2}mv^2.$$

Note that $40\tfrac{km}{h} = 11.1\tfrac{m}{s}$.

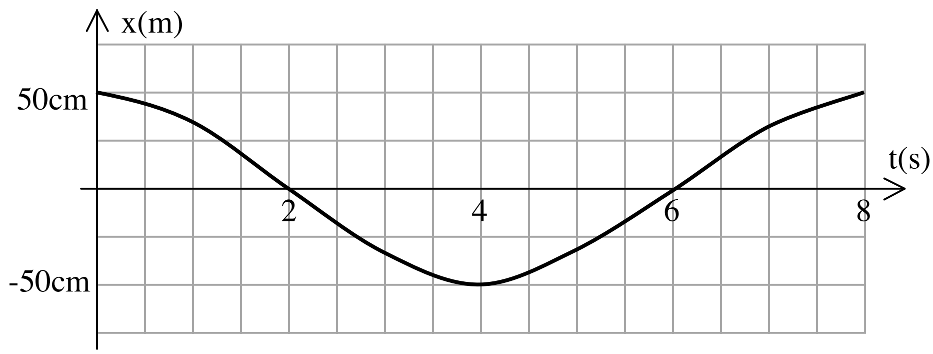
Using the Law of Conservation of Energy,

$$\Delta K + \Delta U = W_{nc} \Rightarrow (K - K_o) + (U - U_o) = 0 \Rightarrow (\tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_o^2) + (0 - mgh) = 0$$

Solving for the final speed,

$$\tfrac{1}{2}mv^2 = \tfrac{1}{2}mv_o^2 + mgh \Rightarrow v = \sqrt{v_o^2 + 2gh} = \sqrt{(11.1)^2 + 2(9.80)(10.0)} \Rightarrow \boxed{v = 17.9m/s = 64.3km/h}.$$

5. A 0.800kg mass oscillates horizontally at the end of spring with a spring constant of 2.00N/m. The graph of its position versus time is shown below. (a)Sketch the graph of the system's potential energy. (b)Sketch the graph of kinetic energy versus time. (c)Sketch the graph of the total energy versus time. Be sure to label the maximum value on vertical axis of each graph. Be sure to your explain your thinking on each part for full credit.



The potential energy is from a spring so,

$$U_s = \tfrac{1}{2}kx^2.$$

The potential energy curve is just the square of the x vs. t graph.

Using the Law of Conservation the total energy must remain a constant. Therefore, at any given time, the difference between the total energy and the potential energy is the kinetic energy.