Name: ______________________________ DISC: ____________ Score: _____ / 20

Instructions:

- Do your own work.
- Answer the questions below in the space provided.
- Make sure you show all your work and any equations that you use.
- Please place a box around your answers.
- Remember to give the correct units with all numerical answers

Q1	Q2	Q3	Q4
10	5	5	5

1. You drop a ball from the roof of the John Hancock Center (height at the roof: 344 m). The ball is of mass 2 kg.

   a. Which kind of energy does the ball have just before you drop it: **(Lecture 9, pp. 7-9, 16; Lecture 10, pp. 3-4, 7)**

   Selection:

   i. Potential Energy ($U = mgh$).

   ii. Kinetic Energy ($K = \frac{1}{2}mv^2$)

   iii. Neither

   b. Calculate the potential energy of the ball at the roof of the building.

   Potential Energy (3 pts):

   $mgh = 2\ kg\ \left(9.81\frac{m}{s^2}\right)(344\ m) = 6749\ J$

   e. Find the velocity of the ball just as it hits the ground (ignore air resistance).

   From conservation of energy: $\frac{1}{2}m\,v^2 = mgh$

   Velocity (3 pts):

   So, $v^2 = 2gh$ from which we get $v = \sqrt{2gh} = \sqrt{2\,(9.81\frac{m}{s^2})(344\ m)} = 82.15\frac{m}{s} = v$

   f. Does the force of gravity do work ($W = F\ d\cos\theta$) on the ball? Explain your answer.

   Answer (3 pts):

   Yes, the force of gravity acts in the direction of the motion of the ball (downward). Since the force (gravity) is in the direction of motion (d), the force of gravity must do work. In fact, the work done by gravity is the same as the potential energy.

2. Impulse changes momentum ($I = \Delta p = F\Delta t$). So momentum and force are related. You throw a ball of mass $m = 0.2\ kg$ straight at the wall of your dorm room. The ball travels with $\vec{v}_i = 5\ m/s$. Change in momentum is $\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$. **(Lecture 11)**
   a. The ball bounces straight off the wall ($\vec{v}_f = -\vec{v}_i$). Calculate $\Delta\vec{p}$:

Answer (3 pts):

$$\Delta\vec{p} = (0.2\ kg)\left(-5\frac{m}{s} - 5\frac{m}{s}\right) = (0.2\ kg)\left(-10\frac{m}{s}\right) = -2\ kg\ \frac{m}{s}$$

   b. If the ball interacts with the wall for 0.1 s, how large is the force experienced by the ball in the collision?

Answer (2 pts):

From the expression for impulse: $I = F\Delta t = \Delta p$. From which we can calculate [Note to graders: Don't worry about the sign]:

$$F = \frac{\Delta p}{\Delta t} = -\frac{2\ kg\frac{m}{s}}{0.1\ s} = -20\ N$$

3. A block of mass 10 kg rests on a frictionless floor. It suddenly explodes breaking into two pieces: piece 1, $m_1 = 2\ kg$ and piece 2, $m_2 = 8\ kg$. The pieces travel in opposite directions along the floor. **(Lecture 12, pp. 9-11)**
   a. Which of the following is conserved:

Selection:

   i. Momentum: $p = mv$
   ii. Kinetic energy: $K = \frac{1}{2}mv^2$

   b. Using conservation of momentum ($\Delta p = 0\ kg\ m/s$) and $\vec{v}_1 = 2\ m/s$, find v_2, the *speed* of part 2.

Answer (2 pts):

Initial state: $p_i = 10\ kg\ 0\frac{m}{s} = 0\ kg\ m/s$

Final state: $p_1 + p_2 = (2\ kg)\left(2\frac{m}{s}\right) + (8\ kg)v_2$ [Note: the masses and velocities are different in the different forms. For some forms the mass of piece 1 is larger than the mass of piece 2.]

Using conservation of momentum: $p_i = p_f$ $(same\ as\ \Delta p = 0)$ So we get: $0\ kg\frac{m}{s} = \left(4\ kg\frac{m}{s}\right) + 8\ kg\ v_2$ We can now solve for v_2 by algebra: $-4\ kg\frac{m}{s} = 8\ kg\ v_2$; $v_2 = -\frac{1}{2}\ m/s$ Note the sign. Remember that velocity (and thus momentum) are vectors.

   c. Which part has the *larger* kinetic energy:

   i. Part 1
   ii. Part 2

[Note: the masses and velocities are different in the different forms. For some forms the mass of piece 1 is larger than the mass of piece 2.]

Solution (2 pts):

For this part we need to calculate the kinetic energy for part 1: $K_1 = \frac{1}{2}(2\ kg)\left(2\frac{m}{s}\right)^2 = 2\ J$

And for the second part: $K_2 = \frac{1}{2}(8\ kg)\left(\frac{1}{2}\frac{m}{s}\right)^2 = 1\ J$ Was this what you had expected? Why or why not?