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 has mass $m = 750\ g$. **(Lecture 10, p. 6 and following)**

   a. Which kind(s) of energy does the ball have half-way down the building :

   Selection (1 pt):

      i. Potential Energy ($U = mgh$).
      ii. Kinetic Energy ($K = \frac{1}{2}mv^2$)
      iii. Neither
      iv. Both

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

   Potential Energy (3 pts):

$$U = mgh = (0.75\ kg) \times (9.8\ m/s^2) \times (344\ m) = 2528.4\ J$$

   c. Find the velocity of the ball at the height of 172 m. Ignore air resistance. (Hint: $E_{Total} = U + K$, and E_{Total} is conserved)

   Velocity (3 pts):

   Total energy is conserved. To find the total energy we look at the system just before the ball is released: $E_{Total,1} = U + K = mgh + 0\ J = mgh$. When the ball is half-way down the building, the ball has *both* kinetic and potential energy: $E_{Total,2} = U + K = mg\frac{1}{2}h + \frac{1}{2}mv^2$ Since the total energy is conserved, $E_{Total,1} = E_{Total,2}$. Therefore, $\frac{1}{2}mv^2 = \frac{1}{2}mgh$, or $v^2 = gh$. $v = 58.06\frac{m}{s}$.

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

   Answer (3 pts):

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

2. Impulse changes momentum ($\vec{I} = \Delta\vec{p} = \vec{F}\Delta t$), so momentum and force are related. You throw a ball of mass $m = 750\ g$ straight at the wall of your dorm room. The ball travels with $\vec{v}_i = 3\ m/s$ before hitting the wall.

   a. The ball bounces straight off the wall with velocity $\vec{v}_f = -\vec{v}_i$. Calculate the change in momentum, $\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$. Make sure to include a correct *sign*. **(Lecture 11, pp. 5-9)**

Answer (3 pts):

$$\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i) = m(-v_f - v_i) = -(0.75\ kg)\left(2 \times 3\frac{m}{s}\right) = -4.5\ kg\ m/s$$

   b. If the ball interacts with the wall for 0.02 s, what is the average magnitude of the force experienced by the ball during the collision?

Answer (2 pts):

$$I = \Delta p = F\Delta t$$

$$F = \frac{I}{\Delta t} = \frac{-4.5\ kg\frac{m}{s}}{0.02\ s} = -225\ N$$

3. A block of mass 15 kg slides along a frictionless floor with velocity $\vec{v}_M = 2.5\ m/s$ along the x-direction. It suddenly explodes breaking into two pieces: piece 1, $m_1 = 5\ kg$ and piece 2, $m_2 = 10\ kg$. The pieces still travel along the x-direction on the floor. **(Lecture 12)**

   a. Which of the following physical quantities is conserved:

Selection (1 pt):

   i. Momentum
   ii. Kinetic energy

   b. If the velocity of piece 1 after the explosion $\vec{v}_1 = 3.5\ m/s$, what is v_2, the *velocity* of piece 2 after the explosion?

Answer (2 pts):

Initial Momentum	$p_i = (15\ kg)(2.5\ m/s) = 37.5\ kg\ m/s$
Final Momentum	$p_f = (5\ kg)(3.5\ {}^m/_s) + (10\ kg)v_2$ $p_f = 17.5\ kg\ {}^m/_s + 10\ kg\ v_2$
Momentum Conservation	$p_f = p_i$
v_2	$17.5\ kg\ {}^m/_s + 10\ kg\ v_2 = 37.5\ kg\ {}^m/_s$ $10\ kg\ v_2 = 37.5\ kg\ {}^m/_s - 17.5\ kg\ {}^m/_s$ $10\ kg\ v_2 = 20\ kg\ {}^m/_s$ $v_2 = (20\ kg\ m/s)/(10\ kg) = 2\ m/s$

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

Solution (2 pts):

   i. Piece 1
   ii. Piece 2
   iii. Both have the same kinetic energy.