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 $m = 0.25\ kg$. **(Lecture 10, p. 6 and following)**

    a. Which kind(s) of energy does the ball have half-way down the the building (i.e. when $h = 172\ m$):

    Selection:

        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 ($h = 344\ m$).

    Potential Energy (3 pts):

    $$U = mgh = (0.25\ kg) \times (9.8\ m/s^2) \times (344\ m) = 842.8J$$

    c. Find the velocity of the ball at $h = 180\ m$. 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:

    $$E_{Total} = U + K = mgh + 0\ J = (0.25\ kg) \times (9.8\ m/s^2) \times (344\ m) = 842.8\ J \text{ This}$$
    number is constant.

    When the ball is half-way down the building, the ball has _both_ kinetic and potential energy, but the _same_ total energy:

    $$E_{Total} = U + K = (0.25\ kg) \times \left(9.8\frac{m}{s^2}\right) \times (180\ m) + \frac{1}{2}(0.25\ kg)v^2 = 842.8\ J$$

    $$3214.4\left(\frac{m}{s}\right)^2 = v^2\ ,\ v = 56.7\frac{m}{s}.$$

d. 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 $m = 0.75\ kg$ straight at the wall of your dorm room. The ball travels with $\vec{v}_i = 10\ m/s$. Change in momentum is $\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$. **(Lecture 11, pp. 5-9)**

a. The ball bounces straight off the wall ($\vec{v}_f = -\vec{v}_i$). Calculate $\Delta\vec{p}$:

Answer (3 pts):

$$\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i) = m(-v_f - v_i) = -(0.75\ kg)\left(2 \times 10\frac{m}{s}\right) = -15\ kg\ m/s$$

b. If the ball interacts with the wall for 0.02 s, how large is the force experienced by the ball in the collision?

Answer (2 pts):

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

$$F = \frac{I}{\Delta t} = \frac{-15\ kg\frac{m}{s}}{0.02\ s} = -750\ N$$

3. A block of mass $12\ kg$ slides along a frictionless floor with velocity $\vec{v}_M = 1.5\ m/s$. It suddenly breaks into two pieces: piece 1, $m_1 = 5\ kg$ and piece 2, $m_2 = 7\ kg$. The pieces travel along the floor in a straight line along the x-axis.

   a. Which of the following is _conserved_: **(Lecture 12)**

   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 $\vec{v}_1 = 2\ m/s$, the _speed_ of m_1, find v_2, the _speed_ of part 2.

   Answer (2 pts):

Initial Momentum	$p_i = (12\ kg)(1.5\ m/s) = 18\ kg\ m/s$
Final Momentum	$p_f = (5\ kg)(2\ ^m/_s) + (7\ kg)v_2$ $p_f = 10\ kg\ ^m/_s + 7\ kg\ v_2$
Momentum Conservation	$p_f - p_i = 0\ kg\ m/s$ so $p_f = p_i$
v_2	$18\ kg\ ^m/_s = 10\ kg\ m/s + 7\ kg\ v_2$ $18\ kg\ ^m/_s - 10\ kg\ ^m/_s = 7\ kg\ v_2$ $8\ kg\ ^m/_s = 7\ kg\ v_2$ $(8\ kg\ m/s)/(7\ kg) = v_2$ $(1.14\ kg\ m/s) = v_2$

   c. Which part has the _larger_ kinetic energy:

   Solution (2 pts):

        (i.) Part 1

        ii. Part 2