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

This part is all or nothing.

   b. Calculate the potential energy of the ball at the roof of the building ($h = 344\ m$).

Potential Energy (3 pts):

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

For my group this part went universally well. Common errors:

1) **Missing unit (-1 pt)**
2) **Arithmetic error (-1 pt each)**

   c. Find the velocity of the ball at $h = 180\ m$. Ignore air resistance. (Hint: $E_{Total} = U + K$, and E_{Total} is <u>*conserved*</u>)

Velocity (3 pts):

Total energy is conserved. To find the total energy we look at the system just before the ball is released:

$\boldsymbol{E_{Total} = U + K = mgh + 0\,J = (0.25\ kg) \times (9.8\ m/s^2) \times (344\ m) = 842.8\,J}$ **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:

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

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

This part generally went well. The most common error was:

1) **$0 = K + U$ rather than $mgh_{top} = mgh + \frac{1}{2}mv^2$ (-2 pts)**
2) **Missing unit (-1 pt)**

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.

This part turned out to be an all-or-nothing kind of problem. Most common error:

1) **Failure to realize that the angle in question is the angle between the force vector and the displacement vector (-3 pts)—this is the point.**

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):

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

This part went well. The most common errors were:

1) **Missing unit (-1 pt)**
2) **Arithmetic mistakes (- 1 pt each)**

I'm not overly concerned about the sign, as long as they were consistent i.e. got the sum of the velocities.

   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):

$$\boldsymbol{I = \Delta p = F\Delta t}$$

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

This part went well. The most common errors were:

1) **Missing unit (-1 pt)**
2) **Arithmetic mistakes (- 1 pt each)**

I'm not overly concerned about the sign.

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

Overall this question went very well. Common errors:

1) **Substituting kinetic energy for momentum (-2 pts)**
2) **Confusing $\Delta p = 0$ with $m_1 v_1 = -m_2 v_2$ (-2 pts)—this is the point of the exercise for part b.**