MOMENTUM AND ENERGY QUIZ REVIEW KEY

***Instructions**: Show your work completely in your journal when answering the following questions.*

1. Define the following (conceptual definition and equation):
   a. Momentum

      Momentum is similar to inertia in motion; $\boldsymbol{p = m \cdot v}$

   b. Impulse

      Impulse is a force applied over a time interval; $\boldsymbol{I = F\Delta t = \Delta p}$

   c. Conservation of Momentum

      The momentum of a system before an event is equal to momentum afterward.

      $$\boldsymbol{p_{before} = p'_{after}}$$

   d. Kinetic Energy

      Energy due to motion; $\boldsymbol{E_K = \frac{1}{2}mv^2}$

   e. Potential Energy

      Energy due to position/location; $\boldsymbol{E_P = mgh}$

   f. Mechanical Energy

      Energy due to motion or location of a physical body; $\boldsymbol{ME = E_K + E_P}$

   g. Conservation of Energy

      Mechanical energy of a system remains constant before and after an event;

      $$\boldsymbol{E_{K1} + E_{P1} = E'_{K2} + E'_{P2}}$$

   h. Elastic Collision

      A collision where objects bounce off each other undamaged;

      $$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$

   i. Inelastic Collision

      A collision where objects bounce off and each is damaged OR objects collide and stick together;

      $$m_1v_1 + m_2v_2 = (m_1 + m_2)\, v'$$

2. What is the kinetic energy for the following objects?
   a. A 65 kg runner moving with a speed of 7.0 $^{\text{m}}/_{\text{s}}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(65\text{ kg})(7.0\ ^{\text{m}}/_{\text{s}})^2$$

$$\boxed{\boldsymbol{E_K = 1600\text{ J}}}$$

   b. A 2.0 million kg space shuttle with a launch speed of 44 $^{\text{m}}/_{\text{s}}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(2000000\text{ kg})(44\ ^{\text{m}}/_{\text{s}})^2$$

$$\boxed{\boldsymbol{E_K = 1.9 \times 10^9\ J}}$$

   c. A 5.0 kg bowling ball moving with a speed of 9.5 $^{\text{m}}/_{\text{s}}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(5.0\text{ kg})(9.5\ ^{\text{m}}/_{\text{s}})^2$$

$$\boxed{\boldsymbol{E_K = 230\text{ J}}}$$

   d. A 75 kg skier at rest

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(75\text{ kg})(0\ ^{\text{m}}/_{\text{s}})^2$$

$$\boxed{\boldsymbol{E_K = 0\text{ J}}}$$

3. What is the potential energy for the following objects?
   a. A 0.50 kg orange sitting on a shelf 2.0 meters off the ground

$$E_P = mgh = (0.50\text{ kg})\left(9.80\ ^{\text{m}}/_{\text{s}^2}\right)(2.0\text{ m})$$

$$\boxed{\boldsymbol{E_P = 9.8\text{ J}}}$$

   b. A 68 kg snowboarder sitting on a ramp 15 meters high

$$E_P = mgh = (68\text{ kg})\left(9.80\ ^{\text{m}}/_{\text{s}^2}\right)(15\text{ m})$$

$$\boxed{\boldsymbol{E_P = 1.0 \times 10^4\text{ J}}}$$

   c. A 1200 kg car parked in a garage 6 stories up (21 meters)

$$E_P = mgh = (1200\text{ kg})\left(9.80\ ^{\text{m}}/_{\text{s}^2}\right)(21\text{ m})$$

$$\boxed{\boldsymbol{E_P = 2.5 \times 10^5\text{ J}}}$$

d. A 16 kg box sitting on the floor

$$E_P = mgh = (16\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(0\text{ m})$$

$$\boxed{\boldsymbol{E_P = 0\text{ J}}}$$

4. You decide to apply your vast knowledge of physics to baseball. You swing the bat and, oops, it's a pop up. The 0.145 kg ball starts straight up off the bat at 35 ${}^{\text{m}}/_{\text{s}}$.
   a. How much kinetic energy does the ball have initially? At the top?

$$E_{K(1)} = \frac{1}{2}mv^2 = \frac{1}{2}(0.145\text{ kg})(35\ {}^{\text{m}}/_{\text{s}})^2$$

$$\boxed{\boldsymbol{E_{K(1)} = 89\text{ J}}}$$

$$\boxed{\boldsymbol{E'_{K(2)} = 0\text{ J}}}$$

   b. At the top, what is the ball's potential energy?

$$E_{K1} + E_{P1} = E'_{K2} + E'_{P2} \rightsquigarrow 89\text{ J} + 0 = 0 + E'_{P2}$$

$$\boxed{\boldsymbol{E'_{P2} = 89\text{ J}}}$$

   c. The catcher catches the ball. Just before it hits, what is the ball's kinetic energy? Potential energy?

   Kinetic energy is conserved in an elastic collision. Thus:

$$\boxed{\boldsymbol{E_K = 89\text{ J}}}$$

$$\boxed{\boldsymbol{E_P = 0\text{ J}}}$$

5. You go next door from the baseball field and find the local pool. You climb up onto the 10. m platform to take a dive. If your mass is 50. kg:
   a. What is the change in potential energy when you climb up there?

$$\Delta E_P = E_{P(2)} - E_{P(1)} = mgh_2 - mgh_1 = (50\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(10\text{ m}) - 0$$

$$\boxed{\boldsymbol{\Delta E_P = 4900\text{ J}}}$$

   b. You jump. How fast are you going just before striking the water 10. m below?

$$E_{K1} + E_{P1} = E'_{K2} + E'_{P2} \rightsquigarrow 0 + 4900\text{ J} = E'_{K2} + 0$$

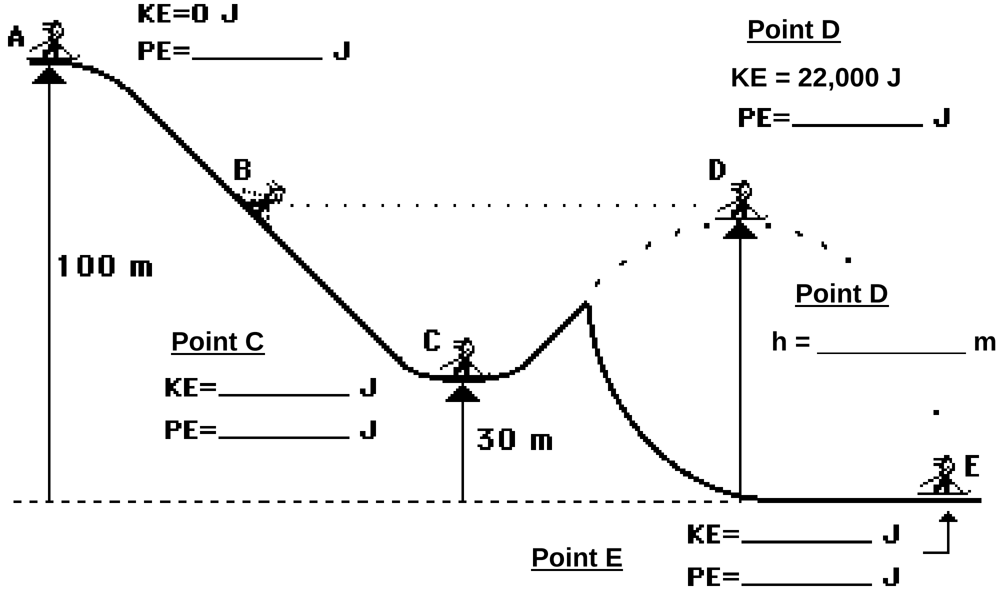
$$E'_{K2} = 4900\text{ J}$$

$$E'_{K(2)} = \frac{1}{2}mv^2 \rightsquigarrow 4900\text{ J} = \frac{1}{2}(50\text{ kg})v^2$$

$$\boxed{\boldsymbol{v = 14\ {}^{\text{m}}/_{\text{s}}}}$$

6. A world-class Olympic athlete starts from rest on top of a 100. meter hill, skis down the incline and makes a world-record setting jump. If she has a mass of 55 kg, use the information given in the diagram to fill in the missing information.

a.



Point A:

$$\boldsymbol{E_P} = mgh = (55\ \mathrm{kg})\left(9.80\ \mathrm{m}/_{\mathrm{s}^2}\right)(100\ \mathrm{m}) = \boxed{\mathbf{53,900\ J}}$$

$$\boldsymbol{E_K} = \frac{1}{2}mv^2 = \underline{\mathbf{0\ J}}$$

$$\boxed{ME = E_K + E_P = 53{,}900\ \mathrm{J}}$$

Point C:

$$ME = constant = \underline{53{,}900\ \mathrm{J}}$$

$$\boldsymbol{E_P} = mgh = (55\ \mathrm{kg})\left(9.80\ \mathrm{m}/_{\mathrm{s}^2}\right)(30\ \mathrm{m}) = \boxed{\mathbf{16,170\ J}}$$

$$ME = E_K + E_P \rightsquigarrow \boldsymbol{E_K} = ME - E_P = 53900\ \mathrm{J} - 16170\ \mathrm{J} = \boxed{\mathbf{37,730\ J}}$$

Point D:

$$ME = constant = \underline{53{,}900\ \mathrm{J}}$$

$$\underline{E_K = 22{,}000\ \mathrm{J}}$$

$$ME = E_K + E_P \rightsquigarrow \boldsymbol{E_P} = ME - E_K = 53900\ \mathrm{J} - 22000\ \mathrm{J} = \boxed{\mathbf{31,900\ J}}$$

$$E_P = mgh \rightsquigarrow \boldsymbol{h} = \frac{E_P}{mg} = \frac{31900\ \mathrm{J}}{(55\ \mathrm{kg})\left(9.80\ \mathrm{m}/_{\mathrm{s}^2}\right)} = \boxed{\mathbf{59\ m}}$$

Point E:

$$ME = constant = \underline{53{,}900\ \mathrm{J}}$$

$$\underline{\boldsymbol{E_P} = \mathbf{0\ J}}$$

$$ME = E_K + E_P \rightsquigarrow \boldsymbol{E_K} = \boxed{\mathbf{53,900\ J}}$$

b. Calculate her velocity at points B and C

<u>Point B *(equivalent to point D since they're at the same height!)*:</u>

$$E_K = \frac{1}{2}mv^2 = 22{,}000 \text{ J}$$

$$v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(22000 \text{ J})}{(55 \text{ kg})}}$$

$$\boxed{\boldsymbol{v_B = 28\,{}^{\mathbf{m}}/_{\mathbf{s}}}}$$

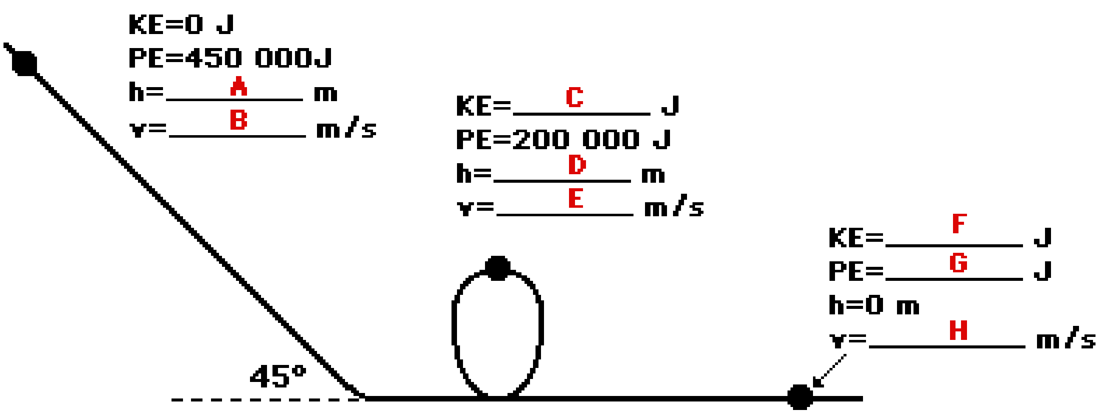
<u>Point C:</u>

$$E_K = \frac{1}{2}mv^2 = 37{,}730 \text{ J}$$

$$v_C = \sqrt{\frac{2E_{K(C)}}{m}} = \sqrt{\frac{2(37730 \text{ J})}{(55 \text{ kg})}}$$

$$\boxed{\boldsymbol{v_C = 37\,{}^{\mathbf{m}}/_{\mathbf{s}}}}$$

7. Use the law of conservation of energy to fill in the blanks at the various marked positions for a 1000. kg roller coaster car.



A. $E_P = mgh \rightsquigarrow h = \frac{E_P}{mg} = \frac{450000 \text{ J}}{(1000 \text{ kg})\left(9.80\,{}^{\text{m}}/_{\text{s}^2}\right)} \rightsquigarrow \boxed{\boldsymbol{h = 46 \text{ m}}}$

B. $E_K = 0 \rightsquigarrow \boxed{\boldsymbol{v_B = 0\,{}^{\mathbf{m}}/_{\mathbf{s}}}}$

C. $ME = E_K + E_P \rightsquigarrow E_K = ME - E_P = 450000 \text{ J} - 200000 \text{ J} \rightsquigarrow \boxed{\boldsymbol{E_K = 250{,}000 \text{ J}}}$

D. $E_P = mgh \rightsquigarrow h = \frac{E_P}{mg} = \frac{200000 \text{ J}}{(1000 \text{ kg})\left(9.80\,{}^{\text{m}}/_{\text{s}^2}\right)} \rightsquigarrow \boxed{\boldsymbol{h = 20. \text{ m}}}$

E. $E_K = \frac{1}{2}mv^2 = 200{,}000 \;\; \leadsto v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(250000\text{ J})}{(1000\text{ kg})}} \leadsto \boxed{\boldsymbol{v_B = 22\,{}^{\mathbf{m}}/_{\mathbf{s}}}}$

F. $ME = E_K + E_P \leadsto \boxed{\boldsymbol{E_K = 450{,}000\text{ J}}}$

G. $E_P = mgh \leadsto \boxed{\boldsymbol{E_P = 0\text{ J}}}$

H. $E_K = \frac{1}{2}mv^2 = 400{,}000 \;\; \leadsto v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(450000\text{ J})}{(1000\text{ kg})}} \leadsto \boxed{\boldsymbol{v_B = 30.\,{}^{\mathbf{m}}/_{\mathbf{s}}}}$