

PHYS101 Quiz - Solution Set

Department of Physics

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Questions:

1. A bullet of mass $m = 5.2g$ and velocity $\vec{v}_{B_0} = 500\frac{m}{s}\hat{i}$ hits a block of wood of mass $M = 700g$ at rest on a frictionless surface. The bullet emerges from the block at a velocity of $\vec{v}_B = 300\frac{m}{s}\hat{i}$.



- (a) Calculate the velocity of the block after the collision. (3 P)

Solution:

$$\begin{aligned} m\vec{v}_{B_0} + M\underbrace{\vec{v}_{W_0}}_{=0} &= m\vec{v}_B + M\vec{v}_W \\ \vec{v}_W &= \frac{m}{M}(\vec{v}_B - \vec{v}_{B_0}) \\ \vec{v}_W &= \frac{5.2gr}{700gr}(500 - 300)\hat{i}\frac{m}{s} = 1.49\hat{i}\frac{m}{s} \end{aligned}$$

- (b) Calculate the impulse on the block. (1 P)

Solution:

$$\Delta\vec{p}_W = \vec{p}_W - \vec{p}_{W_0} = 0.7kg \cdot 1.49\hat{i}\frac{m}{s} - 0 = 1.043\hat{i}kg\frac{m}{s}$$

- (c) Calculate the impulse on the bullet. (1 P)

Solution:

$$\Delta \vec{p}_B = \vec{p}_B - \vec{p}_{B_0} = 0.0052 \text{kg} \cdot 300 \hat{i} \frac{\text{m}}{\text{s}} - 0.0052 \text{kg} \cdot 500 \hat{i} \frac{\text{m}}{\text{s}} = -1.043 \hat{i} \text{kg} \frac{\text{m}}{\text{s}}$$

- (d) Calculate the change of the total kinetic energy of the system, and state whether the collision was elastic or inelastic. (3 P)

Solution:

$$\begin{aligned} \Delta K &= \left(\frac{1}{2} m v_B^2 + \frac{1}{2} M v_W^2 \right) - \left(\frac{1}{2} m v_{B_0}^2 + \frac{1}{2} M \underbrace{v_{W_0}^2}_{=0} \right) = \frac{1}{2} m (v_B^2 - v_{B_0}^2) + \frac{1}{2} M v_W^2 = \\ &= \frac{1}{2} 0.0052 \left(\left(300 \frac{\text{m}}{\text{s}} \right)^2 - \left(500 \frac{\text{m}}{\text{s}} \right)^2 \right) + \frac{1}{2} 0.7 \text{kg} \left(1.49 \frac{\text{m}}{\text{s}} \right)^2 = -415.2 \text{J} \end{aligned}$$

As $\Delta K \neq 0$, the collision is inelastic.

- (e) If the block continues to move on a frictionless surface and moves up an incline, what is the maximum height that the block can reach. (2 P)

Solution:

In this case we the Block - Earth system is isolated with only conservative forces acting, therefore the mechanical Energy is conserved.

$$\begin{aligned} \Delta E_{mech} = \Delta K + \Delta U &= \left(\frac{1}{2} M v_{W_f}^2 - \frac{1}{2} M v_{W_i}^2 \right) + (Mgh - Mg0) \\ \implies h &= \frac{v_{W_i}^2}{2g} = \frac{\left(1.49 \frac{\text{m}}{\text{s}} \right)^2}{2 \cdot 9.8 \frac{\text{m}}{\text{s}^2}} = 0.11 \text{m} \end{aligned}$$

2. A car of mass $m = 1500 \text{kg}$ moves from the point A to the point B (distance 7.5 m) with constant velocity $\vec{v} = 10 \frac{\text{m}}{\text{s}} \hat{i}$. What is the work done on the car if the points A and B are 7.5 m apart from each other? (3 P)

Solution:

As the velocity of the car is constant, there is no net force acting on the car, therefore with

$$W = \int \vec{F} \cdot d\vec{r} = 0,$$

obviously the work done on the car is zero.