PHYS101 Quiz - Solution Set

Department of Physics

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Questions:

1. A bullet of mass $m = 5.2g$ and velocity $\vec{\mathbf{v}}_{B_0} = 500\frac{m}{s}\hat{\mathbf{i}}$ 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 $\vec{\mathbf{v}}_B = 300\frac{m}{s}\hat{\mathbf{i}}$.

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

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

   (b) Calculate the impulse on the block. (1 P)
   Solution:

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

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

Solution:

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

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

Solution:

$$\Delta K = \left(\frac{1}{2}mv_B^2 + \frac{1}{2}Mv_W^2\right) - \left(\frac{1}{2}mv_{B_0}^2 + \frac{1}{2}M\underbrace{v_{W_0}^2}_{=0}\right) = \frac{1}{2}m\left(v_B^2 - v_{B_0}^2\right) + \frac{1}{2}Mv_W^2 =$$
$$= \frac{1}{2}0.0052\left(\left(300\frac{m}{s}\right)^2 - \left(500\frac{m}{s}\right)^2\right) + \frac{1}{2}0.7kg\left(1.49\frac{m}{s}\right)^2 = -415.2J$$

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.

$$\Delta E_{mech} = \Delta K + \Delta U = \left(\frac{1}{2}Mv_{W_f}^2 - \frac{1}{2}Mv_{W_f}^2\right) + (Mgh - Mg0)$$
$$\Longrightarrow h = \frac{v_W^2}{2g} = \frac{\left(1.49\frac{m}{s}\right)^2}{2 \cdot 9.8\frac{m}{s^2}} = 0.11m$$

2. A car of mass $m = 1500kg$ moves from the point A to the point B (distance 7.5 m) with constant velocity $\vec{\mathbf{v}} = 10\frac{m}{s}\hat{\mathbf{i}}$. 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

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

obviously the work done on the car is zero.