Name_______________________________________

Physics 120 Quiz #2.0, April 18, 2014

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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Since the Union men's hockey team just won the Frozen Four, let's look at striking a hockey puck with a stick. A hockey puck of mass $0.20kg$ is sliding across the ice at velocity of $\langle 20,0,0 \rangle \frac{m}{s}$ where the velocity was determined by video analysis. At some instant of time the puck was struck by a player's stick (ultimately breaking the stick) and the direction of motion of the puck changes. The velocity of the puck after the impact was found to be $\langle 20,0,31.7 \rangle \frac{m}{s}$. Examining similar hockey sticks we can determine the force necessary to break the stick by adding weights to a horizontal stick and see how much weight it takes to break the stick. It is found that the stick would break when a force of $1000N$ was applied.

a. What was the force on the puck during the collision of the puck with the stick?

The magnitude of the force is $1000N$. To determine the direction of the force we look at the change in momentum since this is proportional to the net force. The change in momentum is only in the z-direction, so the net force must be in the z-direction. Thus $\vec{F}_{net} = \langle 0,0,1000 \rangle N$.

b. How long was the puck in contact with the hockey stick?

The time is given from the momentum principle. We have

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t$$

$$\Delta t = \frac{p_{fz} - p_{iz}}{F_{net,z}} = \frac{0.2kg \times \langle 20-20, 0-0, 31.7-0 \rangle \frac{m}{s}}{1000N} = 0.0063s.$$

c. Taking the origin of a coordinate system to be at the puck just before it was struck by the stick, what was the distance traveled by the puck during the time the puck was in contact with the stick?

From the position-update we have

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t \rightarrow \Delta\vec{r} = \vec{r}_f - \vec{r}_i = \vec{v}_{avg}\Delta t$$

$$\Delta\vec{r} = \vec{v}_{avg}\Delta t = \frac{\langle 20,0,0\rangle \frac{m}{s} + \langle 20,0,31.7\rangle \frac{m}{s}}{2} \times 0.0063s = \langle 0.126,0,0.0999\rangle m$$

The distance is the magnitude of the displacement vector. We have,

$$r = |\Delta\vec{r}|^2 = \sqrt{(0.0126m)^2 + (0m)^2 + (0.0999m)^2} = 0.16m = 16cm.$$

d. In determining the force exerted on the puck by the hockey stick and the time that the puck was in contact with the stick, it is assumed that

1. The frictional force between the puck and the ice was negligible.
2. The frictional force and the force due to the air were both negligible.
3. The gravitational force was negligible.
4. The force exerted by the stick on the puck was constant during the contact time.

Physics 120 Equation Sheet

$\vec{r} = < r_x, r_y, r_z > = |\vec{r}| \cdot \hat{r}$

magnitude of a vector : $r = |\vec{r}| = \sqrt{r_x^2 + r_y^2 + r_z^2}$

unit vector : $\hat{r} = \dfrac{\vec{r}}{|\vec{r}|}$

$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t}; \ \vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$$

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg} \Delta t$$

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net} \Delta t$$

$$\vec{r}_f = \vec{r}_i + \vec{v}_i \Delta t + \frac{\vec{F}_{net}}{2m} (\Delta t)^2$$

$$\vec{F}_G = -\frac{GM_1 M_2}{r^2} \hat{r}$$

$$\vec{F}_g \sim m\vec{g}$$

Constants:

$g = 9.8 \frac{m}{s^2}$

$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$

$m_e = 9.11 \times 10^{-31} kg$

$m_p = 1.67 \times 10^{-27} kg$

$m_E = 6 \times 10^{24} kg$

$R_E = 6.4 \times 10^6 m$