Name____

Physics 120 Quiz #7, May 30, 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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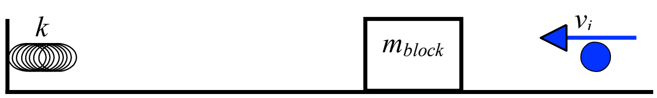
Consider the system shown below in which a ball of mass $m_{ball} = 200g$ is fired at a speed v_i and subsequently collides with a stationary block of mass $m_{block} = 1.7kg$. After the collision, the bullet and block slide across a frictionless surface until they collide with a horizontal spring of stiffness $k = 18\frac{N}{m}$ initially is at its equilibrium length.



a. Derive an expression for the initial speed of the ball, v_i before the collision, in terms of the given masses and the speed of the ball and block after the collision.

$$\frac{d\vec{p}}{dt} = \vec{F}_{net} = 0 \rightarrow \Delta p_{system} = 0 \rightarrow \vec{p}_{f,system} = \vec{p}_{i,system}$$

$$m_{ball}\langle -v_i, 0, 0\rangle = (m_{ball} + m_{block})\langle -V, 0, 0\rangle$$

$$\therefore v_i = \left(\frac{m_{ball} + m_{block}}{m_{ball}}\right)V$$

b. If the ball and block strike the spring and eventually come to rest over a distance of $x = 0.87m$, how fast were the block and ball traveling before they struck the spring assuming that friction $\mu = 0.18$ is present only over the distance the block and ball travel while in contact with the spring?

$$\Delta E = W_{fr} = -\mu(m_{ball} + m_{block})gx = \Delta KE + \Delta U_s = \left(0 - \tfrac{1}{2}(m_{ball} + m_{block})V^2\right) + \left(\tfrac{1}{2}kx^2 - 0\right)$$

$$V = \sqrt{\frac{kx^2 + 2\mu(m_{ball} + m_{block})gx}{m_{ball} + m_{block}}} = \sqrt{\frac{18\frac{N}{m}(0.87m)^2 + 2\times 0.18\times(1.9kg)\times 9.8\frac{m}{s^2}\times 0.87m}{1.9kg}} = 3.2\frac{m}{s}$$

c. What was the initial speed of the ball v_i before it collided with the block?

$$v_i = \left(\frac{m_{ball} + m_{block}}{m_{ball}}\right)V = \left(\frac{1.9kg}{0.2kg}\right) \times 3.2\,\tfrac{m}{s} = 30.4\,\tfrac{m}{s}$$

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 : $\hat{r} = \frac{\vec{r}}{|\vec{r}|}$

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

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

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

$\vec{p} = \gamma m \vec{v}; \; \lim_{v<<c} (\vec{p}) \sim m\vec{v}$

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

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

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

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

Constants:

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

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

$m_e = 9.11 \times 10^{-31} kg = 0.51 \frac{MeV}{c^2}$

$m_p = 1.67 \times 10^{-27} kg = 938.5 \frac{MeV}{c^2}$

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

$R_E = 6.4 \times 10^6 m$

$N_A = 6.02 \times 10^{23}$

$c = 3 \times 10^8 \frac{m}{s}$

$1eV = 1.6 \times 10^{-19} J$

$\frac{d\vec{p}}{dt} = \vec{F}_{net}$

$\vec{F}_s = -k\vec{s}$

$F_{fr} = \mu F_N$

$k_{parallel} = \sum_{i=1}^{N} k_i$

$\frac{1}{k_{series}} = \sum_{i=1}^{N} \frac{1}{k_i}$

$\rho = \frac{m}{V}$

$Y = \frac{k_{IAB}}{d}$

$\text{Stress} = Y \times \text{Strain}; \; \text{Stress} = \frac{F}{A}; \; \text{Strain} = \frac{\Delta l}{l}$

$\vec{F}_{\parallel} = \frac{dp}{dt} \hat{p}$

$\vec{F}_{\perp} = p \frac{d\hat{p}}{dt} \rightarrow |\vec{F}_{\perp}| = \frac{mv^2}{R};$

$\vec{F}_{Net} = \vec{F}_{\parallel} + \vec{F}_{\perp} = \frac{d\vec{p}}{dt} = \frac{dp}{dt} \hat{p} + p \frac{d\hat{p}}{dt}$

$\Delta E = \Delta Q + \Delta W = \Delta KE + \Delta U_g + \Delta U_s + \Delta E_{rest}$

$\Delta W = \Delta KE = \int \vec{F} \cdot d\vec{r}; \quad \vec{F} \cdot d\vec{r} = F_x dx + F_y dy + F_Z dz$

$KE = (\gamma - 1) mc^2; \; \lim_{v<<c} (KE) \sim \frac{1}{2} mv^2$

$E_T = \gamma mc^2; \; E_T^2 = p^2 c^2 + m^2 c^4; \; E_{rest} = mc^2$

$U_g = mgy$

$U_s = \frac{1}{2} kx^2$

$\vec{r}_{com} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i} = \langle r_{x,com}, r_{y,com}, r_{z,com} \rangle$