Name

Physics 110 Quiz #5, May 7, 2021

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.

Consider the situation below in which a block of mass $m_1 = 3kg$ connected to an initially horizontal string of negligible mass and length L = 0.75m held at rest while a block of mass $m_2 = 1kg$ sits at rest on a horizontal table.



1. Using energy ideas, what is the speed of block m_1 just before it collides with block m_2 ?

$$\Delta E = \Delta K + \Delta U_g + \Delta U_s \to 0 = \left(\frac{1}{2}m_1v_{m_1}^2 - 0\right) + (0 - m_1gL)$$
$$v_{3M,i} = \sqrt{2gL} = \sqrt{2 \times 9.8\frac{m}{s^2} \times 0.75m} = 3.8\frac{m}{s}$$

2. After the collision block m_2 is launched horizontally off the table and travels a horizontal distance of 4L and a vertical distance of 2L before landing on the ground. Using this information, what was the speed of block m_2 after the collision?

$$\begin{split} x_f &= x_i + v_{ix}t + \frac{1}{2}a_xt^2 \to 4L = v_Mt \to t = \frac{4L}{v_{m_2}} \\ y_f &= y_i + v_{iy}t + \frac{1}{2}a_yt^2 \to -2L = -\frac{1}{2}g\left(\frac{4L}{v_{m_2}}\right)^2 \\ \to v_{m_2} &= \sqrt{4gL} = \sqrt{4 \times 9.8}\frac{m}{s^2} \times 0.75m = 5.4\frac{m}{s} \end{split}$$

3. What was the speed of block m_1 after the collision?

$$p_{i,system,x} = p_{f,system,x} \to 3Mv_{3M,i} = Mv_M + 3Mv_{3M,f}$$
$$v_{m_1,f} = \frac{m_1v_{m_1} - m_2v_2}{m_1} = \frac{3kg \times 3.8\frac{m}{s} - 1kg \times 5.4\frac{m}{s}}{3kg} = 2.0\frac{m}{s}$$

4. After the collision m_2 continues moving and swings through an angle θ_{max} What is the value of θ_{max} ? You can calculate a number for θ_{max} . $\Delta E = \Delta K + \Delta U_g + \Delta U_S \rightarrow 0 = \left(0 - \frac{1}{2}m_1v_{m_{1,f}}^2\right) + (m_1gL(1 - \cos\theta) - 0)$ $\cos \theta_{max} = 1 - \frac{v_{m_{1,f}}^2}{2gL} = 1 - \frac{(2\frac{m}{s})^2}{2 \times 9.8\frac{m}{s^2} \times 0.75} = 0.7280 \rightarrow \theta_{max} = 43.3^0$ where, $L = y_f + L \cos \theta_{max}$

5. What fraction of the initial energy is lost in the collision and based on this value, is the collision between blocks and elastic or inelastic?

$$f = \frac{\Delta K}{\kappa_i} = \frac{\kappa_f - \kappa_i}{\kappa_i} = \frac{\left(\frac{1}{2}m_1 v_{m_{1,f}}^2 + \frac{1}{2}m_2 v_{m_{2,f}}^2\right) - \frac{1}{2}m_1 v_{m_{1,f}}^2}{\frac{1}{2}m_1 v_{m_{1,f}}^2} = \frac{\left(\frac{1}{2} \times 3kg \left(2\frac{m}{s}\right)^2 + \frac{1}{2} \times 1kg \left(5.4\frac{m}{s}\right)^2\right) - \left(\frac{1}{2} \times 3kg \left(3.8\frac{m}{s}\right)^2\right)}{\left(\frac{1}{2} \times 3kg \left(3.8\frac{m}{s}\right)^2\right)}$$

$$f = \frac{20.58 - 21.66}{21.66} = -0.05 \to -5\%$$

Since this is not zero, the collision is inelastic.

Vectors $v = \sqrt{v_x^2 + v_y^2}$ $\phi = \tan^{-1} \left(\frac{v_y}{v_y}\right)$

Motion Definitions

Displacement: $\Delta x = x_f - x_i$ Average velocity: $v_{avg} = \frac{\Delta x}{\Delta t}$ Average acceleration: $a_{avg} = \frac{\Delta v}{\Delta t}$

Equations of Motion

displacement: $\begin{cases}
x_f = x_i + v_{ix}t + \frac{1}{2}a_xt^2 \\
y_f = y_i + v_{iy}t + \frac{1}{2}a_yt^2
\end{cases}$ velocity: $\begin{cases}
v_{fx} = v_{ix} + a_xt \\
v_{fy} = v_{iy} + a_yt
\end{cases}$ time-independent: $\begin{cases}
v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x \\
v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y
\end{cases}$

Rotational Motion Definitions

Angular displacement: $\Delta s = R\Delta\theta$ Angular velocity: $\omega = \frac{\Delta\theta}{\Delta t} \rightarrow v = R\omega$ Angular acceleration: $\alpha = \frac{\Delta\omega}{\Delta t} \rightarrow \begin{cases} a_t = r\alpha \\ a_c = r\omega^2 \end{cases}$

Rotational Equations of Motion

$$\theta_{f} = \theta_{i} + \omega_{i}t + \frac{1}{2}\alpha t^{2}$$
$$\omega_{f} = \omega_{i} + \alpha t$$
$$\omega_{f}^{2} = \omega_{i}^{2} + 2\alpha\Delta\theta$$

Momentum & Force

$$\vec{p} = m\vec{v} \rightarrow p_x = mv_x; \ p_y = mv_y$$

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

$$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a} \rightarrow F_x = ma_x; \ F_y = ma_y$$

$$F_{fr} = \mu F_N$$

$$F_w = mg$$

$$F_s = -kx$$

$$F_G = G \frac{M_1 M_2}{r^2}$$

$$F_c = ma_c = m \frac{v^2}{R}$$

Work & Energy

$$\begin{cases} W_T = \int \vec{F} \cdot d\vec{r} = F dr \cos \theta = \Delta K_T \\ W_R = \int \vec{\tau} \cdot d\vec{\theta} = \tau d\theta = \Delta K_R \end{cases}$$

$$W_{net} = W_T + W_R = \Delta K_T + \Delta K_R = -\Delta U$$

$$K_{T} = \frac{1}{2}mv^{2}$$

$$K_{R} = \frac{1}{2}I\omega^{2}$$

$$U_{g} = mgy$$

$$U_{s} = \frac{1}{2}kx^{2}$$

$$\Delta E = \Delta E_{R} + \Delta E_{T}$$

$$\Delta E = \Delta K_{R} + \Delta K_{T} + \Delta U_{g} + \Delta U_{s} = \begin{cases} 0\\W_{fr} \end{cases}$$

Rotational Momentum & Force

$$\begin{split} \vec{\tau} &= \vec{r} \times \vec{F}; \ \tau = r_{\perp}F = rF_{\perp} = rF\sin\theta\\ \tau &= \frac{\Delta L}{\Delta t} = I\alpha\\ L &= I\omega\\ \Delta \vec{L} &= \vec{\tau}\Delta t \to \vec{L}_{f} = \vec{L}_{i} + \vec{\tau}\Delta t \end{split}$$

Fluids

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

$$P = \frac{F}{A}$$

$$P_{y} = P_{air} + \rho gy$$

$$F_{B} = \rho gV$$

$$\rho_{1}A_{1}v_{1} = \rho_{2}A_{2}v_{2}; \text{ compressible}$$

$$A_{1}v_{1} = A_{2}v_{2}; \text{ incompressible}$$

$$P_{1} + \frac{1}{2}\rho v_{1}^{2} + \rho gy_{1} = P_{2} + \frac{1}{2}\rho v_{2}^{2} + \rho gy_{2}$$

Simple Harmonic Motion

$$\omega = 2\pi f = \frac{2\pi}{T}$$
$$T_s = 2\pi \sqrt{\frac{m}{k}}; \quad \omega = \sqrt{\frac{k}{m}}$$
$$T_p = 2\pi \sqrt{\frac{l}{g}}; \quad \omega = \sqrt{\frac{g}{l}}$$

Geometry/Algebra

Circles:

 $A = \pi r^2$

Sound

$$\begin{split} v_s &= f\lambda = (331 + 0.6T) \frac{m}{s} \\ \beta &= 10 \log \frac{I}{I_o} \\ f_n &= nf_1 = n \frac{v}{2L}; n = 1,2,3, \dots \text{ open pipes} \\ f_n &= nf_1 = n \frac{v}{4L}; n = 1,3,5, \dots \text{ closed pipes} \end{split}$$

Waves

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = nf_1 = n\frac{v}{2L}; n = 1,2,3,...$$

$$I = 2\pi^2 f^2 \rho v A^2$$

Equations of Motion for SHM

$$x(t) = \begin{cases} x_{max} \sin\left(\frac{2\pi}{T}t\right) \\ x_{max} \cos\left(\frac{2\pi}{T}t\right) \\ x_{max} \cos\left(\frac{2\pi}{T}t\right) \end{cases}$$
$$v(t) = \begin{cases} v_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \end{cases}$$
$$V = \frac{4}{3}\pi r^{3} \qquad a(t) = \begin{cases} -a_{max} \sin\left(\frac{2\pi}{T}t\right) \\ -a_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -a_{max} \cos\left(\frac{2\pi}{T}t\right) \end{cases}$$
$$v = \pm v_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^{2}}$$
$$v = \pm \omega x_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^{2}}$$

Spheres: $A = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$ Triangles: $A = \frac{1}{2}bh$ $v = \pm v_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$ Quadratics: $ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $v = \pm \omega x_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$ Periodic Table of the Elements

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https://www.wuwm.com/post/periodic-table-elements-turns-150#stream/0