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.

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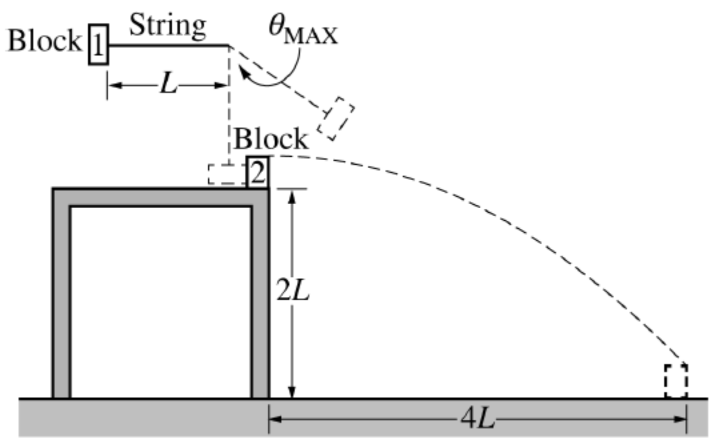
Consider the situation below in which a block of mass $m_1 = 3kg$ connected to an initially horizontal string of negligible mass and length $L = 0.75m$ held at rest while a block of mass $m_2 = 1kg$ sits at rest on a horizontal table.



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

$$\Delta E = \Delta K + \Delta U_g + \Delta U_s \to 0 = \left(\tfrac{1}{2}m_1 v_{m_1}^2 - 0\right) + (0 - m_1 gL)$$

$$v_{3M,i} = \sqrt{2gL} = \sqrt{2 \times 9.8\frac{m}{s^2} \times 0.75m} = 3.8\frac{m}{s}$$

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?

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2 \to 4L = v_M t \to t = \frac{4L}{v_{m_2}}$$

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 \to -2L = -\tfrac{1}{2}g\left(\frac{4L}{v_{m_2}}\right)^2$$

$$\to v_{m_2} = \sqrt{4gL} = \sqrt{4 \times 9.8\frac{m}{s^2} \times 0.75m} = 5.4\frac{m}{s}$$

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

$$p_{i,system,x} = p_{f,system,x} \rightarrow 3Mv_{3M,i} = Mv_M + 3Mv_{3M,f}$$

$$v_{m_1,f} = \frac{m_1 v_{m_1} - m_2 v_2}{m_1} = \frac{3kg \times 3.8\frac{m}{s} - 1kg \times 5.4\frac{m}{s}}{3kg} = 2.0\frac{m}{s}$$

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}.

$$\Delta E = \Delta K + \Delta U_g + \Delta U_S \rightarrow 0 = \left(0 - \frac{1}{2}m_1 v_{m_{1,f}}^2\right) + (m_1 g L(1 - \cos\theta) - 0)$$

$$\cos\theta_{max} = 1 - \frac{v_{m1,f}^2}{2gL} = 1 - \frac{\left(2\frac{m}{s}\right)^2}{2\times 9.8\frac{m}{s^2}\times 0.75} = 0.7280 \rightarrow \theta_{max} = 43.3^0$$

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?

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

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

Since this is not zero, the collision is inelastic.

Physics 110 Formula sheet

Vectors

$v = \sqrt{v_x^2 + v_y^2}$

$\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

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: $\begin{cases} x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\ y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \end{cases}$

velocity: $\begin{cases} v_{fx} = v_{ix} + a_x t \\ v_{fy} = v_{iy} + a_y t \end{cases}$

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

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

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

$K_T = \frac{1}{2}mv^2$

$K_R = \frac{1}{2}I\omega^2$

$U_g = mgy$

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

$\Delta E = \Delta E_R + \Delta E_T$

$\Delta E = \Delta K_R + \Delta K_T + \Delta U_g + \Delta U_s = \begin{cases} 0 \\ W_{fr} \end{cases}$

Rotational Momentum & Force

$\vec{\tau} = \vec{r} \times \vec{F};\ \tau = r_\perp F = rF_\perp = rF\sin\theta$

$\tau = \frac{\Delta L}{\Delta t} = I\alpha$

$L = I\omega$

$\Delta\vec{L} = \vec{\tau}\Delta t \rightarrow \vec{L}_f = \vec{L}_i + \vec{\tau}\Delta t$

Fluids

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

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

$$P_y = P_{air} + \rho g y$$

$$F_B = \rho g V$$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$; compressible

$A_1 v_1 = A_2 v_2$; incompressible

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

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: $A = \pi r^2$ $\quad C = 2\pi r = \pi D$

Spheres: $A = 4\pi r^2$ $\quad V = \frac{4}{3}\pi r^3$

Triangles: $A = \frac{1}{2}bh$

Quadratics: $ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Sound

$$v_s = f\lambda = (331 + 0.6T)\frac{m}{s}$$

$$\beta = 10\log\frac{I}{I_o}$$

$f_n = n f_1 = n\frac{v}{2L}; n = 1,2,3,\ldots$ open pipes

$f_n = n f_1 = n\frac{v}{4L}; n = 1,3,5,\ldots$ closed pipes

Waves

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

$$f_n = n f_1 = n\frac{v}{2L};\ n = 1,2,3,\ldots$$

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

Equations of Motion for SHM

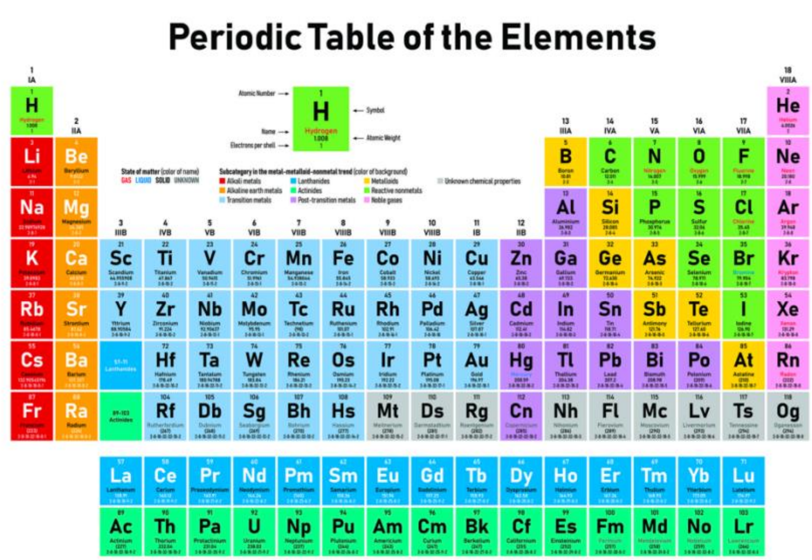
$$x(t) = \begin{cases} x_{max}\sin\left(\frac{2\pi}{T}t\right) \\ x_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$v(t) = \begin{cases} v_{max}\cos\left(\frac{2\pi}{T}t\right) \\ -v_{max}\sin\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$a(t) = \begin{cases} -a_{max}\sin\left(\frac{2\pi}{T}t\right) \\ -a_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$v = \pm v_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$

$$v = \pm \omega x_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$



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