Name____

Physics 110 Quiz #5, May 6, 2022

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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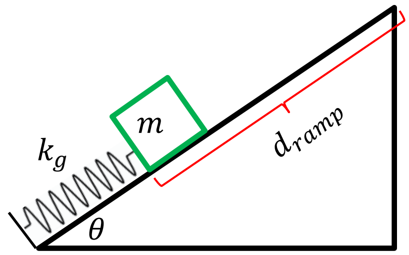
1. A block of mass $m = 2kg$ is placed against an unstretched spring of stiffness $k_g = 52000\frac{N}{m}$. The mass and spring are pushed along the surface of the frictionless ramp a distance $d_{ramp} = 0.25m$. The mass is released from rest and the spring uncompresses. When the spring returns to its original length the mass is launched from the end of the spring at an angle of, $\theta = 30^0$ measured with respect to the horizontal as shown below. Using energy ideas, what is the launch speed of the mass?



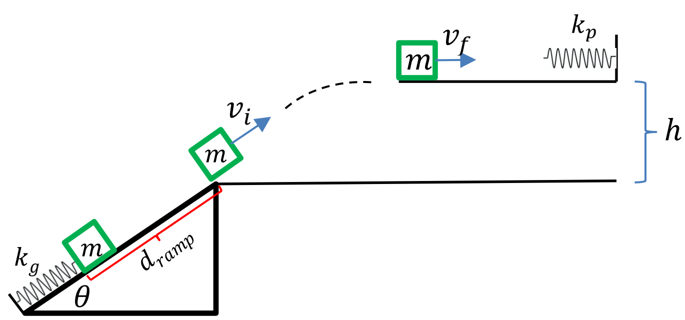
$$\Delta E = 0 = \Delta K + \Delta U_g + \Delta U_s$$

$$0 = \left(\tfrac{1}{2}mv_f^2 - 0\right) + \left(mgy_f - 0\right) + \left(0 - \tfrac{1}{2}kx_i^2\right)$$

$$v_f = \sqrt{\frac{k}{m}x_i^2 - mgy_f} = \sqrt{\frac{k}{m}x_i^2 - 2gd_{ramp}\sin\theta}$$

$$v_f = \sqrt{\frac{52000\frac{N}{m}}{2kg}(0.25m)^2 - 2 \times 9.8\frac{m}{s^2} \times 0.25m\sin 30} = 40.3\frac{m}{s}$$

2. A horizontal platform is located at a height h above the ground such that the mass m lands on the horizontal platform when the mass m reaches the highest point in its motion. Using energy ideas, what is the height h of the platform above the ground? Assume that the mass m was launched from ground level.



$$\Delta E = 0 = \Delta K + \Delta U_g + \Delta U_s$$

$$0 = \left(\tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2\right) + \left(mgy_f - 0\right) \rightarrow y_f = h = \frac{v_i^2 - v_{fx}^2}{2g}$$

$$h = \frac{\left(40.3\frac{m}{s}\right)^2 - \left(40.3\frac{m}{s}\cos 30\right)^2}{2 \times 9.8\frac{m}{s^2}} = 20.7m$$

3. After the mass lands on the horizontal platform, it slides across the horizontal frictionless surface until it collides with a spring of stiffness $k_p = 1600\frac{N}{m}$. How far will the spring have compressed when the mass comes to rest?

$$\Delta E = 0 = \Delta K + \Delta U_g + \Delta U_s$$

$$0 = \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + \left(\frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2\right) = -\frac{1}{2}mv_i^2 + \frac{1}{2}kx_f^2 \rightarrow x_f = \sqrt{\frac{m}{k}}v_{ix}$$

$$x_f = \sqrt{\frac{2kg}{1600\frac{N}{m}}} \times 40.3\frac{m}{s}\cos 30 = 1.23m$$

4. Suppose that the horizontal platform was not frictionless, but that friction exists with coefficient of friction $\mu = 0.8$. If the mass slides a distance $d = 2m$ before striking the spring, with what speed with the mass strike the spring?

$$\Delta E = W_{fr} = -\mu mgd = \Delta K$$

$$-\mu mgd = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \rightarrow v_f = \sqrt{v_{ix}^2 - 2\mu gd}$$

$$v_f = \sqrt{\left(40.3\frac{m}{s}\cos 30\right)^2 - \left(2 \times 0.8 \times 9.8\frac{m}{s^2} \times 2m\right)} = 34.4\frac{m}{s}$$

5. If friction exists under the spring as well, by how much will the spring compress in this case as the mass comes to rest?

$$\Delta E = W_{fr} = \Delta K + \Delta U_g + \Delta U_s$$

$$-\mu mgx_f = \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + \left(\frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2\right) = -\frac{1}{2}mv_i^2 + \frac{1}{2}kx_f^2$$

$$\frac{1}{2}kx_f^2 + \mu mgx_f - \frac{1}{2}mv_i^2 = 0 \rightarrow 800x_f^2 + 15.7x_f - 1183.4 = 0$$

$$x_f = \begin{cases} -1.23m \\ 1.20m \end{cases} \rightarrow x_f = 1.20m$$

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: $\omega = \frac{\Delta\theta}{\Delta t} \to v = r\omega$

Angular acceleration: $\alpha = \frac{\Delta\omega}{\Delta t} \to \begin{cases} a_t = r\alpha \\ a_c = r\omega^2 \end{cases}$

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

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

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

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

$F_{fr} = \mu F_N$

$F_w = mg$

$F_s = -kx$

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

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

Work & Energy

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

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

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

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

$U_g = mgy$

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

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

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

Rotational Momentum & Force

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

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

$L = I\omega$

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

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

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

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

Common Metric Prefixes

$nano = 1 \times 10^{-9}$

$micro = 1 \times 10^{-6}$

$milli = 1 \times 10^{-3}$

$centi = 1 \times 10^{-2}$

$kilo = 1 \times 10^{3}$

$mega = 1 \times 10^{6}$

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

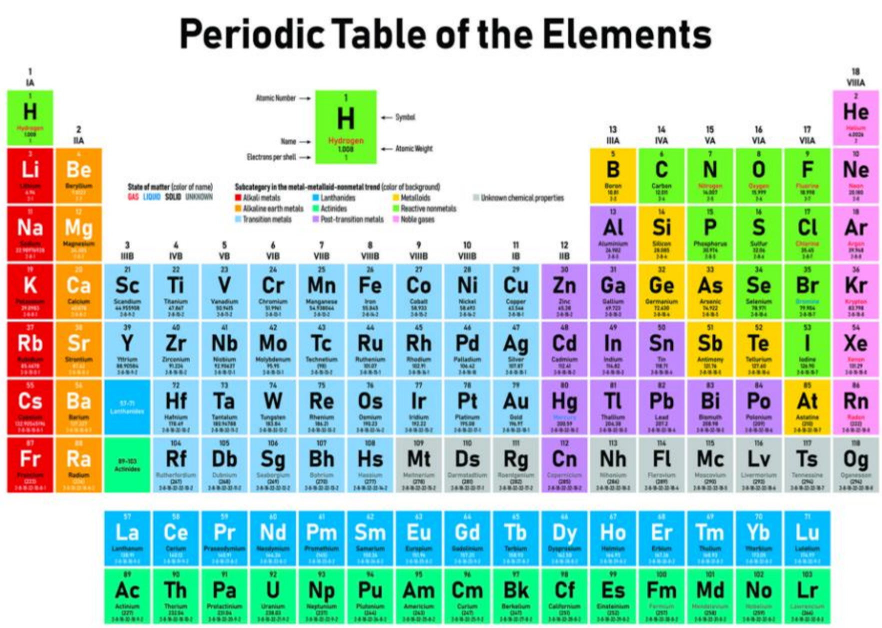
$x(t) = \begin{cases} x_{max}\sin\left(\frac{2\pi}{T}t\right) \\ x_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$

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

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

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

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



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