Name_______________________________________

Physics 110 Quiz #4, April 29, 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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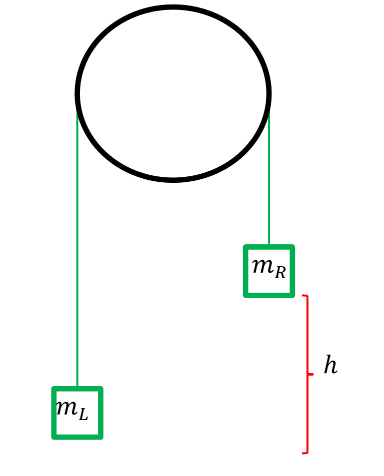
Consider the setup of two masses $m_L = 1kg$ and $m_R = 2kg$ connected to a light rope passed over a massless pulley. The mass on the right is released from rest and falls through a height $h = 1m$.



1. Assuming the system is the mass on the right, m_R, how much work was done on m_R by the force of gravity?

$$W_{gR} = F_{WR}\Delta y\cos\phi = m_R g\Delta y\cos 0 = m_R g\Delta y$$
$$W_{gR} = 2kg \times 9.8\frac{m}{s^2} \times 1m = 19.6J$$

2. Assuming the system is the mass on the left, m_L, how much work was done on m_L by the force of gravity?

$$W_{gL} = F_{WL}\Delta y\cos\phi = m_L g\Delta y\cos 180 = -m_L g\Delta y$$
$$W_{gL} = -1kg \times 9.8\frac{m}{s^2} \times 1m = -9.8J$$

3. Assuming the system is both mases m_L and m_R, what is the net work done on the system of masses?

$$W_{net} = W_L + W_R = (F_T\Delta y\cos\phi - m_L g\Delta y) + (F_T\Delta y\cos\phi + m_R g\Delta y)$$
$$W_{net} = W_L + W_R = (F_T\Delta y\cos 0 - m_L g\Delta y) + (F_T\Delta y\cos 180 + m_R g\Delta y)$$
$$W_{net} = W_L + W_R = -m_L g\Delta y + m_R g\Delta y = -9.8J + 19.6J = 9.8J$$

4. Using the work-kinetic energy theorem, what are the speeds of m_L and m_R, after m_R has fallen through a height $h = 1m$ from rest? Hints: Assume the system is masses m_L and m_R and note that both masses move.

$$W_{net} = W_L + W_R = \Delta K_L + \Delta K_R = \left(\frac{1}{2}m_L v_{fL}^2 - \frac{1}{2}m_L v_{iL}^2\right) + \left(\frac{1}{2}m_R v_{fR}^2 - \frac{1}{2}m_R v_{iR}^2\right)$$
$$W_{net} = W_L + W_R = \Delta K_L + \Delta K_R = \frac{1}{2}m_L v_{fL}^2 + \frac{1}{2}m_R v_{fR}^2 = \frac{1}{2}(m_L + m_R)v_f^2$$
$$v_f = \sqrt{\frac{2W_{net}}{m_L + m_R}} = \sqrt{\frac{2 \times 9.8J}{1kg + 2kg}} = 2.6\frac{m}{s}$$

5. Assuming that the system is m_L, m_R and the Earth and applying conservation of energy, what are the final speeds of m_L and m_R, after m_R has fallen through a height $h = 1m$ from rest? How do these speeds compare the speeds you calculated in part 4?

$$\Delta E = 0 = \Delta U_{gL} + \Delta K_L + \Delta U_{gR} + \Delta K_R$$
$$0 = \left(m_L g y_{Lf} - m_L g y_{Li}\right) + \left(\frac{1}{2}m_L v_{fL}^2 - \frac{1}{2}m_L v_{iL}^2\right) + \left(m_R g y_{Rf} - m_R g y_{Ri}\right) + \left(\frac{1}{2}m_R v_{fR}^2 - \frac{1}{2}m_R v_{iR}^2\right)$$
$$0 = m_L g\left(y_{Lf} - y_{Li}\right) + m_R g\left(y_{Rf} - y_{Ri}\right) + \frac{1}{2}(m_L + m_R)v_f^2 = m_L gh - m_R gh + \frac{1}{2}(m_L + m_R)v_f^2$$
$v_f = \sqrt{2\left(\frac{m_R - m_L}{m_R + m_L}\right)gh} = \sqrt{2\left(\frac{2kg - 1kg}{2kg + 1kg}\right) \times 9.8\frac{m}{s^2} \times 1m} = 2.6\frac{m}{s}$ which is the same as in part 4.

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

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

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

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

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

$U_g = mgy$

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

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

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

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

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

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

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

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

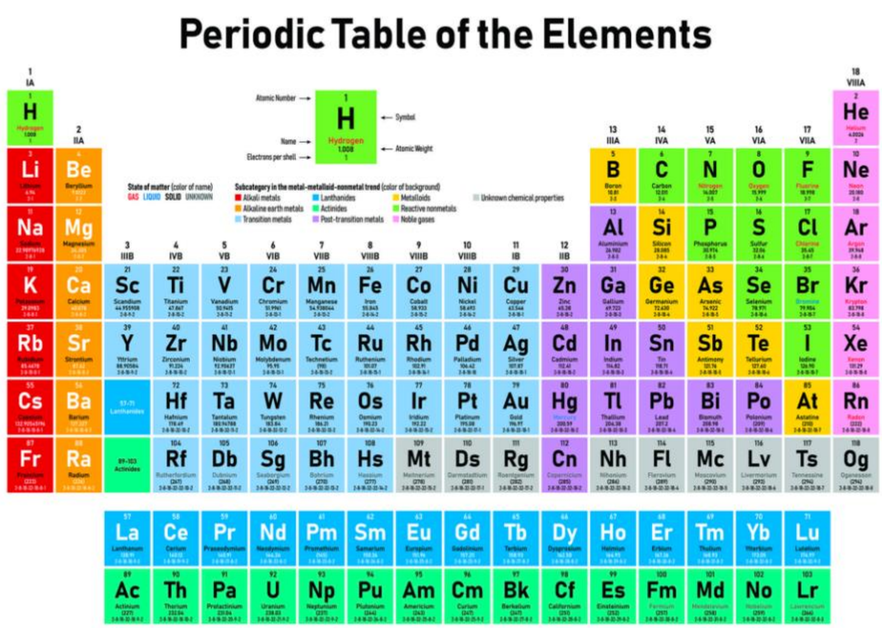
$$x(t) = \begin{cases} x_{max}\sin\left(\frac{2\pi}{T}t\right) \\ x_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

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

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

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

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



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