Name____

Physics 110 Quiz #4, April 30, 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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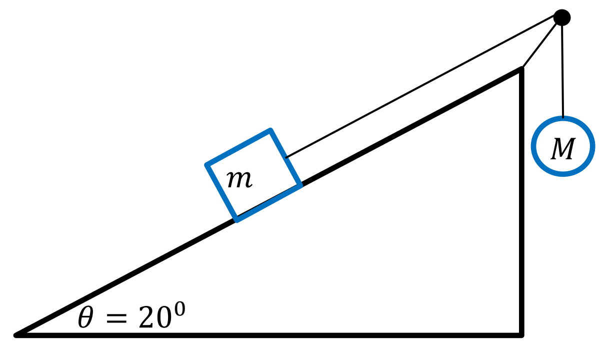
A block of mass $m = 1kg$ is connected to a sphere of mass $M = 2kg$ by a very light cord that passes over a frictionless and massless pulley as shown on the right. The system of masses is released from rest and the sphere falls through a height $h = 0.75m$.



1. What is the expression for the net work done on the sphere of mass M as it falls through height h? Your answer should contain only symbols and no numbers.

Work done by the weight: $W_{F_{W,M}} = F_W \Delta y \cos\phi = Mg\Delta y \cos 0 = Mgh$

Work done by the tension: $W_{F_T} = F_T \Delta y \cos\phi = F_T \Delta y \cos 180 = -F_T h$

Net work done on M: $W_{net,M} = W_{F_W} + W_{F_T} = Mgh - F_T h$

2. What is the expression for the net work done on the block of mass m as it slides up the ramp? Assume that the ramp is frictionless, and your answer should contain only symbols and no numbers.

Work done by the weight: $W_{F_{W,m}} = F_W \Delta x \cos\phi = -mg\Delta x \cos(90 - \theta) = -mgh\sin\theta$

Work done by the tension: $W_{F_T} = F_T \Delta x \cos\phi = F_T \Delta x \cos 0 = F_T h$

Net work done on m: $W_{net,m} = W_{F_{W,m}} + W_{F_T} = -mgh\sin\theta + F_T h$

3. Using the information given, what was the net work done on the system of masses (m and M)? You will get a number for this part.

$W_{net} = W_{net,M} + W_{net,m} = Mgh - F_T h - mgh\sin\theta + F_T h = Mgh - mgh\sin\theta$

$W_{net} = (M - m\sin\theta)gh = (2kg - 1kg\sin 20) \times 9.8\frac{m}{s^2} \times 0.75m = 12.2J$

4. What is the final speed of the system of masses (m and M) if both are released from rest? Hint: Each mass experiences a change in kinetic energy.

$$W_{net} = \Delta K_m + \Delta K_M = \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + \left(\frac{1}{2}Mv_f^2 - \frac{1}{2}Mv_i^2\right) = \frac{1}{2}(m+M)v_f^2$$

$$v_f = \sqrt{\frac{2W}{(m+M)}} = \sqrt{\frac{2\times 12.2J}{3kg}} = 2.85\frac{m}{s}$$

5. In this problem the block of mass m rises and the sphere of mass M falls. The change in gravitational potential energy for the sphere is given by $\Delta U_g = -Mgh$. Which of the following gives the change in gravitational potential energy of the block of mass m?

a. $\Delta U_g = mgh$.

b. $\Delta U_g = \left(\frac{m+M}{m}\right)gh$.

c. $\Delta U_g = \left(\frac{m+M}{M}\right)gh$.

d. $\Delta U_g = mgh\sin\theta$.

e. None of the above give the correct expression for the gravitational potential energy change for the block of mass m.

Physics 110 Formula sheet

Vectors

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

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

$F_{fr} = \mu F_N$

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

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

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

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

$F_w = mg$

$F_s = -kx$

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

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

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

$\omega = 2\pi f$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{l}{g}}$

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

Sound

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

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

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

$f_n = nf_1 = n\frac{v}{4L}; n = 1,3,5,\ldots$ closed pipes

Waves

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

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

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

Equations of Motion for SHM

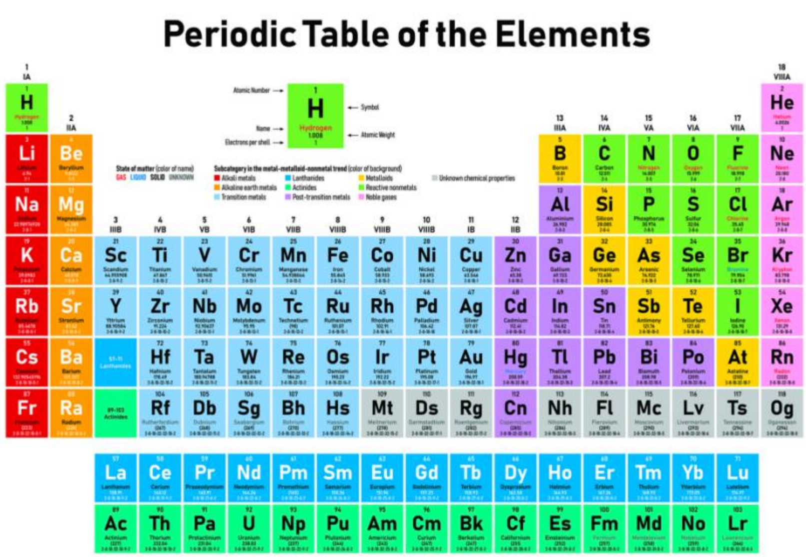
$$x(t) = \begin{cases} x_{max}\sin\left(\frac{2\pi}{T}t\right) \\ x_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

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

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

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

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



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