Name____

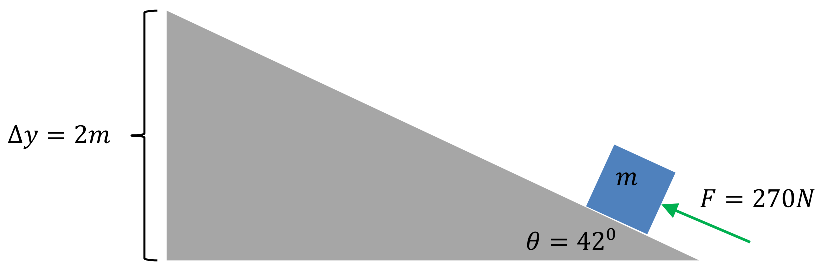
Physics 110 Quiz #3, October 9, 2020

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.

____

A box of mass $10kg$ is pushed up a rough incline ($\mu = 0.3$) angled at 42^0above the horizontal by a force of $F = 270N$ parallel to the incline. The box rises vertically in the air, measured from the ground, by $\Delta y = 2m$ as shown on the right.



1. Through what distance along the incline was the box pushed?

$$\sin\theta = \frac{\Delta y}{\Delta x} \rightarrow \Delta x = \frac{\Delta y}{\sin\theta} = \frac{2m}{\sin 42} = 3m$$

2. How much work was done on box, by all of the forces that act on the box, if the incline is $2m$ high?

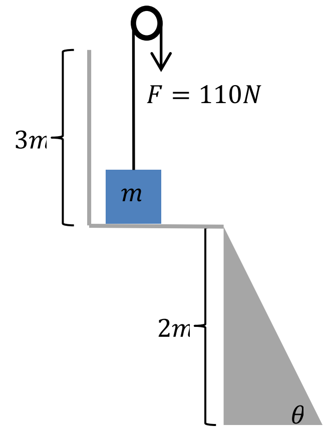
$$W_{net} = F_{wx}\Delta x\cos 180 + F\Delta x\cos 0 + F_{fr}\Delta x\cos 180$$
$$W_{net} = -mg\sin\theta\,\Delta x + F\Delta x - \mu F_N\Delta x = [-mg\sin\theta + F - \mu mg\cos\theta]\Delta x$$
$$W_{net} = \left[-10kg \times 9.8\frac{m}{s^2}\sin 42 + 270N - 0.3 \times 10kg \times 9.8\frac{m}{s^2}\cos 42\right] \times 3m = 547.5J$$

3. If the box starts from rest at the bottom of the incline, what will be the speed of the box at the top of the incline?

$$W_{net} = \Delta K = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2 = \tfrac{1}{2}mv_f^2 \rightarrow v_f = \sqrt{\frac{2W_{net}}{m}}$$

$$v_f = \sqrt{\frac{2W_{net}}{m}} = \sqrt{\frac{2 \times 547.5J}{10kg}} = 10.5\frac{m}{s}$$

Suppose that at the top of the incline the ground becomes horizontal and just to the left of the top of the incline is a $3m$ tall vertical cliff. The person who pushed the box up the incline now ties a light rope to the box and passes the rope over a massless pulley. The person applies a $F = 110N$ force to the box at rest on the ground lifting it vertically $3m$ as shown below.



4. What was the work done on the box by the person lifting it?

$$W_{person} = F\Delta y \cos 0 = F\Delta y = 110N \times 3m = 330J$$

5. What is the speed of the box when it rises $3m$, starting from rest?

$$W_{net} = F_{person}\Delta y \cos 0 + F_W \Delta y \cos 180 = F_{person}\Delta y - F_W \Delta y$$
$$W_{net} = [F_{person} - F_W]\Delta y = [F_{person} - mg]\Delta y = \left[110N - 10kg \times 9.8\frac{m}{s^2}\right] \times 3m = 294J$$

$$W_{net} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 \rightarrow v_f = \sqrt{\frac{2W_{net}}{m}} = \sqrt{\frac{2 \times 294J}{10kg}} = 2.7\frac{m}{s}$$

Physics 110 Formulas

Motion

$\Delta x = x_f - x_i \qquad v_{avg} = \frac{\Delta x}{\Delta t} \qquad a_{avg} = \frac{\Delta v}{\Delta t}$

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: $\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x \text{D}x \\ v_{fy}^2 = v_{iy}^2 + 2a_y \text{D}y \end{cases}$

Uniform Circular Motion

$F_r = ma_r = m\frac{v^2}{r}; \quad a_r = \frac{v^2}{r}$

$v = \frac{2pr}{T}$

$F_G = G\frac{m_1 m_2}{r^2}$

Geometry /Algebra

Circles *Triangles* *Spheres*

$C = 2pr \qquad A = \frac{1}{2}bh \qquad A = 4pr^2$

$A = pr^2 \qquad V = \frac{4}{3}pr^3$

Quadratic equation : $ax^2 + bx + c = 0$,

whose solutions are given by : $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

magnitude of a vector: $v = |\vec{v}| = \sqrt{v_x{}^2 + v^2{}_y}$

direction of a vector: $\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

Useful Constants

$g = 9.8\,{}^{m}\!/_{s^2} \qquad G = 6.67 ´\ 10^{-11}\,{}^{Nm^2}\!/_{kg^2}$

$N_A = 6.02 ´\ 10^{23}\,{}^{atoms}\!/_{mole} \qquad k_B = 1.38 ´\ 10^{-23}\,{}^{J}\!/_{K}$

$s = 5.67 ´\ 10^{-8}\,{}^{W}\!/_{m^2K^4} \qquad v_{sound} = 343\,{}^{m}\!/_{s}$

Linear Momentum/Forces

$\vec{p} = m\vec{v}$

$\vec{p}_f = \vec{p}_i + \vec{F}\,\text{D}t$

$\vec{F} = m\vec{a}$

$\vec{F}_s = -k\vec{x}$

$F_f = mF_N$

Work/Energy

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

$K_r = \frac{1}{2}Iw^2$

$U_g = mgh$

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

$W_T = FdCos\,q = \text{D}E_T$

$W_R = tq = \text{D}E_R$

$W_{net} = W_R + W_T = \text{D}E_R + \text{D}E_T$

$\text{D}E_R + \text{D}E_T + \text{D}U_g + \text{D}U_S = 0$

$\text{D}E_R + \text{D}E_T + \text{D}U_g + \text{D}U_S = -\text{D}E_{diss}$

Heat

$T_C = \frac{5}{9}[T_F - 32]$

$T_F = \frac{9}{5}T_C + 32$

$L_{new} = L_{old}(1 + a\text{D}T)$

$A_{new} = A_{old}(1 + 2a\text{D}T)$

$V_{new} = V_{old}(1 + b\text{D}T) : b = 3a$

$PV = Nk_BT$

$\frac{3}{2}k_BT = \frac{1}{2}mv^2$

$\text{D}Q = mc\text{D}T$

$P_C = \frac{\text{D}Q}{\text{D}t} = \frac{kA}{L}\text{D}T$

$P_R = \frac{\text{D}Q}{\text{D}T} = esA\text{D}T^4$

$\text{D}U = \text{D}Q - \text{D}W$

Rotational Motion

$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$\omega_f = \omega_i + \alpha t$

$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

$\Delta s = r\Delta\theta : v = r\omega : a_t = r\alpha$

$a_r = r\omega^2$

Sound

$v = fl = (331 + 0.6T)\,\frac{m}{s}$

$b = 10\log\frac{I}{I_0}; \quad I_o = 1 ´\ 10^{-12}\,\frac{W}{m^2}$

$f_n = nf_1 = n\frac{v}{2L}; \quad f_n = nf_1 = n\frac{v}{4L}$

Fluids

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

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

$P_d = P_0 + \rho gd$

$F_B = \rho gV$

$A_1v_1 = A_2v_2$

$\rho_1A_1v_1 = \rho_2A_2v_2$

$P_1 + \frac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \frac{1}{2}\rho v^2{}_2 + \rho gh_2$

Simple Harmonic Motion/Waves

$w = 2pf = \frac{2p}{T}$

$T_S = 2p\sqrt{\frac{m}{k}}$

$T_P = 2p\sqrt{\frac{l}{g}}$

$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$

$x(t) = A\sin\left(\frac{2pt}{T}\right)$

$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\frac{2pt}{T}\right)$

$a(t) = -A\frac{k}{m}\sin\left(\frac{2pt}{T}\right)$

$v = fl = \sqrt{\frac{F_T}{m}}$

$f_n = nf_1 = n\frac{v}{2L}$

$I = 2p^2f^2rvA^2$