Name____

Physics 110 Quiz #6, November 6, 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.

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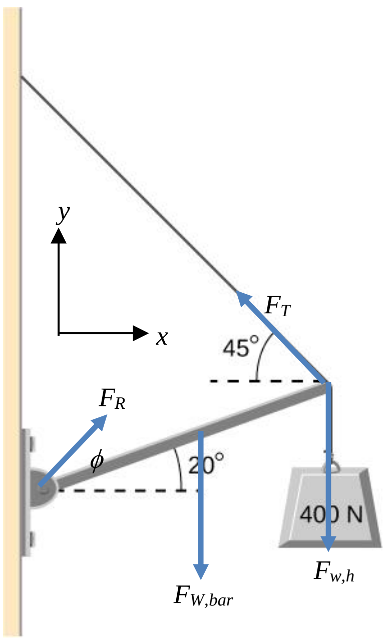
A very light cable holds up a uniform bar ($W_{bar} = 700N$) to which a weight of $400N$ is attached to the far right end of the bar of length $l = 8m$.



1. Using the coordinate system shown, what are the two expressions for the sum of the forces in the horizontal and vertical directions?

$$\sum F_x: \; F_R \cos\phi - F_T \cos 45 = m_{sys} a_x = 0$$

$$\sum F_y: F_R \sin\phi - F_{w,bar} - F_{w,h} + F_T \sin 45 = m_{sys} a_x = 0$$

2. Taking the pivot to be at the hinge where the bar attaches to the wall, what is the expression for the sum of the torques about the pivot? Assume clockwise is the positive direction for the torque.

$$\sum \tau: \; +\frac{l}{2} F_{w,bar} \sin 70 + l F_{w,h} \sin 70 - l F_T \sin 65 = I_{sys} \alpha = 0$$

3. What is the magnitude of the tension force in the cable?

From the torques:

$$F_T \sin 65 = \left(\frac{F_{w,bar}}{2} + F_{w,h}\right) \sin 70 \rightarrow F_T = \left(\frac{700N}{2} + 400N\right) \frac{\sin 70}{\sin 65} = 777.6N$$

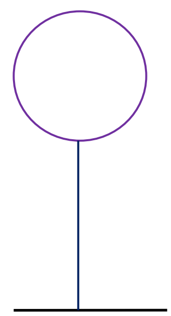
4. What are the magnitude and direction of the reaction force due to the hinge?

From the horizontal forces:
$F_R \cos\phi - F_T \cos 45 = 0 \rightarrow F_{Rx} = F_R \cos\phi = F_T \cos 45 = 777.6N \cos 45 = 549.9N$

From the vertical forces:
$F_R \sin\phi - F_{w,bar} - F_{w,h} + F_T \sin 45 = 0 \rightarrow F_{Ry} = F_R \sin\phi = F_{w,bar} + F_{w,h} - F_T \sin 45$
$F_{Ry} = F_R \sin\phi = 700N + 400N - 777.6N \sin 45 = 550.6N$

The magnitude of the reaction force:
$$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2} = \sqrt{(549.9N)^2 + (550.6N)^2} = 778.2N$$
The direction of the rection force:
$$\tan\phi = \frac{F_{Ry}}{F_{Rx}} \rightarrow \phi = \tan^{-1}\left(\frac{F_{Ry}}{F_{Rx}}\right) = \tan^{-1}\left(\frac{550.6N}{549.9N}\right) = 45^0$$

5. A large balloon is filled with helium gas. To prevent it from floating away the balloon is tied to the ground by a light string. What is the magnitude of the tension in the rope if $\rho_{he} = 0.164\frac{kg}{m^3}$, $\rho_{air} = 1.3\frac{kg}{m^3}$, and the volume of the balloon is $22m^3$. Assume the balloon itself is very light.



$$\sum F_y:\ F_B - F_T - F_{w,He} = m_{system}a_y = 0$$
$$F_T = F_B - F_{w,He} = \rho_{air}gV - \rho_{He}gV$$
$$F_T = (\rho_{air} - \rho_{He})gV = \left(1.3\frac{kg}{m^3} - 0.164\frac{kg}{m^3}\right) \times 9.8\frac{m}{s^2} \times 22m^3$$
$$F_T = 244.9N$$

Physics 110 Formulas

Motion

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

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

Uniform Circular Motion

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

$v = \frac{2\pi r}{T}$

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

Geometry /Algebra

Circles *Triangles* *Spheres*

$C = 2\pi r$ $A = \frac{1}{2}bh$ $A = 4\pi r^2$

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

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: $v = |\vec{v}| = \sqrt{v_x^{\,2} + v_y^{\,2}}$

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

Useful Constants

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

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

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

Linear Momentum/Forces

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

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

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

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

$F_f = \mu F_N$

Work/Energy

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

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

$U_g = mgh$

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

$W_T = Fd\cos\theta = \Delta E_T$

$W_R = \tau\theta = \Delta E_R$

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

$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$

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

Heat

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

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

$L_{new} = L_{old}(1 + \alpha\Delta T)$

$A_{new} = A_{old}(1 + 2\alpha\Delta T)$

$V_{new} = V_{old}(1 + \beta\Delta T) : \beta = 3\alpha$

$PV = Nk_B T$

$\frac{3}{2}k_B T = \frac{1}{2}mv^2$

$\Delta Q = mc\Delta T$

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

$P_R = \frac{\Delta Q}{\Delta T} = e\sigma A\Delta T^4$

$\Delta U = \Delta Q - \Delta W$

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

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

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

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

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

$\omega = 2\pi f = \frac{2\pi}{T}$

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

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

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

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

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

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

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

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

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