Name_______________________________________

Physics 110 Quiz #4, May 1, 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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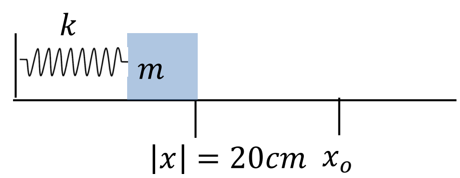
Consider a horizontal spring of stiffness $k = 87\frac{N}{m}$ attached to a $m = 1.5kg$ block at one end and a wall at the other. The spring is compressed by an amount $|x| = 20cm$ from its equilibrium (unstretched) length, x_o.



a. If the mass is released from rest, how much work was done on the mass by the spring as the spring uncompresses and returns to its equilibrium length

Taking $x_f = x_0 = 0m$ the work done by the spring on the mass:

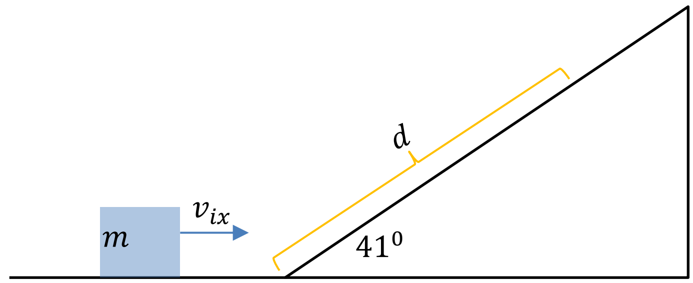
$$W_s = -\Delta U_s = -\left(\frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2\right) = \frac{1}{2}kx_i^2 = \frac{1}{2} \times 87\frac{N}{m}(0.2m)^2 = 1.74J$$

b. Suppose the mass loses contact with the spring when the spring is at its equilibrium length. Using the work-kinetic energy theorem, what is the sped of the mass when it loses contact with the spring?

Taking $v_{ix} = 0\frac{m}{s}$ the speed of the mass:

$$W_s = -\Delta U_s = \Delta K_m = \frac{1}{2}mv_{xf}^2 - \frac{1}{2}mv_{ix}^2 \to v_{fx} = \sqrt{\frac{2W_s}{m}} = \sqrt{\frac{2 \times 1.74J}{1.5kg}} = 1.52\frac{m}{s}$$

c. The mass slides along the horizontal surface and at some point, it encounters a ramp inclined at an angle of 41^0 measured with respect to the horizontal. There is friction between the block and the ramp with coefficient of friction $\mu = 0.5$. What is the total work done on the block by all outside forces bringing the mass to rest?



Taking $v_{fx} = 0\frac{m}{s}$ the total work done by the work-kinetic energy theorem:

$$W_{net,m} = \Delta K_m = \frac{1}{2}mv_{xf}^2 - \frac{1}{2}mv_{ix}^2 = -\frac{1}{2}mv_{ix}^2 = -\frac{1}{2} \times 1.5kg\left(1.52\frac{m}{s}\right)^2 = -1.74J$$

d. How far along the ramp, d, does the block slide before coming to rest?

$$W_{net,m} = W_{F_N} + W_{F_{Wy}} + W_{F_{Wx}} + W_{F_{fr}}$$
$$W_{net,m} = F_N d\cos 90 + F_{Wy} d\cos 90 + F_{Wx} d\cos 180 + F_{fr} d\cos 180$$
$$W_{net,m} = 0 + 0 - (\mathrm{mg}\sin\theta)d - (\mu mg\cos\theta)d = -1.5kg \times 9.8\frac{m}{s^2}(\sin 41 + 0.5\cos 41)d$$
$$W_{net,m} = -1.74J = -15.2d \rightarrow d = 0.11m$$

e. Suppose that after stopping momentarily on the ramp, the block slides back down the ramp again. Which of the following would give the net work done by friction on the block as it slid distance d up along the ramp and distance d back down along the ramp?

1. $W_{fr} = 0J$.
2. $W_{fr} = \mu mg\sin\theta$
3. $W_{fr} = -\mu mgd\sin\theta$
4. $W_{fr} = 2\mu mgd\cos\theta$
5. $W_{fr} = -2\mu mgd\cos\theta$

Physics 110 Formulas

Motion

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

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

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

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

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

Geometry /Algebra

Circles $\quad$ *Triangles* $\quad$ *Spheres*

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

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

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

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

Useful Constants

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

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

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

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

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

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

$U_g = mgh$

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

$W_T = FdCos\theta = \Delta E_T$

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

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

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

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

Heat

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

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

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

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

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

$PV = Nk_B T$

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

$\Delta Q = mc\Delta T$

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

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

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

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

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

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

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

Fluids

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

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

$P_d = P_0 + \rho gd$

$F_B = \rho gV$

$A_1 v_1 = A_2 v_2$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

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

Simple Harmonic Motion/Waves

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

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

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

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

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

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

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

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

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

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