Name____

Physics 110 Quiz #2, September 25, 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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1. A ball of mass $1kg$ is launched at an angle of 42^0above the horizontal with an initial speed of $42\frac{m}{s}$. The ball is initially located a horizontal distance $\Delta x = 100m$ from the base of a cliff that is high $\Delta y = 50m$. What is the time of flight of the projectile from when it is launched until it strikes the cliff?

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2 \rightarrow x_f = v_{ix}t = (v_i \cos\theta)t \rightarrow t = \frac{x_f}{v_i \cos\theta} = \frac{100m}{42\frac{m}{s}\cos 42} = 3.2s$$

2. With respect to the ground, at what height will the ball strike the cliff?

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 = v_{iy}t - \tfrac{1}{2}gt^2 = (v_i \sin\theta)t - \tfrac{1}{2}gt^2$$
$$y_f = \left(42\tfrac{m}{s}\sin 42 \times 3.2s\right) - \tfrac{1}{2}\left(9.8\tfrac{m}{s^2}\right)(3.2s)^2 = 39.8m$$

3. Will the ball strike the cliff when it is rising or falling? Provide a calculation to justify your answer. Simply saying rising or falling will earn no credit.

$$v_{fy} = v_{iy} + a_y t = v_i \sin\theta - gt = 42\frac{m}{s}\sin 42 - 9.8\frac{m}{s^2} \times 3.2s = -3.26\frac{m}{s}$$

Since the y-component of the final velocity is negative the ball strikes the cliff when it is falling.

4. What is the impact speed of the ball with the side of the cliff?

$$v_{fy} = -3.26\frac{m}{s}$$
$$v_{fx} = v_{ix} + a_x t = v_{ix} = v_i \cos\theta = 42\frac{m}{s}\cos 42 = 31.2\frac{m}{s}$$
$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{\left(31.2\frac{m}{s}\right)^2 + \left(-3.26\frac{m}{s}\right)^2} = 31.4\frac{m}{s}$$

5. Assuming that the ball is always launched at angle of 42^0above the horizontal with an initial speed of $42\frac{m}{s}$ and that you want the ball to land on the top of the cliff with only a horizontal component to its velocity, which of the following could make that happen?
   a. Moving the launcher closer to the base of the cliff.
   b. Moving the launcher farther from the base of the cliff.
   c. Keep the launcher where it is since at this spot the ball will land with its velocity horizontal.
   d. There is not change you can make so that the ball will land on the cliff with its velocity horizontal. To see this calculate y_{max} and see that it is never over the height of the cliff.

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

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 — $C = 2\pi r$, $A = \pi r^2$

Triangles — $A = \frac{1}{2}bh$

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

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

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

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

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

Linear Momentum/Forces

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

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

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

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

$F_f = \mu F_N$

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

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

$\omega_f = \omega_i + \alpha t$

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

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

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

$a_r = r\omega^2$

Fluids

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

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

$P_d = P_0 + \rho g d$

$F_B = \rho g V$

$A_1 v_1 = A_2 v_2$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$P_1 + \frac{1}{2}\rho v^2{}_1 + \rho g h_1 = P_2 + \frac{1}{2}\rho v^2{}_2 + \rho g h_2$

Simple Harmonic Motion/Waves

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

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

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

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

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

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

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

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

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

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

Sound

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

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

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