Name____

Physics 110 Quiz #2, April 12, 2013

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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Suppose a ball is held in place at a height $15m$ above the ground. The "holding" mechanism is connected to a projectile launcher on the ground located a horizontal distance of $30m$ away from where the ball is suspended. At some point, a projectile is launched from the launcher in the direction of the suspended ball, at a speed of $25\frac{m}{s}$ at an angle 27^o with respect to the horizontal. At the very same time that the projectile is launched the ball is released from rest by the "holding" mechanism and falls vertically to the ground. Take the origin of the coordinate system for this problem to be at the location of the projectile launcher.

1. Will the launched projectile strike the falling ball? If so, what will the vertical coordinate of the collision?

   If the ball and the projectile collide then they have to be at the same vertical position and the same horizontal position at a given time. For the vertical motion we have $y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 = h - \frac{1}{2}gt^2$ for the ball while for the projectile $y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 = v_i \sin\theta - \frac{1}{2}gt^2$. Equating these two expressions we find that there is a collision at a time given by

   $y_f = h - \frac{1}{2}gt^2 = v_i \sin\theta - \frac{1}{2}gt^2 \rightarrow t = \dfrac{h}{v_i \sin\theta} = \dfrac{15m}{25\frac{m}{s}\sin 27} = 1.32s$. At this time, the ball and the projectile have the same vertical coordinate given from $y_f = h - \frac{1}{2}gt^2 = 15m - \frac{1}{2}\left(9.8\frac{m}{s^2}\right)(1.32s)^2 = 6.46m$. As a check, the horizontal coordinate of the projectile at this time is $x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 = (v_i \cos\theta)t = \left(25\frac{m}{s}\cos 27\right)(1.32s) = 29.5m$, which is fine due to the rounding of the angle in the problem.

2. Supposing that a collision does occur, at what time after the ball is dropped does the launched projectile collide with the falling ball?

   See the solution above for the time.

3. Suppose that you're an astronaut and you have the ability to bring this experiment to the moon. On Earth, you know that the launched projectile will hit the falling ball as long as the launcher is aimed directly at the suspended ball. (Hint: This should be consistent with your answer to the question in part 1…) On the Moon however, the force of gravity is only one-sixth as strong as it is on Earth. How should you aim the launcher to hit the ball on the Moon?

   a. You should aim the launcher directly at the suspended ball.
   b. You should aim the launcher above the suspended ball.
   c. You should aim the launcher below the suspended ball.
   d. There is not enough information given in order to solve this problem

Useful formulas:

Motion in the r = x, y or z-directions

$r_f = r_0 + v_{0r}t + \frac{1}{2}a_r t^2$

$v_{fr} = v_{0r} + a_r t$

$v_{fr}^2 = v_{0r}^2 + 2a_r \Delta r$

Uniform Circular Motion

$a_r = \frac{v^2}{r}$

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

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

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

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

$$magnitude\ of\ a\ vector = \sqrt{v_x^2 + v_y^2}$$

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

Useful Constants

$g = 9.8\ m/s^2$ $\quad G = 6.67\times10^{-11}\ Nm^2/kg^2$

$N_A = 6.02\times10^{23}\ atoms/mole$ $\quad k_B = 1.38\times10^{-23}\ J/K$

$\sigma = 5.67\times10^{-8}\ W/m^2K^4$ $\quad v_{sound} = 343\ m/s$

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

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

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

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

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

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

$PV = Nk_BT$

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

$\Delta Q = mc\Delta T$

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

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

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

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

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

$\beta = 10\log\frac{I}{I_0};\quad I_o = 1\times10^{-12}\ \frac{W}{m^2}$

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

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

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

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

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

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

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

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

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

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

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

$I = 2\pi^2f^2\rho vA^2$