Name____
Physics 110 Quiz #3, April 15, 2022
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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As spring is springing and the grass is greening, sports are taking to the field. One of the sports that many people of all ages look forward to is the opening of golf courses. Suppose that you go golfing on a windless day and when you hit the ball it leaves the club head at a speed of $67\frac{m}{s}$ $(\sim 150mph)$at an angle 40^0 with respect to the horizontal. In the problems below assume a standard coordinate system with up and to the right (the directions the ball is hit) as the positive y- and x-directions respectively.

1. What is the time-of-flight of the golf ball through the air?

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 \rightarrow 0 = (v_i \sin\theta)t - \tfrac{1}{2}gt^2 = \left(v_i \sin\theta - \tfrac{1}{2}gt\right)t$$

$t = 0$ when the ball was struck.

$$0 = v_i \sin\theta - \tfrac{1}{2}gt \rightarrow t_{tof} = \frac{2v_i \sin\theta}{g} = \frac{2 \times 67\frac{m}{s} \times \sin 40}{9.8\frac{m}{s^2}} = 8.8s$$

2. How far from where the golf ball was hit by the club does the golf ball land?

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2 = v_{ix}t = (v_i \cos\theta)t_{tof} = 67\frac{m}{s} \times 8.8s \times \cos 40 = 451m$$

3. What was the maximum height above the ground reached by the golf ball?

$$v_{fy} = v_{iy} + a_y t \rightarrow 0 = v_i \sin\theta - gt \rightarrow t_{rise} = \frac{v_i \sin\theta}{g} = \frac{67\frac{m}{s}\sin 40}{9.8\frac{m}{s^2}} = 4.4s$$

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 = (v_i \sin\theta)t_{rise} - \tfrac{1}{2}g t_{rise}^2$$

$$y_{max} = 67\frac{m}{s} \times 4.4s \times \sin 40 - \frac{1}{2} \times 9.8\frac{m}{s^2}(4.4s)^2 = 94.6m$$

4. What was the impact velocity of the golf ball with the ground?

$$v_{fx} = v_{ix} + a_x t \rightarrow v_{fx} = v_{ix} = v_i \cos\theta = 67\frac{m}{s}\cos 40 = 51.3\frac{m}{s}$$

$$v_{fy} = v_{iy} + a_y t = v_i \sin\theta - g t_{tof} = 67\frac{m}{s}\sin 40 - 9.8\frac{m}{s^2} \times 8.8s = -43.2\frac{m}{s}$$

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{\left(51.3\frac{m}{s}\right)^2 + \left(-43.2\frac{m}{s}\right)^2} = 67\frac{m}{s}$$

$$\tan\phi = \frac{v_{fy}}{v_{fx}} \rightarrow \phi = \tan^{-1}\left(\frac{v_{fy}}{v_{fx}}\right) = \tan^{-1}\left(\frac{-43.2\frac{m}{s}}{51.3\frac{m}{s}}\right) = -40^0$$ or 40^0 below the positive x-axis.

5. Suppose that while you're playing the wind picks up such that the wind creates a constant acceleration of $2.7\frac{m}{s^2}$ in the negative x-direction. Supposing that the golf ball leaves the club with the same initial velocity, how far away does the golf ball land?

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 \rightarrow 0 = (v_i \sin\theta)t - \tfrac{1}{2}gt^2 = \left(v_i \sin\theta - \tfrac{1}{2}gt\right)t$$

$t = 0$ when the ball was struck.

$$0 = v_i \sin\theta - \tfrac{1}{2}gt \rightarrow t_{tof} = \frac{2v_i \sin\theta}{g} = \frac{2 \times 67\frac{m}{s} \times \sin 40}{9.8\frac{m}{s^2}} = 8.8s$$

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2 = (v_i \cos\theta)t_{tof} - \tfrac{1}{2}a t_{tof}^2$$

$$x_f = 67\frac{m}{s} \times 8.8s \times \cos 40 - \frac{1}{2} \times 2.7\frac{m}{s^2}(8.8s)^2 = 347m$$

Physics 110 Formula sheet

Vectors

$v = \sqrt{v_x^2 + v_y^2}$

$\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

Motion Definitions

Displacement: $\Delta x = x_f - x_i$

Average velocity: $v_{avg} = \frac{\Delta x}{\Delta t}$

Average acceleration: $a_{avg} = \frac{\Delta v}{\Delta t}$

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

Rotational Motion Definitions

Angular displacement: $\Delta s = R\Delta\theta$

Angular velocity: $\omega = \frac{\Delta\theta}{\Delta t} \rightarrow v = R\omega$

Angular acceleration: $\alpha = \frac{\Delta\omega}{\Delta t} \rightarrow \begin{cases} a_t = r\alpha \\ a_c = r\omega^2 \end{cases}$

Rotational Equations of Motion

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

$\omega_f = \omega_i + \alpha t$

$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$

Momentum & Force

$\vec{p} = m\vec{v} \rightarrow p_x = mv_x;\ p_y = mv_y$

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

$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a} \rightarrow F_x = ma_x; F_y = ma_y$

$F_{fr} = \mu F_N$

$F_w = mg$

$F_s = -kx$

$F_G = G\frac{M_1 M_2}{r^2}$

$F_c = ma_c = m\frac{v^2}{R}$

Work & Energy

$\begin{cases} W_T = \int \vec{F} \cdot d\vec{r} = Fdr\cos\theta = \Delta K_T \\ W_R = \int \vec{\tau} \cdot d\vec{\theta} = \tau d\theta = \Delta K_R \end{cases}$

$W_{net} = W_T + W_R = \Delta K_T + \Delta K_R = -\Delta U$

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

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

$U_g = mgy$

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

$\Delta E = \Delta E_R + \Delta E_T$

$\Delta E = \Delta K_R + \Delta K_T + \Delta U_g + \Delta U_s = \begin{cases} 0 \\ W_{fr} \end{cases}$

Rotational Momentum & Force

$\vec{\tau} = \vec{r} \times \vec{F};\ \tau = r_\perp F = rF_\perp = rF\sin\theta$

$\tau = \frac{\Delta L}{\Delta t} = I\alpha$

$L = I\omega$

$\Delta\vec{L} = \vec{\tau}\Delta t \rightarrow \vec{L}_f = \vec{L}_i + \vec{\tau}\Delta t$

Fluids

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

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

$P_y = P_{air} + \rho g y$

$F_B = \rho g V$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$; compressible

$A_1 v_1 = A_2 v_2$; incompressible

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

Simple Harmonic Motion

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

$$T_s = 2\pi\sqrt{\frac{m}{k}}; \quad \omega = \sqrt{\frac{k}{m}}$$

$$T_p = 2\pi\sqrt{\frac{l}{g}}; \quad \omega = \sqrt{\frac{g}{l}}$$

Geometry/Algebra

Circles: $A = \pi r^2$ $\quad C = 2\pi r = \pi D$

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

Triangles: $A = \frac{1}{2}bh$

Quadratics: $ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Common Metric Prefixes

$nano = 1 \times 10^{-9}$

$micro = 1 \times 10^{-6}$

$milli = 1 \times 10^{-3}$

$centi = 1 \times 10^{-2}$

$kilo = 1 \times 10^{3}$

$mega = 1 \times 10^{6}$

Sound

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

$\beta = 10 \log \frac{I}{I_o}$

$f_n = n f_1 = n\frac{v}{2L}; n = 1,2,3,\ldots$ open pipes

$f_n = n f_1 = n\frac{v}{4L}; n = 1,3,5,\ldots$ closed pipes

Waves

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

$f_n = n f_1 = n\frac{v}{2L}; \; n = 1,2,3,\ldots$

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

Equations of Motion for SHM

$$x(t) = \begin{cases} x_{max}\sin\left(\frac{2\pi}{T}t\right) \\ x_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

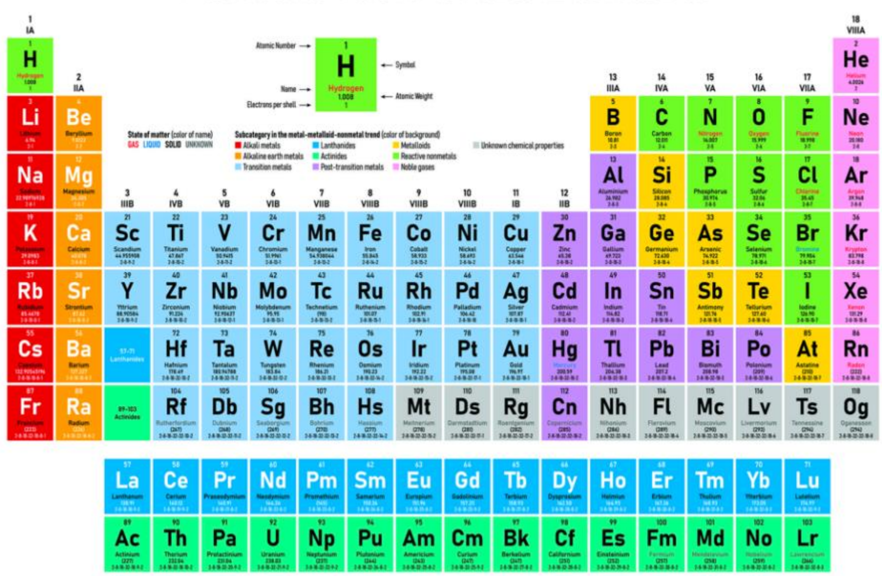
$$v(t) = \begin{cases} v_{max}\cos\left(\frac{2\pi}{T}t\right) \\ -v_{max}\sin\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$a(t) = \begin{cases} -a_{max}\sin\left(\frac{2\pi}{T}t\right) \\ -a_{max}\cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$v = \pm v_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$

$$v = \pm \omega x_{max}\sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$

Periodic Table of the Elements



https://www.wuwm.com/post/periodic-table-elements-turns-150#stream/0