Name____
Physics 110 Quiz #2, April 8, 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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A parachutist "walks" out of an airplane that is flying in a horizontal straight line $2500m$ above the ground. Suppose that the parachutist free-falls from rest a distance of $50m$ and that air resistance on the person is negligible. In the questions below, assume that the positive y-direction points up from the ground.

1. How long does it take the parachutist to fall through $50m$?

$$y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \rightarrow t = \sqrt{\frac{2y_f}{g}} = \sqrt{\frac{2 \times 50m}{9.8\frac{m}{s^2}}} = 3.2s$$

2. What is the speed of the parachutist after they have fallen through $50m$?

$$v_{fy} = v_{iy} + a_y t = -gt = -9.8\frac{m}{s^2} \times 3.2s = -31.3\frac{m}{s}$$

The speed $|v_{fy}| = \left|-31.3\frac{m}{s}\right| = 31.3\frac{m}{s}$

3. After the parachutist has fallen $50m$, they open their parachute and fall the rest of the way to the ground with a constant acceleration. If the parachutist has a speed of $9\frac{m}{s}$ just before touching down on the ground, what was the magnitude and direction of constant acceleration?

$$v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y \rightarrow a_y = \frac{v_{fy}^2 - v_{iy}^2}{2\Delta y} = \frac{\left(-9\frac{m}{s}\right)^2 - \left(-31.3\frac{m}{s}\right)^2}{2(0-2450m)} = +0.18\frac{m}{s^2}$$

4. How long did it take the parachutist to land on the ground from the time they left the airplane?

$$t_{total} = t_{fall} + t_{chute}$$
$$v_{fy} = v_{iy} + a_y t_{chute} \rightarrow t_{chute} = \frac{v_{fy} - v_{iy}}{a_y} = \frac{-9\frac{m}{s} - \left(-31.3\frac{m}{s}\right)}{0.18\frac{m}{s^2}} = 123.9s$$
$$t_{total} = t_{fall} + t_{chute} = 3.2s + 123.9s = 127.1s$$

5. In the last 4 questions we assumed that air resistance was negligible. What if it was not? As you fall through the air, the air exerts a force on you opposite your velocity. This air force creates an additional constant acceleration on you opposite to the acceleration due to gravity. If we do not ignore air resistance, what happens to your displacement, velocity, acceleration and time to fall the first $50m$?

Δx does not change.
v decreases and you fall slightly slower since you are not in free fall and the net acceleration is still down but smaller.
a is smaller and is given by $-g + a_{air}$.
t_{fall} is larger since the net acceleration is smaller.

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

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

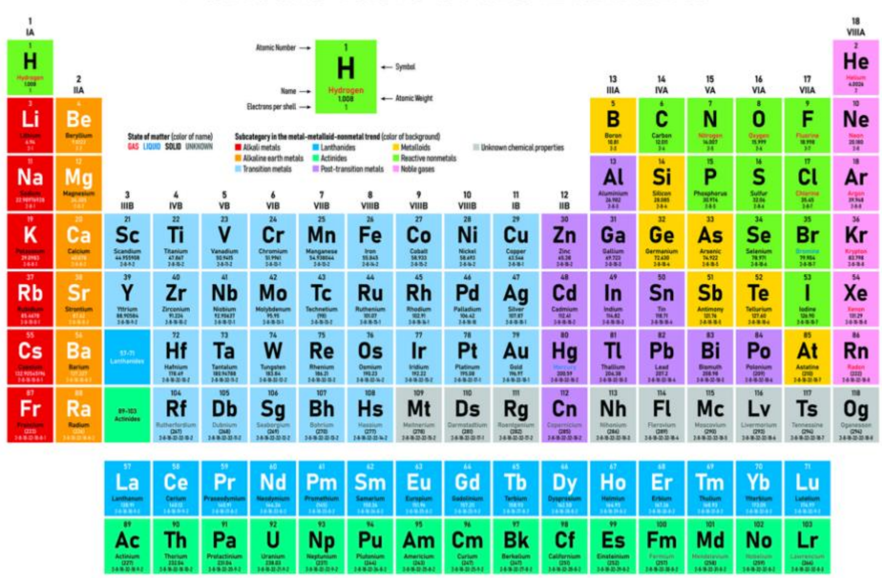
$$v(t) = \begin{cases} v_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \end{cases}$$

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

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

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

Periodic Table of the Elements



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