Name_______________________________________

Physics 110 Quiz #7, May 28, 2021

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 hurricane is a tropical storm formed over the ocean by low atmospheric pressure. As the hurricane approaches land from the open ocean, we get large tides (ocean swells) that come much farther up the beach than they would normally. Consider an area of the beach where there is no hurricane. The winds are calm ($v_A \sim 0\frac{m}{s}$) and the air pressure is $1.01 \times 10^5 \frac{N}{m^2}$, as shown in Figure A. Suppose that in Figure B, a category 5 hurricane has made landfall ($v_B = 69\frac{m}{s}$ ($\sim 155\frac{mi}{hr}$)) and the air pressure now has been reduced to $6.8 \times 10^4 \frac{N}{m^2}$. How high ($h$) will the seawater rise into the air? The density of seawater and are $\rho_{SW} = 1025\frac{kg}{m^3}$ and $\rho_{air} = 1.29\frac{kg}{m^3}$ respectively.

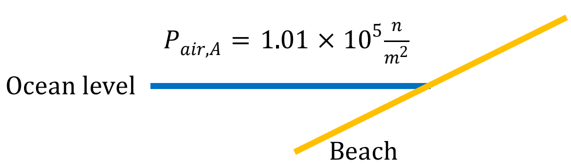


Figure A

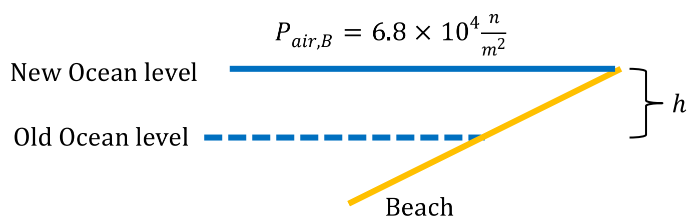


Figure B

$$P_A + \frac{1}{2}\rho_{air} v_{air,A}^2 + \rho_{SW} g h_A = P_B + \frac{1}{2}\rho_{air} v_{air,B}^2 + \rho_{SW} g h_B$$

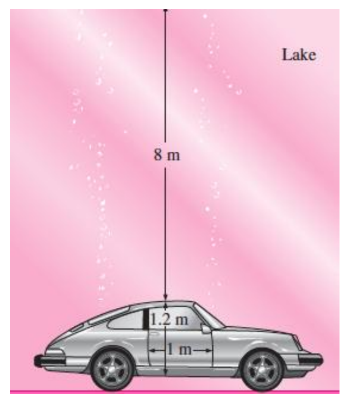
$$h = h_B - h_A = \frac{(P_A - P_B) + \left(\frac{1}{2}\rho_{air} v_{air,A}^2 - \frac{1}{2}\rho_{air} v_{air,B}^2\right)}{\rho_{SW} g}$$

$$h = \frac{\left(1.01 \times 10^5 \frac{N}{m^2} - 6.8 \times 10^4 \frac{N}{m^2}\right) + \left(0 - \frac{1}{2}\left(1.29\frac{kg}{m^3}\right)\left(69\frac{m}{s}\right)^2\right)}{1025\frac{kg}{m^3} \times 9.8\frac{m}{s^2}} = 3m$$

2. A helium filled balloon is tied to the ground. The balloon/basket/riders have a mass of $200kg$. What is the initial magnitude of the upward acceleration of the system when the balloon/basket/riders lift off from the ground? Hint: The density of air and helium are $\rho_{air} = 1.29\frac{kg}{m^3}$ and $\rho_{He} = 0.18\frac{kg}{m^3}$ respectively and model the balloon as a sphere with volume $\frac{4}{3}\pi r^3$.

$$F_B - F_{W,He} - F_{W,bbr} = m_{system}a$$
$$\rho_{air} g V_{air} - \rho_{He} g V_{He} - m_{bbr} g = (m_{bbr} + M_{He})a$$
$$a = \frac{(\rho_{air} - \rho_{he}) g V_{He} - m_{bbr} g}{m_{bbr} + \rho_{He} V_{He}}$$
$$a = \frac{\left(1.29\frac{kg}{m^3} - 0.18\frac{kg}{m^3}\right) \times 9.8\frac{m}{s^2} \times \frac{4}{3}\pi(5m)^3 - 200kg \times 9.8\frac{m}{s^2}}{200kg + \left(0.18\frac{kg}{m^3} \times \frac{4}{3}\pi(5m)^3\right)}$$
$$a = 12.7\frac{m}{s^2}$$

3. An auto accident leaves a car and driver submerged at the bottom of a lake ($\rho_{water} = 1000\frac{kg}{m^3}$). What is the difference in pressure between the inside and outside of the car? Assume that the windows were rolled up and remained rolled up when the car went into the lake. Assume that the pressure from the water acts at the center of the car's door.



$$P_{inside} = P_{air}$$
$$P_{outisde} = P_{air} + \rho_{water} g d$$
$$\Delta P = P_{outside} - P_{inside} = \rho_{water} g d$$
$$\Delta P = 1000\frac{kg}{m^3} \times 9.8\frac{m}{s^2} \times 8.6m = 8.4 \times 10^4 \frac{N}{m^2}$$

4. What is the magnitude and direction of the net force on the car door?

$$\Delta P = \frac{F_{net}}{A_{door}} \rightarrow F_{net} = \Delta P A_{door} = 8.4 \times 10^4 \frac{N}{m^2} \times (1.2m \times 1.0m) = 1.0 \times 10^5 N$$

Since the pressure is greater on the outside than the inside the net force points into the car from the water.

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

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

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

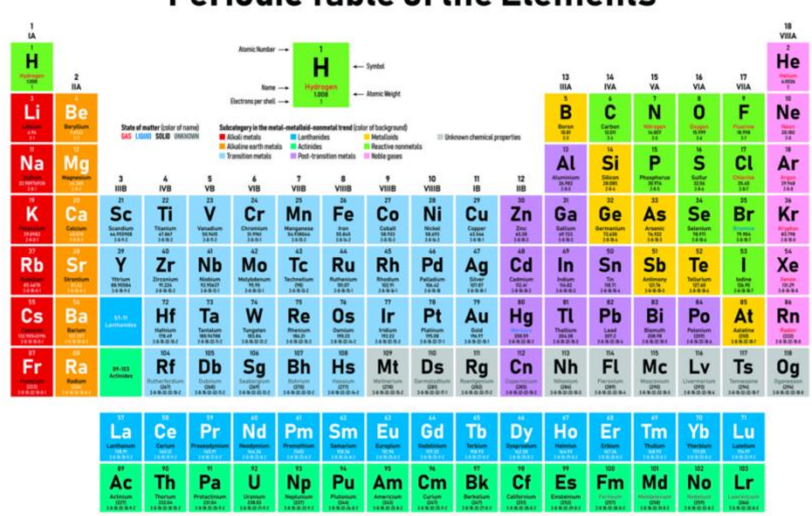
$$v(t) = \begin{cases} v_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \end{cases}$$

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

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

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

Periodic Table of the Elements



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