Name_______________________________________

Physics 110 Quiz #7, November 11, 2016

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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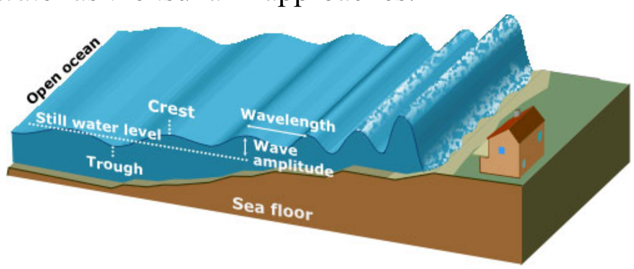
1. A tsunami is a wave pulse consisting of several crests (high points of a wave) and troughs (low points of a wave) that become drastically large as they enter shallow water at the shore. Tsunamis are large amplitude ocean waves and as the wave climbs up the shoreline the height of the approaching wall of water gets very tall on land as shown in the diagram below. Assume that the tsunami has a wavelength of $\lambda = 235 km$ and a velocity of $v = 153 \frac{m}{s}$ that was caused by an earthquake out in the Pacific Ocean. As the tsunami approaches Hawaii, people are drawn to the shoreline to observe the drastic withdrawal of water as the tsunami approaches. Approximately how much time do they have to run to safety before the wave hits the shoreline? (In the absence of knowledge and warning systems people have died during tsunamis, some of them attracted to the shore to see stranded fish and boats.)



From the crest of the wave to the ground represents one half of a wavelength. Thus,

$$\Delta x = \frac{\lambda}{2} \text{ and } v = \frac{\Delta x}{\Delta t} \to \Delta t = \frac{\Delta x}{v} = \frac{\lambda}{2v} = \frac{235 \times 10^2 m}{2 \times 153 \frac{m}{s}} = 768 s \times \frac{1 \min}{60 s} = 12.8 \min .$$

2. A string of length $L = 3m$ and mass $0.5kg$ has a weight of $48kg \times 9.8 \frac{m}{s^2} = 470N$ suspended from one end. The end of string with the attached weight passes over a massive pulley ($m_p = 3kg$) and the other end is oscillated at a frequency $f = 475 Hz$. How many standing loops will be produced if the distance between the point of oscillation and the pulley is $l = 8m$?

$$v = \sqrt{\frac{F_T}{\mu}} = f\lambda = f\left(\frac{2l}{n}\right) \to n = 2lf\sqrt{\frac{\mu}{F_T}} =$$

$$n = 2 \times 8m \times 475 s^{-1} \sqrt{\frac{0.5kg / 3m}{470N}}$$

$$n = 143$$

3. A stone is dropped from the top of a cliff. The splash it makes is heard $2.7s$ later. How high is the cliff?

The time for the stone to fall is $y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \rightarrow h = \frac{1}{2}gt_{down}^2$. When the stone hits the water the sound of the splash travels up the same distance the stone fell and this time is given by $v_{sound} = \frac{h}{t_{up}} \rightarrow t_{up} = \frac{h}{v_{sound}}$. The total time from dropping the stone to hearing the sound is $T = t_{up} + t_{down}$. Thus $t_{down} = T - t_{up} = T - \frac{h}{v_{sound}}$ and $h = \frac{1}{2}gt_{down}^2 = \frac{1}{2}g\left(T - \frac{h}{v_{sound}}\right)^2$. Expanding this and solving for the height we have:

$$h = \frac{1}{2}g\left(T - \frac{h}{v_{sound}}\right)^2 = \frac{1}{2}g\left(T^2 - 2T\frac{h}{v_{sound}} + \frac{h^2}{v_{sound}^2}\right)$$

$$0 = \frac{gT^2}{2} - \left(1 + \frac{gT}{v_{sound}}\right)h + \left(\frac{g}{2v_{sound}^2}\right)h^2 .$$

$$0 = 35.7 - 1.08h + 4.2\times10^{-5}h^2$$

$$h = \begin{cases} 33m \\ 2.6\times10^4 m \end{cases}$$

Since the total time of travel is only $2.7s$, we choose the smaller distance. Thus the height of the cliff is $33m$.

4. Two sounds A and B differ in intensity level by $20dB$. What is the ratio of the intensity of sound A to that of sound B? Hint: $\log M - \log N = \log\frac{M}{N}$.

$$\beta_A - \beta_B = 20dB = 10\log\frac{I_A}{I_{th}} - 10\log\frac{I_B}{I_{th}} = 10\log\frac{I_A}{I_B}$$

$$\frac{I_A}{I_B} = 10^{\frac{\beta_A - \beta_B}{10}} = 10^{\frac{20}{10}} = 10^2 = 100$$

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: $C = 2\pi r$, $A = \pi r^2$

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

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

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

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

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

$\omega_f = \omega_i + \alpha t$

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

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

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

$a_r = r\omega^2$

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

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

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

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

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

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

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

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

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

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

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

Sound

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

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

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