Name____

Physics 110 Quiz #6, November 8, 2019

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.

____

a. A wooden raft is made of 12 logs tied together side-by-side. Each log is $45cm$ in diameter and has a length of $6.5m$. How many people could the raft hold before their feet start to get wet, assuming that the mass of each person standing on the log is $m_p = 60kg$. You may need the following to answer the question: $\rho_{wood} = 600\frac{kg}{m^3}$, $\rho_{water} = 1000\frac{kg}{m^3}$, and $\rho_{air} = 1.3\frac{kg}{m^3}$.

For the people to get their feet wet the whole volume of the raft needs to be at the water's surface. Thus we need to displace a volume of water equal to the volume of the raft. Examining the vertical forces we have

$$\sum F_y : F_B - F_{raft} - F_{people} = ma_y = 0 \rightarrow F_{people} = F_B - F_{raft}$$

$$F_{people} = Nm_p g = \left(\rho_{water} V_{raft}\right)g - \left(\rho_{wood} V_{raft}\right)g$$

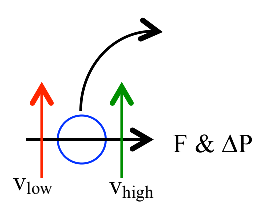
$$N = \frac{\left(\rho_{water} - \rho_{wood}\right)}{m_p} V_{raft} = \frac{\left(1000\frac{kg}{m^3} - 600\frac{kg}{m^3}\right)}{60kg}\left[12 \times \pi \left(\frac{0.45m}{2}\right)^2 \times 6.5m\right]$$

$$N = 82.7 \sim 82$$

So we can put 82 people on the raft and have it be at the water's surface. The 83^{rd} person will cause the raft to be under water.

b. Baseball pitchers need to have good control when they throw a baseball. When a baseball curves to the right (as seen from above), air is flowing

1. faster over the left side than over the right side.
2. faster over the right side than over the left side.
3. faster over the top than underneath.
4. faster underneath than over the top.
5. at the same speed all around the baseball, but the ball curves as a result of the way the wind I blowing on the field.



c. Kayaking is a popular sport on many rivers, lakes and even the ocean. Suppose that you are floating in you kayak and not paddling. The kayak is simply riding on the current in the river. The river has a constant depth of $d = 6m(\sim 18ft)$ but a variable width. At one point in your kayaking adventure the river has a width of $w_1 = 16m(\sim 50ft)$ across and at a later point in your journey the river's width narrows to just across $w_2 = 2m(\sim 6ft)$. At the $2m$ wide point the speed of your kayak (and the river) is $v_2 = 9\frac{m}{s}(\sim 20mph)$ and the portion of your kayak that is under the water has a cross-sectional area of $0.09m^2$. What average force does the river exert on your kayak to push it along with the current?

The equation of continuity relates the flow speeds at the two spots. Then the difference in pressure in the water at the two spots gives over the area of the kayak under water gives the applied force on the kayak from the water.

$$A_1 v_1 = A_2 v_2$$

$$A_{up} v_{up} = A_{down} v_{down} \rightarrow v_{up} = \frac{A_{down}}{A_{up}} v_{down} = \left(\frac{2m \times 6m}{16m \times 6m} \right) \times 9\frac{m}{s} = 1.1\frac{m}{s}$$

$$P_1 - P_2 = \Delta K_T + \Delta U_g = \tfrac{1}{2}\rho v_2^2 - \tfrac{1}{2}\rho v_1^2$$

$$P_{up} - P_{down} = \Delta K_T + \Delta U_g = \tfrac{1}{2}\rho v_{down}^2 - \tfrac{1}{2}\rho v_{up}^2 = \tfrac{1}{2} \times 1000\tfrac{kg}{m^3}\left[\left(9\tfrac{m}{s}\right)^2 - \left(1.1\tfrac{m}{s}\right)^2 \right]$$

$$P_{up} - P_{down} = 39900\tfrac{N}{m^2} = \frac{F}{A}$$

$$F = \left(P_{up} - P_{down}\right) A = 39900\tfrac{N}{m^2} \times 0.09m^2 = 3591N$$

Physics 110 Formulas

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

Uniform Circular Motion

$F_r = ma_r = m\dfrac{v^2}{r}; \quad a_r = \dfrac{v^2}{r}$

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

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

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 : $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

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

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

Useful Constants

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

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

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

Linear Momentum/Forces

$\vec{p} = m\vec{v}$

$\vec{p}_f = \vec{p}_i + \vec{F}\cdot dt$

$\vec{F} = m\vec{a} = \dfrac{d\vec{p}}{dt}$

$\vec{F}_s = -k\vec{x}$

$|\vec{F}_{fr}| = \mu|\vec{F}_N|$

Work/Energy

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

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

$U_g = mgh$

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

$W_T = F\Delta x \text{Cos}\theta = \Delta K_T$

$W_R = \tau\theta = \Delta K_R$

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

$\Delta K_R + \Delta K_T + \Delta U_g + \Delta U_S = \Delta E_{system} = 0$

$\Delta K_R + \Delta K_T + \Delta U_g + \Delta U_S = \Delta E_{system} = W_{fr} = -F_{fr}\Delta x$

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

$\rho = \dfrac{M}{V}$

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

$P_d = P_0 + \rho g d$

$F_B = \rho g V$

$A_1 v_1 = A_2 v_2$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$P_1 - P_2 = \Delta K_T + \Delta U_g = \left(\frac{1}{2}\rho v_2^2 - \frac{1}{2}\rho v_1^2\right) + \left(\rho g y_2 - \rho g y_1\right)$

Simple Harmonic Motion/Waves

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

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

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

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

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

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

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

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

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

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

Sound

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

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

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