Sample Exam 3  Physics 180  
(Note, the test format is different than what you will have but questions are similar)

1. If you have a piece of aluminum which weighs 2 kg, but only appears to weigh 1.65 kg, when submerged in an unknown liquid, find the density of the unknown liquid.

\[ M = 2 \text{kg} = \rho_{\text{Al}} \cdot \text{Vol}_{\text{Al}} \quad \text{Vol}_{\text{Al}} = \frac{2}{2.7 \times 10^3} \]

\[ W - W_{\text{app}} = \mathbf{F} \]

\[ mg - 1.65g = \rho_{\text{fluid}} \cdot \text{Vol}_{\text{disp}} - g \]

\[ 2 - 1.65 = \rho_{\text{fluid}} (0.00074) \quad \rho_{\text{fluid}} = \frac{475}{1000.74} = \frac{475}{\text{m}^3} \]

2. A 10 meter diameter, 10 meter tall tank has a 2 cm. pipe at the very bottom. The tank top is sealed, and the pressure at the top is only .9 atmospheres. If it filled with water,

a) what is the initial volume rate of flow (m³/sec) through the pipe?

\[ \rho g h_1 + \frac{1}{2} \rho v_1^2 + P_i = \rho g h_2 + \frac{1}{2} \rho v_2^2 + P_2 \]

\[ \rho g h_1 + \frac{1}{2} \rho v_1^2 + 9 \text{kPa} = \rho g h_2 + \frac{1}{2} \rho v_2^2 + 9 \text{kPa} \]

\[ V_2 = \sqrt{\frac{1000(9.8)(10) - 1(1 \times 10^5)}{500}} \]

\[ V_2 = 13.3 \text{m}^3/\text{sec} \quad A_2 v_2 = \pi (0.01) V_2 = 0.004 \text{m}^3/\text{sec} \]

b) if the pipe is extended up the side of the tank, what is the maximum height it could be extended and still have some leakage?

look for \( h_2 \) such that \( v_2 = 0 \)

\[ 1000(9.8)(10) - 1(1 \times 10^5) = \rho g h_2 + 0 \]

\[ h_2 = 8.98 \text{ meter} \]

3. A man hangs from a spring which has a 5000 nt./meter spring constant. Over a period of 20 seconds he "oscillates" through 25 complete up and down cycles. What is his mass?

\[ f = \frac{25 \text{cycles}}{2.0 \text{sec}} = 1.25 \text{ Hz} = \frac{1}{2 \pi} \sqrt{\frac{k}{m}} \]

\[ m = \frac{5000}{4\pi^2 (1.25)^2} = 81 \text{ kg} \]
4. A stretched string and an air column which is closed at one end, open at the other are in resonance with each other. The air column is 40 cm. long, filled with air at 0°C, and is vibrating at its fundamental frequency. The string is one meter long and has a total mass of 10 grams. (m/L is just 10 grams per meter) If the string is vibrating in its 3rd harmonic frequency (and this matches the pipes fundamental)

a) what is the fundamental frequency of the vibrating air column in the pipe?

\[ f_1 = 206 \text{ Hz} \]

\[ \lambda = \frac{4}{4} \text{ L} = 4 \text{ cm} \]

\[ \lambda = 4 \text{ L} = 4 \times 4 \text{ cm} \]

\[ \lambda = 1.6 \text{ meter} \]

b) what is the speed of the wave in the string?

\[ V = f_3 \lambda_3 = \frac{2}{3} \text{ L} = 0.67 \text{ meter} \]

\[ V = 206 \times 0.67 = 138 \text{ m/sec} \]

c) what is the tension in the string?

\[ V = 138 = \sqrt{\frac{T}{\mu}} \]

\[ \mu = 10 \times 10^{-3} \text{ meter}^{-1} \]

\[ (138)^2 (10 \times 10^{-3}) = T = 191 \text{ newton} \]

5. A policeman aims his speed gun as a moving car. The "gun" emits a sonar signal instead of radar (the wave travels at 340 m/sec. as it is a sound wave, not a light wave) The source sends out a signal at 500 Hz. The car has a receiver which "hears" the signal and it appears to be 555Hz.

How fast is the car traveling if the police car is stationary?

\[ f = f_0 \left( \frac{v}{v + v_0} \right) \]

\[ \frac{555}{500} = \frac{340 + v_0}{340} \]

\[ v_0 = 37.4 \text{ m/sec} \]

6. A sign is supported by a hinge attachment on a wall, and a wire attached to a point 3/4L from the hinge at a 40 degree angle running back to the wall. The sign weighs 500 newtons, and is its length is "L". Find the tension in the wire and the forces at the hinge.

\[ \sum F_y = 0 \rightarrow T_y \left( \frac{3}{4} L \right) - 500 \cos \left( \frac{L}{2} \right) = 0 \]

\[ T_y = \frac{500}{\frac{3}{4} L} = 333 \text{ N} \]

\[ T = \frac{T_y}{\sin 40^\circ} = 519 \text{ N} \]

\[ T_x = F_x = 519 \cos 40^\circ (\approx F_x = 0) \]

\[ F_y + T_y = 500 \text{ N} \]

\[ F_y = 500 - 333 = 167 \text{ N} \]