Name____

Physics 110 Quiz #6, November 6, 2013

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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1a. Suppose that you have a patient that is to receive an intravenous injection of medication. In order to work properly the pressure of the fluid containing the medication must be $109\frac{kN}{m^2}$ at the injection point and the medication should just barely enter the blood in the vein. If the density of the medication is $1020\frac{kg}{m^3}$ what height above the patient should the medicine bag be suspended? Assume that the pressure in the medication bag is normal air pressure $101\frac{kN}{m^2}$.

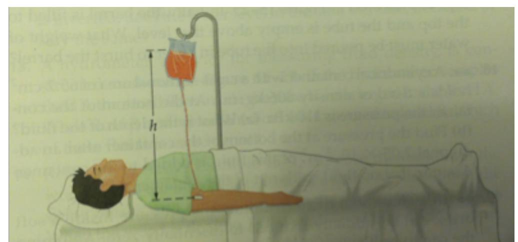

Image from *Physics*, by J. Walker.

$$P_1 - P_2 = P_{air} - P_{arm} = \rho g y_{arm} - \rho g y_{bag} = -\rho g y_{bag}$$

$$\rightarrow y_{bag} = \frac{P_{air} - P_{arm}}{-\rho g} = \frac{1.01\times10^5\,\frac{N}{m^2} - 1.09\times10^5\,\frac{N}{m^2}}{-1020\frac{kg}{m^3}\times 9.8\frac{m}{s^2}} = 0.8m$$

1b. If the density of the fluid were increased, the height that the bag would need to be hung would

a. increase.
b. decrease.
c. remain the same.
d. have to change but in a way that cannot be determined from the given information.

2a. A siphon tube is useful for removing liquid from a tank. Suppose that the siphon tube is inserted a distance d into the tank of fluid of density ρ and that the siphon hose is allowed to hang a distance y below the top of the liquid. What is the expression for the speed of the fluid as it is leaving the tube? Assume that the cross-sectional area of the tube is much smaller than the cross-sectional area of the tank. (Hints: Take location #1 to be at the bottom of the tube that is in the fluid, location #2 to be where the fluid is exiting the tube and the distance h and point A are irrelevant for this problem.)

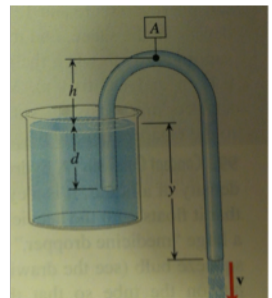

Image from *Physics* by Cutnell & Johnson

$$P_1 - P_2 = \left(\tfrac{1}{2}\rho v_2^2 - \tfrac{1}{2}\rho v_1^2\right) + \left(\rho g y_2 - \rho g y_1\right) \rightarrow \left(P_{air} + \rho g d\right) - P_{air} = \tfrac{1}{2}\rho v_2^2 - \rho g\left(y - d\right)$$

$$0 = \tfrac{1}{2}\rho v_2^2 - \rho g y \rightarrow v_2 = \sqrt{2gy}$$

2b. At what value of the vertical distance y will the siphon stop working? Explain your answer with a calculation and with words.

The siphon stops working when $v_2 = 0$. This occurs when the vertical height $y = 0$ or the exit tube's opening is at the level of the fluid's surface.

Useful formulas:

Motion in the r = x, y or z-directions

$$r_f = r_0 + v_{0r}t + \tfrac{1}{2}a_r t^2$$

$$v_{fr} = v_{0r} + a_r t$$

$$v_{fr}^{\;2} = v_{0r}^{\;2} + 2a_r\Delta r$$

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 — $A = \tfrac{1}{2}bh$

Spheres — $A = 4\pi r^2$, $V = \tfrac{4}{3}\pi r^3$

Quadratic equation: $ax^2 + bx + c = 0,$

whose solutions are given by: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

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

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

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

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

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

$$U_g = mgh$$

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

$$W_T = FdCos\theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = -\Delta E_{diss}$$

Heat

$$T_C = \tfrac{5}{9}\left[T_F - 32\right]$$

$$T_F = \tfrac{9}{5}T_C + 32$$

$$L_{new} = L_{old}\left(1 + \alpha\Delta T\right)$$

$$A_{new} = A_{old}\left(1 + 2\alpha\Delta T\right)$$

$$V_{new} = V_{old}\left(1 + \beta\Delta T\right):\ \beta = 3\alpha$$

$$PV = Nk_BT$$

$$\tfrac{3}{2}k_BT = \tfrac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L}\Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \varepsilon\sigma A\Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

Rotational Motion

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

$$\omega_f = \omega_i + \alpha t$$

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

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$L_f = L_i + \tau\Delta t$$

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

$$a_r = r\omega^2$$

Sound

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

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

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

Fluids

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

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

$$P_d = P_0 + \rho gd$$

$$F_B = \rho gV$$

$$A_1v_1 = A_2v_2$$

$$\rho_1A_1v_1 = \rho_2A_2v_2$$

$$P_1 + \tfrac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \tfrac{1}{2}\rho v^2{}_2 + \rho gh_2$$

Simple Harmonic Motion/Waves

$$\omega = \sqrt{\frac{k}{m}} = 2\pi f = \frac{2\pi}{T}$$

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

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

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

$$x(t) = x_{\max}\sin(\omega t)\ \ or\ \ x_{\max}\cos(\omega t)$$

$$v(t) = v_{\max}\cos(\omega t)\ \ or\ \ -v_{\max}\sin(\omega t)$$

$$a(t) = -a_{\max}\sin(\omega t)\ \ or\ \ -a_{\max}\cos(\omega t)$$

$$v_{\max} = \omega x_{\max};\quad a_{\max} = \omega^2 x_{\max}$$

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

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

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