

Problem 1. A nurse applies a force of 4.4 Newtons to the piston of a syringe. The piston has a cross-sectional area of 0.5 square centimeters.

(a)(5) What is the pressure applied to the fluid by the piston?

(b)(15) The syringe is attached to a needle with an inner radius of 0.3 millimeters and a length of 3 centimeters, and is injected into a vein which has a gauge pressure of 16 mm-Hg. What is the flow rate (cm^3/sec)? The viscosity of the fluid is 0.002 Pa-sec.

(c)(5) The needle used in a flu shot hurts less than the needle used in a blood drive because its radius is half as big. If it takes 10 minutes at a blood drive to remove a pint of blood, how long would it take using a flu shot needle (all else being equal)?

$$a) \quad P = \frac{F}{A} = \frac{4.4 \text{ N}}{.5 \times 10^{-4} \text{ m}^2} = \boxed{88000 \text{ Pa}}$$

$$b) \quad \frac{\Delta V}{\Delta t} = \frac{\pi \Delta P R^4}{8 \eta L} \quad P_{\text{vein}} = 16 \text{ mm-Hg} \cdot \frac{10^5 \text{ Pa}}{760 \text{ mm-Hg}} = 2100 \text{ Pa}$$

$$\frac{\Delta V}{\Delta t} = \frac{\pi (88000 - 2100) (.3 \times 10^{-3})^4}{8 (.002) (.03)} = 4.55 \times 10^{-6} \text{ m}^3/\text{se} = \boxed{4.55 \text{ cm}^3/\text{sec}}$$

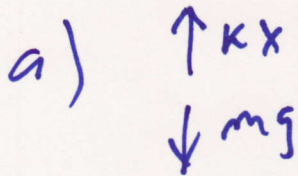
$$c) \quad \left(\frac{\Delta V}{\Delta t}\right)_{\text{flu}} = \left(\frac{\Delta V}{\Delta t}\right)_{\text{blood drive}} \left(\frac{1}{2}\right)^4 \Rightarrow \boxed{t = 160 \text{ minutes}}$$

Problem 3. Two unrelated questions.

1. An 80 kg person has a density of 1100 kg/m^3 . She is hung from a spring which stretches 40 cm.

(a)(5) What is the force constant of the spring? (entirely from earlier chapters)

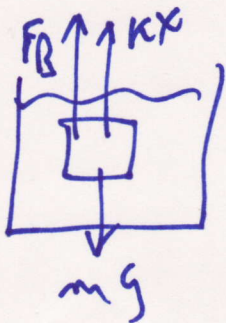
(b)(10) Still attached to the spring, she is submerged in water. Now how much does the spring stretch?



$$kx = mg$$

$$k = \frac{mg}{x} = \frac{(80)(10)}{(0.4)} = \boxed{2000 \text{ N/m}}$$

b)



$$F_{\text{down}} = mg = (80)(10) = 800 \text{ N}$$

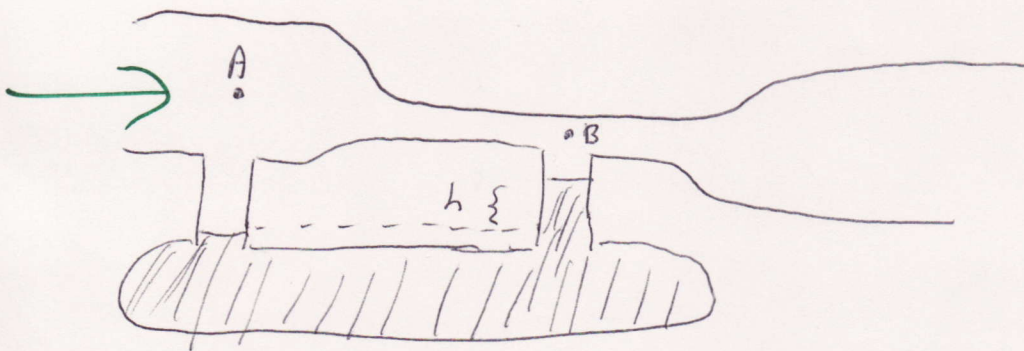
$$F_{\text{up}} = kx + \rho_{\text{fluid}} g V$$

$$= 2000x + (1000)(10) \left(\frac{80}{1100} \right)$$

$$F_{\text{up}} = F_{\text{down}}$$

\Rightarrow

$$\boxed{x = .037 \text{ meters}}$$



Problem 2. In the apparatus shown above, air streams smoothly from left to right. The fluid is water. At point A, the air is moving at 5 meters per second, and the cylindrical tube has a radius of 4 cm. At point B, the tube narrows to a radius of 2 cm. (Note: since the air streams smoothly, it acts like an incompressible fluid with density $\rho = 1.3 \text{ kg/m}^3$.)

- (a)(7) What is the speed of the air at point B?
 (b)(8) What is the pressure difference between point A and point B?
 (c)(10) What is the height difference, h , between the two columns?

$$a) A_A v_A = A_B v_B \Rightarrow v_B = \frac{A_A}{A_B} v_A = 4 v_A = \boxed{20 \text{ m/sec}}$$

$$b) \text{Bernoulli: } \Delta P = \frac{1}{2} \rho (v_A^2 - v_B^2)$$

$$= \frac{1}{2} (1.3) (5^2 - 20^2) = \boxed{-243 \text{ Pa}}$$

$$c) \Delta P = \rho g h \quad h = \frac{|\Delta P|}{\rho g} = \frac{243}{(10)(1000)} = \boxed{2.4 \text{ cm}}$$

Next
4 pages

- FROM PHYSICS 108 - Spring 2008

1. A mole of an ideal diatomic gas initially at 10 °C undergoes an expansion at a constant pressure of 1 atmosphere to four times its original volume.

- (a)(5) What is the new temperature of the gas?
- (b)(10) What is the work done on the gas?
- (c)(10) How much heat flows into the gas?

} from Chapter 15 - not an
107 exam 3

$$\frac{T_f}{T_i} = \frac{V_f}{V_i} = 4$$

$$T_f = 4(283 \text{ K}) = 1132 \text{ K}$$

2. Two unrelated problems.

(a)(10) A pair of eyeglass frames are made of a plastic with a coefficient of linear expansion of $130 \times 10^{-6} / ^\circ\text{C}$. At 20.0°C , the frames have circular lens holes 2.20 cm in radius. To what temperature must the frames be heated in order to insert lenses 2.21 cm in radius?

(b)(15) A reversible engine operates between 80°C and 350°C . It takes in 21000 Joules of energy from the hot reservoir. The duration of each cycle of the engine is 2 seconds . What is the efficiency of the engine? How much energy does it expel to the low temperature reservoir? What is its mechanical power output?

} from chapter 15

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta T = \frac{\Delta L}{\alpha L_0} = \frac{.01}{(130 \times 10^{-6})(2.20)} = 34.8^\circ\text{C}$$

(not on exam 3-10?)

$$T = 54.8^\circ\text{C}$$

3. 50 grams of ice at 0°C is combined with 10 grams of steam at 100°C . The ice melts and the steam condenses. What is the final temperature of the water?

$$Q_{\text{lost by steam}} = Q_{\text{gained by ice}}$$

$$Q_{\text{ice}} = m_{\text{ice}} L_{\text{fusion}} + m_{\text{ice}} C_{\text{H}_2\text{O}} (T_f - 0)$$

$$Q_{\text{steam}} = m_{\text{steam}} L_{\text{vap.}} + m_{\text{steam}} C_{\text{H}_2\text{O}} (100 - T_f)$$

$$(50)(80) + (50)(1) T_f = (10)(540) + (10)(1)(100 - T_f)$$

$$T_f = 40^{\circ}\text{C}$$

4. A large pizza has a diameter of 70 cm, a mass of 1 kg, an initial temperature of 100 °C and a specific heat which is 0.2 times that of water. Its emissivity is 0.8. It's New York style, so you can ignore the width of the pizza.

(a)(15) It is magically transported into outer space, where it just sits there and radiates. What is the rate of energy loss?

(b)(10) How long does it take to cool off to 20 °C?

$$\begin{aligned}
 a) \quad \frac{Q}{t} &= e \sigma A T^4 && 2 \text{ (surfaces)} \\
 &= (0.8) (5.67 \times 10^{-8}) (\pi (0.35)^2) (373)^4 \\
 &= \boxed{675 \text{ W}}
 \end{aligned}$$

$$\begin{aligned}
 b) \quad \frac{Q}{t} &= m c \frac{\Delta T}{t} = \frac{(1 \text{ kg}) (0.2 \cdot 4186 \frac{\text{J}}{\text{kg} \cdot \text{K}}) (80)}{t} \\
 t &= \frac{(1) (0.2) (4186) (80)}{675} = \boxed{95 \text{ seconds}}
 \end{aligned}$$