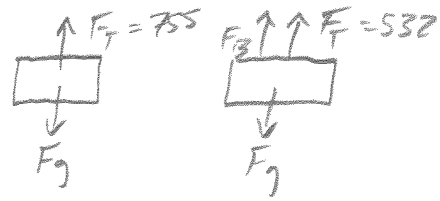
Physics 10154 - Exam #4d

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A block weighs 755 N in air and 532 N when completely immersed in water. What is the volume and density of the block?



$$\rho_b g V_b = 755$$

$$\rho_b g V_b - \rho_w g V_w = 532$$

$$755 - (1000)(9.8) V_w = 532$$

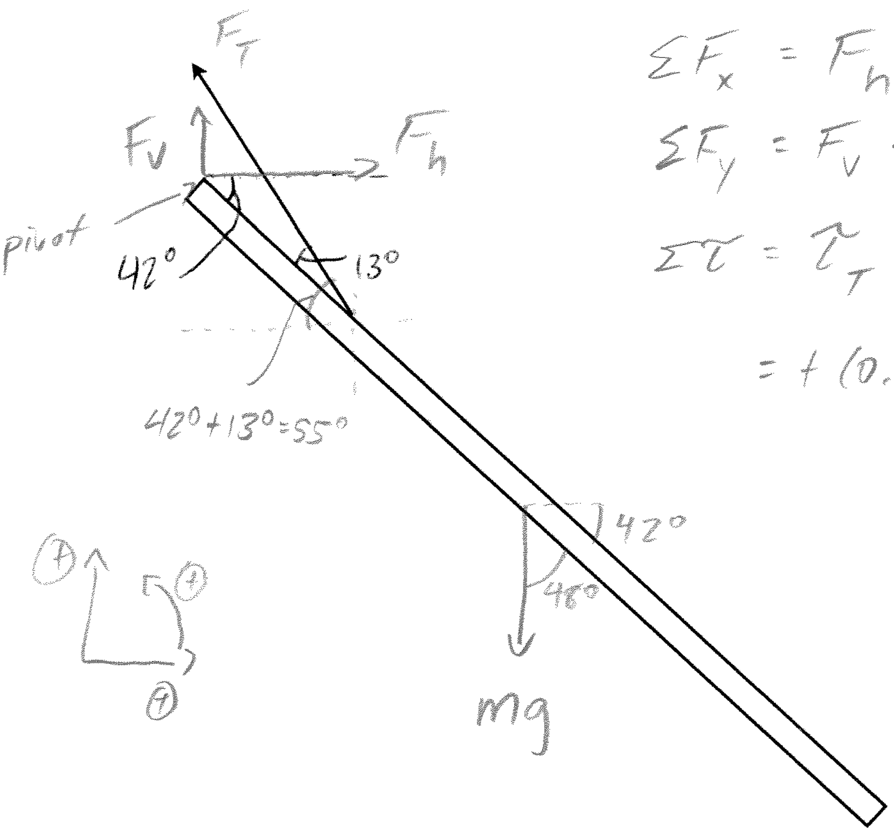
$$V_w = \frac{-223}{-9800} = .0228\ m^3$$

Since object is immersed, $V_w = V_b$

$$V_b = 0.0228\ m^3$$

$$\rho_b = \frac{755}{g V_b} = \frac{755}{(9.8)(.0228)} = 3400\ kg/m^3$$

2. (40 pts) A human arm can be approximated as a uniform thin rod with a length of 76 cm and mass 14 kg. In the figure below, the arm makes an angle of 42° below the horizontal. At the top left end, the arm is attached to the shoulder, and the shoulder exerts a horizontal and vertical reaction force on the arm. Also, the deltoid muscle attaches to the arm at a distance 16 cm from the shoulder, making an angle of 13° above the arm. Find (a) the tension in the deltoid muscle, (b) the horizontal component, and (c) the vertical component of the shoulder's reaction force.



$$\Sigma F_x = F_h - F_T \cos 55° = 0$$

$$\Sigma F_y = F_v + F_T \sin 55 - mg = 0$$

$$\Sigma \tau = \tau_T + \tau_{mg} = 0$$

$$= +(0.16) F_T \sin 167°$$

$$-(0.38)(14)(9.8) \sin 48° = 0$$

$$\Sigma \tau = .036 F_T - 38.74 = 0 \quad \Rightarrow F_T = \frac{38.74}{.036} = 1080 \text{ N}$$

$$\Sigma F_x = F_h - 1080 \cos 55° \quad \Rightarrow F_h = 617 \text{ N}$$

$$\Sigma F_y = F_v + 1080 \sin 55° - (14)(9.8) \quad \Rightarrow F_v = -744 \text{ N}$$

$F_T = 1100$ N

$F_h = 620$ N, $+x$

$F_v = 744$ N, $-y$

3. (30 pts) A vertical pipe is open to the air at both ends. A pump attached to the bottom of the pipe helps water move through the pipe by providing an additional 55000 Pa of pressure. The top of the pipe is 2.7 meters above the bottom of the pipe. The diameter of the bottom part of the (circular cross-section) pipe is 1.8 cm, but the pipe tapers to a diameter of 1.2 cm at the top. How long does it take (in seconds) to fill a 3.0 gallon container from water coming out of the top end of the pipe?

$$P_{bot} + \rho g y_{bot} + \frac{1}{2}\rho v_{bot}^2 = P_{top} + \rho g y_{top} + \frac{1}{2}\rho v_{TOP}^2$$

$$(\cancel{101300} + 55000) + 0 + 500 v_{bot}^2 = \cancel{101300} + (1000)(9.8)(2.7) + 500 v_{TOP}^2$$

$$55000 + 500 v_{bot}^2 = 26460 + 500 v_{TOP}^2$$

Also, $A_{TOP} V_{TOP} = A_{BOT} V_{BOT}$

$$V_{BOT} = \frac{A_{TOP}}{A_{BOT}} V_{TOP}$$

$$= \frac{\pi(.012)^2/4}{\pi(.018)^2/4} V_{TOP}$$

$$V_{BOT} = 0.444\, V_{TOP}$$

$$3\text{ gal} \cdot \frac{3.786\times10^{-3}\text{ m}^3}{\text{gal}} = .01136\text{ m}^3$$

$$55000 + 500(.444 V_{TOP})^2 = 26460 + 500 v_{TOP}^2$$

$$28540 = 401.23 V_{TOP}^2$$

$$\underline{V_{TOP} = 8.43\text{ m/s}}$$

$$A_{TOP} V_{TOP} = \frac{3\text{ gal}}{t} \Rightarrow \left(\frac{\pi(.012)^2}{4}\right)(8.43) = \frac{.01136}{t} \Rightarrow t = 12\text{ s}$$