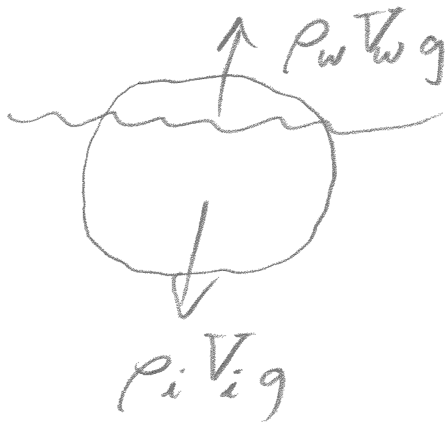
# Physics 10154 - Exam #4b

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) The density of ice is 920 kg/m$^3$. The density of seawater is 1030 kg/m$^3$. When an iceberg is floating on the ocean, what percentage of the total volume of the iceberg is above the waterline? Answer with 3 SF.




$$\Sigma F_y = \rho_w V_w \cancel{g} - \rho_i V_i \cancel{g} = 0$$

$$\rho_w V_w = \rho_i V_i$$

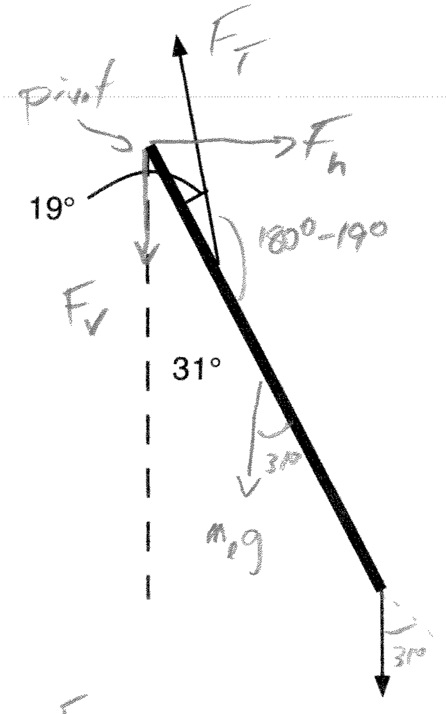
$$\frac{V_w}{V_i} = \frac{\rho_i}{\rho_w} = \frac{920}{1030} = 0.893$$

Ice is 89.3% submerged, so

10.7% above waterline

2. (35 pts) The lower leg can be modeled as a uniform rod with a weight of 30.0 Newtons. Assume the leg makes an angle of 31° from the vertical, and the 14.0 Newton foot exerts a vertically downward force on the end of the leg.

Meanwhile, the quadriceps tendon attaches to the upper end of the leg, exactly one-fifth of the way down the leg from the knee, making an angle of 19° above the leg as shown. Find the tension force in the tendon as well as the horizontal and vertical forces exerted on the leg by the knee.




$$\Sigma F_x = F_h - F_T \cos 78°$$

$$\Sigma F_y = F_T \sin 78° - F_V - 30 - 14 = 0$$

$$\Sigma \tau = \tau_T + \tau_{leg} + \tau_{foot}$$

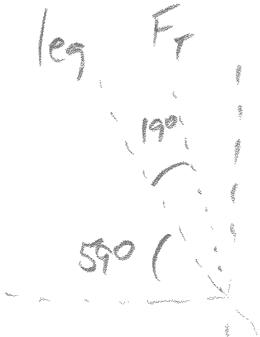
$$\tau_T = +\left(\frac{l}{5}\right) F_T \sin 161° = .065\, l\, F_T$$

$$\tau_{leg} = -\left(\frac{l}{2}\right)(30) \sin 31° = -7.726\, l$$

$$\tau_{foot} = -l(14) \sin 31° = -7.210\, l$$

$$0.065 \cancel{l} F_T - 7.726 \cancel{l} - 7.210 \cancel{l} = 0$$

$$.065 F_T = 14.94$$




$F_T$ is $59° + 19° = 78°$ above horizontal

$$F_T = 230\ N$$

$$F_h = F_T \cos 78° = 48\ N$$

$$F_V = 230 \sin 78° - 44 = 180\ N$$

3. (35 pts) A 3.5-meter tall plumbing line is open to the air at both ends. The bottom end also has a pump attached that provides an additional 75,000 Pa of pressure to the water. If water at the bottom end is initially at rest and water flows out of the top end, how much time does it take to fill a 12 gallon container if the pipe diameter is 1.8 cm?

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

$$P_{bot} = 101300 + 75000 = 176300$$

$$y_{bot} = 0 \quad \text{so } \rho g y_{bot} = 0$$

$$V_{bot} = 0 \quad \text{so } \frac{1}{2}\rho V_{bot}^2 = 0$$

$$P_{top} = 101300$$

$$y_{top} = 3.5m, \text{ so } \rho g y_{top} = 34300$$

$$176300 = 101300 + 34300 + 500 V_{top}^2$$

$$40700 = 500 V_{top}^2$$

$$V_{top} = 9.0 \ m/s$$

$$A_{top} = \frac{\pi d^2}{4} = \frac{\pi(.018)^2}{4} = .000254 \ m^2$$

$$\text{Volume} = 12 \text{ gal} \cdot \frac{3.786 L}{\text{gal}} \cdot \frac{10^{-3} m^3}{L} = .04543 \ m^3$$

$$A_{top} V_{top} = \frac{\text{Volume}}{\text{time}} \qquad \text{time} = \frac{\text{Volume}}{A_t V_t} = \frac{.04543}{(.000254)(9.0)} = 20 \text{ sec}$$