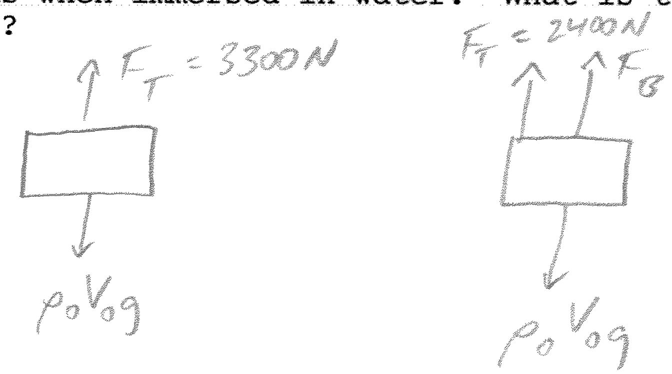
Physics 10154 - Exam #4d

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) An object weighs 3300 Newtons in air and 2400 Newtons when immersed in water. What is the density of the object?



$F_T - \rho_o V_o g = 0$

$\rho_o V_o g = 3300$

$F_T + F_B - \rho_o V_o g = 0$

$2400 + F_B - 3300 = 0$

$F_B = 900$

$\rho_f V_f g = 900$

$V_f = V_o$ since object submerged $\rightarrow$ $\rho_f V_o g = 900$

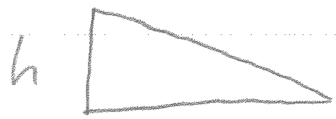
$V_o = \frac{900}{(1000)(9.8)} = .0918$

$\rho_o = \frac{3300}{(.0918)(9.8)} = \boxed{3700\ kg/m^3}$

2. (40 pts) A 3.0 kg sphere with radius 15 cm rolls without slipping down a 7.0 meter long ramp inclined 22° with respect to the horizontal.

a) If it starts from rest, how many seconds does it take for the sphere to reach the bottom of the ramp?

b) What percentage of the sphere's kinetic energy is due to rotation when it reaches the bottom of the ramp?



$h = 7 \sin 22° = 2.62 m$

$$\Sigma W_F = \Delta K$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v^2}{R^2}\right)$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$mgh = \frac{7}{10}mv^2$$

$$v = \sqrt{\frac{10}{7}gh} = 6.06 \text{ m/s}$$

$$\Delta s = \frac{1}{2}(v + v_0)t$$

$$7.0 = \frac{1}{2}(6.06 + 0)t \qquad \boxed{t = 2.3 \text{ s}}$$

b) $$\frac{K_r}{K_{TOT}} = \frac{\frac{1}{5}mv^2}{\frac{7}{10}mv^2} = \frac{2}{7} = \boxed{29\%}$$

3. (30 pts) A pipe with constant diameter of 2.5 cm carries water up from the ground floor to the top of a tall building. Both ends of the pipe are open to the air, but the bottom end also has a pump attached to provide additional pressure. The water at the bottom end of the pipe is initially at rest.

a) What minimum pressure must the pump provide for water to reach a level 45 meters above the ground floor?

b) Assume the pump has a pressure that is 25% larger than the pressure calculated in part (a). How long (in seconds) does it take water from a pipe 45 meters above the ground floor to fill a 5.0 gallon container?

$$P_{TOP} + \rho g h_{TOP} + \frac{1}{2}\rho v_{TOP}^2 = P_{BOT} + \rho g h_{BOT} + \frac{1}{2}\rho v_{BOT}^2$$

Given $h_{BOT} = 0$, $v_{BOT} = 0$

So, "minimum pressure" means $V_{TOP} = 0$

$$P_{TOP} + \rho g h_{TOP} = P_{BOT}$$

$$101300 + (1000)(9.8)(45) = 101300 + P_{pump}$$

$$(1000)(9.8)(45) = P_{pump}$$

$$\boxed{P_{pump} = 4.4 \times 10^5 \ N/m^2}$$

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b) If $P_{pump} = 5.5 \times 10^5$ and $v_{TOP} \neq 0$

$$P_{TOP} + \rho g h_{TOP} + \frac{1}{2}\rho v_{TOP}^2 = P_{BOT}$$

$$\cancel{101300} + 4.4 \times 10^5 + 500 v_{TOP}^2 = \cancel{101300} + 5.5 \times 10^5$$

$$500 v_{TOP}^2 = 1.1 \times 10^5$$

$$\boxed{V_{TOP} = 15 \ m/s}$$