

## FINAL EXAM SAMPLE PROBLEMS

~~The Final Exam will be given on Monday, January 30 from 9 am - Noon  
There will be no makeup exam.~~

~~You will be provided with a copy of the formula sheet during the exam. You may wish to memorize other formulas but a good understanding of the concepts and applicability of these formulas should allow you to do all of the problems on the exam.~~

~~The problems on the following pages are mostly problems from exams in previous 8.01L classes. Note that all topics for which you are responsible are NOT included in this sample. We have only included sample problems for the material since the last exam. You should also review the previous three exams (and the sample problems for them) as well as the material included on all of the homework assignments. The final exam will contain about 7-9 problems similar in difficulty to these, with roughly half the exam covering material since the last exam.~~

~~Some of these problems were from exams where calculators were allowed. You will **not** be allowed to use a calculator in this exam.~~

### ~~Problem 1~~

~~a) A closed weather balloon with an initial volume  $V$  rises up in the atmosphere to a point where the outside air pressure is  $1/10$  of the pressure at the surface and the temperature of the air has dropped by a factor of  $3$ . Assume that the balloon is filled with an ideal gas and that the material of the balloon exerts no pressure and does not insulate so that the temperature and pressure are the same inside and outside the balloon. Does the volume of the gas increase, decrease, or stay the same as the balloon rises? Justify your answer.~~

~~b) A solid object of a material with a density of  $4000 \text{ kg/m}^3$  has a volume of  $0.002 \text{ m}^3$  and thus a mass of  $8 \text{ kg}$ . How much force do you need to exert to support this object~~

~~i) In air.~~

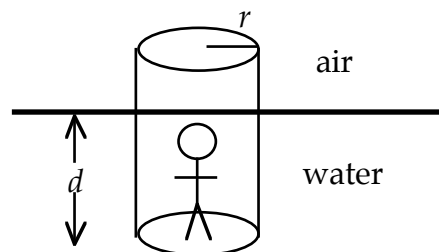
~~ii) When it is completely submerged in water.~~

~~The density of water is  $1000 \text{ kg/m}^3$ . Use  $g=10 \text{ m/s}^2$  in this problem.~~

~~c) Assume that water is flowing through a rubber tube. Due to a weakness in the material, a section of the tube expands so it has a larger radius than the other parts. Describe what would happen to the water flow velocity and the water pressure in the enlarged section of the tube.~~

### ~~Problem 2~~

~~a) Your physics professor is standing inside a cylinder of radius  $r$  which is floating in equilibrium in water of density  $\rho$ . The cylinder is filled with air of negligible mass. The physicist and cylinder have a combined total weight of  $W$ . Find the depth  $d$  to which the bottom of the cylinder sinks into the water.~~



~~b) Now assume that the cylinder starts at a higher position and falls down into the water. Find the acceleration when the bottom of the cylinder is at a depth of  $d/2$ . Assume that you can ignore the viscous force of the water (the liquid equivalent of air resistance).~~

### ~~Problem 3~~

~~a) Archeologists have recently uncovered evidence that people living in South America many centuries ago were able to climb to the summit of a mountain at a height of  $6500 \text{ m}$  above sea level. The air pressure at sea level is  $1.013 \times 10^5 \text{ N/m}^2$ . Assuming that the atmosphere has an average density of  $0.95 \text{ kg/m}^3$ , find the air pressure at the top of this mountain.~~

~~b) Assume that a pressurized helium bottle contains gas at a pressure of  $1.50 \times 10^7 \text{ N/m}^2$  and is inside a building at a temperature of  $20^\circ\text{C}$ . If you take the bottle outside to a New Year's Day parade where the temperature is  $-20^\circ\text{C}$ , what will the pressure inside the bottle be once it has fully cooled?~~

Massachusetts Institute of Technology  
Department of Physics

Physics 8.01L

~~SAMPLE FINAL EXAM~~

~~SOLUTIONS~~

~~January 25, 2006~~

**Problem 1**

a)  $V = \frac{NkT}{P}$ ,  $V_{NEW} = \frac{Nk\frac{T}{3}}{\frac{P}{10}} = \frac{10}{3} \frac{NkT}{P}$ ,  $\Rightarrow V$  goes up

b) (i)  $F = mg = 8(10) = 80N$

(ii)  $F_{Buoy} = (1000)(.002)(10) = 20N$ ,

$\therefore F = 80 - 20 = 60N$

c)  $\text{Velocity goes down, pressure goes up.}$

**Problem 2**

a) Equilibrium, so  $F_{Buoyant} - w = 0 \Rightarrow F_B = w$ .

$F_B = V_f \rho_f g = (\pi r^2 d) \rho g = w$ ,  $d = \frac{w}{\pi r^2 \rho g}$

b)  $F_{TOT} = Ma = F_B - w$ ,  $F_B = \pi r^2 \left(\frac{d}{2}\right) \rho g = d \left(\frac{\pi r^2 \rho g}{2}\right)$

From (a),  $d = \frac{w}{\pi r^2 \rho g} \Rightarrow F_B = \frac{w}{\pi r^2 \rho g} \left(\frac{\pi r^2 \rho g}{2}\right) = \frac{w}{2}$

Half as deep  $\Rightarrow$  half as large buoyancy force.

$F_{TOT} = Ma = \frac{w}{2} - w = -\frac{w}{2}$ ,  $a = \frac{-w}{2m}$ , but  $w = Mg$ .

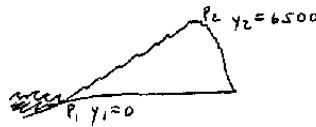
$\Rightarrow a = \frac{-g}{2}$ , accelerating downward at  $\frac{g}{2}$ .

**Problem 3**

a)  $P + \rho g y = \text{constant}$ ,  $P_1 + \rho g(0) = P_2 + \rho g(6500)$

$P_2 = P_1 - \rho g(y_2) = 1.013 \times 10^5 - (0.95)(9.8)(6500)$ ,

$P_2 = 4.08 \times 10^4 N/m^2 = 0.40 \text{ atm}$



b)  $N = \text{const}$ ,  $V = \text{const}$ ,  $PV = NkT$

$\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$ ,  $T_1 = 293$ ,  $P_1 = 1.5 \times 10^7$ ,  $T_2 = 253$ ,  $P_2 = \frac{P_1 T_2}{T_1} = 1.30 \times 10^7 N/m^2$

**Problem 4**

ii)  $f$  exerts torque around center of mass, so you fall over.

