Midterm Exam 1

(9:30-10:45 am on October 19, 2010)

Problem 1 (10 pts). An air bubble, 1 cm in diameter, is released from the regulator of a scuba diver swimming 30 m below the surface of the ocean. You may assume that the gas in the bubble obeys the ideal gas law and that the sea water density does not change over the 30 m depth. Please complete the following:

(a:3) Determine the pressure distribution in the ocean for the depths from 0 m to 30 m. Calculate the gage pressure and the absolute pressure at a depth of 30 m.

(b:2) Determine the pressure inside the air bubble.

(c:5) Estimate the diameter of the air bubble described in the problem statement (1 cm diameter at 30 m depth) when it just reaches the surface of the ocean.

Helpful values: $SG_{sea} = 1.025$, $\sigma = 0.070\ N/m$, $R_{air} = 287$ J/(kg·K), $P_{atm} = 101.3\ kPa$

Problem 2 (20 pts). A block of mass M slides on a thin film of oil as shown in the figure below. The film thickness is h and the area of the block is A. When released from rest, mass m exerts tension on the cord, causing the block to accelerate. You may neglect friction in the pulley and air resistance. Please complete the following:

(a:3) Develop an algebraic expression for the viscous force, F_{visc}, that acts on the block when it moves at a speed V. Please be sure to state any necessary assumptions.

(b:6) Derive a differential equation for the block speed as a function of time. Make sure that you include a properly labeled Free Body Diagram (identify forces on the block).

(c:4) Obtain an expression for the block speed as a function of time.

(d:2) If $M = 5\ kg$, $m = 1\ kg$, $A = 25\ cm^2$, $h = 0.5\ mm$, and it takes 1 s for the speed to reach 1 m/s estimate the viscosity of the oil.

(e:5) Is there any heat dissipation in the system? Justify your answer quantitatively using an energy balance.

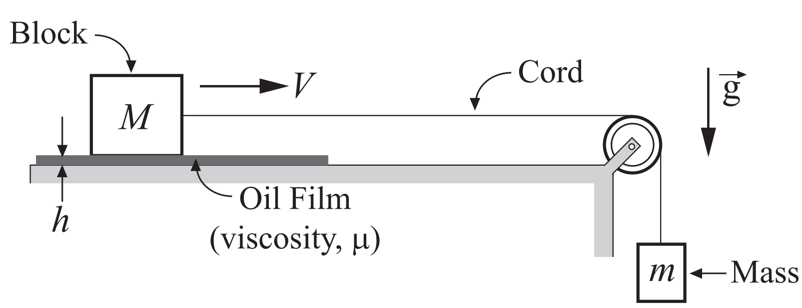

Figure 1: Block sliding along thin film of oil.

Problem 3 (7 pts). Can a solid steel ball of certain size float on water? What if it were an aluminum ball? You may neglect buoyancy forces (aka Archimedes forces), but you must justify your answer with a free body diagram and clearly state any assumptions used. Estimate the magnitude of the forces acting on the ball.

Helpful values: $\rho_{steel} \approx 8{,}000\ kg/m^3$ and $\rho_{Al} \approx 3{,}000\ kg/m^3$