AML160 Mechanics of Fluids **MINOR I**

(*Max marks 60*) 30 August 2013 11.00 pm to 12.00 pm

1) Prove that for a fluid at rest (no internal motion), at any point in the fluid, the normal stresses are all equal to $-p$. Here, p, is the local pressure. Clearly state all your assumptions. (6)

2) A uniform cylinder of diameter, D, and height, H, is made of wood of specific gravity, 0.6. What should the ratio of diameter to height be so that it is stable when it floats upright in water (i.e. the axis is vertical)? (10)

3) A shaft of diameter, d, rotates in a bearing at a constant angular speed ω. The clearance between the shaft and the bearing is δ. The viscosity of the oil in the gap is μ. If the length of the bearing is L, find the torque, T, required to overcome friction in the bearing. (Assume a linear velocity profile in the gap.) (8)

4) A steady jet of water is used to propel a cart along a horizontal track as shown. The resistance due to air on the cart is given by: $F_D = 0.9\ A\ U^2$, where, A is the cross sectional area of the cart and U is the speed of the cart. The mass of the cart, M, is 15 Kg.

i) For the jet shown find the force F required to maintain the cart at a steady speed $U = 5$ m/s if $A = 100\ cm^2$.

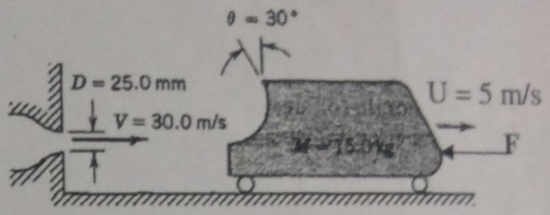

Figure Q4

ii) How would the answer to part i) change if the cart is at rest, i.e. $U = 0$ m/s? (16)

5) A barge has overturned and sunk to the bottom of the sea as shown in the figure Q5a. The depth, D, of the sea at this point is 30m. The barge has a length, $L = 30$m, height, $H = 10$m, and width, $W = 10m$. Its mass M is 300 metric tons (1 metric ton = 1000 Kg.). A crane is to be used to lift the barge out of the water, however, the lifting capacity of the crane is only 100 metric tons. It is therefore planned to pump air into the barge to make it more buoyant as shown in the figure Q5b.

i) Determine the volume of air required so that the crane is just able to lift the barge. The volume of the steel structure of the empty barge is negligible. The density of sea water is 1030 Kg/m^3, and that of air is 1 Kg/m^3. (14)

ii) What is the gauge pressure in the air, just before the barge is lifted?

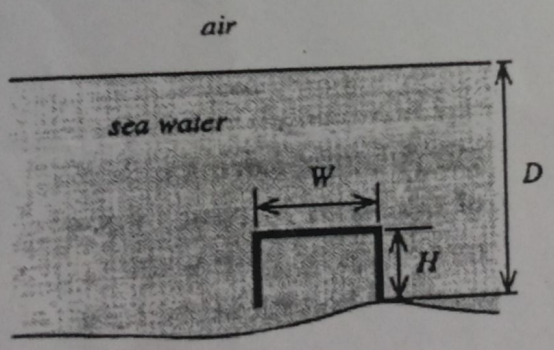

Figure Q5a

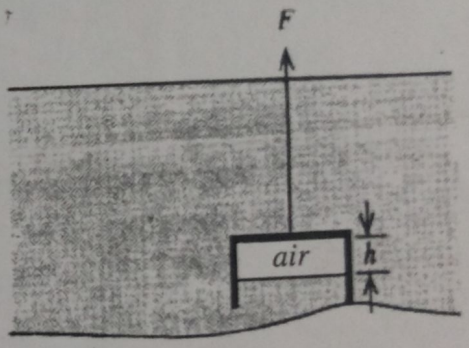

Figure Q5b

6) The fuel gauge in most cars employs a float. The higher the float rises in the tank, the larger is the reading on the gauge. In a certain car it is noticed that when the car accelerates or when it is makes a right turn the reading increases.

i) Where is the float located (A, B, C, … or I)? The fuel tank is being viewed from above.

ii) For the gauge to be least sensitive to accelerations of the car where should the float be located?

Give reasons to support your answers.

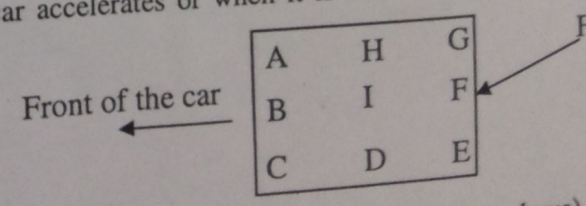

Figure Q2: Plan view (i.e. view from above) (6)

BONUS QUESTION

7) Why is it that a vacuum cleaner does not do a very good job of cleaning fine dust off a smooth flat surface? (4)
(Hint: You must treat air as a viscous fluid.)