

# ES2A7 - Fluid Mechanics Example Classes

## Example Questions (Set III)

### Question 1: Distance between molecules:

Find the mean distance between water molecules

- in a liquid state
- in vaporous state at  $T=400\text{K}$  and  $P=1\text{bar}$ . This gas is assumed to follow the law of perfect gas.

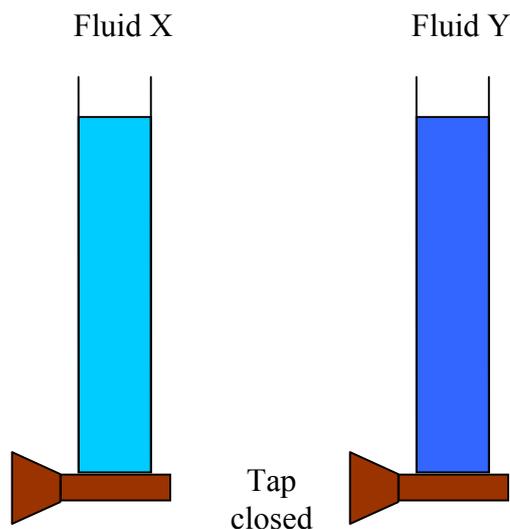
Data:

- Density of liquid water:  $\rho = 1000 \text{ kg.m}^{-3}$
- Avogadro Number:  $N_A = 6.10^{23} \text{ mol}^{-1}$
- Molecular mass of water:  $M = 18 \text{ g.mol}^{-1}$
- Perfect Gas constant:  $R = 8.31 \text{ J.K}^{-1}.\text{mol}^{-1}$

### Question 2: Type of Fluid

Consider 2 identical vertical tubes (X and Y) with a free surface on their upper part and close by a tap on their lower part. Both are filled with the same height of fluid: A Newtonian fluid is used with tube X whereas a non-Newtonian fluid is used with tube Y. Taps are open simultaneously. At the beginning the fluid in tube Y flows more rapidly than that in tube X. After a moment, when the height of fluid becomes small, the non-Newtonian fluid decelerates compare to the Newtonian fluid, and in the end the Newtonian fluid flows fast than the non-Newtonian fluid.

What is the type of the non-Newtonian fluid ? Explain the experiment and give an example of such fluid



Sketch of the experiment before it starts

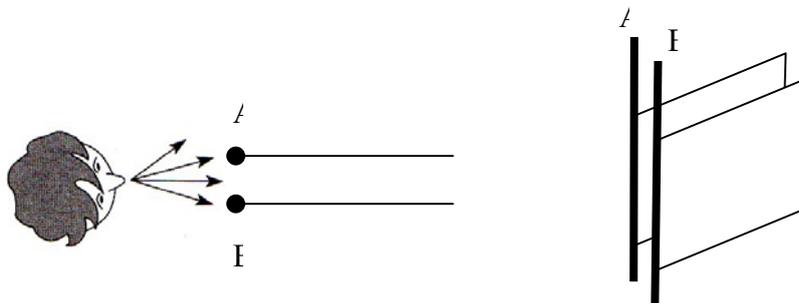
### **Question 3: Type of Fluid**

Classify the following fluid: Ketchup, Silly putty, mixture of water and corn flour, honey, wet sand, blood, paint

### **Question 4: Venturi Effect**

Consider two vertical pieces of paper (typical 80g/m<sup>2</sup> A4) separate by a small distance (2-3cm). On one side, the vertical edges of both sheet of paper are hold firmly so that they can't move. The other edges remain free of motion.

Describe what happen when someone standing behind the fixed edges blows between the 2 sheets of paper. Explain the experiment



Picture at t=0. A and B are fixed rod holding the edges of paper sheets fix

### **Question 5: Newtonian Fluid**

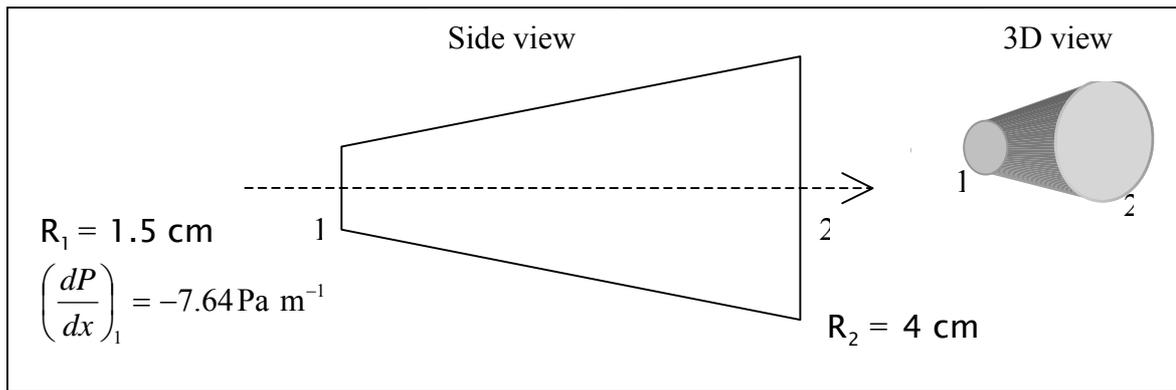
Let consider the flow within a Taylor-Couette device. It consists of two concentric cylinder of which inner cylinder rotates at  $\Omega$  rad/s. At low rotation speed, the velocity field is purely azimuthal and evolves as  $v_\theta(r) = Xr + Y/r$  for a Newtonian fluid (the effect of the boundary in the axial direction are neglected). Find the expression of X and Y as a function of the radii of the cylinders, and then determine the expression of the mean velocity.

### **Question 6: Newtonian Fluid**

Consider the flow of water (dynamic viscosity  $\mu = 8.9 \times 10^{-4}$  Pa s) through an expanding tube. The flow velocity of the water at the wall of the tube is zero since it has to satisfy the no-slip condition. The flow velocity of the water is dependent on the radial position within the tube. The radial variation of the velocity,  $\frac{dV(r)}{dr}$ , is given

by the relation  $\frac{dV(r)}{dr} = \frac{r}{2m} \frac{dP}{dx}$  where  $r$  is the distance from the centreline,  $x$  is the

coordinate in the direction along the centreline and  $\frac{dP}{dx}$  is the pressure gradient along the centreline axis.



Determine the mean velocity of the water flow at the exit (section 2).  
 (Hint: Calculate first the velocity profile  $V(r)$  and then the mean velocity at the entrance (section 1)).