FLUIDS I
Example sheet 3: 1D Fluid Flow

1. If wind blows at 30m/s, what would be the pressure recorded by a Pitot tube facing the wind? The atmospheric pressure is 1×10^5 N/m^2 and the density of the air is 1.2 kg/m^3.
If one end of a u-tube mercury manometer is connected to the Pitot tube while the other end is at atmospheric pressure, what would be the difference in height of mercury in the two limbs of the manometer? The Density of mercury is 13560 kg/m^3

[Ans: 100540N/m^2 ,4.06mm]

2. A light aircraft is moving at a Mach number of 0.25 at an altitude of 3000m, where the atmospheric pressure and temperature are 0.701×10^5 N/m^2 and -4.35^{o}C respectively. What would be the ratio of the total and atmospheric pressure at the front of the aircraft? You can use the relation for the speed of sound $a = \sqrt{\gamma RT}$, where γ is a constant (equal to 1.4 for air) while for air R=287 J/kg K.
If the aircraft were moving at a Mach number of 0.82 (typical civil airliner), could the same method of solution be adopted?

[Ans: 1.044]

3. The air supply to a diesel engine is measured by being taken directly from the atmosphere into a large reservoir through a sharp edged circular orifice of diameter 50mm. The pressure difference across the orifice is measured by an alcohol manometer set at a slope of $\sin^{-1}(0.1)$ to the horizontal. Calculate the volume flow rate of air if the manometer reading is 271mm along the slope. The density of alcohol is 800 kg/m^3, the vena contractor has an area that is 0. 602 of the area of the orifice, the atmospheric pressure is 775 mm Hg and the temperature is 15.95^{o}C. (R=287, density of mercury is 13560 kg/m^3)

[Ans: 0.0219 m^3/s]

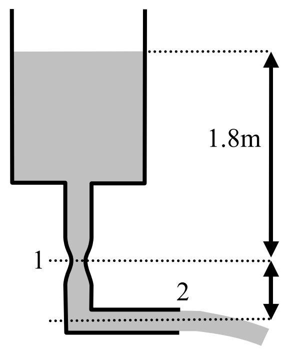
4. Apply the continuity and Bernoulli's equation between the inlet (area A1) the throat (area A2) of a venture-meter to show that the volumetric flow rate, Q, of a gas (negligible hydrostatic pressure) and the difference in static pressures between the two sections are related by:

$$Q = A_1\left(\frac{2(p_1 - p_2)}{\rho\left((A_1/A_2)^2 - 1\right)}\right)^{1/2}$$

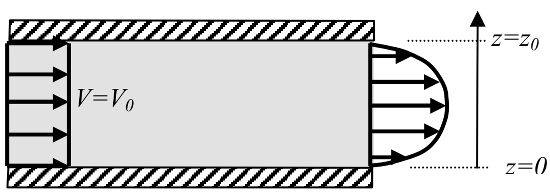
where ρ is the density of the gas

5. If the atmospheric pressure is 1×10^5 N/m^2 and the vapour pressure of water is 2.39×10^3 N/m^2, find the value of h for cavitation to just occur at section 1. The diameter at sections 1 and 2 are 50mm and 75mm respectively. Assume that the reservoir area is very large and so can be assumed fixed in height above 1.

[Ans: 0.521m]



6. The flow at the inlet between two parallel plates is uniform, while downstream the flow develops into a parabolic laminar velocity profile given by $V = az(z_0 - z)$. Find the value of the constant, a & the centreline velocity, in terms of V_0 and z_0. Note: the profile develops because of viscosity. However, continuity is unaffected by viscosity.



[Ans: $6V_0/z_0^2$,$3V_0/2$]

7. Water leaks through a sharp-edged orifice of area a at the bottom of a large reservoir which has a uniform horizontal cross-sectional area A. Assuming that the flow is quasi-steady, show that the time required for the level in the reservoir to decrease from h_1 to h_2 is given by

$$t = \frac{2A}{C_d a\sqrt{2g}}\left(\sqrt{h_1} - \sqrt{h_2}\right)$$

where C_d is the ratio of cross-sectional area of the vena-contracta to that of the orifice.