ES2A7 - Fluid Mechanics Example Classes

Example Questions (Set I)

<u>Question 1:</u> Wind Tunnel

A simple wind-tunnel is depicted schematically in Figure 1. The flow speed in the working section is assumed to be constant with a value of V_B = 60m/s at point B. The cross-sectional area of the working section is 1 m^2.

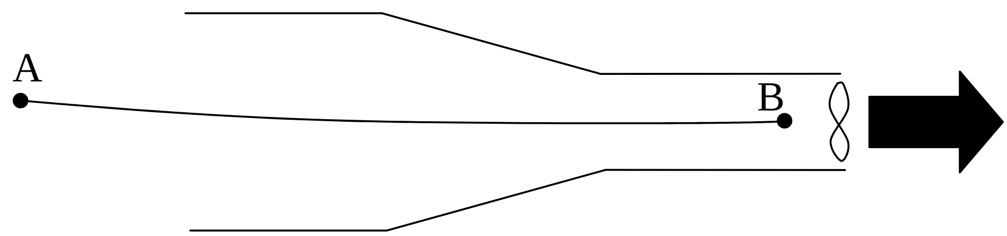

Figure 1: Sketch of simple wind-tunnel

i) Neglecting irreversible losses, such as those due to viscous effects, calculate the gauge pressure in the working section. (Assume a value of $\rho = 1.2$ kg/m^3 for the density of air).
ii) Calculate the mass flow rate across the cross-section in the working section.

<u>Question 2:</u> Plunger

A plunger is moving through a cylinder as schematically illustrated in the Figure 2. The velocity of the plunger is V_p = 10 ms^{-1}. The oil film separating the plunger from the cylinder has a dynamic viscosity of $\mu = 0.3$ Nsm^{-2}. Assume that the oil-film thickness is uniform over the entire peripheral surface of the plunger. Calculate the force and the power required to maintain this motion.

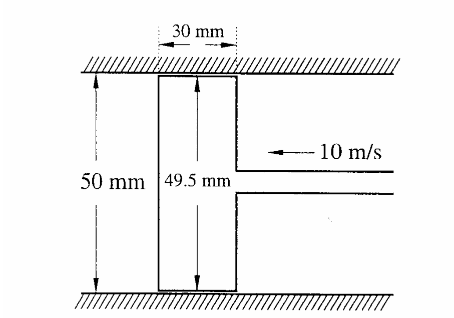

Figure 2: Plunger moving through cylinder.

Question 3: **Flow over Wing**

Assume that a plane is flying with a constant velocity of $v_0 = 55\,\text{ms}^{-1}$ at standard sea level conditions (Density air: ρ_0=1.23 kg m^{-3}, Pressure: $p_0 = 1.01 \times 10^5\,\text{Nm}^{-2}$). At some point on one of the plane's wings the pressure is measured as $p = 0.95 \times 10^5\,\text{Nm}^{-2}$. Calculate the flow velocity v at this point.

Question 4: **Sphere in Fluid**

A sphere moves through oil. The constant velocity of the sphere is $u = 1\,\text{mms}^{-1}$. The dynamic viscosity of the oil is $\mu = 0.05$ Nsm^{-2} and its density is $\rho_O = 900\,\text{kgm}^{-3}$. The radius of the sphere is $r = 10$ mm and its density is $\rho_S = 1200\,\text{kgm}^{-3}$. (i) Use Figure 3 to estimate the drag forces acting on the sphere. (ii) Calculate the buoyancy force acting on the sphere.

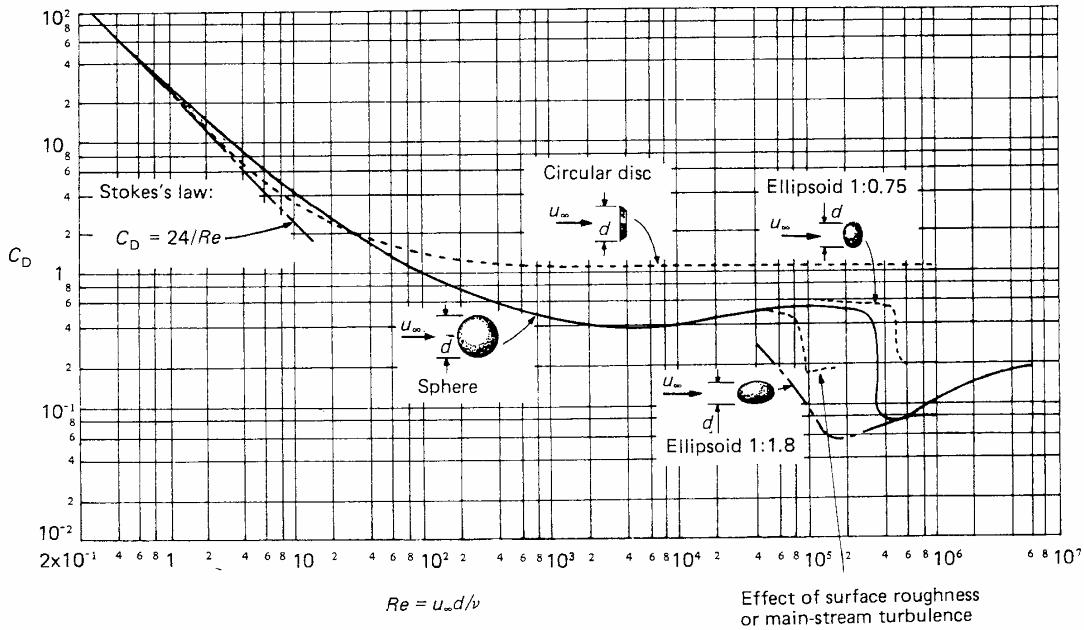

Figure 3: Drag coefficient of smooth, axially symmetric bodies (From: Massey, Mechanics of Fluids, Chapman & Hall, 1989, 6th Edition)

Question 5: **Fire Engine**

A fire engine pump develops a head of 50 m, i.e. it increases the energy per unit weight of the water passing through it by 50 N m N^{-1}. The pump draws water from a sump at A (Fig. 4) through a 150 mm diameter pipe in which there is a loss of energy per unit weight due to friction $h_1 = 5u_1^2/2g$ varying with the mean velocity u_1 in the pipe, and discharges it through a 75 mm nozzle at C, 30 m above the pump, at the end of a 100 mm diameter delivery pipe in which there is a loss of energy per unit weight $h_2 = 12u_2^2/2g$. Calculate (a) the velocity of the jet issuing from the nozzle at C and (b) the pressure in the suction pipe at the inlet to the pump at B.

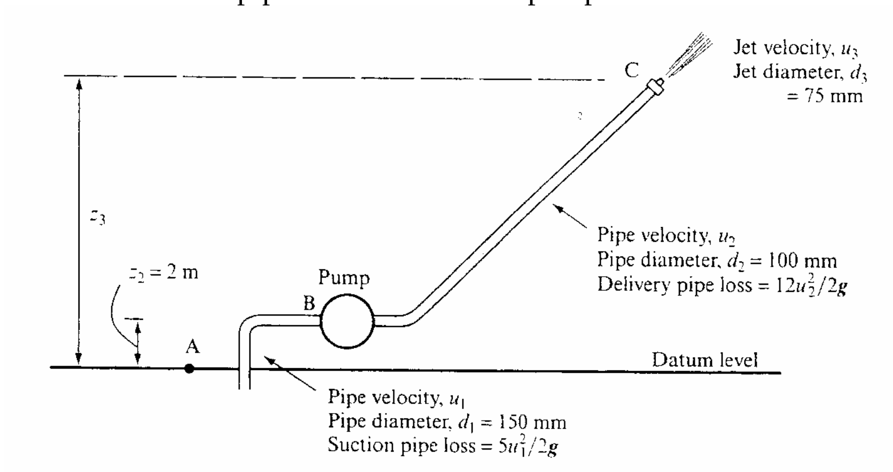

Figure 4: Fire engine Pump

Question 6: **Multi-Fluid Manometer**

A multi-fluid manometer is set up as shown in Fig.5. The pressure at its right end is $p_2 = 0.9\times10^5$ Nm^{-2}. The densities of the fluids are $\rho_A = 1000$ kg m^{-3}, $\rho_B = 900$ kg m^{-3} $\rho_C = 13000$ kg m^{-3}. One measures $h_1 = 0.5$ m $h_2 = 0.3$ m and $h_3 = 0.6$ m. Find the pressure p_1.

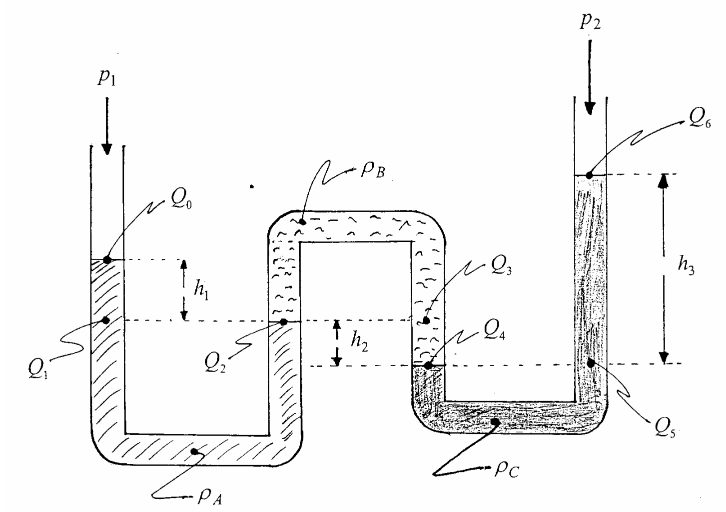

Figure 5: Multi-fluid manometer