1. (a) A 60 mm diameter pipe has a discharge of 450 litres/min. At a section, the pipe has a sudden expansion to a size of 90 mm diameter. If the pressure just upstream of (before) the expansion is 20 kN/m^2, calculate the pressure just after the expansion. Assume the pipe to be horizontal.

(b) A 2500 m long pipeline is used for transmission of hydraulic power. 120 kW power is to be transmitted through the pipe in which water having a pressure of 4000 kN/m^2 at inlet is flowing. If the pressure drop over the length of pipe is 800 $kN/^2$ and skin-friction coefficient $C_f = 0.006$, find (i) diameter of pipe, and (ii) efficiency of hydraulic power transmission.

(c) Draw velocity and shear stress profile of a turbulent flow near a wall. Identify various flow regions like laminar sub-layer, overlap region and outer turbulent layer in these profile.

(5+5+4)=14

2. (a) A smooth flat plate 2 m wide and 2.5 m long is towed in oil (relative density=0.8, kinematic viscosity = 10^{-4} m^2/s) at a velocity of 1.5 m/s along its length. Find the thickness of the boundary layer and shear stress at (i) the centre and (ii) at the training edge of the plate. (iii) Also find the power required for towing the plate.

(b) For a velocity profile $u/U=2(y/\delta)-(y/\delta)^2$, calculate (i) displacement thickness and (ii) momentum thickness. Note, δ is the boundary layer thickness.

(c) Air is flowing over a flat plate 5 m long and 2.5 m wide with a velocity of 4 m/s at 15 °C. If density of air is 1.208 kg/m^3 and kinematic viscosity is 1.47×10^{-5} m^2/s, calculate (i) length of the plate over which boundary layer is laminar, and the thickness of the laminar boundary layer. (ii) Shear stress at the location where boundary layer ceases to be laminar, and (iii) total drag force on both sides on that portion of plate where boundary layer is laminar. Use Blasius formulations.

(6+4+6)=16

3. (a) Determine the largest diameter and corresponding terminal velocity of a spherical solid particle settling in air. Assume it obeys Stokes law. Take density of solid particle = 1047.9 kg/m^3, density of air = 1.2 kg/m^3, kinematic viscosity of air = 1.5×10^{-5} m^2/s.

(b) Experiments were conducted in a wind tunnel at 50 km/hour on a flat plate of 2 m long and 1 m wide. The specific weight of air is 11.28 N/m^3. The plate is kept at such an angle that the lift coefficient and drag coefficient are 0.75 and 0.15 respectively. Determine the lift force, drag force, resulting force, inclination of flat plate with main stream (angle of attack) and power exerted by air stream on the plate.

(c) What is flow separation? Enlist a few techniques of flow separation control.

(d) For the following velocity profiles, determine whether flow is attached to the solid surface or detached from it.

(i) $\frac{u}{U}=2\left(\frac{y}{\delta}\right)-\left(\frac{y}{\delta}\right)^2$; (ii) $\frac{u}{U}=-2\left(\frac{y}{\delta}\right)+\left(\frac{y}{\delta}\right)^3+2\left(\frac{y}{\delta}\right)^4$

(4+6+4+4)=18

4. (a) Write formula and physical significance of (i) Froude number- Fr, (ii) Mach number- M, and (iii) Euler number-Eu.

(b) The streamline is represented by $\psi = x^2 - y^2$. Determine the velocity and its direction at a point (2, 2).

(c) In the following figure of a compound manometer, calculate the pressure difference between points A and B. Take, specific weight of water = 10 kN/m^3, specific weight of mercury = 136 kN/m^3 and specific weight of oil = 8.5 kN/m^3.

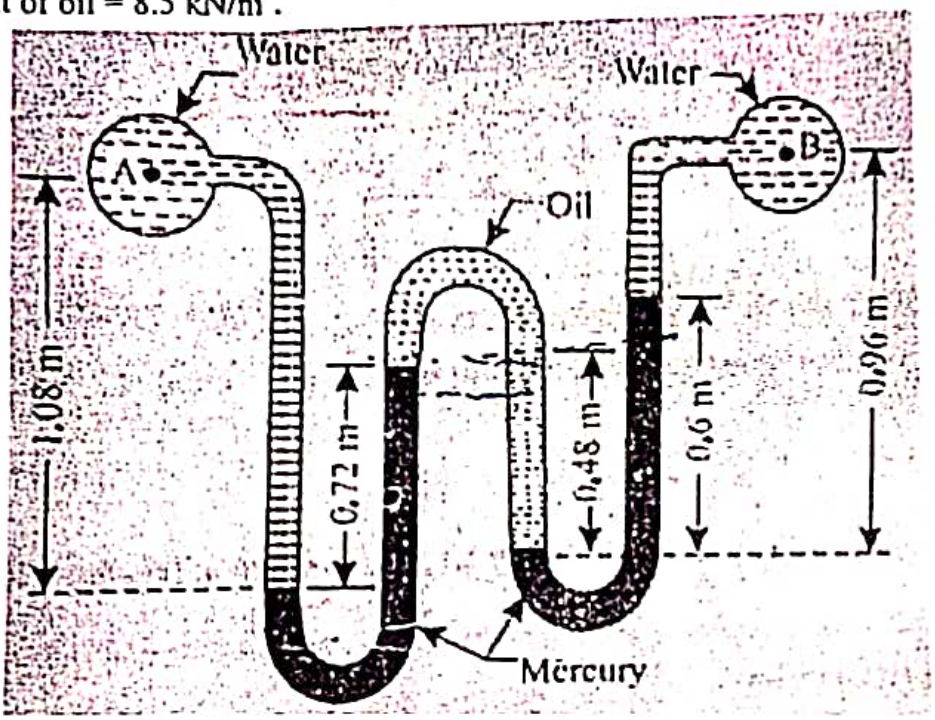

Figure to Prob. 4 (c)

(d) Mark true (√) or false (×) against the following statements.

(i) A piezometer tube is not suitable to measure negative pressure.

(ii) At a liquid-air-solid interface, the contact angle measured in the wetting liquid is less than 90°.

(iii) The point of application of the total pressure on the surface is called 'centroid of the surface'.

(iv) If the inviscid flow is irrotational as well as steady, it is called potential flow.

(v) A venturimeter is used to measure total energy.

(vi) Reynolds number is the ratio of the inertia force to the viscous force.

(vii) In case of laminar flow, the loss of pressure head is proportional to velocity.

(viii) A streamlined body is defined as a body in which drag is maximum.

(3+3+4+8)=18

5. (a) Explain the working mechanism of a centrifugal pump.

(b) What is cavitation? Enlist the factors responsible for cavitation in turbomachines.

(c) Write expression of specific speed of a turbine and a pump.

(d) Draw layout of a hydroelectric power plant and label all important components.

(e) Explain with help of a neat diagram the working of any non-intrusive flow measuring device.

(3+3+2+3+3)=14

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