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THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 05
FINAL EXAMINATION– 2009/2010

MEX5230 – FLUID MECHANICS

DATE : 11th MARCH 2010
TIME : 0930 HRS. – 1230 HRS.
DURATION : THREE HOURS

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS.

Density of water = 1000kg/m^3. Acceleration due to gravity=9.81m/s^2

QUESTION 01

i. A heavy cylinder 1m long rests on the bottom of a tank 1m long as shown in Figure Q1. The tank contains water on one side of the cylinder for a depth of 0.6m and oil of specific gravity 0.75m on the other side of the cylinder for a depth of 1.2m. If the radius of the cylinder is 1.2m, find the horizontal and vertical forces exerted by the liquids on the cylinder.

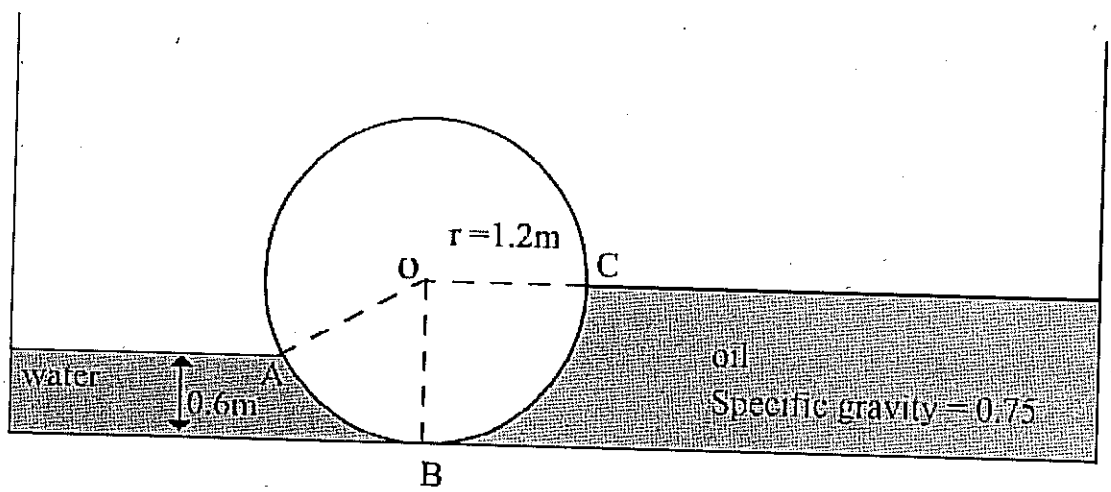


Figure Q1

ii. A 90mm diameter orifice discharges horizontally 30.3*l/s* under a head of 3m. a vertical flat plate held normal to the jet near the orifice needs a force of 227N to resist the impact of the jet. Find the coefficients of the orifice.

QUESTION 02

Figure Q2 shows a bush bearing of radius R and length l. thickness of the oil film is t and viscosity is μ. If the shaft is rotating at an angular velocity ω, show that the torque T required for overcome the viscous resistance is

$$T = \frac{2\pi\mu\omega l R^3}{t}$$

A bush bearing of length 300mm supports a shaft of 150mm diameter rotating at 120rev/min. If the internal diameter of the bearing is 150.25mm, find the torque required to keep the shaft in rotation at the speed mentioned above. Find also the power required. The viscosity of oil is 0.25Pas.

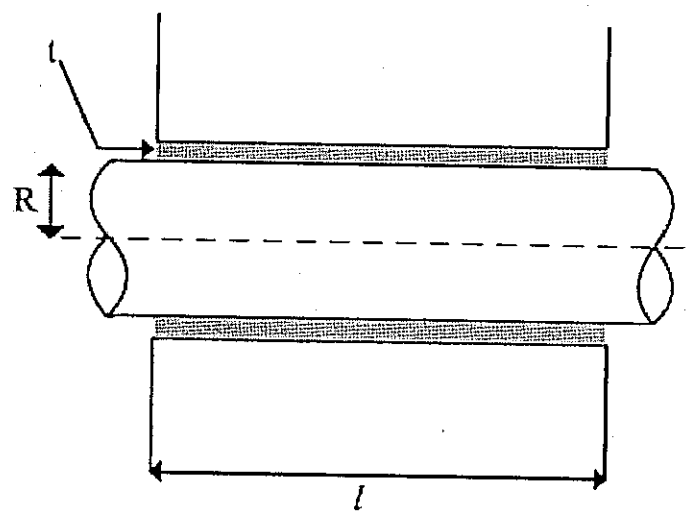


Figure Q2

QUESTION 03

The efficiency η of a fan depends on the density ρ, the dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rotor and the discharge Q. By using the Buckingham's Pi theorem show that

$$\eta = \phi\left[\frac{\mu}{D^2\omega\rho}, \frac{Q}{D^2\omega}\right]$$

QUESTION 04

(a) Show that for turbulent flow in a pipe of radius R the variation of the difference between the maximum velocity V_{max} and the local velocity u at any distance y from the bounding surface follows same variation with respect to the relative distance y/R in both the smooth and rough pipes.

(b) Water is being conveyed through a 100mm diameter rough pipe. Measurements made by a pitot-static probe indicate that velocity at a point 30mm from pipe wall is 30% more than the velocity at a 10mm from the pipe wall. Determine the roughness height.

You may use the following equations with usual notation:
For turbulent flow through smooth pipes

$$\frac{u}{u^*} = 5.5 + 5.75log\left(\frac{yu^*}{v}\right)$$

For turbulent flow through rough pipes

$$\frac{u}{u^*} = 8.5 + 5.75log\left(\frac{yu^*}{v}\right)$$

For flow through a rough pipe the velocity at any point at a distance y from the wall is

$$\frac{u}{u^*} = 8.5 + 5.75log\left(\frac{y}{k}\right)$$

QUESTION 05

Three reservoirs A, B and C are connected by a pipe system shown in Figure Q5. If the discharge from the reservoir A is $0.05m^3$, determine the rate of flow into or from the reservoirs B and C. Find also the head of water level in the reservoir C. Take f=0.008.

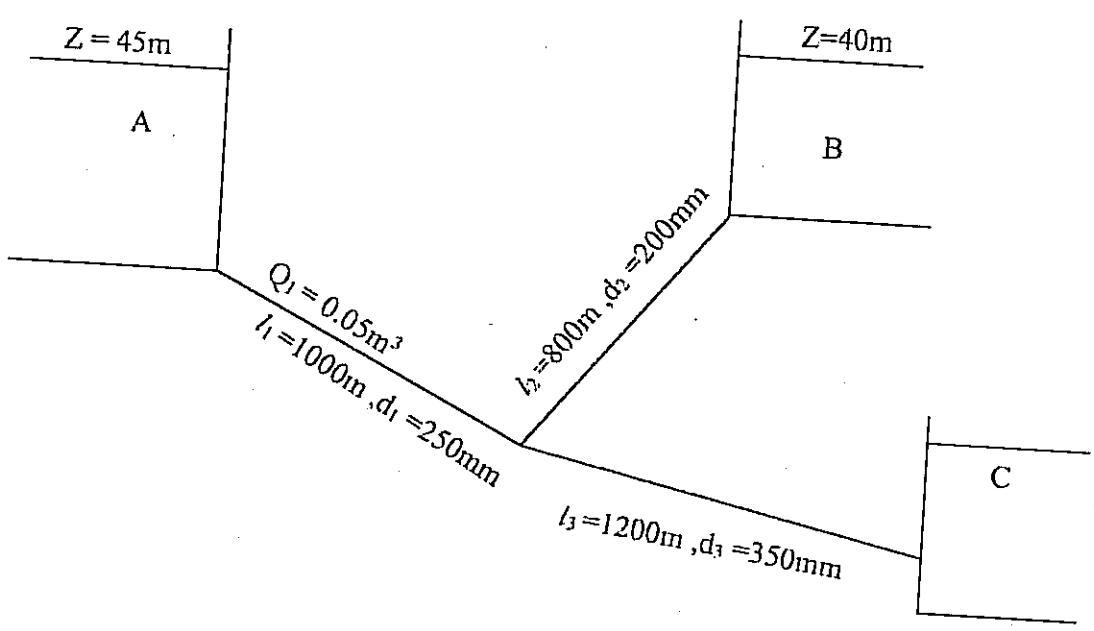


Figure Q5

QUESTION 06

By using the circle theorem show that the image of a source outside a circle consists of an equal source at the inverse point and equal sink at the centre of the circle.
In a two dimensional fluid motion produced by a source of strength m placed at a point S outside a rigid circular disc of radius a whose centre is O. Find the velocity of the fluid in contact with the disc and show that the magnitude of the maximum velocity is $2m.\frac{OS}{(OS^2 - a^2)}$

QUESTION 07

(a) Show that water in the boundary layer, which forms as the fluid flows over a flat plate, would be entirely in streamline motion if the plate were 480mm long in the direction of flow and when the fluid beyond the boundary layer is flowing with a uniform velocity of 196mm/s. It is given that $Re_{x,crit} = 10^5$.
(b) Find thickness of the boundary layer at a point 300mm from the leading edge.
(c) What would be the water velocity in the middle of the boundary layer?
(d) What shear stress would be exerted on the plate by the fluid 300mm from the leading edge?
(e) What would be the mean shear stress experienced over the whole plate under these conditions?
(f) If the plate is 2.6m wide, what would be the total force experienced by the plate?

You may assume the velocity profile for boundary layer as follows;

$$\frac{u}{U} = \left(\frac{3y}{2\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

Blasius solution for boundary layer

$$\delta = 4.91\frac{x}{\sqrt{Re}}$$

$$\tau = 0.332\frac{\mu U}{x}\sqrt{Re}$$

$$C_d = \frac{1.328}{\sqrt{Re}}$$

QUESTION 08

A model is built of a flow phenomenon which is dominated by the action of gravity and surface tension. Show that the length scale ratio which will ensure complete hydraulic similitude between the model and the prototype is

$$L_r = \sqrt{\frac{\sigma_r}{\rho_r}}$$

where σ_r and ρ_r are the ratio of model to prototype for surface tension and density of fluid.
Obtain an expression for the scale model, which has to satisfy both Froude's model law and Reynolds model Law.
Oil of kinematic viscosity 5×10^{-5} m^2/s is used in a flow situation where the prototype is influenced both by viscous and gravity forces. For model scale ratio 1:5, what should be the kinematic viscosity to be used with the model so as to achieve dynamic similarity with regard to these forces?

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