THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING
BACHELOR IN TECHNOLOGY – LEVEL 05
FINAL EXAMINATION 2006/2007
MEX 5230– FLUID MECHANICS
DATE :08TH MARCH 2007
TIME :0930 HRS - 1230 HRS
DURATION :03 HOURS

ANSWER ANY FIVE (05) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

QUESTION 01

a) What are the uses of dimensional analysis?

b) The discharge 'Q' of a centrifugal pump depends upon the mass density of fluid (ρ), the rotational speed of the pump (N), the diameter of the impeller (D), the manometric head (H) and the viscosity of fluid (μ). Show that

$$Q = ND^3\Phi\left[\frac{gH}{N^2D^2}, \frac{\mu}{\rho ND^2}\right],$$

where Φ is a general function.

QUESTION 02

a) Explain briefly the function of the following instruments
(i) Piezometer (ii) U – tube manometer

b) Fig. Q2 shows an inverted differential manometer having an oil of specific gravity 0.8, connected to two different pipes carrying water under pressure. Determine the pressure in the pipe '***B***', if the pressure in pipe '***A***' is 2.0 meters of water.

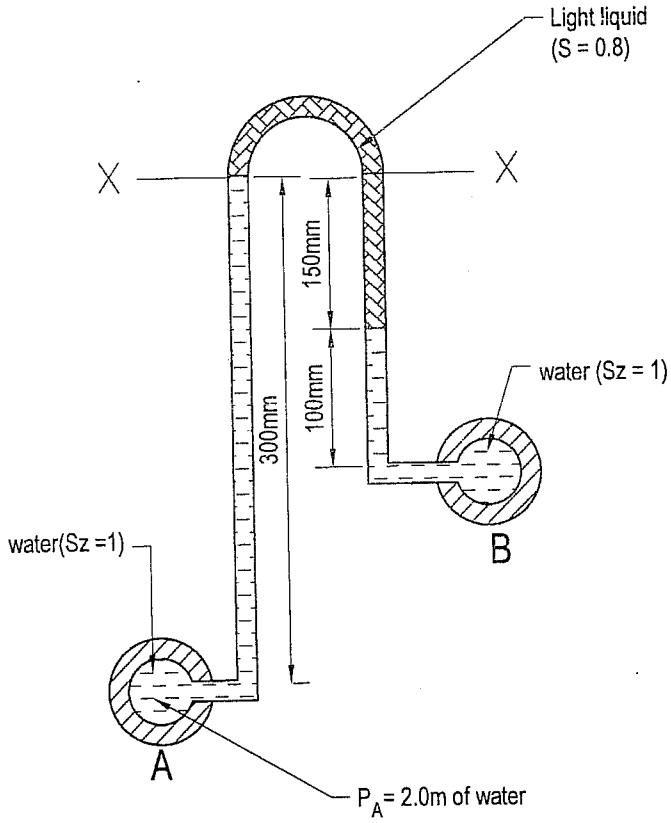


Fig. Q2

QUESTION 03

A pipe of diameter 100 mm and length 1000 m is used to pump oil of viscosity 0.85 Ns/m^2 and specific gravity 0.92 at the rate of 1.2 m^3 / min. The first 300 m of pipe is laid along the ground sloping upwards 10^0 to the horizontal and the remaining pipe is laid on the ground sloping upwards at 15^0 to the horizontal. The oil is discharged to atmosphere and the suction pressure of the pump is equal to atmospheric pressure:

(i) State whether the flow is laminar or turbulent.

(ii) Determine the pressure to be developed by the pump and the power of the driving motor if the pump efficiency is 65%. Neglect the energy loss at the junction.

Assume suitable data for friction factor '*f*', if required.

QUESTION 04

Two reservoirs with a difference in elevation of 15 m are connected by the three pipes in series. The pipes are: 300 m long and diameter 300 mm, 150 m long and diameter 200mm and 200 m long and diameter 250 mm respectively. Determine the flow rate in liters/second.
Take the friction factor (f) in the relation,

$$h_f = \frac{fLV^2}{D \times 2g}$$

for the three pipes are 0.018, 0.020 and 0.019 respectively, for friction losses. Further, it can be assumed that the contractions and expansions are sudden and the loss coefficient for sudden contraction from diameter 300 mm to 200mm is 0.24. Use appropriate equation to predict the loss at the sudden expansion.

QUESTION 05

a) Explain what is meant by boundary layer thickness (δ) and displacement thickness (δ^*).

b) Determine the relationship between the boundary layer thickness and displacement thickness for a boundary layer which is

(i) laminar throughout

(ii) turbulent throughout.

Assume the following:

- In the laminar boundary layer the flow obeys the law, shear stress $\tau = \mu\, du/dy$, where μ is the viscosity and which leads to the velocity profile $(U-u) = k(\delta - y)^2$ where 'U' is the free stream velocity, 'u' is the velocity at a distance y above the plate and k is a constant.

- The velocity distribution in the turbulent boundary layer is given by

$$\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/7}$$

QUESTION 06

a) Water flows over a flat plate at a free stream velocity of 0.15m/s. There is no pressure gradient and the laminar boundary layer at a location is 6 mm thick. Assuming a sinusoidal velocity profile given by

$$\frac{u}{U} = \sin\frac{\pi}{2}\left[\frac{y}{\delta}\right]$$

where δ is the boundary layer thickness, U is the free stream velocity, and 'u' is the velocity at a distance y from the wall, calculate the local shear stress on the plate (at the point where δ = 6 mm).

Take $\mu = 1.02 \times 10^{-3}$ Ns/m^2 and
$\rho = 1000$kg/m^3

b) A plate 25 m long x 1.25 m wide is moving under water in the direction of its length. The drag force on the two sides of the plate is estimated to be 8500N. Calculate the velocity of the plate. Assume C_D as 0.002.

QUESTION 07

a) State the advantages of using externally pressurized bearings.

b)

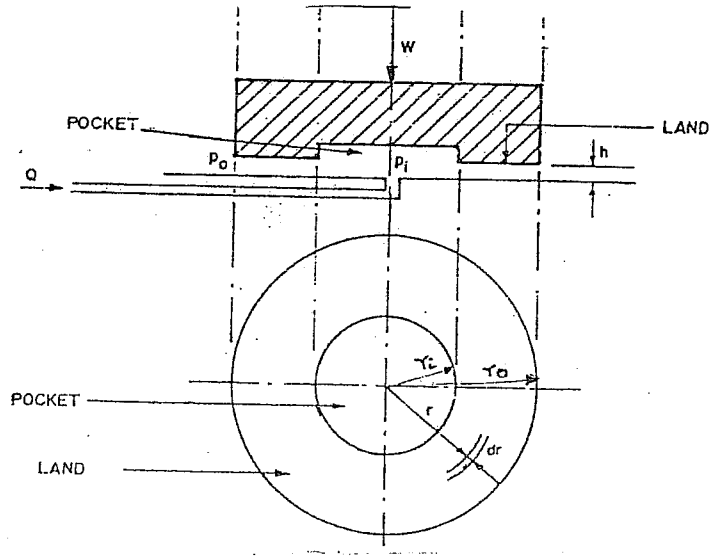


Fig.Q7

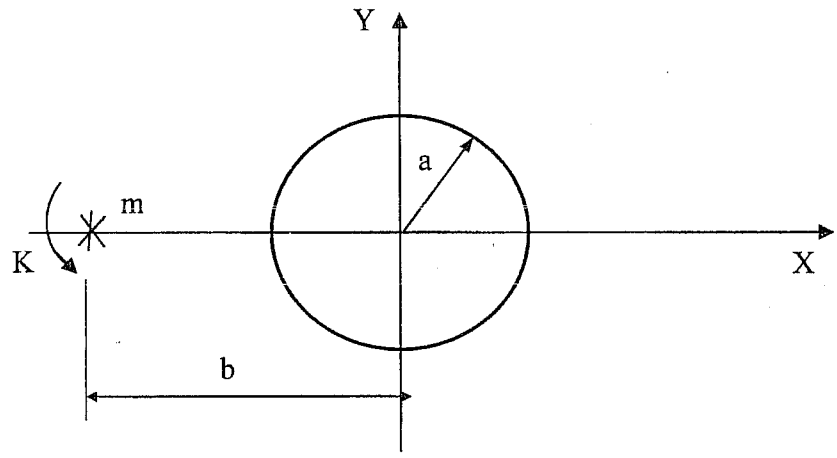
The step bearing of circular shape supports a load W when film thickness is h and the pressure in the pocket is P_i as shown in Fig.Q7. If the fluid is supplied at a rate Q and it escapes through the restriction formed by the annular land surrounding the pocket, show that the load W of the bearing as

$$W = \frac{\pi P_i \left(r_o^2 - r_i^2\right)}{2\log\left(r_o / r_i\right)}$$, where r_i and r_o are inner and outer diameters of the bearing.

Consider the flow rate per unit width in a thin film,

$$Q = \frac{uh}{2} - \frac{h^3}{12\eta} dp/dx$$, with usual notations.

QUESTION 08



A cylinder of radius $|Z| = a$ is placed at the origin of a flow field consisting of a coincident line source of strength m and a line vortex of strength K located at $Z = -b$ where $b>a$. Show that the cylinder is attracted by the coincident singularities by a force

$$F = \frac{-2\pi\rho\left(m^2 + K^2\right)a^2}{b\left(b^2 - a^2\right)}$$

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