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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	**:**	**MEX5230 Fluid Mechanics**
Academic Year	:	2012/13
Date	:	21.08.2013
Time	:	0930hrs-1230hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. Answer five questions.
3. All questions carry equal marks.
4. Density of water = 1000kg/m^3. Acceleration due to gravity = 9.81m/s^2.

QUESTION 1

Show, on the basis of dimensional analysis, that the thrust ***P*** developed by a propeller can be represented by

$$P = D^2V^2\rho \int \frac{D\omega}{V}, \frac{\mu}{DV\rho}, \frac{C}{V}$$

thrust ***P*** depends upon the angular velocity ω, speed of advance ***V***, diameter ***D***, dynamic viscosity μ, mass density ρ, elasticity of the fluid medium which can be denoted by the speed of sound in the medium ***C***.

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QUESTION 2

The cross section of a tank full of water is shown in Figure Q2. The length of the tank is 3m. An empty cylinder lies along the length of the tank on one of its corners as shown in Figure. Find the horizontal and vertical components of the force acting on the curved surface LMN of the cylinder.

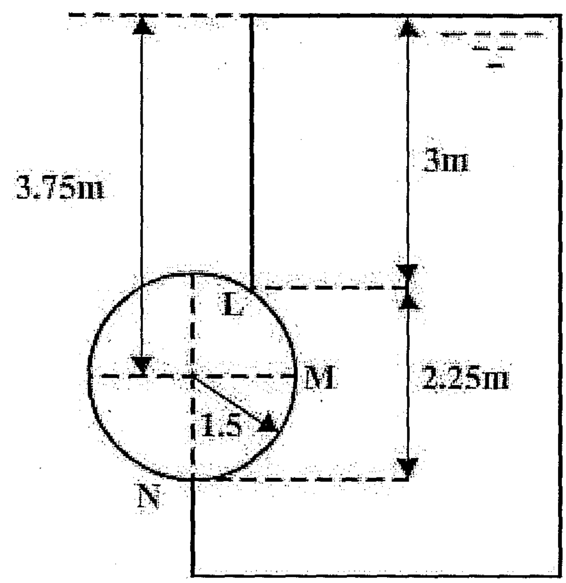

Figure Q2

QUESTION 3

A 250 mm diameter, 3km long straight pipe runs between two reservoirs having a difference of surface elevations of 75m. A 1.5km long 300mm diameter pipe is laid parallel to the 250mm diameter from its midpoint to the lower reservoir. Neglecting all minor losses and assuming a friction factor of 0.02 for both pipes, find the increase in discharge caused by the addition of 300 diameter pipe.

QUESTION 4

(a) The velocity distribution in a pipe is given by

$$\frac{u}{u_{max}} = 1 - \left(\frac{r}{R}\right)^n$$

where u_{max} is the maximum velocity at the centre of pipe, u is the velocity at a distance r from the centre and R is the pipe radius. Obtain an expression for mean velocity in terms of u_{max} and n.

(b) If the diameter of the pipe is 300mm and the maximum velocity of flow is 2m/s find the mean velocity and the radius at which it occurs. Also find the velocity at 50mm from the wall of the pipe.

QUESTION 5

The following data is related to an inclined venturimeter shown in Figure Q5.

Diameter of the pipeline	400mm
Inclination of the pipeline with the horizontal	30°
Throat diameter	200mm
The length of the throat	600mm
Specific gravity of oil flowing through the pipeline	0.7
Specific gravity of manometric fluid	13.6
Height difference of the manometric fluid	50mm

Determine the rate of flow in the pipeline.

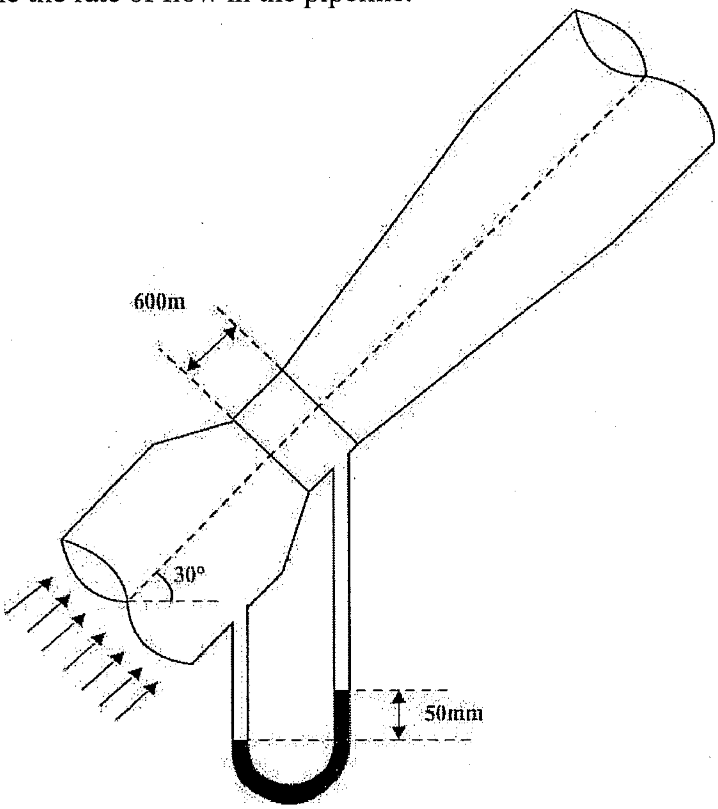

Figure Q5

QUESTION 6

A film of oil with a flow rate of 10^{-3} m^2/s per unit width flows over an inclined ramp that makes an angle of 30 degrees with respect to the horizontal. The width of the oil film δ is unknown. The density of the oil is $\rho = 900$ kg/m^3 and its absolute viscosity 0.42 kg/(ms). Consider a zone over the inclined ramp where the flow can be taken as fully developed as shown in Figure Q6. (i.e. where the velocity does not change with the longitudinal direction). The influence of the lateral walls can be assumed negligible, i.e., assume a very wide oil film so that there is an extended central area where the lateral walls effects are irrelevant. The oil free surface is in contact with the atmosphere; neglect the viscous stresses between the oil and the air and assume an hydrostatic pressure distribution in the surrounding atmosphere. The air density is $\rho_{air} = 1.2 kg/m^3$.

a. Write down the oil mass balance equation and simplify it. Based on the simplified equation determine the velocity component perpendicular to the plate.
b. Write down the oil momentum equation and simplify it. What is the proper boundary condition for the pressure?
c. Compute the pressure in the film in two points over the same cross section, relative to the pressure in the oil free surface in that cross section.
d. Compute an expression for the longitudinal velocity *u(x,y)* as a function of δ . State the necessary boundary conditions.
e. Compute the film width δ and the maximum velocity in the oil

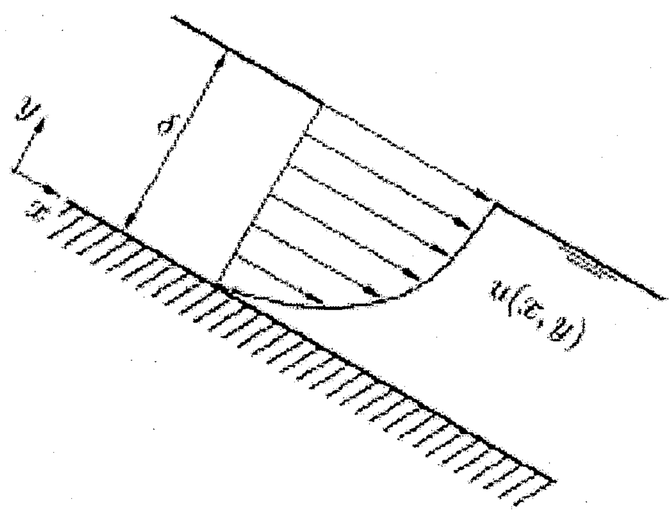

Figure Q6

QUESTION 7

Water flows over a flat plate at a free stream velocity of 0.25m/s at a particular location where there is no pressure gradient, and laminar boundary layer is 7mm thick. Calculate the local shear stress and the skin friction coefficient on the plate.
The velocity distribution in the boundary layer is assumed to be of the form

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

In which ***U*** is the free stream velocity, ***u*** is the velocity in the boundary layer at distance ***y*** from the plate surface and ***δ*** is the boundary layer thickness.
For water, $\mu = 1.02\times10^{-3}$Pas,
$\rho = 1000$kg/m^3

During flow over a flat plate, the laminar boundary layer undergoes a transition to turbulent boundary layer as the flow proceeds in the downstream. If the turbulent velocity at a section is given by

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

calculate the momentum flux within the turbulent boundary layer. Take the width of the boundary layer as ***a*** and thickness as ***δ***.

QUESTION 8

Show that the velocity potential $\phi = \frac{1}{2}\ln\frac{(x+a)^2+y^2}{(x-a)^2+y^2}$ gives a possible motion. Determine the stream function and show that the curves of equal speed are the ovals given by $rr' = C$.