S.E (MECHANICAL) (SEM IV) (CBSGS)
Fluid Mechanics

23rd May, 2014
3.00 pm to 6.00 pm

QP Code : NP-19710

(3 Hours) **[Total Marks : 100**

N.B.:

(1) Question No.1 is compulsory

(2) Attempt any **three** questions out of remaining **five** questions

(3) Figures to right indicate full marks

(4) Assume suitable data if **necessary and justify the same.**

Q.No.1 Answer any 4 **20**

(1) How fluids are classified? Represent different types of fluid on shear stress Vs velocity gradient plot.

(2) A fluid flow is given by $v_r = \left(1-\frac{a}{r^2}\right)\cos\theta,\ v_\theta = -\left(1+\frac{a}{r^2}\right)\sin\theta$

(i) Show that it represents a physically possible flow.

(ii) Determine whether the flow is rotational or irrotational.

(3) Define displacement thickness in boundary layer theory and derive its relation in terms of dimensionless velocity profile, $\frac{u}{U}$, where u is the velocity at a perpendicular distance y from the surface of the flat plate and U is the free stream velocity.

(4) An object is immersed in an air flow with a static pressure of 200 kPa (abs), a static temperature of 20^0 C, and a velocity of 200 m/s. What is the pressure and temperature at the stagnation point?

(5) Two discs of 250 mm diameter are placed 1.5 mm apart and the gap is filled with an oil. A power of 500 W is required to rotate the upper disc at 500 rpm while keeping the lower one stationary. Determine the viscosity of the oil.

Q.No.2

(1) Find the magnitude and direction of the resultant water pressure acting on a curved face of a dam which is shaped according to the relation $y = \frac{x^2}{9}$ as shown in Figure 1. The height of the water retained by the dam is 10 m. Consider the width of the dam as unity **10**

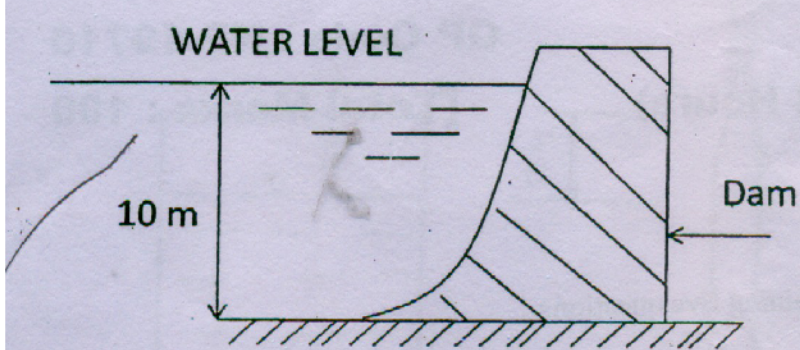

Fig.1

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(2) For the velocity profile for laminar boundary flow $\frac{u}{U} = \sin\left(\frac{\pi y}{2\,\delta}\right)$ where u is the velocity at the distance y from the surface of the flat plate and U be the free stream velocity at the boundary layer thickness δ. Obtain an expression for the boundary layer thickness and the average drag coefficient in terms of the Reynold's number

Q.No.3

8

(1) Consider a viscous incompressible flow of a Newtonian fluid between two parallel planes, separated by a distance 'c'. One of the plates is stationary and the other is moving with a uniform velocity V. There is no pressure gradient in the flow. Workings from Navier-Stokes equation obtain the expression for the discharge and velocity distribution along the vertical direction (direction perpendicular to the direction of fluid flow).

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(2) The streamline is represented by $\Psi = x^2 - y^2$. Determine (i) the velocity and its direction at (2,2), (ii) sketch the streamline and show the direction of flow

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(3) A nozzle is designed to expand air isentropically to atmospheric pressure from a large tank in which properties are held constant at 5^0 C and 304 kPa (abs). The desired flow rate is 1 kg/s. Determine the exit area of the nozzle.

Q.No.4

8

(1) A pipeline 45 m long connects two reservoirs which have a difference of water level of 18 m. For a length of 20 m from the upper tank the pipe diameter is 40 mm and for the remaining part the pipe is 65 mm in diameter. At the change in section a partially

open valve having a K value of 6 is fitted. Considering all major and minor losses calculate the flow rate through the pipeline. Take f =0.022 for both the pipes

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(2) Explain what is meant by separation of boundary layer and describe in detail the methods to control the same?

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(3) Derive an expression for discharge through an orifice meter. Draw a neat sketch of the orificemeter

Q.No.5

8

(1) A vertical reducing bend has a diameter of 300 mm at inlet and 150 mm at exit. The bend is initially horizontal and turns the flow through 120^0. The inlet pressure is 1.4 kg/cm^2 (g) and flow rate through the bend is 225 litres/sec. The exit is 1.4 m below the inlet. The total volume of oil in the bend is 85 litres. Assuming frictionless flow, use the equations of the control volume to determine the magnitude and direction of the resultant force on the bend. Draw a sketch of the set up.

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(2) Write short note on induced drag in an aerofoil

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(3) Drive the $1/7^{th}$ power law velocity profile for turbulent flow in a pipe

Q.No.6

8

(1) A converging –diverging nozzle with an exit area of 40 cm2 and a throat area of 10 cm2 is attached to a reservoir with T= 200C and p = 500 kPa absolute. Determine the the two exit pressures that result in M=1 at the throat for an isentropic flow. Also determine the associated exit temperatures and velocities.

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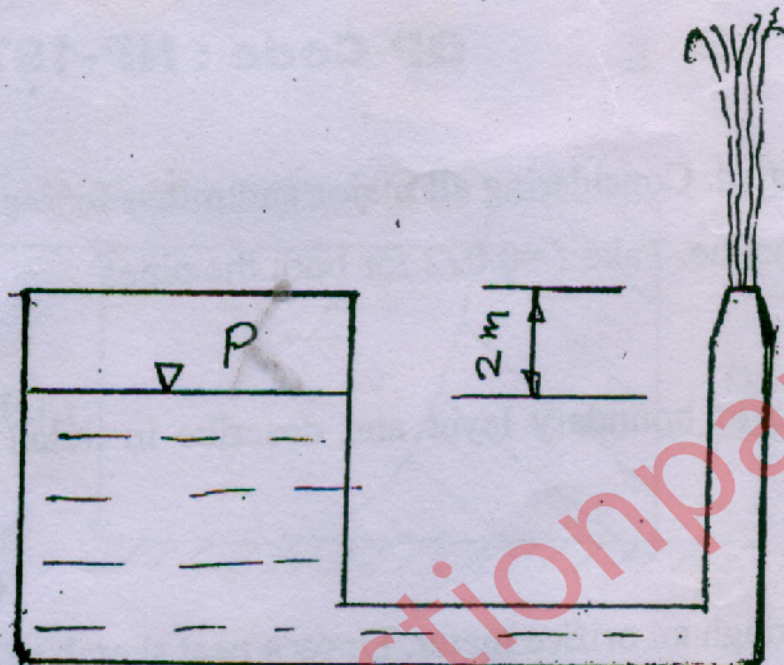
(2) A pipe is connected to a pressurized chamber as shown in the diagram. If the jet of water issuing from the nozzle rises to a height of 14 m calculate the pressure in the tank. The pipe diameter is 60 mm and the nozzle exit diameter is 25 mm. Assume the flow to be frictionless



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(3) Explain the following terms with reference to fluids:

(i) Source and sink (2) circulation and vorticity (3) stream function and velocity potential function