8. a) Deduce the Hagen-Poiseuille Equation for steady, laminar, fully-developed, incompressible flow through a circular

   pipe, in the form $Q = \dfrac{\pi D^4}{128\mu L}\Delta P$

   All symbols have their usual meanings. 9

   (b) Hence show that the average velocity of a Newtonian fluid, flowing under fully-developed condition through a circular pipe, is half of the maximum velocity. 6

9. (a) Specific speed of hydraulic turbines is given by $Ns=(N\sqrt{P})/H^{5/4}$ 5

   b) In a Francis turbine the supply head is 12 m and flow rate is 0.28 m³/s, outer diameter is half the inner diameter 12 m. The velocity of flow is 0.15√(2gH). The inner vanes are radial at inlet and runner rotates at 300 rpm. The hydraulic efficiency is 80%. Determine guide vane angle and runner vane angle at exit for radial discharge. 5

   c) A Pelton wheel is driven by two similar jets transmits 3750 kW to the shaft running at 375 rev/min. The total head available is 200 m and losses are 0.1 times of the total head. The diameter of the wheel is 1.45 m, the relative velocity coefficient of the bucket is 0.9, and the deflection of the jet is 165⁰. Find the hydraulic efficiency, overall efficiency and the diameter of each jet, if the mechanical efficiency is 90%. 5

10. a) Define Displacement thickness and Momentum thickness. 4

    b) For the velocity profile for laminar boundary layer,

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

    Determine the boundary layer Thickness, Shear stress, Drag Coefficient in terms of Reynolds number. 11

11. a) State Buckingham's π -theorem.

    b) The pressure difference in a pipe depends on diameter D, length L, velocity V, viscosity . Density p and roughness K. Using Buckingham's π-theorem obtain an expression for . 3+12

2014
Fluid Mechanics & Hydraulic Machines

Time Allotted : 3 Hours   **Full Marks : 70**

The figure in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternative of the following   10x1=10

   i. For a two-dimensional flow field, the equation of a stream line is given by –

   a) $\dfrac{dx}{u} = \dfrac{dy}{v}$ b) $\dfrac{dx}{v} = \dfrac{dy}{u}$ c) $\dfrac{u}{dx} = \dfrac{dy}{v}$ d) $\dfrac{du}{dx} + \dfrac{dv}{dy} = 0$

   ii. Convective acceleration is zero for a –
   a) steady flow   b) uniform flow
   c) non-uniform flow   d) unsteady flow

   iii. What is the dimension of kinematic viscosity?
   a) MLT^2 b) $ML^{-1}T^{-1}$ c) L^3T^{-1} d) L^2T^{-1}

   iv. Lift force is defined as the force exerted by a flowing fluid on a solid body –
   a) In the direction of flow
   b) Perpendicular to the direction of flow
   c) At an angle of 45⁰ to the direction of flow
   d) None of the above

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v. The co-efficient of discharge C_d in terms of C_v and C_c is –
   a) $C_d = C_v / C_c$
   b) $C_d = C_v \times C_c$
   c) $C_d = C_c / C_v$
   d) None of the above

vi. Bernoulli's theorem deals with the law of conservation of–
   a) mass b) momentum c) energy d) none of the above

vii. Reynold's number is define as the –
   a) ratio of inertia force to gravity force
   b) ratio of viscous force to gravity force
   c) ratio of viscous force to elastic force
   d) ratio of inertia force to viscous force

viii. Francis turbine is –
   a) An impulse turbine   b) A radial flow impulse turbine
   c) An axial flow turbine d) A reaction radial flow turbine

ix. The specific speed of a pump is the speed at which a pump runs when –
   a) Head developed is unity and discharge is one cubic meter
   b) Head developed is unity and shaft horse power is also unity
   c) Discharge is one cubic meter and shaft power is unity
   d) None of the above

x. Cavitation will take place if the pressure of the flowing fluid at any point is –
   a) More than the vapour pressure of the fluid
   b) Equal to the vapour pressure of the fluid
   c) Is less than the vapour pressure of the fluid
   d) None of the above

Group-B

(Short answer type questions)

Answer any *three* of the following   5x3=15

2. The velocity fiekd in a fluid flow is given by, $v = x^2 y\hat{i} - y^2 z\hat{j} + (2xyz + yz^2)\hat{k}$. Determine the velocity and acceleration at (1, 1, 2).   5

3. Water flows over a rectangular weir 1m wide at a depth of 150mm and afterwards passes through a triangular right-angled weir. Taking C_d for the rectangular weir and triangular weir as 0.62 and 0.59 respectively, find the depth of water over the triangular weir.   5

4. An inverted U-tube manometer is connected to two horizontal pipes A and B through which water is flowing. The vertical distance between the axes of these pipes is 30 cm. When an oil of specific gravity 0.8 is used as a gauge fluid, the vertical heights of water columns in the two limbs of the inverted manometer (when measured from the respective centre lines of the pipes) are found to be same and equal to 35 cm. Determine the difference of pressure between the pipes.   5

5. Explain the terms : (i) Path line, (ii) Streak line, (iii) Stream line   5

6. Show that the efficiency can never exceed 50%, when a jet strike normally on a series of flat plates mounted on the periphery of a wheel.   5

Group – C

(Long answer type questions)

Answer any *three* of the following   3x15=45

7. a) A Venturimeter is to be fitted in a 150 mm dia. Pipeline horizontally at a section where the pressure is 100 KN/m². If the maximum flow of water in the pipe is 150 ltr/Sec, find the diameter of the throat so that the pressure at the throat does not fall below 75kN/m²(Vacuum). Assume that 3% of the differential head is lost between the inlet and the throat.   8

b) The internal and external diameter of a centrifugal pump is 300 mm and 600 mm respectively. The pump runs at 1000 rpm. The vane angles at inlet and outlet are 20° and 30° respectively. Water enters the impeller radially, the velocity of flow is constant. Determine the work done by the impellor per unit weight of water.   7