Total No. of printed pages = 4

CE 181401

30/6/23

Roll No. of candidate | | | | | | | | | | |

2023

B.Tech. 4th Semester End-Term Examination

HYDRAULICS AND HYDRAULIC MACHINES

(New Regulation) (w.e.f. 2017–18)) & (New syllabus) (w.e.f. 2018-19))

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any *four* questions.

1. Choose the correct answer : (10 × 1 = 10)

(i) The friction factor (f) in pipe flow with velocity (V) of a liquid having density (ρ) in terms of shear stress (τ_0) is given by

(a) $f = \frac{8\tau_0}{\rho V^2}$ (b) $f = \frac{2\tau_0}{\rho V^2}$

(c) $f = \frac{\tau_0}{8\rho V^2}$ (d) $f = \frac{2\rho V^2}{\tau_0}$

(ii) The drag force (F_D) on a sphere of diameter (D) over which fluid is flowing with a velocity of U for Reynold's no. (Re) less than 0.2 is given by

(a) $F_D = \pi \mu DU$ (b) $F_D = 3\pi \mu DU$

(c) $F_D = \frac{24}{R_e}\pi D^2 U^2$ (d) $F_D = \frac{24}{R_e} 1 + \left[1 + \frac{3}{16 R_e}\right]$

(iii) In case of laminar flow between two straight stationary parallel plates the ratio of the maximum velocity to the average velocity is equal to

(a) 0.5 (b) 1.25

(c) 1.5 (d) 2

[Turn over

(iv) Kaplan turbine is

(a) Low head, high discharge axial flow reaction turbine

(b) High head, low discharge axial flow reaction turbine

(c) Low head, high discharge radial flow reaction turbine

(d) High head, low discharge radial flow reaction turbine

(v) A turbine is called reaction turbine if at the inlet of the turbine, the total energy is

(a) kinetic energy only

(b) pressure energy only

(c) potential energy, kinetic energy and pressure energy

(d) kinetic energy and pressure energy

(vi) The condition for the flow detached from the boundary after separation _____

(a) $\left(\frac{\partial u}{\partial y}\right)_{y=0} = -ve, \frac{\partial p}{\partial x} = -ve$

(b) $\left(\frac{\partial u}{\partial y}\right)_{y=0} = +ve, \frac{\partial p}{\partial x} = +ve$

(c) $\left(\frac{\partial u}{\partial y}\right)_{y=0} = 0, \frac{\partial p}{\partial x} = 0$

(d) $\left(\frac{\partial u}{\partial y}\right)_{y=0} = -ve, \frac{\partial p}{\partial x} = +ve$

(vii) When a falling body has attained terminal velocity, the weight of the body is equal to

(a) drag force + buoyant force

(b) drag force – buoyant force

(c) buoyant force – drag force

(d) drag force

(viii) The force exerted by a curved plate in the direction of jet is equal to

(a) ρAV^2

(b) $\rho AV^2 \sin^2\theta$

(c) $\rho AV^2 (1 + Cos\,\theta)$

(d) $\rho AV^2 (1 - \sin\theta)$

(ix) The work saved by fitting an air vessel to a single-acting reciprocating pump is

(a) 92.3%

(b) 84.4%

(c) 66.67%

(d) 39.2%

(x) In case of smooth pipe, the expression for laminar sub-layer thickness (δl) is

(a) $\frac{10.6 u_*}{\upsilon}$

(b) $\int_0^{\delta} \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$

(c) $\frac{11.6 u_*}{\upsilon}$

(d) $\frac{11.6 \upsilon}{u_*}$

2. (a) If the velocity distribution within the laminar boundary layer on a flat plate is assumed to in the form, $u = a\sin(by) + c$, where a, b, c are constants, determine the velocity distribution law. (4)

(b) A cylinder rotates at 200 r.p.m. with its axis perpendicular to the stream of air having a velocity of 20 m/s,. The cylinder is 2m in diameter and 8m long. Find-

(i) the circulation

(ii) the position of stagnation points

(iii) the speed of rotation of the cylinder for single stagnation point

Take, $\rho_{air} = 1.24\ kg/m^3$. (6)

(c) A sphere 5 cm in diameter and of relative diameter 2.5 is attached to a string is suspended from the roof of a wind tunnel. If an air stream flows past the sphere with a speed of 80 kmph, find the inclination of the string to the horizontal and the tension in the string. (5)

Take, $\rho_{air} = 1.25\ kg/m^3$, $\eta_{air} = 1.4 \times 10^{-5}\ m^2/s$

$C_d = 0.5$ for $10^4 < \text{Re} < 3\times 10^5$; $C_d = 0.2$ for $\text{Re} \geq 3 \times 10^5$

3. (a) Starting from N-S equation derive the expression for velocity distribution and rate of flow for laminar flow between two straight stationary parallel plates with non- zero pressure gradient. (8)

(b) Crude oil of $\mu = 1.5$ poise and relative density 0.9 flows through a 25 mm diameter vertical pipe. Two pressure gauges are fixed 20 m apart and the at pressure readings at lower one and upper one read 60.25 N/cm² and 20.65 N/cm² respectively. Find the direction and rate of flow. (7)

4. (a) Considering pipe to be elastic and water to be compressible, derive an expression for intensity of pressure developed inside the pipe due to sudden closure of the valve in water hammer situation. (8)

(b) The velocity of flow in a rough 10 cm pipe is found to increase 10% as a pitot tube is moved from a point 1.5 cm from the wall to a point 3.0 cm from the wall. To Estimate the relative roughness $\frac{r_0}{\epsilon}$ and friction factor of the pipe, where r_0 be the radius of the pipe and ϵ, the pipe surface roughness. (7)

5. (a) A jet of water of diameter 7.5 cm strikes a smooth curved plate at its centre with a velocity of 25 m/s. The curved plate is moving with a velocity of 10 m/s in the direction of the jet. The jet is deflected through an angle of 165°. Find

(i) The force exerted on the plate in the direction of the jet

(ii) Power of the jet. (4)

(b) A Kaplan turbine working under a head of 15 m is running at 120 r.p.m. If the vane angle at the extreme edge of the runner at outlet is 15° and flow ratio is 0.6, find the velocity of flow and the diameter of the runner. (5)

(c) A Pelton wheel is having a mean bucket of 1.2m and is running at 1200 r.p.m. The net head on the turbine is 750 m. If the side clearance is 15° and the discharge through the nozzle is 0.12 m^3/s. Take $C_v = 0.98$. Find - (6)

(i) Power available at the nozzle

(ii) Hydraulic efficiency of the turbine.

6. (a) A centrifugal pump is running at 1000 r.p.m. The outlet vane angle of the impeller is 45° and velocity of flow at outlet is 2.5m/s. The discharge through the pump is 200 litres/s, when the pump is working against a total head of 20m. If the manometric efficiency of the pump is 80%, determine the diameter of the impeller and the width of the impeller at outlet. (9)

(b) Draw and explain the indicator diagram considering the effect of acceleration and friction in suction and delivery pipes of a reciprocating pump. (6)

7. (a) Explain Prandtl mixing length theory and find the expression for turbulent shear stress. (6)

(b) Write short notes with sketches where necessary: (any *three*): (3×3=9)

(i) Cavitation and its effect in Hydraulic machines

(ii) Karman Vortex trail

(iii) Moody's Diagram for friction factor in pipe

(iv) Hydraulically rough and smooth boundary

(v) Hardy cross Method.
