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AS-4139

B. Tech. (Fifth Semester) Examination, 2013

(Civil Engg. Branch)

FLUID MECHANICS-II

(CE31T03)

Time Allowed : Three hours

Maximum Marks : 60

Note : *Section A carries 20 marks and Section B carries 40 marks. Attempt both the section.*

Section-A **10×2=20**

Note : *Answer all questions. Each question carries 2 marks.*

Department of Civil Engineering

Institute of Technology, GGV

B.Tech. Third Year [Vth Sem.]

Subject: Fluid Mechanics II

Subject Code: CE31T03

Maximum Masks:60

SET- II

Note: (i) Section-A, all questions carry equal marks. 02 Marks allotted for each question.

(ii) Section-B, Attempt any one question from each Unit. All question carry equal Marks.

SECTION – A

Q(1) In turbulent flow the shear stress is mainly due to the

(a) density of the fluid (b) dynamic viscosity of the fluid

(c) kinematic viscosity of the fluid (d) eddy viscosity of the fluid

ANSWER: (d)

Q(2) The losses are more in

(a) laminar flow (b) turbulent flow (c) transition flow (d) critical flow

ANSWER: (b)

Q(3) For boundary layer thickness δ, velocity u is given by expression

(a) $u=0.88\ U_\infty$ (b) $U_\infty=0.99\ u$ (c) $u=0.99\ U_\infty$ (d) $U_\infty=0.88\ u$

where u is velocity at *y* distance from wall, U_∞= Free stream velocity

ANSWER: (c)

Q(4) The wake

(a) always occurs before a separation point (b) always occurs after a separation point

(c) is a region of high pressure intensity (d) none of the above

ANSWER: (b)

Q(5) In a channel the alternate depth of flow are the depths

(a) which occur at the same specific energy (b) at which total energies are same

(c) for the same specific force (d) none of the above

ANSWER: (a)

Q(6) When Froude Number is in between 4.5 to 9, type of jump is

(a) Oscillating Jump (b) Strong Jump (c) Uniform Jump (d) Steady Jump

ANSWER: (d)

Q(7) The rapid closure of valve in a water pipeline will result in water hammer pressure of magnitude:

(a) $\rho C^2 V$ (b) ρ/CV^2 (c) $\rho C/V$ (d) ρCV

ANSWER: (d)

Q(8) . Dimensional analysis is useful in

(a) checking the correctness of a physical equation

(b) determining the number of variables involved in a particular phenomenon

(c) determining the dimensionless groups from the given variables

(d) the exact formulation of a physical phenomenon

ANSWER: (c)

Q(9) In a Francis turbine, maximum efficiency is obtained when

(a) relative velocity is radial at the outlet (b) absolute velocity is radial at the outlet

(c) velocity of flow is constant (d) guide vane angle is 90 degrees

ANSWER: (a)

Q(10) A fast centrifugal pump impeller will have

(a) Propeller type blades (b) Parabolic blades

(c) Backward facing blades (d) Forward facing blades

ANSWER: (c)

SECTION – B

Unit-I

Q (1)(a) Explain in brief Colebrook-White equation. **Marks 02**

* for Smooth Pipe $\frac{1}{\sqrt{f}} - 2\log_{10}\left(\frac{d}{k_s}\right) = \log_{10} R\left(\frac{k_s}{d}\right)\sqrt{f} - 0.80$

OR $\frac{1}{\sqrt{4f}} - 2\log_{10}\left(\frac{R}{k}\right) = 2\log_{10}\left(Re\sqrt{4f}\right) - 0.8 - 2\log_{10}\left(\frac{R}{k}\right)$

* For Rough Pipe - $\frac{1}{\sqrt{f}} - 2\log_{10}\frac{d}{k_s} = 1.14$

OR $\frac{1}{\sqrt{4f}} - 2\log_{10}\left(\frac{R}{k}\right) = 2\log_{10}\left(\frac{R}{k}\right) + 1.74 - 2\log_{10}\left(\frac{R}{k}\right) = 1.74$

(b)A rough pipe of diameter 50 cm and length 500m carries water at the rate of 0.50 m^3/sec The wall roughness is 0.020 mm Determine (i) coefficient of frication (ii) center line velocity. (iii) velocity at a distance of 20 cm from the pipe wall. **Marks 06**

$D = 50cm = 0.50m \quad L = 500m \quad Q = 0.50m^3/sec \quad k = 0.020\times10^{-3}m$

$R = \frac{50}{2}cm = 0.25m$

① The value of coefficient of friction f for Rough pipe is given by

$\frac{1}{\sqrt{4f}} = 2\log_{10}\left(\frac{R}{k}\right) + 1.74 \qquad \frac{1}{\sqrt{4f}} = 2\log_{10}\left(\frac{0.25}{0.020\times10^{-3}}\right) + 1.74$

$\frac{1}{\sqrt{4f}} = 9.9338 \quad \therefore f = 0.00253$

(2) Centre - line Velocity (U_{max})

for Rough pipe is given by $\frac{U_{max}}{U_*} = 5.75\log_{10}\left(\frac{R}{k}\right) + 8.5$

$U_* = \sqrt{\frac{\tau_0}{\rho}} \Rightarrow \tau_0 = \frac{f\cdot\rho\cdot V^2}{2} \quad \therefore V = \frac{Q}{A} = \frac{0.50}{\frac{\pi(0.5)^2}{4}} = \frac{1\times4}{\pi\times0.5} = 2.54m/sec$

$\tau_0 = \frac{0.00253\times1000\times(2.54)^2}{2} = 8.21\ N/m^2$

$U_* = \sqrt{\frac{8.21}{1000}} = 0.090\ m/sec \qquad \frac{U_{max}}{U_*} = 5.75\log_{10}\left(\frac{0.25}{0.020\times10^{-3}}\right) + 8.5$

$\therefore U_{max} = 0.090\times32.057 = 2.885\ m/sec$

③ velocity at 20 cm from pipe wall $\quad \frac{u}{U_*} = 5.75\log_{10}\left(\frac{y}{k}\right) + 8.5$

$u = 0.090\times\left[5.75\log_{10}\left(\frac{0.20}{0.020\times10^{-3}}\right) + 8.5\right] = 0.090\times31.50 = 2.835m/sec$

OR

Q (2) (a) What is explicit equation? **Marks 02**

For Given Reynolds number R and relative roughness ks/d, evaluation of friction factor requires a trial ~~proced~~ procedure. Explicit equation on the other hand enable direct computation of friction factor there by eliminating many trials otherwise necessary.

For Smooth - turbulent flow - $f = \frac{0.3164}{R^{0.25}} \qquad R \le 10^5$

Jain - $\frac{1}{\sqrt{f}} = 1.8\log_{10}R - 1.5786 \qquad R \le 10^8$

$f = a + bR^{-c}$

$\frac{1}{\sqrt{f}} = 1.14 - 2\log_{10}\left[\frac{k_s}{d} + \frac{21.25}{R^{0.9}}\right] \qquad a = 0.094(k_s/d)^{0.225} + 0.53\,k_s/d$

$b = 88(k_s/d)^{0.44} \quad C = 1.62\left(\frac{k_s}{d}\right)^{0.134}$

(b) For turbulent flow in pipe of diameter 200 mm, Find the discharge when center line velocity is 30 m/sec and at a point 80 mm from the center as measured by pitot tube is 2.0 m/sec.

Marks 06

$D = 200mm = 0.20m \qquad R = \frac{0.20}{2} = 0.10m$

$u_{max.} = 30 m/sec \qquad y = R - r = 0.1 - 0.08 = 0.02m.$

$$\frac{u_{max} - u}{u_*} = 5.75 \log_{10}\left(\frac{R}{y}\right)$$

$$\frac{30 - 2}{u_*} = 5.75 \log_{10} \frac{0.10}{0.02} \Rightarrow \frac{28}{u_*} = 4.019 \, m/sec$$

$$\therefore u_* = \frac{28}{4.019} = 6.96 \, m/sec$$

$$\frac{u_{max.} - \bar{U}}{u_*} = 5.75 \log_{10}\left(\frac{y}{R}\right) + 3.75 \Rightarrow \frac{30 - \bar{U}}{6.96} = 5.75 \log_{10}\left(\frac{R}{R}\right) + 3.75$$

$$= 5.75 \log_{10}(1) + 3.75$$

$$\frac{30 - \bar{U}}{6.96} = 3.75 \Rightarrow 30 - \bar{U} = 26.10 \qquad \bar{U} = 30 - 26.10 = 3.90 \, m/sec$$

$$\therefore Q = \text{Area} \times \text{Velocity (Avg)} = \frac{\pi \times D^2}{4} \times \bar{U} = \frac{\pi \times 0.2^2}{4} \times 3.90 = 0.1224 \, m^3/sec$$

Unit-II

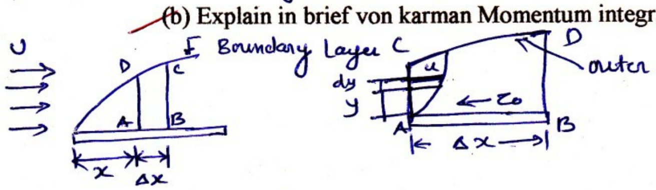
Q (1) (a) What is Boundary layer thickness?

Marks 02

Boundary Layer thickness - It is defined as the distance from the boundary of the solid body measured in the y-direction to the point, where the velocity of the fluid is approximately equal to 0.99 times the free stream velocity (U) of the fluid. It is denoted by the symbol δ.

(b) Explain in brief von karman Momentum integral equation for boundary layer flow.

Marks 06



The mass rate of flow entering through the side AD

$= \int_0^\delta \rho \times \text{velocity} \times \text{area of strip of thickness } dy$

$= \int_0^\delta \rho u b \, dy$

$\therefore \Delta F_D = \text{Shear stress} \times \text{area} = \tau_0 \times \Delta x \times b$

Mass rate of flow leaving the side BC

$= \text{mass through } AD + \frac{\partial}{\partial x}(\text{mass through } AD) \times \Delta x$

$= \int_0^\delta \rho u b \, dy + \frac{\partial}{\partial x}\left[\int_0^\delta (\rho u b \, dy)\right] \Delta x.$

Mass Rate of flow entering AD + mass rate of flow entering DC = mass rate of flow leaving BC

$\because$ Mass Rate of flow entering DC = mass rate of flow through BC − mass rate of flow through AD

$$= \int_0^{\delta} \rho u b dy + \frac{\partial}{\partial x}\left[\int_0^{\delta} \rho u b dy\right]\Delta x - \int_0^{\delta} \rho u b dy$$

$$\therefore = \frac{\partial}{\partial x}\int_0^{\delta}(\rho u b dy)\Delta x$$

Rate of change of momentum of the control volume = M.F. through BC − M.F. through AD − M.F. through DC

$$= \int_0^{\delta} \rho u^2 b dy + \frac{\partial}{\partial x}\left[\int_0^{\delta}(\rho u^2 b dy)\Delta x\right] - \int_0^{\delta} \rho u^2 b dy - \frac{\partial}{\partial x}\left[\int_0^{\delta}(\rho u U b dy)\Delta x\right]$$

$$= \frac{\partial}{\partial x}\left[\rho b \int_0^{\delta}(u^2 - uU) dy\right] \times \Delta x = \Delta F_D = -\tau_0 \times \Delta x \times b$$

$$\therefore \tau_0 = -\rho \frac{\partial}{\partial x}\left[\int_0^{\delta}(u^2 - uU) dy\right] = \rho \frac{\partial}{\partial x}\int_0^{\delta}(uU - u^2) dy = \rho U^2 \frac{\partial}{\partial x}\left[\int_0^{\delta}\frac{u}{U}\left(1 - \frac{u}{U}\right) dy\right]$$

$$\because \tau_0 = \rho U^2 \frac{\partial}{\partial x}\left[\int_0^{\delta}\frac{u}{U}\left(1 - \frac{u}{U}\right) dy\right] = \rho U^2 \frac{\partial \theta}{\partial x}$$

$$\because \boxed{\frac{\tau_0}{\rho U^2} = \frac{\partial \theta}{\partial x}}$$

OR

Q (2) (a) Explain in brief local friction coefficient. of Drag $[C_D^*]$ **Marks 02**

Local friction Coefficient – It is defined as the ratio of the Shear Stress τ_0 to the quantity $\frac{1}{2}\rho U^2$. It is denoted by C_D^*

$$\therefore C_D^* = \frac{\tau_0}{\frac{1}{2}\rho U^2}$$

(b) Find Displacement thickness and Energy thickness for velocity distribution in the boundary layer given by $\frac{u}{U} = 2\left[\frac{y}{\delta}\right] - \left[\frac{y}{\delta}\right]^2$ **Marks 06**

① Displacement thickness

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

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

$$\delta^* = \int_0^{\delta}\left\{1 - \left[2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2\right]\right\} dy$$

$$= \left[y - \frac{2y^2}{2\delta} + \frac{y^3}{3\delta^2}\right]_0^{\delta}$$

$$= \delta - \frac{\delta^2}{\delta} + \frac{\delta^3}{3\delta^2} = \delta - \delta + \frac{\delta}{3}$$

$$\boxed{\delta^* = \frac{\delta}{3}}$$

(2) Energy thickness (δ^{**})

$$\delta^{**} = \int_0^{\delta} \frac{u}{U}\left(1-\frac{u^2}{U^2}\right)dy \qquad \delta^{**} = \int_0^{\delta} \left[2\left(\frac{y}{\delta}\right)-\left(\frac{y}{\delta}\right)^2\right] \times \left[1-\left[2\left(\frac{y}{\delta}\right)-\left(\frac{y}{\delta}\right)^2\right]^2\right] dy$$

$$\delta^{**} = \int_0^{\delta}\left(\frac{2y}{\delta}-\frac{y^2}{\delta^2}\right)\left(1-\frac{4y^2}{\delta^2}-\frac{y^4}{\delta^4}+\frac{4y^3}{\delta^3}\right)dy$$

$$= \left[\frac{2y^2}{2\delta}-\frac{y^3}{3\delta^2}-\frac{8y^4}{4\delta^3}+\frac{12y^5}{5\delta^4}-\frac{6y^6}{6\delta^5}+\frac{y^7}{7\delta^6}\right]_0^{\delta}$$

$$= -2\delta-\frac{\delta}{3}+\frac{12}{5}\delta+\frac{\delta}{7} \qquad \therefore \boxed{\delta^{**} = \frac{22}{105}\delta}$$

$$= \frac{-245\delta+267\delta}{105} = \frac{22\delta}{105}$$

Unit-III

Q(1) (a) Explain in brief strong hydraulic jump. **Marks 02**

Strong Hydraulic Jump – For Froude number greater than 9.0 the Surface downstream of the jump is rough and the energy dissipation may be upto 85%.

strong jump ($F_r > 9$)

(b) A 4.0 m wide rectangular channel convey 20 m^3/sec of water at a depth of 2.0 m. Calculate (i) specific energy and critical depth (ii) critical velocity and minimum specific energy. Also compute the Froude number and comment on the nature of flow.

Marks 06

Discharge = 20 m^3/sec b = 4.0 m depth y = 2.0 m

(1) Specific Energy (E) is given by $\quad V = \frac{Q}{A} = \frac{20}{b \times y} = \frac{20}{4 \times 2} = 2.5$ m/sec

$$E = y + \frac{V^2}{2g} = 2.0 + \frac{(2.5)^2}{2 \times 9.81} = 2.31\ m$$

(2) Critical velocity ($F_r = 1$) $\quad F_r = \frac{V_c}{\sqrt{g y_c}} = 1.0$

$$V_c = \sqrt{g y_c} \qquad V_c = \sqrt{g y_c}$$

$$\text{But } y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left[\left(\frac{20}{4}\right)^2 \times \frac{1}{9.81}\right]^{1/3} = \left(\frac{5^2}{9.81}\right)^{1/3} = 1.37\ m$$

$$V_c = \sqrt{9.81 \times 1.37} = 3.671\ m/sec$$

(3) E_{min} $\quad \therefore E_{min} = \frac{3}{2} y_c = 1.5 \times 1.37 = 2.055$ m.

(Specific Energy minimum.)

① Specific Energy = 2.31 m.

critical depth = 1.37 m.

② Critical velocity = 3.67 m/sec

minimum specific Energy = 2.055 m.

③ Froude Number $Fr = \frac{V}{\sqrt{gy}} = \frac{2.5}{\sqrt{9.81 \times 2.0}} = \frac{2.5}{4.429} = 0.564$

Flow is Sub Critical (Fr < 1)

OR

Q (2) (a) Explain in brief critical flow. **Marks 02**

FOR RECTANGULAR CHANNEL

$Fr = \frac{V}{\sqrt{gy}}$ when Fr = 1 the flow is critical

OR $V_c = \sqrt{g y_c}$ y_c = Critical depth

whe Specific energy is minimum and $\left| \frac{Q^2}{g} = \frac{A^3}{T} \right|$

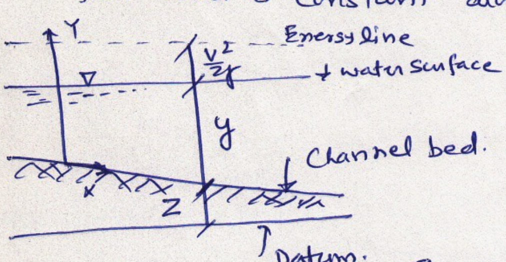
(b) Derive an expression for gradually varied flow. **Marks 06**

Assumptions :- ① flow is steady ② Pressure Distribution Hydrostatic

③ head loss is same as uniform flow ④ channel slope is small.

⑤ channel is prismatic ⑥ K.E. correction factor = 1.0.

⑦ the channel Roughness does not depend upon the depth of flow and is constant along the channel length.



$$H = z + y + \frac{V^2}{2g}$$

$$\frac{dH}{dx} = \frac{dz}{dx} + \frac{dy}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right)$$

Se = slope of the energy line

So = Slope of the Channel bottom.

$$-S_e = -S_0 + \frac{dy}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right) = -S_0 + \frac{dy}{dx} + \frac{d}{dy}\left(\frac{Q^2}{2gA^2}\right)\frac{dy}{dx}$$

$$\frac{dy}{dx} = \frac{S_0 - S_e}{1 - \frac{Q^2}{gA^3}\frac{dA}{dy}}$$

$$\therefore \frac{dy}{dx} = \frac{S_0 - S_e}{1 - \frac{V^2}{gD}} \qquad \frac{Q^2 T}{gA^3} = \frac{V^2}{gD} = F^2$$

$$\boxed{\because \frac{dy}{dx} = \frac{S_0 - S_e}{1 - F^2}}$$

Unit-IV

Q(1) (a) Discuss the factor which affect the magnitude of pressure rise in water hammer in pipes. **Marks 02**

① the velocity of flow of water in pipe
② the length of pipe
③ time taken to close the valve
④ elastic properties of the material of the pipe.

(b) Using Buckingham's π- theorem, show that the velocity through a circular orifice given by

V= √2gH Φ[D/H, μ/ρVH] **Marks 06**

Total Number of Variable $n = 6$

$\therefore$ Number of π terms $= n - m = 6 - 3 = 3$

$$\therefore f_1(\pi_1, \pi_2, \pi_3) = 0$$

$$\therefore \pi_1 = H^{a_1} \cdot g^{b_1} \cdot \rho^{c_1} \cdot V$$

$$\pi_2 = H^{a_2} \cdot g^{b_2} \cdot \rho^{c_2} \cdot D$$

$$\pi_3 = H^{a_3} \cdot g^{b_3} \cdot \rho^{c_3} \cdot \mu$$

$M^0L^0T^0 = L^{a_1}(LT^{-2})^{b_1}(MT^{-3})^{c_1} LT^{-1}$

$\therefore a_1 = -\frac{1}{2} \quad b_1 = -\frac{1}{2} \quad c_1 = 0 \qquad \therefore \pi_1 = H^{-1} g^{-1} \rho^0 V = \frac{V}{\sqrt{gH}}$

$\pi_2 = M^0L^0T^0 = L^{a_2}(LT^{-2})^{b_2}(ML^{-3})^{c_2}.L$

$a_2 = -1 \quad b_2 = 0 \quad c_2 = 0$

$M^0L^0T^0 = H^{a_3}\rho^{b_3}\rho^{c_3}\mu \qquad \pi_2 = H^{-1}, g^6, \rho^0, .D = \frac{D}{H}$

$M^0L^0T^0 = L^{a_3}.(LT^{-2})^{b_3}.(ML^{-3})^{c_3}, (ML^{-1}T^{-1})$

$a_3 = -3/2 \quad b_3 = -\frac{1}{2} \quad c_3 = -1 \qquad \pi_3 = \frac{\mu}{\sqrt{g}\rho H^{3/2}}$

$\therefore f_1\left(\frac{V}{\sqrt{gH}}, \frac{D}{H}, \frac{\mu}{H\rho V}\right) = 0$

$\therefore \frac{V}{\sqrt{gH}} = \phi\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$ **OR** $\therefore V = \sqrt{2gH}\,\phi\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$

Q (2) (a) Explain in brief dimensional analysis. **Marks 02**

Dimensional Analysis is a method of dimensions. It is mathematical technique used in research work for design and for conducting model tests. It deals with the dimensions of the physical quantities involved in the phenomenon. All physical Quantities are measured by comparison, which is made with respect to an arbitraily fixed Value.

(b) In the model test of a spillway the discharge and velocity of flow over the model were 3.0 m^3/sec and 1.5 m/sec respectively. Calculate the velocity and discharge over the Prototype which is 36 times the model size.

Applying Froude number Similarity **Marks 06**

$$\frac{V_p}{\sqrt{l_p g_p}} = \frac{V_m}{\sqrt{l_m g_m}} \Rightarrow \frac{V_p}{V_m} = \sqrt{\frac{l_p}{l_m}} = \sqrt{36}$$

$$\therefore \frac{V_p}{V_m} = 6 \qquad \therefore \boxed{V_p = 6V_m}$$

$$V_p = 6 \times 1.5 \text{ m/sec} = 9.0 \text{ m/sec}$$

Discharge $Q = AV = l^2 V$

$$\therefore \frac{Q_p}{Q_m} = \left(\frac{l_p}{l_m}\right)^2 \times \left(\frac{V_p}{V_m}\right)$$

$$\therefore \frac{Q_p}{Q_m} = 36^2 \times \sqrt{36}$$

$$\therefore Q_p = Q_m \times 36^2 \times 6$$

$$= 3.0 \times 36^2 \times 6$$

$$= 23328 \, m^3/sec$$

$$\boxed{Q_p = 23328 \, m^3/sec}$$

Unit-V

Q (1) (a) What is Tangential flow Turbine? **Marks 02**

If the water flows along the tangent of the runner, the turbine is known as tangential flow turbine.

Example- Pelton wheel turbine is a tangential flow ~~impulse~~ impulse turbine.

(b) A turbine is to operate under a head of 25 m at 250 r.p.m. The discharge is $10 m^3/sec$. If the efficiency is 85%, determine the performance of the turbine under a water head of 20 m.

Marks 06

Head on turbine $H_1 = 25m$

Speed $N_1 = 250 \, r.p.m.$

Discharge $Q_1 = 10 m^3/sec$

$\eta_o = 85\%$

Head $(H_2) = 20m$.

$$\eta_o = \frac{P}{w.p.} \Rightarrow P = \eta_o \times w.P = \eta_o \times \frac{\rho g Q_1 \times H}{1000}$$

$$P = \frac{0.85 \times 1000 \times 9.81 \times 10 \times 25}{1000}$$

$$P = 2084.62 \, kW$$

$$\therefore \frac{N_1}{\sqrt{H_1}} = \frac{N_2}{\sqrt{H_2}} \Rightarrow N_2 = \frac{N_1 \sqrt{H_2}}{\sqrt{H_1}}$$

$$N_2 = 250 \times \frac{\sqrt{20}}{\sqrt{25}} = 223.606 \text{ r.p.m.}$$

$$\frac{Q_1}{\sqrt{H_1}} = \frac{Q_2}{\sqrt{H_2}} \Rightarrow Q_2 = \sqrt{H_2} \times \frac{Q_1}{\sqrt{H_1}} = 10 \times \sqrt{\frac{20}{25}} = 8.94 \text{ m}^3/\text{sec}$$

$\therefore P_2 = 1491.63 \text{ kW.}$ **OR** Power $\Rightarrow \frac{P_1}{H_1^{3/2}} = \frac{P_2}{H_2^{3/2}} \Rightarrow P_2 = \frac{H_2^{3/2}}{H_1^{3/2}} \times P_1 = \left(\frac{20}{25}\right)^{3/2} \times 2084.52$

Q(2) (a) Discuss cavitations in pump. **Marks 02**

Cavation is defined as the phenomenon of formation of vappour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure and the sudden collapsing of these vapour bubbles in a region of heigherpressure. When the vapour bubbles collapse, a very high pressure is created.

(b) The following data is given for Pelton Wheel turbine:

S.P. of Wheel -----------	9600kW
Head-------------	350 m
Speed of Wheel---------	750 rpm
Speed ratio --------------	0.45
Coefficient of velocity ----------	0.985
Overall efficiency ---------------	85%

Where jet diameter not to exceed to 1/6 of the wheel diameter

Design Pelton Wheel and find out (i) Wheel diameter (D) (ii) diameter of jet(d) (iii) size of buckets (iv) number of buckets.

Marks 06

(a) Power $= P = \gamma Q H \eta_o = \rho g Q H \eta_o = 9.81 \times 1000 \times Q \times 350 \times 0.85$

$$\therefore Q = \frac{9600 \times 1000}{9.81 \times 1000 \times 350 \times 0.85} = 3.289 \text{ m}^3/\text{sec}$$

(b) Velocity of jet $V = k_v \sqrt{2gH} = 0.985 \times \sqrt{2 \times 9.81 \times 350}$

$$V = 0.985 \times \sqrt{2 \times 9.81 \times 350} = 81.624 \text{ m/sec}$$

$$\therefore u = k_u \sqrt{2gH} = 0.45 \times \sqrt{2 \times 9.81 \times 350} = 37.29 \text{ m/sec}$$

Now $u = \frac{\pi D N}{60}$ $\therefore 37.29 = \frac{\pi \times D \times 750}{60} \Rightarrow D = \frac{37.29 \times 60}{3.14 \times 750}$

$D = 0.9500 \text{ m}$ jet diameter $d = ?$ $Q = C_d \times \sqrt{2gH} \times \frac{\pi d^2}{4}$

$d = \frac{0.95}{6} = 0.158 \text{ m.}$ ✓ $3.289 = 0.98 \times \sqrt{2 \times 9.81 \times 350} \times \frac{\pi \times d^2}{4}$

$d^2 = \frac{3.289}{63.749} \Rightarrow d = 0.2271 \text{ m.}$ (Not used)

(c) Size of buckets → Width of bucket (3 to 4 times d) $= 15.8 \times 3 = 47.4 \text{ cm} = 48 \text{ cm}$ (63.2 cm = 64 cm)

Depth of buckets $= 0.8$ to 1.2 times d $= 0.8 \times 15.8 = 12.64 = 13.0$ cm (18.96 = 19 cm)

Radial length of buckets $= 2$ to 3 times $d = 2 \times 15.8 = 31.6$ cm $= (32$ cm$)$

(d) Number of buckets $= Z = 0.5 \times m + 15 = 0.5 \times \frac{D}{d} + 15 = 0.5 \times \frac{0.95}{0.158} + 15 = 18.00$ buckets.