Printed Pages– 8

Centre Supdt.
Centre No. - 84
I. T., G G V. Bilaspur [C.G.]

AS-4135

B. Tec. (Fifth Semester) Examination, 2013

(Civil Engg.)

FLUID MECHANICS-II

Time Allowed : Three hours

Maximum Marks : 60

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

(Objective Type Questions) **10×2=20**

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

Department of Civil Engineering

Institute of Technology, GGV

B.Tech. Third Year [V^th Sem.]

Subject: Fluid Mechanics II

Question Bank

SET-I

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) The eddy viscosity is defined as :
(a) μ/ρ (b) ρ/η (c) $\rho\ \eta$ (d) η/ρ
ANSWER: (d)

Q(2) Turbulence generated in the shear flow near a solid boundary is:
(a) Solid Turbulence (b) Free turbulence (c) Wall turbulence (d) none
ANSWER: (c)

Q(3) The boundary layer exists in :
(a) Only pipe flow (b) Free Flow (c) Real fluid flow (d) Vertical flow
ANSWER: (c)

Q(4) In The direction of flow in laminar boundary layer, the velocity gradient becomes
(a) More steep (b) Less steep (c) Flat (d) none
ANSWER: (b)

Q(5) Non uniform flow occurs when
(a) Direction and magnitude of velocity at all points are identical
(b) Velocity of successive fluid particles, at any point, is same at successive periods of time
(c) Magnitude and direction of velocity do not change from point to point in the fluid
(d) Velocity, depth, pressure, etc. changes point to point in the fluid flow
ANSWER: (d)

Q(6) The maximum velocity in open channels occurs
(a) at center of channel (b) at channel bottom (c) a little below the free surface (d) at free surface
ANSWER: (c)

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) The pressure wave in a fluid medium travels as a sound wave, the velocity of which is given by:
(a) $C= \sqrt{E/\rho}$ (b) $C= \sqrt{\rho/E}$ (c) $C= \sqrt{\rho E}$ (d) $C= E/\rho$
ANSWER: (a)

Q(9) Pelton wheel Turbine is type of turbine:
(a) High head turbine (b) Medium head turbine (c) Low head turbine (d) Very Low head turbine
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) What do you understand by wall turbulence and free turbulence? **Marks 02**

The turbulence generated by the fluid flowing at different velocities in the absence of a solid wall is termed as free turbulence. Turbulent mixing of submerged jets and the turbulence in the wake regions are examples of this category of turbulence.

(b) Derive an expression for velocity distribution equation for turbulent flow for smooth pipes. **Marks 06**

From Prandtl mixing length theory $u' = l\frac{du}{dy}$ $\quad v' = l\frac{du}{dy}$

But shear stress $\bar{\tau} = \overline{\rho u'v'}$ $\quad \bar{\tau} = \tau = \rho \times \left(l\frac{du}{dy}\right) \times \left(l\frac{du}{dy}\right) = \rho l^2 \left(\frac{du}{dy}\right)^2$

$\tau = \rho l^2 \left(\frac{du}{dy}\right)^2 \quad \therefore \frac{du}{dy} = \frac{1}{l}\sqrt{\frac{\tau}{\rho}} \quad \therefore \frac{du}{dy} = \frac{1}{ky} u_*$

$l = ky \quad l = 0.4y \qquad \therefore u = 2.5\, u_* \log_e y + c$

OR $u = \frac{u_*}{k}\log_e y + c \qquad u = 0 \quad y = y' \quad \therefore 0 = \frac{u_*}{k}\log_e y' + c$

$c = -\frac{u_*}{k}\log_e y' \qquad \therefore u = \frac{u_*}{k}\log_e\left(\frac{y}{y'}\right)$

for smooth pipe $y' = \frac{11.6\nu}{u_*} \times \frac{1}{107}$ $\quad$ OR $y' = \frac{0.108\nu}{u_*}$

$\therefore \frac{u}{u_*} = 5.75\log_{10}\frac{u_* y}{\nu} + 5.75\log_{10} 9.259$

$$\therefore \boxed{\frac{u}{u_*} = 5.75\log_{10}\left(\frac{u_* y}{\nu}\right) + 5.55}$$

OR

Q (2) (a) Discuss the Colebrook-White equation for turbulent flow in pipe. **Marks 02**

* for smooth pipe $\frac{1}{\sqrt{f}} - 2\log_{10}\left(\frac{d}{k_s}\right) = \log_{10} R\left(\frac{k_s}{d}\right)\sqrt{f} - 0.8$

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

* for rough pipe $\frac{1}{\sqrt{f}} - 2\log_{10}\left(\frac{d}{k_s}\right) = 1.14$

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)~~ Water is flowing through a rough pipe of diameter 650 mm at the rate of 650 litres/sec. The wall roughness is 3.5 mm. Find the power lost for 1 km length of pipe. **Marks 06**

$D = 650\ mm \quad Q = 650\ lit/sec = 0.650\ m^3/sec$

$R = \frac{650}{2} = 325\ mm = 0.325\ mm. \quad k = 3.5\times10^{-3}\ m = \quad 0.0035\ m.$

$$\frac{1}{\sqrt{4f}} = 2\log_{10}\left(\frac{R}{K}\right) + 1.74 = 2\log_{10}\left(\frac{0.325}{0.0035}\right) + 1.74 = 5.675$$

$$\therefore \frac{1}{\sqrt{4f}} = 5.675 \quad \therefore \sqrt{4f} = \frac{1}{5.675} \quad \therefore 4f = \left(\frac{1}{5.675}\right)^2$$

$$\therefore f = \frac{1}{4}\times 0.03104 = 0.00776 \quad \text{OR} \quad 4f = 0.03104$$

$$Q = A\times V \quad \therefore \quad V = \frac{Q}{A} = \frac{0.65}{\frac{\pi\times(0.65)^2}{4}} = \frac{4}{\pi\times0.65} = 1.959\ m/sec$$

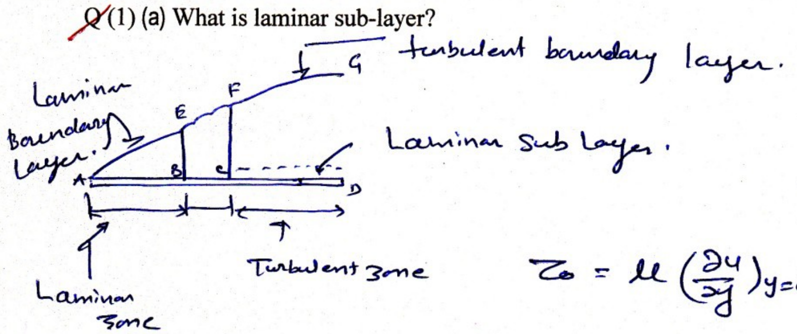
$$V = 1.959\ m/sec \quad h_f = \frac{4fLV^2}{2gD} = \frac{0.03104\times1000\times1.959^2}{2\times9.81\times0.65} = 9.34\ m$$

$$\text{Power } P = \frac{\gamma Q h_f}{1000} = \frac{\rho g Q h_f}{1000} = \frac{1000\times9.81\times0.650\times9.34}{1000}$$

$$P = 59.55\ kW.$$

Unit-II

~~Q~~(1) (a) What is laminar sub-layer? **Marks 02**

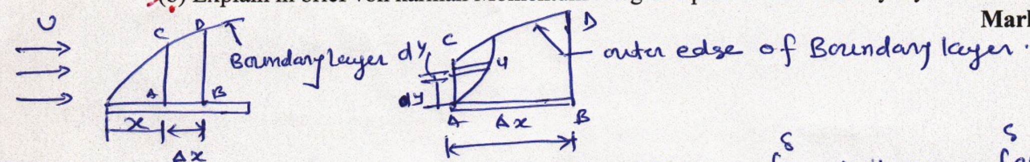


$$\tau_0 = \mu\left(\frac{\partial u}{\partial y}\right)_{y=0} = \mu\left(\frac{u}{y}\right)$$

$$\text{linear Variation } \frac{\partial u}{\partial y} = \left(\frac{u}{y}\right)$$

~~(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 $= \int_0^\delta \rho \times \text{velocity} \times \text{Area} = \int_0^\delta \rho u b\,dy$

ΔF_D = Shear stress × area $= \tau_0 \times b \times \Delta x$ Mass rate of flow leaving the side BC

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

Mass Rate of flow entering AD + mass rate of flow entering DC

= mass rate of flow leaving BC

∵ Mass Rate of flow entering DC = mass rate of flow through BC

− mass rate of flow through AD

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

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

− M.F. through AD − M.F. ~~flow~~ through DC

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

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

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

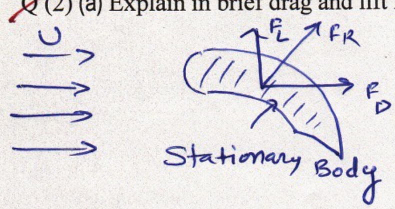
$$\therefore \tau_0 = \rho U^2 \frac{\partial}{\partial x}\left[\int_0^\delta \frac{u}{U}\left(1-\frac{u}{U}\right)dy\right] \quad \text{OR} \quad \boxed{\frac{\tau_0}{\rho U^2} = \frac{\partial \theta}{\partial x}}$$

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

OR

~~Q~~ (2) (a) Explain in brief drag and lift force on a body.

Marks 02



The component of the total force (F_R) in the direction ⊥ to the direction of ~~flow~~ motion is known as lift.

It is denoted by F_L.

(b) A truck having a projected area 12 square meters travelling at 60 km/hr has total resistance of 2943 N. Of this 25% is due to rolling friction and 15% is due to surface frication. The rest is due to form drag. Calculate the coefficient of drag if the density of air is 1.25 kg/m^3 **Marks 06**

Projected Area $A = 12 m^2$ Speed $U = 60 km/hr = \frac{60 \times 1000}{60 \times 60} = 16.67$ m/sec

$F_T = 2943 N$ $F_c = 25\%$ of total Resistance $= 0.25 \times 2943$
$= 735.75 N$

Rolling friction 25%.

Surface friction 15%. $F_S = 10\%$ of total Resistance $= 0.15 \times 2943$
$= 441.45 N$

From Drag $F_D = F_T - F_c - F_s = 2943 - 735.75 - 441.45$
$= 1765.80 N$

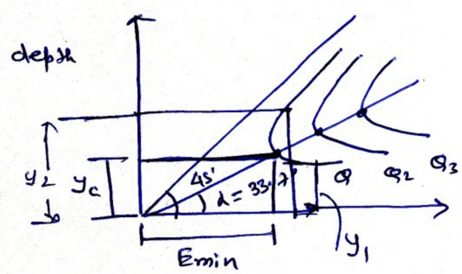
$\therefore F_D = C_D A \times \frac{\rho U^2}{2}$ $\therefore 1765.80 = C_D \times 12 \times \frac{\cancel{1000} 1.25 \times (16.67)^2}{2}$

$\therefore C_D = \frac{1765.80}{16667.40} = \frac{1765.80 \times 2}{12 \times 1.25 \times (16.67)^2} = \frac{3531.60}{4168.33} = 0.8472$

$\therefore C_D = 0.8472$

Unit-III

Q (1) (a) Draw the specific Energy curve and discuss it in brief. **Marks 02**



$V_c = \sqrt{g y_c}$

$\frac{V_c^2}{2g} =$

$Fr = 1 = \frac{V_c}{\sqrt{2g y_c}}$

$E = y + \frac{v^2}{2g}$

$E = y + \frac{Q^2}{2gA^2}$

$E = y + \frac{q^2}{2gy^2}$ So $E_{min} = y_c + \frac{V_c^2}{2g}$

Sp. energy min. at critical ~~flo~~ flow $= y_c + \frac{g y_c}{2g}$

for Rectangular Channel. $y_c = \left(\frac{q^2}{g}\right)^{1/3}$ OR $Fr = 1$ $= \frac{3}{2} y_c$

$\therefore E_{min} = 1.5 y_c$

(b) A 3.5 m wide rectangular channel convey 15 m^3/sec of water at a depth of 2.5 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 $Q = 15$ m^3/sec $\quad b = 3.50$ m $\quad$ depth $y = 2.50$ m.

① E_s = Specific Energy $= y + \frac{v^2}{2g} = 2.5 + \frac{(1.71^2)}{2g} = 2.5 + \frac{2.938}{2 \times 9.81} = 2.64$ M.

$v = \frac{Q}{A} = \frac{15}{3.5 \times 2.5} = 1.71$ m/sec $\qquad y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left[\frac{(4.28)^2}{9.81}\right]^{1/3} = 1.23$ m.

$q = \left(\frac{15}{3.5}\right) = 4.28$ m^3/sec/m $\qquad E_s = 2.64$ m & $y_c = 1.23$ m.

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

$V_c = \sqrt{9.81 \times 1.23} = 3.47$ m/sec

$E_{min.} = \frac{3}{2} y_c = 1.5 \times 1.23 = 1.845$ m.

$F_r = \frac{V}{\sqrt{gy}} = \frac{1.71}{\sqrt{9.81 \times 2.5}} = 0.3454$

$F_r < 1$ Flow is Sub critical.

(E_{min} - minimum specific Energy)

Ans → ① $E_s = 2.64$ m $\quad y_c = 1.23$ m ② $V_c = 3.47$ m/sec $\quad E_{min} = 1.845$ m.

Flow is Subcritical ($F_r < 1$)

OR

Q (2) (a) Explain in brief Torrential Flow.

Marks 02

Super critical flow is called Torrential flow.

When $F_r = \frac{V}{\sqrt{gy}} > 1$ the flow is called Super Critical flow.

(b) Derive an expression for gradually varied flow.

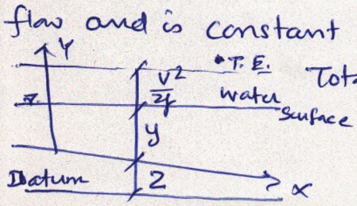
Marks 06

Assumptions:-

① Flow steady ② Pressure Distribution is 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.

S_e = slope of energy line

S_o = slope of the channel bottom.



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

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

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

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

$$\therefore \frac{dy}{dx} = \frac{S_o - S_e}{1 - \frac{V^2}{gD}} \quad \text{OR} \quad \boxed{\frac{dy}{dx} = \frac{S_o - S_e}{1 - F^2}}$$

Unit-IV

Q(1) (a) What is water hammer in pipes? **Marks 02**

If the valve of pipe is suddenly closed the momentum of the flowing water will be destroyed and consequently a wave of higher pressure will be set up This wave of high pressure will be transmitted along the pipe with a velocity equal to velocity of sound wave and may create noise called knocking or water hammer.

(b) A 60 cm diameter and 120 m long pipeline carrying 0.6 m^3/sec discharge is fitted with a valve at the downstream end. Calculate the rise in pressure caused within the pipe due to valve closure in (i) 1.5 sec (ii) instantaneously. Take sonic velocity as 1450 m/sec **Marks 06**

$$t = \frac{2L}{C} = \frac{2 \times 120}{1450} = 0.165 \text{ sec} \quad t > 1.5 \text{ sec}$$

(1) The pressure rise can be computed

$$\Delta p = \frac{2\rho VL}{t_c} = \frac{2 \times 1000}{9.81} \times \frac{4 \times 0.6}{\pi \times (0.6)^2} \times \frac{120}{1.5}$$

$$\therefore \Delta P = 34628.21 \text{ kg/m}^2 = 34.628 \times 10^3 \text{ kg/m}^2$$

(2) FOR Instantaneous valve closure

$$(\Delta P)_{max} = \rho C V = \frac{1000}{9.81} \times 1450 \times 2.123 = 313797.1456 \text{ kg/m}^2$$

$$V = \frac{Q}{A} = \frac{0.60}{\frac{\pi \times (0.6)^2}{4}} = \frac{4}{\pi \times 0.6} = 2.123 \text{ m/sec} \quad \therefore (\Delta p)_{max.} = 313.79 \times 10^3 \text{ kg/m}^2$$

OR

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

$$\frac{\text{length of prototype}}{\text{Length of model}} = \frac{L_p}{L_m} = L_r$$

L_r = scale ratio.

(b) The resistance R, to the motion of a completely sub-merged body depends upon the length of the body L, velocity of flow V, mass density ρ and kinematic viscosity $\boldsymbol{\nu}$. By dimensional analysis prove that

$$R = \rho V^2 L^2 \Phi\left[\frac{VL}{\nu}\right]$$

Marks 06

$R = f(l, V, \nu, \rho)$ $n = 5$

$f_1 = (R, l, V, \nu, \rho)$ $m = 3$ $\therefore$ π terms = 5 − 3 = 2.0

$\pi_1 = l^{a_1} V^{b_1} \rho^{c_1} R$

$\pi_2 = l^{a_2} V^{b_2} \rho^{c_2} \nu$

$\pi_1 = M^0 L^0 T^0 = (L)^{a_1} (LT^{-1})^{b_1} (ML^{-3})^{c_1} \times (MLT^{-2})$

$\pi_2 = M^0 L^0 T^0 = (L)^{a_2} (LT^{-1})^{b_2} (ML^{-3})^{c_3} (L^2 T^{-1})$

$f_1(\pi_1 \; \pi_2) = 0$

$\therefore \pi_1 = f_2(\pi_2)$

$\because R = \rho V^2 L^2 \phi \left[\frac{VL}{\nu}\right]$

OR

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

$$\frac{\text{length of prototype}}{\text{Length of model}} = \frac{L_p}{L_m} = L_r$$

L_r = scale ratio.

(b) The resistance R, to the motion of a completely sub-merged body depends upon the length of the body L, velocity of flow V, mass density ρ and kinematic viscosity $\boldsymbol{\nu}$. By dimensional analysis prove that

$$R = \rho V^2 L^2 \Phi\left[\frac{VL}{\nu}\right]$$

Marks 06

$R = f(l, V, \nu, \rho)$ $n = 5$

$f_1 = (R, l, V, \nu, \rho)$ $m = 3$ $\therefore$ π terms $= 5 - 3 = 2.0$

$\pi_1 = l^{a_1} V^{b_1} \rho^{c_1} R$

$\pi_2 = l^{a_2} V^{b_2} \rho^{c_2} \nu$

$\pi_1 = M^0 L^0 T^0 = (L)^{a_1} (LT^{-1})^{b_1} (ML^{-3})^{c_1} \times (MLT^{-2})$

$\pi_2 = M^0 L^0 T^0 = (L)^{a_2} (LT^{-1})^{b_2} (ML^{-3})^{c_3} (L^2 T^{-1})$

$f_1(\pi_1 \ \pi_2) = 0$

$\therefore \ \pi_1 = f_2(\pi_2)$

$\because \ R = \rho V^2 L^2 \phi \left[\frac{VL}{\nu}\right]$

Unit-V

Q (1) (a) What is overall efficiency of a Turbine? **Marks 02**

$$\eta_o = \frac{\text{Volume available at the Shaft of turbine}}{\text{Power Supplied at the inlet of the turbine}}$$

$$= \frac{\text{Shaft Power}}{\text{Water Power}} = \frac{S.P.}{W.P} = \frac{S.P}{R.P} \times \frac{R.P.}{W.P} = \eta_m \times \eta_h$$

(b) A turbine is to operate under a head of 25 m at 250 r.p.m. The discharge is 10m^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 $(H_2) = 20m$.

$$\eta_o = \frac{P}{W.P.} \quad P = \eta_o \times W.P. = \eta_o \times \frac{\rho g Q H}{1000} = \frac{0.85 \times 1000 \times 9.81 \times 10 \times 25}{1000}$$

$$P = 2084.625 \text{ KW} \quad \frac{N_1}{\sqrt{H_1}} = \frac{N_2}{\sqrt{H_2}} \quad \therefore N_2 = \frac{N_1\sqrt{H_2}}{\sqrt{H_1}} = 250 \times \sqrt{\frac{20}{25}} = 223.606 \text{ r.p.m.}$$

Discharge

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

Power $$\frac{P_1}{H_1^{3/2}} = \frac{P_2}{H_2^{3/2}} \Rightarrow P_2 = \frac{H_2^{3/2}}{H_1^{3/2}} \times P_1 = 2084.625 \times \left(\frac{20}{25}\right)^{3/2} =$$

$$P_2 = 1491.63 \text{ KW}.$$

Ans.

$$\left.\begin{aligned} N_2 &= 223.606 \text{ r.p.m.} \\ Q_2 &= 8.94 \ m^3/sec \\ P_2 &= 1491.63 \text{ KW} \end{aligned}\right\}$$

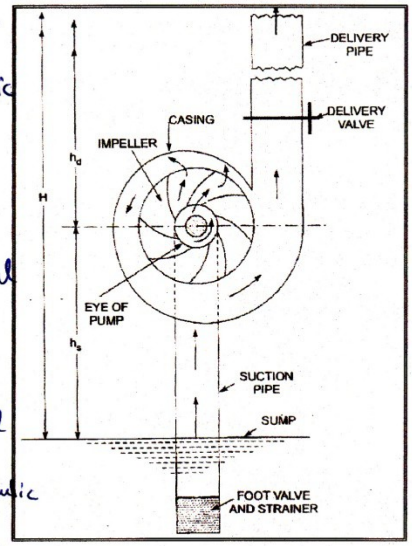
OR

Q (2) (a) Discuss Specific speed of pump. **Marks 02**

The Specific speed of a centrifugal pump is defined as the speed of a geometrically similar pump which would deliver one cubic metre of liquid per second against a head of one meter.

$$N_s = \frac{N\sqrt{Q}}{H_m^{3/4}}$$

(b) Define a centrifugal pump. Explain the working of a single stage centrifugal pump with neat sketch.



The hydraulic machines which convert the mechanical energy into hydraulic energy called pumps.
The hydraulic energy in the form of pressure energy. If the mechanical energy is converted, into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

Main parts of Centrifugal Pump (Explain it)

① Impeller

② Casing ← ① Volute casing
② Vortex casing
③ Casing with guide blades.

③ Suction pipe with a foot valve and a Strainer

④ Delivery pipe.