Name :- Muhammad Imran

ID :- 7847

Section :- B

Semister :- 6th

Subject :- Hydraulic Engineering

Teacher :- Engr. Fawad

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Question No 01

A Prototype gate value which will control the flow in a pipe system conveying paraffin is to be studied in a model. list the signifficient variable on which ....

Solution:-

The pressure drop Δp is expected to depend upon the gate opening h, the overall depth d, the velocity V. ~~depth~~ density ρ and viscousity μ.

List the relevent variables.

$\Delta p, h, d, V, \rho, \mu$.

Write down dimensions:

Δp	$ML^{-1}T^{-2}$
h	L
d	L
V	LT^{-1}
ρ	ML^{-3}
μ	$ML^{-1}T^{1}$

Number of variable . $n = 6$

Number of independent dimension: $m = 3$ (M.L and T)

Number of non-dimensional group: $n - m = 3$

Choose m (=3) scaling variables
geometric (d): kinematic/time-dependent (V):
dynamic/mass-dependent (ρ).

Form dimensionless group by non-dimensionalising the remaining variables. Δp, h and μ.

$$\Pi_1 = \Delta p\, d^a V^b \rho^c$$

$$M^0 L^0 T^0 = (ML^{-1}T^{-2})(L)^a (LT^{-1})^b (ML^{-3})^c$$

$$= M^{1+c} L^{-1+a+b-3c} T^{-2-b}$$

M = $0 = 1+c$ ⇒ $c = -1$

T: $0 = -2-b$ ⇒ $b = -2$

L: $0 = -1+a+b-3c$ ⇒ $a = 1+3c-b = 0$

$$\Pi_1 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$$

$\Pi_2 = \dfrac{h}{d}$ (by inspection since h is length)

$$\Pi_3 = \mu d^a V^b \rho^c$$

$$M^0 L^0 T^0 = (ML^{-1}T^{-1})(L)^a (LT^{-})^b (ML^{-3})$$

$$= M^{1+c} L^{-1+a+b-3c} T^{-1-b}$$

M: $0 = 1+c$ ⇒ $c = 1$

T: $0 = -1-b+0$ ⇒ $b = -1$

L: $0 = -1+a+b-3c$ ⇒ $a = 1+3c-b = -1$

$\Rightarrow \Pi_1 = \mu d^{-1} V^{-1} \rho^{-1} = \dfrac{\mu}{\rho V d}$

Recognition of the Reynolds number suggest that we replace Π_3 by

$$\Pi_3' = (\Pi_3)^{-1} = \frac{\rho V d}{\mu}$$

Hence dimensional analysis yield.

$$\Pi_3' = \left(\frac{\rho V d}{\mu}\right)_p = \left(\frac{\rho V d}{\mu}\right)_m$$

from the last, we have a velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \frac{d_m}{d_p} = \frac{0.002/800}{1.0 \times 10^{-6}} \times \frac{1}{5} = 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0\,ms^{-1}$$

(b) The ratio of the quantities of flow is

$$\frac{Q_p}{Q_m} = \frac{(\text{velocity} \times \text{area})_p}{(\text{velocity} \times \text{area})_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2 = 0.5 \times 5^2$$

$$= 12.5$$

(c) Finally. for the Pressure drop.

$$\Pi_1 = \left(\frac{\Delta p}{\rho V^2}\right)_p = \left(\frac{\Delta p}{\rho V^2}\right)_m \Rightarrow \frac{(\Delta p)_p}{(\Delta p)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

$$= \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence.

$$\Delta p_p = 0.2 \times \Delta p_m = 0.2 \times 60 = 12.0 \text{ kPa}$$

Question No 2

Given

Max depth = 78 m

Specific Gravity = 2.4

f_{au} = 784 T/m²

Height of wave = 1.2 m

Solution

(1)

$$H_{limiting} = \frac{f_{au}}{\gamma_w (G - \omega + 1)}$$

$$= \frac{784 \times 1000}{1000(24 - 0 + 1)}$$

$$H_{limiting} = 230.588$$

(2) Top width : "a"

Free board = 1.5 × h_{wave}

= 1.5 × 1.2

= 1.8

Height of Dam = Hw + F.B = 78 + 1.8

HD = 79.8

a = 14% of HD

= 0.14 × 79.8

= 11.172 m

3) Base width

$$b' = \frac{Hw}{\mu G} = \frac{78}{0.7 \times 2.4}$$

= 46.42 m

= 47

4) For no tension criteria.

$$b' = \frac{Hw}{\sqrt{G}} = \frac{78}{\sqrt{2.4}}$$

= 50.34

Depth of vertical Portion on U/s side

$h' = 2a\sqrt{G \cdot \omega}$

$= 2 \times 11.172 \sqrt{2.4 - 0}$

$= 34.60$

$= 35\ m$

Upstream off set : $\frac{a}{16} = \frac{11.172}{16}$

$= 0.6$

Depth of below the water level to the end of inclined Portion U/s $= 3.14a\sqrt{G}$

$= 3.14 \times 11.17 \sqrt{2.4}$

$= 54.33$

Total width of the base of the dam.

$b = b' + \frac{a}{16} = 50.34 + \frac{11.172}{16}$

$= 51.03$

$$\text{Tan } \theta = \frac{b'}{H} = \frac{50.34}{78}$$

$$\theta = \tan^{-1}(0.64)$$

$$= 44.80^\circ$$

Depth of vertical Portion on D/s (from WL on U/s side)

$$\text{Tan } \theta = \frac{a}{d'} = \frac{11.172}{d'}$$

$$\text{Tan } \theta = \frac{11.172}{d'}$$

$$\left(\frac{839}{1300}\right) \times d' = 11.172$$

$$d' = 17.30 \text{ m}$$

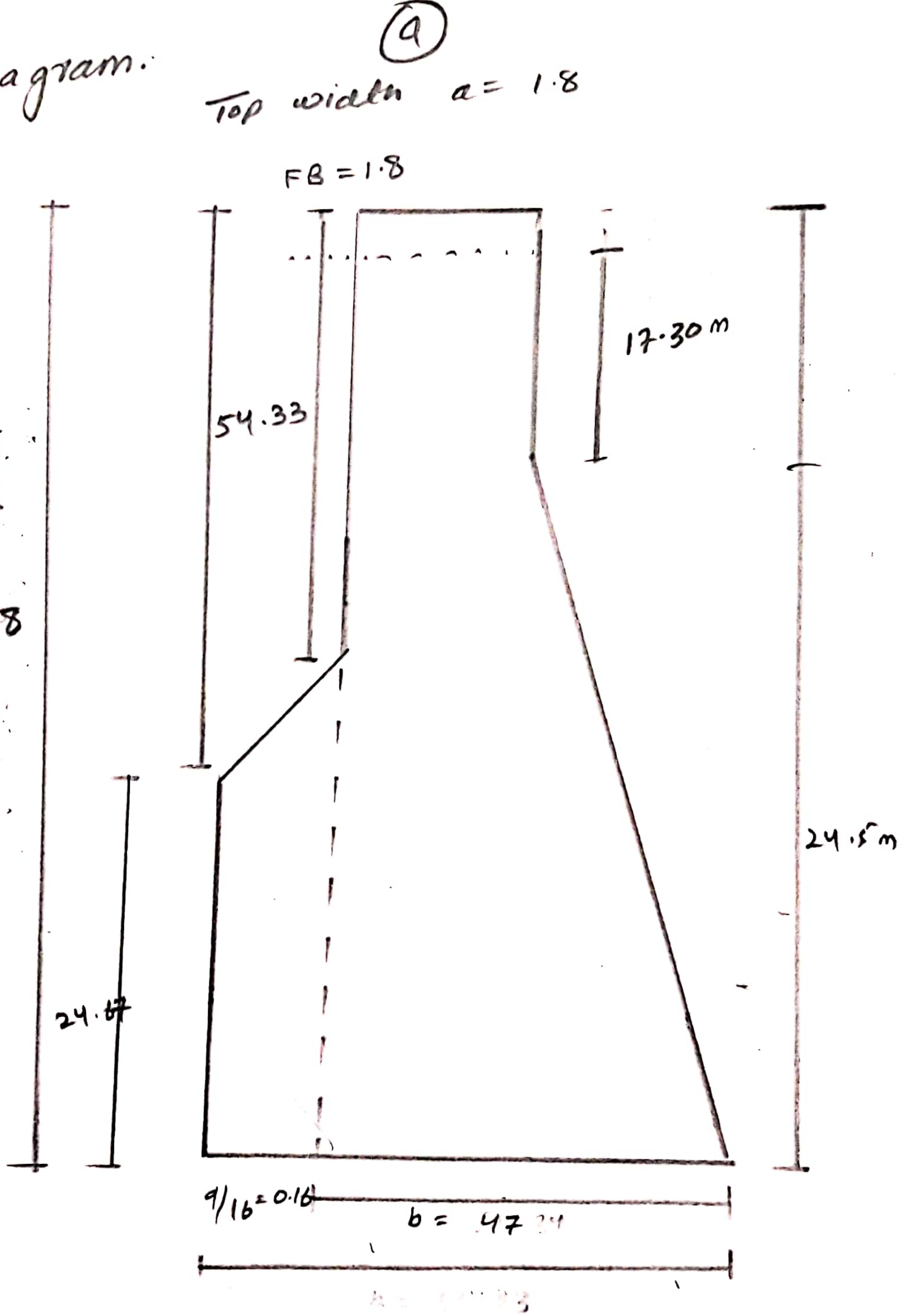
Depth of vertical Portion

$$d = d' + F.B$$

$$= 17.30 + 1.8$$

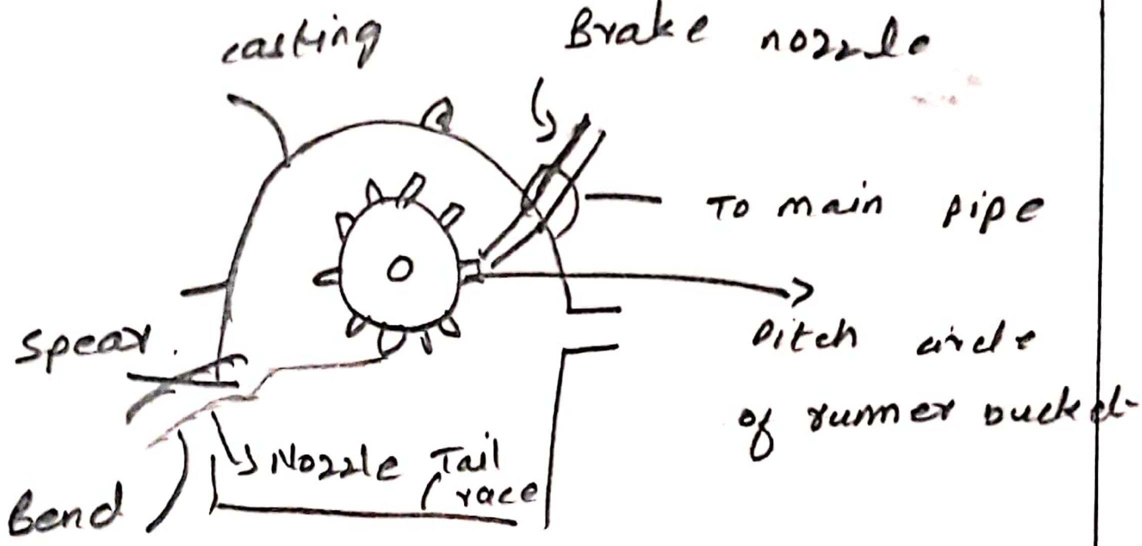
$$= 19.1$$

Diagram:



Question No. 03 (10)

Answer No. 03.



Work done and Efficiency of Pelton wheel

figure shows the shape of buckets and inlet and outlet velocity triangles of a Pelton wheel

$$P = \rho Q [V_{w_1} u_1 \pm V_{w_2} u_2]$$

for a Pelton wheel, $u_1 = u_2 = u = \frac{\pi D N}{60}$

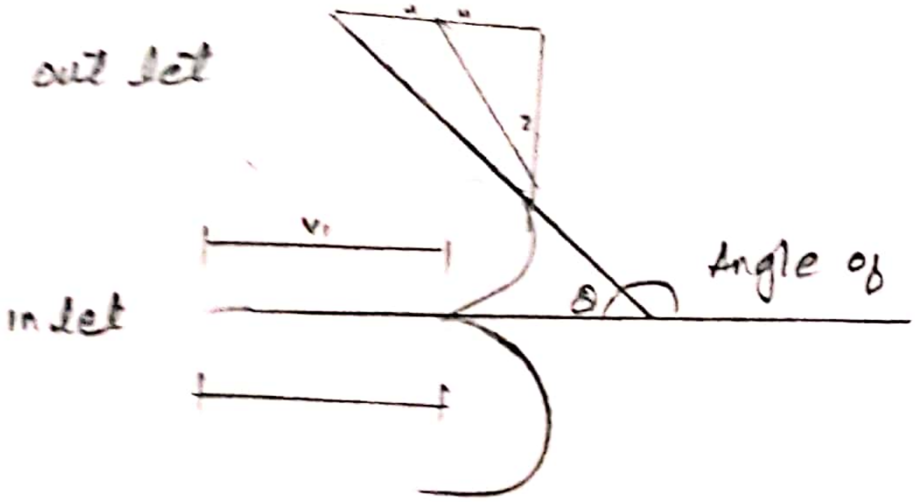
from the velocity triangles in figure we have. α = angle between the direction of flow at inlet and rediation of motion runner $= 0°$

θ = angle made by the relative velocity V_{r_1} with direction of motion runner $= 0°$

The quantity of flow striking the runner

$Q = aV_1$ in which a = area of jet =

$= \frac{\pi d^2}{4}$



Hence the work done by the jet in the case of Pelton wheel by

$$\text{work done} = \frac{\rho a V_1 [V_{w_1} - V_{w_2}] \times u}{\rho a V_1 \times g} = \frac{1}{8}\left[V_{w_1} + V_{w_2}\right] \times u$$

$$P = \rho a V_1 (V_{w_1} + V_{w_2}) u$$

The kinetic energy of the jet

$$= \frac{1}{2} m V_1^2 = \frac{1}{2} (\rho a V_1) V_1^2$$

Hydraulic efficiency $\eta_h = \frac{\text{work done per sec}}{\text{Kinetic energy}}$

$$= \frac{\rho a V_1 (V_{w_1} + V_{w_2}) u}{\frac{1}{2} (\rho a V_1) V_1^2}$$

from the velocity triangle in figure we have

~~F ~~ ~~$\rho a V_1$~~

$V_{w_1} = V_1$, $V_{r_1} = V_1 - u$

Hence $V_{r_2} = V_1 - u$ and $V_{w_2} = V_{r_2} \cos\phi - u_2$

$= (V_1 - u) \cos\phi - u$

$$\eta_h = \frac{2 [V_1 + (V_1 - u) \cos\phi - u] u}{V_1^2}$$

$$= \frac{2 [(V_1 - u)(1 + \cos\phi)] u}{V_1^2}$$

The efficiency η_h will be maximum for a given V_1. when

$$\frac{d}{du}(\eta_h) = 0 \quad \text{or} \quad \frac{d}{du}\left[\frac{2u (V_1 - u)(1 + \cos\phi)}{V_1^2}\right] = 0$$

or $\frac{d}{du}\left[2u(V_1-u)\right]=0$ since $\frac{(1+\cos\theta)}{V_1^2}$ is

a constant

Hence ~~$2V_1$~~

$$2V_1-4u=0 \text{ or, } u=\frac{V_1}{2}$$

Equation shows that the hydraulic efficiency η_h of a Pelton wheel will be maximum when the velocity of the runner is half the velocity.

Hydraulic efficiency $\eta_h=\frac{(1+\cos\theta)}{2}$

$$\max.\eta_h=\frac{(1+\cos\theta)}{2}$$

Design of Pelton wheel.

The formula are employ in the design of Pelton wheel

i) The velocity of Jet inlet at inlet, $V_1=C_v\sqrt{2gH}$ in which $C_v=$ coefficient of velocity $=0.98$

ii) The velocity of wheel $u = k_u\sqrt{2gH}$ in which k_u = speed ratio = 0.43 – 0.48

iii) The angle of deflection of the Jet through the bucket is taken as 165° if this is not otherwise specified

iv) The main diameter or Pitch diameter D of the wheel is given by

$$D = \frac{60u}{\pi N} \quad \left(\text{from } u = \frac{\pi D N}{60}\right)$$

v) The jet ratio, m which is the ratio of Pitch diameter D of the wheel to the diameter of the jet is given by:

$$m = \frac{D}{d} = 11 \text{ to } 16$$

A value of 12 is generally adopted in Practice.

vi) Number of buckets, Z on the the runner is given by

$$Z = 15 + \frac{D}{2d} = 15 + 0.5m$$

Question No (04)

what will be the effect of sediment Particle diameter. Particle density, Particle concentration, Particle shape. viscosity of water. turbulence of water flowing in reservoir on fall velocity? Explain in detail.

Answer:-

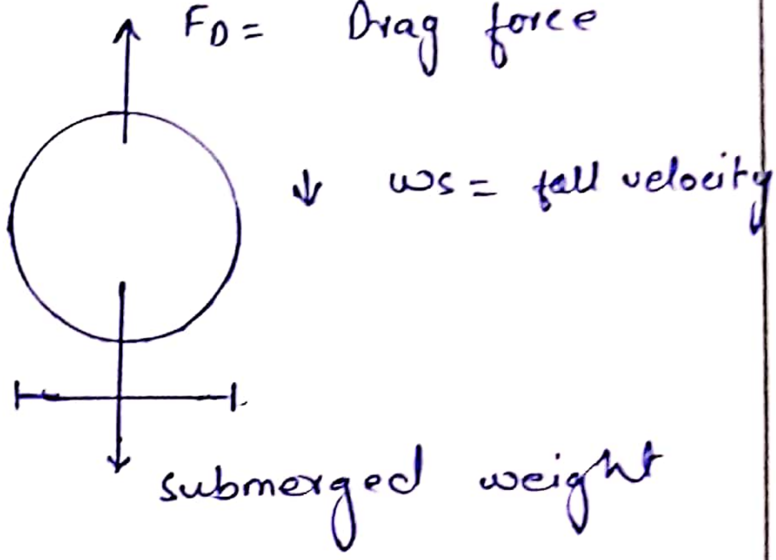
Fall velocity.

when a grain falls down in still water it obtains a constant velocity when the upward fluid drag force on the grain is equal to the down ward submerged weight of the grain.

This constant velocity is defined as the fall velocity of the grain This is also called Setting velocity.

Fall velocity depends on :

i) Particle diameter.
2) Particle density.
3) Particle concentration.
4) Particle shape
5) Viscosity of water (temperature)
6) Turbulence.



The force balance b/w The drag force and the submerged weight gives

F_D = submerged weight

$$\frac{1}{2}\rho C_D \frac{\pi d^2}{4} w_s^2 = (\rho_s - \rho) g \frac{\pi d^3}{6}$$

$A = \frac{\pi d^2}{4}$ = Projected Area

C_D = Drag coefficient

w_s = Fall velocity of sediment

ρ = Density of water

ρ_s = Density of sediment Particle.

Particle diameter:- The diameter of the Particle is directly Proportional to the fall velocity because of greater the size of Particle so it will tends to more faster as compared to the Particles of small size thus there will be more gravitational force ~~and~~ on Particle of greater size so it will fall quickely due to its weight

Particle Density :- Density of Particle is directly Proportional to the rate of fall velocity since Particle with high density tends to settle down early compared with particle of low density.

Particle concentration :-
consentration of Particle size will considerably effect its fall velocity as the section having greater concentration will be sittled down at the Place thus causing more fall velocity comparing with section of low concentration.

Particle shape :-

Particles having regular shapes tends to be effected more then irregular shape since regular shapes Particles have even surfaces whic offer very little or no friction which while Particles with irregular shape offer more frictions, as the Particles with smaller surface area are more likely to be effected due to their less resistance.

viscosity of water:- from the experimental study we can see that Parameter such as temperature and Pressure changes the magnitude of viscosity so the section of water having more temperature and Pressure will fall objectively more due to increase in the kinetic energy so fall velocity will be more.

Turbulence of water.

Turbulance of water depends upon the different factor such as velocity It will effect the fall velocity. because of it zigzag motion. thus the velocity varies at every Point which is why it effected the fall velocity more ever increase in the kinetic energy tends to effect the fall of velocity compared with steady fluid.