IES MASTER
Institute for Engineers (IES/GATE/PSUs)

ESE-2016

Detailed Exam Solutions
(Objective Paper-II)
Civil Engineering

In case there is any kind of discrepancy in solutions please write to us at ***ies_master@yahoo.co.in*** or call us at : **Ph: 011-41013406, 09711853908** for rectification/deletion/updation of the same.

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Explanation of Civil Engg. Objective Paper-II (ESE - 2016)

SET - A

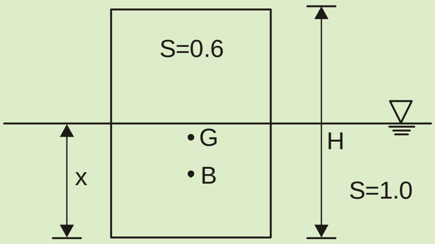
1. A solid cylinder of length H, diameter D and of relative density S floats in neutral equilibrium in water with its axis vertical. What is the ratio of H to D if S = 0.6?

(a) 0.86 (b) 0.72

(c) 0.52 (d) 0.46

Ans. (b)

Sol.



Body will be floating

$$\Rightarrow AHS\gamma_w = Ax\gamma_w$$

$$\boxed{x = 0.6H}$$

For Neutral equilibrium

Metacentric height BM = BG

Centre of Bouyouncy will be at 0.3H from bottom as hence BG = 0.5 H – 0.3 H = 0.2 H

$$BM = \frac{I}{V} = \frac{\left(\pi D^4/64\right)}{\frac{\pi D^2}{4} \times 0.6H}$$

$$BM = \frac{D^2}{16 \times 0.6H} = 0.2H$$

$$\left(\frac{H}{D}\right)^2 = \frac{1}{16 \times 0.12}$$

$$\boxed{\frac{H}{D} = 0.72}$$

2. In a two-dimensional flow, with its stream function $\psi = 2xy$, the velocity at a point (3,4) is

(a) 12.0 units (b) 10.0 units

(c) 8.0 units (d) 6.0 units

Ans. (b)

Sol. Stream function

$$\psi = 2xy$$

$$u = -\frac{\partial \psi}{\partial y} = -2x$$

$$v = \frac{\partial \psi}{\partial x} = +2y$$

$$\vec{v} = -2x\hat{i} + 2y\hat{j}$$

$$\text{at } (3.4) \quad \vec{v} = -6\hat{i} + 8\hat{j}$$

$$|\,v\,| = \sqrt{6^2 + 8^2}$$

$$\boxed{V = 10 \text{ m/sec}}$$

3. An open rectangular tank of dimensions 4m×3m×2m contains water to a height of 1.6m. It is then accelerated along the longer side. What is the maximum acceleration possible without spilling the water? If this acceleration is then increased by 10%, what amount of water will be spilt off?

(a) 1.472 m/s^2 and 0.48 m^3

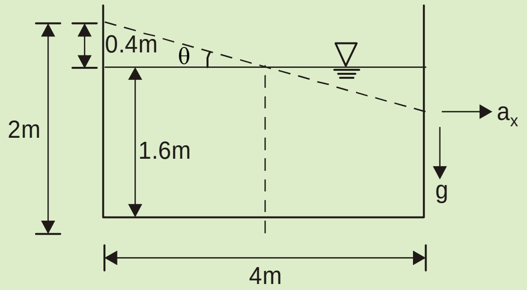
(b) 1.962 m/s^2 and 0.48 m^3

(c) 1.472 m/s^2 and 0.52 m^3

(d) 1.962 m/s^2 and 0.52 m^3

Ans. (b)

Sol. Rectangular tank 4m × 3m × 2m



For maximum acceleration

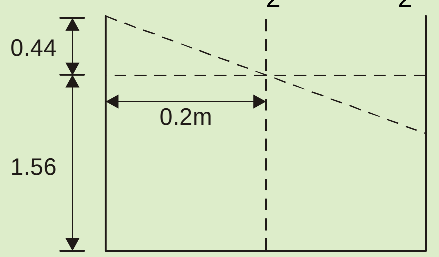
$$\frac{a_x}{g} = \frac{0.4}{2}$$

$$a_x = \frac{0.4\times 9.81}{2}$$

$$\boxed{a_x = 1.962 \text{ m/sec}^2}$$

if acceleration is increased by 10%

$$\tan\theta = \frac{0.4}{2}\times 1.1 = \frac{0.44}{2}$$



Water remaining in the tank at this stage

= 1.56 ×3 × 4

Inital volume of water in tank = 1.6 × 3×4

Volume of spilling of water = 0.04 × 3 × 4

= 0.48 m^3

4. In a laminar flow between two fixed plates held parallel to each other at a distance d, the shear stress is:

1. Maximum at plane $\frac{d}{2}$ away from each plate and zero at the plate boundaries.
2. Zero throughout the passage.
3. Maximum at the plate boundaries and zero at a plane $\frac{d}{2}$ away from each plate.

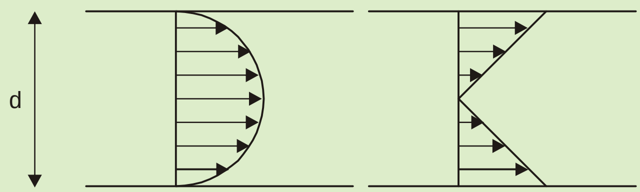
Which of the above statements is/are correct?

(a) 1 only (b) 3 only

(c) 2 only (d) 1, 2 and 3

Ans. **(b)**

Sol.



Velocity distribution in laminar flow

shear stress distribution in laminar flow

Hence statement 3 is correct

5. While conducting the flow measurement using a triangular notch, an error of +2% in head over the notch is observed. The percentage error in the computed discharge would be

(a) +7% (b) –3%

(c) +5% (d) –4%

Ans. **(c)**

Sol. For flow measurement using triangular notch

discharge, $Q \propto H^{5/2}$

Hence, $$\frac{dQ}{Q} = \frac{5}{2}\frac{dH}{H}$$

% error in discharge = $\frac{5}{2}\times(+2\%) = +5\%$

6. An orifice is located in the side of a tank with its centre 10 cm above the base of the tank. The constant water level is 1.0 m above the centre of orifice. The coefficient of velocity is

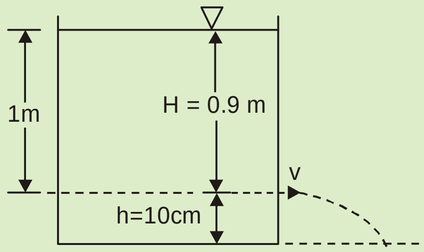
0.98. On the issuing jet, the horizontal distance from the vena-contracta to where the jet is 10 cm below vena-contracta is

(a) 1.62m (b) 1.00m

(c) 0.62m (d) 0.32m

Ans. **(c)**

Sol.



$$\text{Velocity of jet} = C_v\sqrt{2gH}$$

$$h = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

horizontal distance $x = ut$

$$= C_V\sqrt{2gH}\times\sqrt{\frac{2h}{g}}$$

$$= C_V\sqrt{4Hh}$$

$$= 0.98\sqrt{4\times1\times0.1}$$

$$x = 0.62 \text{ m}$$

7. The velocity of water at the outer edge of a 60cm diameter whirlpool, where the water level is horizontal is 2.5 m/s. The velocity of water at a level where the diameter of the whirlpool is 15 cm, is

(a) 1 m/s

(b) 5 m/s

(c) 8 m/s

(d) 10 m/s

Ans. **(d)**

Sol. Whirlpool is an example of free vortex formation. Hence

$$V = \frac{C}{r} \text{ i.e. } Vr = \text{Constant}$$

$$V_1r_1 = V_2r_2$$

$$V_2 = \frac{V_1r_1}{r_2} = \frac{60\times2.5}{15}$$

$$V_2 = 10 \text{ m/sec.}$$

8. In a trapezoidal channel with bed width of 2m, and side slopes of 2V on 1H, critical flow occurs at a depth of 1m. What will be the quantity of flow and the flow velocity? Take g as 10m/s^2.

(a) 7.22 m^3/s and 3.10 m/s

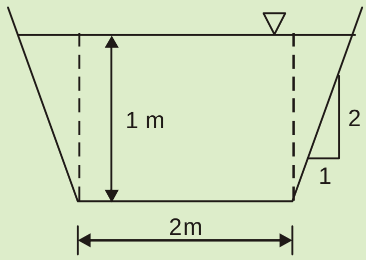
(b) 6.82 m^3/s and 2.89 m/s

(c) 7.22 m^3/s and 2.89 m/s

(d) 6.82 m^3/s and 3.10 m/s

Ans. **(c)**

Sol.



$$B = 2 \text{ m}$$

$$\text{Depth of } y_c = 1 \text{ m}$$

$$\text{Area, } A = \frac{1}{2}\times(B+B+y)\times y$$

$$= \frac{1}{2}\times(2+2+1)\times1$$

$= 2.5 m^2$

Top width, $T = 3$ m

For critical flow $F_r = 1$

$$\frac{V}{\sqrt{gA/T}} = 1 \Rightarrow V = \sqrt{9.81 \times \frac{2.5}{3}}$$

Velocity, $V = 2.86$ m/sec.

Discharge, $Q = VA = 2.86 \times 2.5$

$Q = 7.15\ m^3/s$

Hence Answer is (c)

9. A 7.5 m wide rectangular channel conveys 12 m^3/s of water with a velocity of 1.5 m/s. The specific energy head of the flow is

(a) 1.18m (b) 1.78m

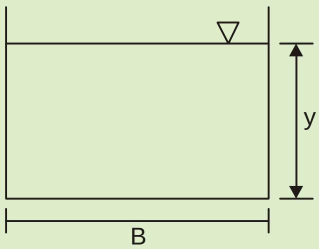
(c) 2.18m (d) 2.78m

Ans. (a)

Sol. $Q = 12\ m^3/s$

$B = 7.5$ m

$V = 1.5$ m/s



$$\text{Area, } A = \frac{Q}{V} = \frac{12}{1.5} = 8 m^2$$

$By = 8 m^2$

$$y = \frac{8}{7.5} = 1.06 m$$

$$\text{Specific energy} = y + \frac{U^2}{2g}$$

$$= 1.06 + \frac{(1.5)^2}{19.62}$$

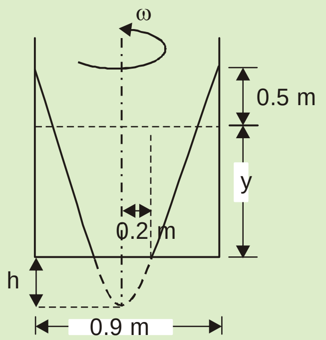
$= 1.18$ m

10. A cylindrical vessel with closed bottom and open top is 0.9 m in diameter. What is the rotational speed about its vertical axis (with closed bottom below and open top above) when the contained incompressible fluid will rise 0.5m at the inner circumference of the vessel and a space of 0.4m diameter at the bottom will have no fluid thereon? Take $g = 10\ m/s^2$.

(a) 650 rpm (b) 600 rpm

(c) 580 rpm (d) 470 rpm

Ans. (*)



$$\frac{\omega^2 (0.2)^2}{2g} = h$$

$$\frac{\omega^2 (0.45)^2}{2g} = h + y + 0.5$$

$$\pi(0.45)^2 \times y = (y+0.5)\times\pi(0.45)^2 - \left[\frac{\pi(0.45)^2 \times (h+y+0.5)}{2} - \frac{\pi(0.2)^2 \times h}{2}\right]$$

$$\pi(0.45)^2 \times 0.5 = \frac{\pi}{2}(0.45)^2[h+y+0.5] - \frac{\pi(0.2)^2 \times h}{2}$$

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$$\frac{\pi(0.45)^2\times 0.5}{2} = \frac{\pi}{2}(0.45)^2(h+y)-\frac{\pi(0.2)^2 h}{2}$$

$$0.5 = h + y - \left(\frac{0.2}{0.45}\right)^2 h$$

$$\Rightarrow \quad h+y = 0.5+\frac{16}{81}h$$

$$\Rightarrow \quad \frac{\omega^2(0.2)^2}{2g} = h$$

$$\frac{\omega^2(0.45)^2}{2g} = 0.5+\frac{16}{81}h+0.5$$

$$\frac{h(0.45)^2}{(0.2)^2} = 1+\frac{16h}{81}$$

$$\frac{81h}{16}-\frac{16h}{81} = 1$$

$$\Rightarrow \quad h = 0.2056 \text{ m}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{2\times 10\times 0.2056}{(0.2)^2}}$$

$$\omega = 10.139 \text{ rad/sec}$$

$$N = \frac{60\times 10.139}{2\pi} = 96 \text{ rpm}$$

11. The sequent depth ratio in a hydraulic jump formed in a rectangular horizontal channel is 10. The Froude number of the supercritical flow is

(a) 12.2 (b) 10.4

(c) 7.42 (d) 4.21

Ans. (c)

Sol.

$$\frac{y_2}{y_1} = 10 = \frac{1}{2}\left[\sqrt{1+8F_1^2}-1\right]$$

Froud no. of super critical flow,

$$F_1 = \sqrt{\frac{21^2-1}{8}}$$

$$\boxed{F_1 = 7.416}$$

12. A fluid flow is described by a velocity field $\bar{U} = 4x^2i-5x^2yj+1k$.

What is the absolute velocity (in magnitude) at the point (2,2,1)?

(a) $\sqrt{1802}$ (b) $\sqrt{1828}$

(c) $\sqrt{1840}$ (d) $\sqrt{1857}$

Ans. (d)

Sol.

$$\vec{u} = 4x^2\hat{i}-5x^2yj+1K$$

At (2, 2, 1)

$$\vec{u} = 4\times 2^2 i-5\times 2^2\times 2j+1K$$

$$\vec{u} = 16i-40j+1K$$

Absolute velocity, $|u| = \sqrt{16^2+40^2+1}$

$$|u| = \sqrt{1857}\text{ m/s}$$

13. A partially open sluice gate discharges water at 6 m/s with a depth of 40 cm in a rectangular horizontal channel of width 5 m. What would be the post-jump depth of flow on the downstream of the gate by taking g as 10 m/s^2?

(a) 1.51 m (b) 1.70 m

(c) 1.85 m (d) 1.95 m

Ans. (a)

Sol.

$$y_1 = 0.4 \text{ m}$$
$$v_1 = 6 \text{ m/s}$$
$$B = 5 \text{ m}$$

Froude No. $F_{r_1} = \frac{V_1}{\sqrt{gy_1}} = \frac{6}{\sqrt{10\times 0.4}} = 3.0$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fr_1^2}-1\right]$$

$$\frac{y_2}{0.4} = \frac{1}{2}\left[\sqrt{1+8\times 3^2}-1\right] = 3.77$$

Post jump depth $y_2 = 1.508\text{m}$

14. What is the maximum power available at the downstream end of a pipeline 3 km long, 20 cm in diameter, if water enters at the upstream end at a pressure of 720 m of water, with the taking pipe friction coefficient as 0.03 and g as 10m/s^2?

(a) 770 mhp (b) 740 mhp

(c) 700 mhp (d) 660 mhp

Ans. **(d)**

Sol. In question, instead of friction coefficient it should be friction factor = 0.03

In case of max. power transmission through pipe, head lost in friction = 1/3rd of total available head.

$$\therefore \quad h_f = \frac{H}{3} = \frac{720}{3} = 240 \text{ m}$$

$$h_f = \frac{flQ^2}{12.1D^5}$$

$$= \frac{0.03 \times 3000 \times Q^2}{12.1 \times (0.2)^5}$$

$$240 = 23243.8Q^2$$

$$\Rightarrow \quad Q = 0.1016 \text{ m}^3/\text{s}$$

Net available had = H – h_f = 720 – 240 = 480m

$$P = \rho QgH$$

$$= 1000 \times 0.1016 \times 10 \times 480$$

$$= 487.68 \text{ kW}$$

In hp

$$P = \frac{487.68 \times 10^3}{735} = 663.5 \text{ hp}$$

$$= 663.5 \times 1.0138$$

$$= 672.65 \text{ metric hp}$$

15. In the design of pipeline the usual practice is to assume that due to aging of pipelines:

1. The effective roughness increases linearly with time
2. The friction factor increases linearly with time
3. The flow through the pipe becomes linearly lesser with time.

Which of the above statements is/are correct?

(a) 1,2 and 3 (b) 3 only

(c) 2 only (d) 1 only

Ans. **(d)**

Sol. Effective toughness increases linearly with time statement 2 & 3 are incorrect.

16. Consider the following statements:

1. In flow through hydrodynamically smooth pipes, the friction factor f is always a constant.
2. In flow through hydrodynamically smooth pipes, the friction factor f is always a function of the flow Reynolds number.
3. In a fully developed rough turbulent pipe flow, the friction factor f is a function of relative roughness only.
4. In a fully developed rough turbulent pipe flow, the friction factor f is a function of the flow Reynolds number and relative roughness.

Which of the above statements are correct?

(a) 1 and 3 (b) 2 and 3

(c) 2 and 4 (d) 1 and 4

Ans. **(b)**

Sol. Statement 2 & 3 are correct.

17. Two identical centrifugal pumps are connected in parallel to a common delivery pipe of a system. The pump curve of each of the pumps is represented by H = 20 – 60Q^2 where H is manometric head of the pump and Q is the discharge of the pump. The head loss equation when two such fully-similar pumps jointly deliver the same discharge Q will be

(a) $H = 40 - 15Q^2$ (b) $H = 20 - 60Q^2$

(c) $H = 40 - 60Q^2$ (d) $H = 20 - 15Q^2$

Ans. (d)

Sol. Given that $H = 20 - 60Q^2$

When two pumps (joined in parallel) required to deliver discharge Q each pump will be delivering Q/2 discharge. Hence Head loss equation

$$H = 20 - 60 \times \left(\frac{Q}{2}\right)^2$$

$$H = 20 - 15Q^2$$

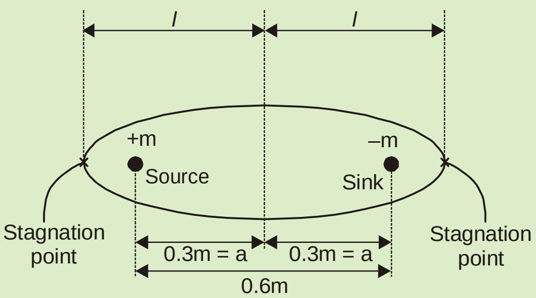
18. A line source of strength $15\pi m/s$ is situated within a uniform stream flowing at –12 m/s (i.e., righ to left). At a distance of 0.6m downstream from the source is an equal sink. How far will the stagnation points be from the nearest source/sink?

(a) 0.38m (b) 0.46m

(c) 0.52m (d) 0.58m

Ans. (a)

Sol.



$$l = \sqrt{\frac{ma}{\pi U} + a^2}$$

$$m = 15\pi \text{ m/s}$$

$$a = \frac{0.6 \text{ m}}{2} = 0.3 \text{ m}$$

$$U = 12 \text{ m/s}$$

$$\Rightarrow \quad l = \sqrt{\frac{15\pi \times 0.3}{\pi \times 12} + (0.3)^2} = 0.682 \text{ m}$$

Distance between source/sink and stagnation point = l – a = 0.682 – 0.3 = 0.382 m.

19. At the point of operation with maximum efficiency, a turbine indicated unit power of 12 units and unit speed of 98 units and operates with 3300 kgf/s of flow. What are the speed in rpm and the specific speed of the machine respectively when its design head is 8.5m?

(a) 285 rpm and 339 (b) 270 rpm and 360

(c) 285 rpm and 360 (d) 270 rpm and 339

Ans. (a)

Sol. Given that

Unit speed = $N_u = 98$

Unit power P_u = 12

Design Head, H = 8.5 m

Unit speed is defined as speed of turbine working under unit head

Hence $N = N_u \sqrt{H}$

Speed $N = 98\sqrt{8.5} = 285.7 \text{ rpm}$

Simlarly $P = P_u (H)^{3/2}$

$$P = 12(8.5)^{3/2}$$

$$P = 297.38 \text{ KW}$$

Hence, Specific Speed $N_s = \dfrac{N\sqrt{P}}{H^{5/4}}$

$$= \frac{285.7 \times \sqrt{297.38}}{(8.5)^{5/4}}$$

$$N_S = 339.46 \text{ rpm}$$

20. A hydraulic turbine develops 8000 kW when running at 300 rpm under a head of 45 m. the speed of the same turbine under a head of 60m is

(a) 224.4 rpm (b) 346.4 rpm

(c) 424.8 rpm (d) 485.8 rpm

Ans. (c)

Sol. Power $P = 8000$ KW

Speed $N = 300$ rpm

Head $H = 45$ m

Specific Speed, $N_S = \dfrac{N\sqrt{P}}{H^{5/4}}$

i.e. for same power

$$N \propto H^{5/4}$$

$$N_2 = N_1\left(\frac{H_2}{H_1}\right)^{5/4}$$

$$= 300 \times \left(\frac{60}{45}\right)^{5/4}$$

$$N_2 = 429.82 \text{ rpm}$$

21. In a single-acting reciprocating pump, the acceleration head at the beginning of the suction stroke is 3.5m. If the pump is 1.5m below the water level in the supply reservoir, the pressure head at the cylinder reservoir, the pressure head at the cylinder at that instant, considering the atmospheric pressure as 10.0m is

(a) 2 m (abs) (b) 4 m (abs)

(c) 8 m (abs) (d) 16 m (abs)

Ans. (c)

Sol. Available head at the entrance of cylinder would be 10 + 1.5 = 11.5 m.

Suction head created by pump = –3.5m

Hence, pressure head at the cylinder

= 11.5 – 3.5

= 8 m (abs)

22. A solid cylinder of circular section of diameter d is of material with specific gravity S_s. This floats in a liquid of specific gravity S_l. What is the maximum length of the cylinder if equilibrium is to be stable with the cylinder aixs veritcal?

(a) $\dfrac{dS_s}{2\sqrt{S_s(S_l - S_s)}}$

(b) $\dfrac{dS_l}{\sqrt{8S_s(S_l - S_s)}}$

(c) $\dfrac{dS_l}{\sqrt{2S_s(S_l - S_s)}}$

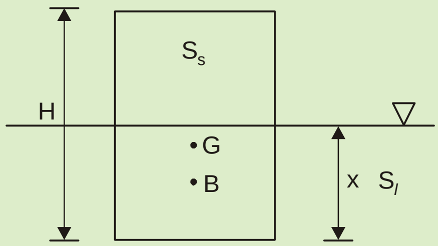
(d) $\dfrac{d}{\sqrt{8(S_l - S_s)}}$

Ans. (b)

Sol. Let height at cylinder be H.

Sp. gravity of cylinder = S_s

Sp. gravity of liquid = S_l



Now, $AH\gamma_w S_s = Ax\gamma_w S_l$

$$x = \frac{HS_s}{S_l}$$

Hence, centre of bouyancy will be at x/2 from bottom of cylinder.

$$BG = \frac{H}{2} - \frac{x}{2}$$

$$BG = \frac{H}{2}\left(1 - \frac{S_s}{S_l}\right)$$

Let M be the meta centre

$$BM = \frac{I}{V} = \frac{\left(\frac{\pi D^4}{64}\right)}{\frac{\pi D^2}{4} \times \frac{S_S}{S_l} H} = \frac{D^2}{16\frac{S_S}{S_l}H}$$

For stable equilibrium

$$BM > BG$$

$$\frac{D^2}{16\frac{S_S}{S_l}H} > \frac{H}{2}\left(1 - \frac{S_S}{S_l}\right)$$

$$H^2 < \frac{D^2}{8\frac{S_S}{S_l}\left(1-\frac{S_s}{S_l}\right)}$$

$$H < \frac{DS_l}{\sqrt{8S_S(S_l - S_S)}}$$

Maximum height of cylinder = $\dfrac{DS_l}{\sqrt{8S_S(S_l - S_S)}}$

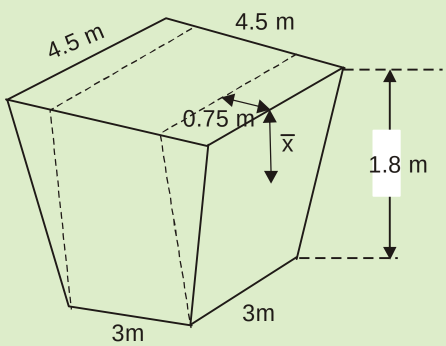
23. A tank is 1.8m deep and square length of 4.5m at the top and square length of 3m at the bottom. The four sides are plane and each has the same trapezoidal shape. The tank is completely full of oil weighing 936kg/m^3. What is the resultant pressure on each side?

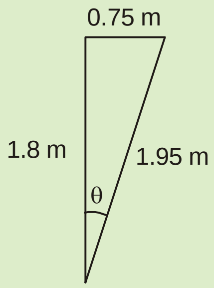
(a) 5750 kgf (b) 5500 kgf

(c) 5250 kgf (d) 5140 kgf

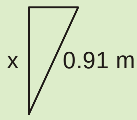
Ans. (a)

Sol.





$$\bar{x} = \frac{2\times3+4.5}{7.5}\times\frac{1.95}{3} = 0.91\,m$$



$$\frac{x}{0.91} = \frac{1.8}{1.95}$$

$$\Rightarrow \quad x = 0.84 \text{ m}$$

pressure at C.G × Area = pressure force

$$= \gamma x \times \frac{3+4.5}{2} \times 1.95$$

$$= 9.81 \times 936 \times 0.84 \times \frac{7.5}{2} \times 1.95$$

$$= 56401.4178 \text{ N}$$

$$= 5749.38 \text{ kgf}$$

24. Over a basin of area 333 km^2, there was a storm for 6 h with a uniform intensity of 2 cm/h. The observed runoff was 20×10^6 m^3. the average rate of infiltration for the basin was

(a) 5 mm/h (b) 10 mm/h

(c) 20 mm/h (d) 40 mm/h

Ans. (b)

Sol. Area of basin = 333 km^2

Intensity i = 2 cm/hr

duraiton = 6 hr

Runoff = 20×10^6 m^3

Average rate of infiltration = $\frac{Ait - R}{At}$

$= \frac{333 \times 10^6 \times 0.02 \times 6 - 20 \times 10^6}{333 \times 10^6 \times 6}$

= 10 mm/hr

25. International Traffic Intelligent Survey Data are related with

(a) Origin and destination studies

(b) Speed and delay studies

(c) Classified traffic volume studies

(d) Accident profiling studies

Ans. (b)

26. A peak flow of a flood hydrograph due to a six-hour storm is 470 m^3/s. The corresponding average depth of rainfall is 8 cm. Assume an infiltration loss of 0.25 cm/hour and a constant base flow of 15 m^3/s. What is the peak discharge of 6 hour unit hydrograph for this catchment?

(a) 60 m^3/s (b) 70 m^3/s

(c) 80 m^3/s (d) 90 m^3/s

Ans. (b)

Sol. Given,

$Q_f = 470\ m^3/s$

$d = 8$ cm i = 0.25 cm/hr, $Q_b = 15\ m^3/s$

$d_e = d - i \times t$

(d_e = effective depth of rainfall)

$= 8 - 0.25 \times 6$

$= 6.5$ cm

$Q_d = Q_f - Q_b$

$= 470 - 15$

$= 455$

Q_P of 6hr unit hydrograph = $\frac{Q_d}{d_e} = \frac{455}{6.5}$

$= 70\ m^3/s$

27. A new reservoir has a capacity of 12 Mm^3 and its catchment area is 400 km^2. The annual sediment yield from this catchment is 0.1 ha.m/km^2 and the trap efficiency can be assumed constant at 90%. The number of years it takes for the reservoir to lose 50% of its initial capacity is, nearly

(a) 177 years (b) 77 years

(c) 17 years (d) 7 years

Ans. (c)

Sol. Capacity of reservoir = 12 Mm^3

Catchment area = 400 km^2

Annual sediment yield = 0.1 ha.m/km^2

Total sediment yield in a layer

$= 400 \times 0.1 \times 0.9$

= 36 ha.m

50% of initial capacity = 12 $Mm^3 \times 0.5$

$= 6 \times 10^6\ m^3$

Years required to lose 50% of initial capacity

$= \frac{6 \times 10^6}{36 \times 10^4}$

= 16.67 year

$\simeq$ 17 years

28. Cavitation is likely to occur if

1. Pressure becomes very high
2. Temperature becomes low
3. Pressure at the specific points falls below vapour pressure
4. Energy is released with the onset of a high intensity wave due to noise and vibration of the machine.

Which of the above statements are correct?

(a) 1 and 3 (b) 2 and 3
(c) 3 and 4 (d) 2 and 4

Ans. (c)

Sol. Cavitation occurs when at a point fluid temperature gets too high or the fluid pressure becomes too low.

In cavitation, energy is released with the start of a high intensity wave due to noise and vibration of machine.

29. Which of the following statements are correct as regards aquifer characteristics?

1. The storage coefficient is the volume of water released from storage from the entire aquifer due to unit depression of peizometric head.
2. The storage coefficient is the same as the specific yield for water table aquifer.
3. Both the aquifer constants, viz. storage coefficient S and Transmissivity T are dimensionless numbers.

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

Ans. (b)

Sol.

(i) Storage coefficient or storativity is the volume of water released from the storage per unit decline in piezometric head, per unit area of aquifer.

(ii) Water table aqifer $\Rightarrow$ unconfined aquifer. For unconfined aquifer, storage coefficient is approximately equal to the specific yield.

(iii) Storage coefficient is a dimensionless number

Transmissivity = kd

Unit = $\frac{m}{day} \times m = m^2/day$

So transmissivity is not a dimensionless number.

30. The important parameters describing the performance of a hydraulic machine are P the power input, H the head produced across the machine and the efficiency, η. For a given geometrical design of the machine, the performance is characterized by the variables: H - the head increase across the machine, ρ - the fluid density, ω - the angular velocity of the rotor, D - the diameter of the rotor, μ - the fluid viscosity and Q - the flow rate; and both P and η are expressed thorugh these variables. How many non-dimensional parameters are involved herein? Gravitational acceleration g has also to be considered necessarily?

(a) 7 (b) 6
(c) 5 (d) 4

Ans. (d)

Sol. P and n can be expressed in terms of 7 parameters viz H, $H, \rho, \omega, D, u, Q, g$.

$\therefore$ No. of non dimensional parameter = 7– 3=4

31. What are the values of coefficients a and c if velocity distribution in a laminar boundary layer on a flat is:

$$f(n)\frac{u}{U_0} = a + bn + cn^2 + dn^3$$

Where, $n = \frac{y}{\delta}$

(a) $\frac{1}{2}$ and 1 (b) 0 and 1
(c) $-\frac{1}{2}$ and 0 (d) 0 and 0

Ans. (d)

Sol. $\frac{u}{U_0}$ = a + bn + cn^2 + dn^3,

$$n = \frac{y}{\delta}$$

At $y = 0, \quad u = 0$

$\therefore \quad 0 = a + 0 + 0 + 0$

$\Rightarrow \quad \mathbf{a = 0}$

At $y = \delta, \quad u = U_0$

$\Rightarrow \quad \frac{u_0}{u_0} = b + c + d = 1$

And at $\quad y = \delta, \quad \frac{du}{dy} = 0$

$$\frac{du}{dy} = b + 2cn + 3dn^2$$

$$0 = b + 2c + 3d$$

at $\quad y = 0 \quad \frac{d^2u}{dy^2} = 0$

$\therefore \quad 0 = 2c$

$\Rightarrow \quad \mathbf{c = 0}$

32. The conditions to be satisfied for a channel in 'Regime' as per Lacey are

1. Constant discharge
2. Silt grade and silt concentration are constant
3. The channel is flowing in unlimited incoherent alluvium of the same alluvial character as that transported.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1, 2 and 3

(c) 1 and 3 only (d) 2 and 3 only

Ans. (b)

Sol. All three are the essential characteristics for the true regime condition according to lacey According to Laceys theory for True Regime condition

1. Discharge is constant.
2. Flow is uniform
3. Silt charge is constant, i.e. amount of silt is constant.
4. Silt grade is constant, i.e. type and size of silt is always same.
5. Channel is flowing through incoherent alluvium, and it is of same grade which is transported.

33. Consider the following statements related to uplift pressure in gravity dams:

1. A drainage gallery reduces the uplift pressure at all levels below the gallery.
2. A drainage gallery below uipstream water level reduces the uplift pressure at all levels below the upstream water level.
3. A grout curtain near the heel reduces seepage and uplift pressure everywhere on the gravity dam whatever the upstream water level.

Which of the above statements are correct?

(a) 2 and 3 only (b) 1 and 2 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

34. A barrage on a major river in the Gangetic plains has been designed for a flood discharge 7000 m^3/s. It has been provided with a waterway of 360 m length. The losseness factor of this barrage is

(a) 1.7 (b) 1.1

(c) 0.7 (d) 0.1

Ans. (*)

Sol. Looseness factor $= \frac{\text{Actual width}}{\text{Regime width}}$

Actual width = 360 m (Given)

According to Laceys theory

Regime width

$\Rightarrow W = 4.75\sqrt{Q}$

$W = 4.75\sqrt{7000}$

$W = 397.41$

Looseness factor = $\frac{360}{397.41}$ = 0.90

35. A 20 m long horizontal concrete floor under a barrage on a permeable foundation retains a 5m head of water and has a 5 m deep downstream end pile. The exit gradient is

(a) 1 in 4 (b) 1 in 5
(c) 1 in 6 (d) 1 in 8

Ans. (b)

Sol. $G_E = \frac{H}{d} \cdot \frac{1}{\pi\sqrt{\lambda}}$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$$

$$\alpha = \frac{b}{d} = \frac{20}{5} = 4$$

$$\lambda = \frac{1+\sqrt{1+4^2}}{2} = 2.56$$

$$G_E = \frac{5}{5} \cdot \frac{1}{3.14 \times \sqrt{2.56}}$$

$$G_E = \frac{1}{5}$$

36. Electrical conductivity (EC) of water and total dissolved solids (TDS) are relatable as:

The value of EC will

(a) Decrease with increase in TDS
(b) Increase with increase in TDS
(c) Decrease initially and then increase with increase in TDS
(d) Increase initially and then decrease with increase in TDS

Ans. (b)

Sol. EC×640 =TDS

Hence, value of EC will increase with increase in TDS

37. Consider the following properties of fluorine:

1. It is a member of the halogen family
2. It is a greenish yellow diatomic gas
3. Chlorine, iodine, bromine and Helium are members of the halogen family.
4. Even fireproof of asbestos burns in the ambience of fluorine.

Which of the above are correct?

(a) 1, 2 and 3 only (b) 3 and 4 only
(c) 1, 2 and 4 only (d) 1, 2, 3 and 4

Ans. (c)

Sol. (i) Flourine is the lightest halogen and exists as a highly toxic pale yellow diatomic gas.

(ii) Helium is not a member of hologen family

(iii) Even fireproof abestos burns in the ambience of fluorine

38. The following are certain operating problems of a rapid sand filter:

1. Sand depth should never be depleted by more than 10 cm.
2. Air binding results due to development of negative head and fomration of air bubbles in the filter sand.
3. Water softening with lime-soda leads to incrustation of sand.
4. Bumping of filter bed is caused due to negative head.

Which of the above statements are correct?

(a) 1, 2 and 4 only (b) 1, 2 and 3 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Sol. Sand bed should never be depleted more than 10cm from the original thickness.

Bumping is caused by improper back wash.

39. Consider the following characteristics of E.Coli bacteria:

1. Gram negative
2. Spore-forming
3. Facultative anaerobic
4. Bacillus

Which of the above are correct?

(a) 1, 2 and 3 only (b) 2 and 4 only

(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Ans. **(c)**

Sol. E-coli bacteria is a gram negative, non-spore forming, facultatively anaerobic bacteria.

40. How much bleaching powder is needed to chlorinate 5000*l* of water whose chlorine demand is 2 mg/*l*, assuming that the bleaching powder has 25% available chlorine?

(a) 4 g (b) 40 g

(c) 140 g (d) 400 g

Ans. **(b)**

Sol. Bleaching power required to chlorinate 5000*l* of water

$$= 5000 \times \frac{2 \times 10^{-3}}{0.25} \text{gm}$$

$$= 40 \text{ gm}$$

41. A water supply distribution system for an averagely-populated township is to be designed for

(a) Maximum daily demand
(b) Maximum hourly demand and fire demand
(c) Average demand
(d) Maximum daily demand and fire demand or maximum hourly demand, whichever is higher

Ans. **(d)**

Sol. A water supply distribution system is designed for Max. of $\begin{Bmatrix} \text{Max. daily demand} + \text{Fire demand} \\ \text{Max. hourly demand} \end{Bmatrix}$

42. A combined sewerage system is more appropriate for developed areas where

(a) Rainfall occurs for a very few days in a year
(b) Rainfall occurs almost uniformly throughout the year
(c) Air temperatures are nearly uniform throughout the year
(d) Air temperatures through the year include extremes during certain runs of days

Ans. **(b)**

Sol. A combined sewerage system is more appropriate for developed areas where rainfall occurs almost uniformly throughout the year.

43. The velocity distribution in the boundary layer is given by $\frac{u}{U} = \frac{y}{\delta}$, where u is the velocity at a distance of y from the boundary and u = U at y = δ, δ being boundary layer thickness. Then the value of momentum thickness will be

(a) $\frac{\delta}{2}$ (b) $\frac{\delta}{4}$

(c) $\frac{\delta}{6}$ (d) $\frac{\delta}{8}$

Ans. **(c)**

Sol. Given $\frac{u}{U_0} = \frac{y}{\delta}$

$$\text{Momentum Thickness} = \int_0^{\delta} \left(1 - \frac{u}{U_0}\right) \frac{u}{U_0} dy$$

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

$$\theta = \int_0^\delta \left(\frac{y}{\delta}-\frac{y^2}{\delta^2}\right) dy$$

$$\theta = \left|\frac{y^2}{2\delta}-\frac{y^3}{3\delta^2}\right|_0^\delta$$

$$\theta = \frac{\delta}{2}-\frac{\delta}{3}$$

$$\theta = \frac{\delta}{6}$$

44. 100 m^3 of sludge holds a moisture content of 95%. If its moisture content chagnes to 90%, the volume of this sludge will then be

(a) $40.5m^3$ (b) $50m^3$

(c) $75m^3$ (d) $94.7m^3$

Ans. **(b)**

Sol. With the change in moisture content, volume of solids remains same in both case.

Therefore equating the volume of solids in both cases.

$$V_1(1-P_1) = V_2(1-P_2)$$

$$100(1-0.95) = V_2(1-0.9)$$

$$5 = V_2 \times 0.1$$

$$V_2 = 50 \text{ m}^3$$

45. The design overflow rate of a sedimentation tank is chosen considering

(a) Flow rate through the tank

(b) Diameter of the particle intended to be removed

(c) Volume of the sedimentation tank

(d) Detention time in the tank

Ans. **(b)**

Sol. Design overflow rate of sedimentation tank is chosen considering diameter of teh particle intended to be removed.

$$V_s = \frac{(G_s-1)gd^2}{18\mu}$$

V_s = Setting velocity of particle

d = diameter of the particle

46. Consider the following statements in respect of flow equalization in a waste water treatement plant :

1. Bilogical treatement is enhanced because shock loadings are eliminated or minimized
2. Flow equalization is an attrative option for upgrading the performance of overloaded treatement plants.
3. Inhibiting substances can be diluted and pH can be stabilized
4. Thickening performance of primary sedimentation tanks following grit removal is improved

Which of the above statements are correct?

(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only

(c) 1, 2 and 4 only (d) 3 and 4 only

Ans. **(a)**

Sol.

(i) Flow equalization is a method to overcome problems related to fluctuations in flow rate and pollution load.

(ii) It helps in lowering the strength of waste water by diluting it with waste water already present in equalization tank.

(iii) Flow equalization basin is located after screening and grit removal but before primary sedimentation.

(iv) Thickner/settler and filter performance gets enchanced and their surface area gets reduced.

47. A drain carrying $5m^3/s$ of wastewater with its BOD of 100mg/*l* joins a stream carrying 50 m^3/s flow with its BOD of 5mg/*l*. What will be the value of the BOD of the combined flow after complete mixing?

(a) 3.6 mg/*l*

(b) 13.6 mg/*l*

(c) 33.6 mg/*l*

(d) 53.6 mg/*l*

Ans. (b)

Sol. BOD after complete mixing

$$= \frac{Q_w BOD_w + Q_s BOD_s}{Q_w + Q_s}$$

$$= \frac{5 \times 100 + 50 \times 5}{5 + 50}$$

$$= 13.63 \text{mg}/l$$

48. Consider the following statements in respect of aerated grit chamber:

1. The grit accumulates at the bottom in advancing sprial-flow aeration tanks, locationally preceded by grit chambers, led to the eventual development of aerated grit chambers.
2. The excessive wear on grit handling equipment is a major factor for the popularity of aerated grit chambers.
3. Aerated grit chambers are designed to provide detention period of 1 minute at maximum rate of flow.
4. Diffusers are located at 0.45 m to 0.6 m above the bottom of teh chamber.

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 3 and 4 only

(c) 1, 2 and 4 only (d) 1, 2, 3 and 4

Ans. (c)

Sol. (i) It is designed for typical detention time of 3 minutes at maximum flow.

(ii) Diffusers are located at 0.45 – 0.6m from the bottom

(iii) Excessive wear of grit handling equipment and necessity of separate grit washer can be eliminated by using aerated grit chamber.

(iv) An aerated grit chamber consists of a standard flow aeration tank provided with air diffusion tubes placed on one side of the tank.

49. The side of a square land was measured as 150 m and is in error by 0.05 m. What is the corresponding error in the computed area of the land.

(a) 5 m^2 (b) 10 m^2

(c) 15 m^2 (d) 20 m^2

Ans. (c)

Sol.

$$\text{Area} = (\text{side})^2$$

$$\frac{d\,(\text{Area})}{d\,(\text{side})} = 2 \times \text{side}$$

$$d\,(\text{Area}) = 2 \times \text{side} \times d\,(\text{side})$$

$$d(\text{Area}) = 2 \times 150 \times 0.05$$

$$d(\text{Area}) = 15 \text{ m}^2$$

50. Consider the following statements in respect of anerobic sludge digester:

1. It is less expensive compared to several other methods available.
2. Processing of separable solids impacts the environment to a minimum
3. Quantity of separated solids requiring disposal is minimal
4. Digested sludge is very readily dewaterable.

Which of the above statements are correct?

(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only
(c) 3 and 4 only (d) 1, 2 and 4 only

Ans. (a)

51. Consider the following statements as regards a Septic Tank:

1. The size required is large and uneconomical when serving more than roughly 100 persons.
2. It can remove around 90% of BOD and 80% of suspended solids.
3. As compared to the sludge holdings of a plain sedimentation tank, a septic tank can hold about 90% less of sludge volume.
4. Frequent removal of sludge is not required

Which of the above statements are correct?

(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

Ans. (c)

Sol. (i) Septic tank canbe provided when number of user does not exceed 300 persons.

(ii) Septic tank removes around (25 – 65)% BOD and (40 –75)% of suspended solids

Statement 3 and 4 are correct.

52. Sewage sickness relates to

(a) Toxicity of sewage interfering with 'response' to treatment
(b) Destruction fo aquatic flora and fauna due to gross pollution of receiving bodies of water by the sewage
(c) reduction in the waste purifying capacity of the soil
(d) Clogging of pores in soil due to excessive application of sewage leading to obstruction of land areation thereby leading to septic conditions in the land

Ans. (d)

Sol. Sewage sickness relates to clogging of pores in soil due to excessive application of sewage loading to obstruction of land aeration thereby leading to septic conditions in the land.

53. The waste water of a certain large colony contains $10^{-5.6}$ mmol/l of OH^- ions at 25ºC. The pH of this sample is

(a) 8.6 (b) 7.9
(c) 5.4 (d) 4.5

Ans. (c)

Sol. Concentraiton of OH^- ion = $10^{-5.6}$ mmol/litre

$$= 10^{-5.6} \times 10^{-3} \text{ mol/litre}$$
$$= 10^{-8.6} \text{ mol/litre}$$
$$pOH = -\log [OH]$$
$$= -\log 10^{-8.6}$$
$$= 8.6$$
$$pH = 14 - pOH$$
$$= 14 - 8.6$$
$$= 5.4$$

54. Consider the relevance of the following features for causing photochemical smog:

1. Air stagnation
2. Abundant sunlight
3. High concentration of NO_x in atmosphere.
4. High concentration of SO_2 in atmosphere.

Which of the above statements are correct?

(a) 1, 2 and 4 only
(b) 3 and 4 only
(c) 1, 2 and 3 only
(d) 1, 2, 3 and 4

Ans. (c)

Sol. A photochemical smog is a chemical reaction of sunlight, nitrogen oxides and volatile organic compounds in the atmosphere, which leaves airborne particles and ground-level ozone.

55. Consider the following statements related to ecology:

1. All the physical, chemical and biological factors that a species needs in order to live and reproduce is called ecological niche.
2. The boudnary zone between two ecosystems is known as ecotone.
3. The forests in the Arctics are known as tundra.
4. A biome usually has a distinct climate and life forms adapted to that climate. Biome is more extensive and complex than an ecosystem

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. **(d)**

Sol. All the above statements are correct.

56. Consider the following laws of ecology suggested by Barry Commoner:

1. Everything is connected to everything else.
2. Everything must go somewhere.
3. Nature knows best.
4. There is no such thing as a free lunch.

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. **(d)**

Sol. These are four laws of ecology formulated by ecologist Barry commoner.

57. For a hydraulically efficient rectangular channel of bed width 5m, the hydraulic radius is

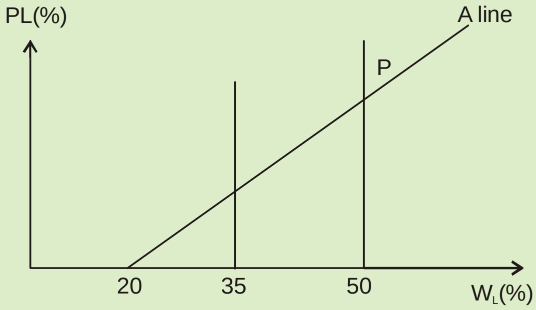
(a) 0.5m (b) 1.25m
(c) 2.75m (d) 4.25m

Ans. **(b)**

Sol. For a hydraulically efficient rectangular channel, hydraulic radius = $\frac{y}{2}$ and B = 2y for hydraulically efficient channel

$$\therefore \quad R = \frac{B}{2\times 2} = \frac{B}{4} = \frac{5}{4} = 1.25 \text{ m}$$

58. The standard plasticity chart by casagrande to classify fine-grained soils is shown in the figure.

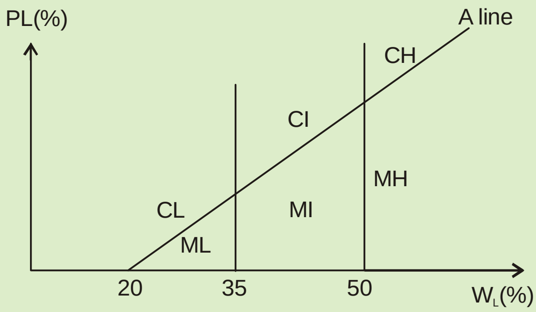


The area marked P represents.

(a) Inorganic clays of high plasticity
(b) Organic clays and highly plastic organic silts
(c) Organic and inorganic silts and siltclays
(d) Clays

Ans. **(a)**

Sol.



$\therefore$ P lies in the area of inorganic clays of high plasticity.

59. A soil sample has shrinkage limit of 6%, and the specific gravity of the soil grains is 2.6. The porosity of soil at shrinkage limit is

(a) 7.5% (b) 9.5%
(c) 13.5% (d) 16.5%

Ans. (c)

Sol. ω_s = 6% G_S = 2.6

At shrinkage limit, soil is fully saturated.

Now $Se = \omega G_s$

$1 \times e = 0.06 \times 2.6$

$e = 0.156$

$$n = \frac{e}{1+e} = \frac{0.156}{1+0.156} = 0.135$$

60. What is the dry unit weight of a clay soil when the void ratio of a sample thereof is 0.50, the degree of saturation is 70%, and the specific gravity of the soil grains is 2.7? Take the value of γ_ω to be 9.81 kN/m^3?

(a) 13.65 kN/m^2 (b) 19.95 kN/m^2
(c) 26.65 kN/m^2 (d) 29.95 kN/m^2

Ans. (*)

Sol.
$$\gamma_d = \frac{G\gamma_\omega}{1+e}$$
$$= \frac{2.7 \times 9.81}{1+0.5} = 17.658 \text{ KN/m}^3$$
$$\gamma_{bulk} = \frac{(G_s + Se)\gamma_w}{1+e}$$
$$= \frac{(2.7 + 0.7 \times 0.5) \times 9.81}{1+0.5}$$
= 19.95 kN/m^3

(In question it should be γ_{bulk} and not γ_{dry})

61. Which technique of stabilization for the sub-base is preferred for a heavy plastic soil?

(a) cement stabilization
(b) mechanical stabilization
(c) lime stabilization
(d) bitumen stabilization

Ans. (c)

Sol. Lime changes the nature of the adsorbed layer and provides pozzolonic action. Plasticity index of highly plastic soils are reduced by addition as lime with soil. There is an increase in optimum water content and a decrease in the maximum compacted density and the strength and durability of soil increases.

62. A fill having volume of 150000 m^3 is to be constructed at a void ratio of 0.8. The borrow pit solid has a void ratio of 1.4. The volume of soil required to be excavated from the borrow pit will be

(a) 150000 m^3 (b) 200000 m^3
(c) 250000 m^3 (d) 300000 m^3

Ans. (b)

Sol. Solid volume required fill construction

$$= \frac{150000}{1+0.8} = 83333.33 \text{m}^3$$

Volume of soil excavated from borrow pit

$$= 83333.33 \times (14)$$
$$= V_d(1+1.4) = 200{,}000 \text{m}^3$$

63. A channel designed by Lacey's theory has a mean velocity of 1.1 m/s. The silt factor is 1.1. Then hydraulic mean radius will be

(a) 1.13 m (b) 2.27 m
(c) 3.13 m (d) 4.27 m

Ans. **(*)**

Sol. $$R = \frac{5}{2}\frac{v^2}{f}$$

$$R = \frac{5}{2}\times\frac{1.1^2}{1.1}$$

$$R = 2.5 \times 1.1$$

$$R = 2.75 \text{ m}$$

64. Consider the following assumptions as regards field permeability test:

1. The flow is laminar and Darcy's law is valid.
2. The flow is horizontal and uniform at all the points in the vertical section.
3. The velocity of flow is proportional to the 'tangent magnitude' of the hydraulic gradient.

Which of the above assumptions are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. **(d)**

65. In a three-layered soil system, the thicknesses of the top and bottom layers each are half the thickness of the middle layer. The coefficients of permeability of the top and bottom layers each are double the coefficient of permeability k of the middle layer. When horizontal flow occurs, the equivalent coefficient of permeability of the system will be

(a) 1.5 k (b) 3.0 k

(c) 4.5 k (d) 6.0 k

Ans. **(a)**

Sol. $$K_H = \frac{K_1H_1 + K_2H_2 + K_3H_3}{H_1 + H_2 + H_3}$$

$$= \frac{2K\times\frac{t}{2} + K\times t + 2K\times\frac{t}{2}}{\frac{t}{2} + t + \frac{t}{2}}$$

$$= \frac{3Kt}{2t} = 1.5K$$

66. A uniform collapsible sand stratum, 2.5 m thick, has specific gravity of its sand as 2.65, with a natural void ratio of 0.65. The hydraulic head required to cause quick collapsible sand condition is

(a) 2.50 m (b) 2.75 m

(c) 3.25 m (d) 3.50 m

Ans. **(a)**

Sol. $$i_{Cr} = \frac{G_s - 1}{1+e} = \frac{1.65}{1.65} = 1$$

$$i_{Cr} = \frac{h}{H}$$

$$h = i_{Cr}\times H$$

$$= 1 \times 2.5$$

$$= 2.5 \text{ m}$$

67. The ratio of dry unit weight to unit weight of water represents

(a) Specific gravity of soil solids

(b) Specific gravity of soil mass

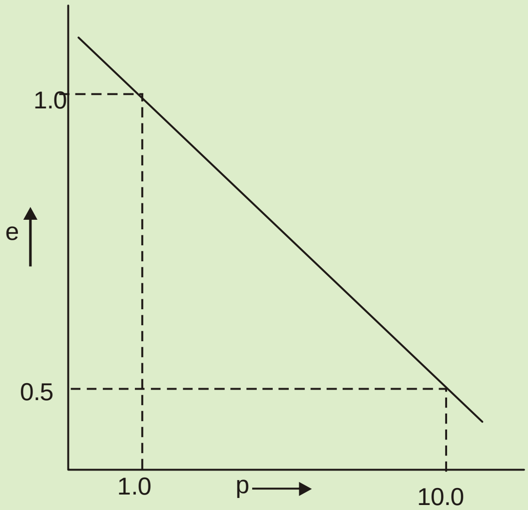
(c) Specific gravity of dry soil

(d) Shrinkage ratio

Ans. **(d)**

Sol. Shrinkage ratio is mass specific gravity of the soil in dry state

68.



The virgin compression curve with axes adopted as per convention in this regard for a clay soil is shown in the figure. The compression index of the soil is

(a) 0.25 (b) 0.50

(c) 1.00 (d) 1.25

Ans. (b)

Sol.

$$C_c = \frac{\Delta e}{\log_{10}\left(\frac{\bar{\sigma}_2}{\bar{\sigma}_1}\right)}$$

$$= \frac{1-0.5}{\log_{10}\left(\frac{10}{1}\right)} = 0.5$$

69. Proctor's compaction test for the maximum dry density of a certain soil gave the results as : 1.77 gm/cc and OMC 14.44%. The specific gravity of the clay soil grain was 2.66. What was the saturation degree for this soil?

(a) 44% (b) 55%

(c) 66% (d) 77%

Ans. (d)

Sol.

$$\gamma_d = \frac{G\gamma_w}{1+e}$$

$$1+e = \frac{2.66\times 1}{1.77}$$

$$e = 0.5028$$

$$S = \frac{wG}{e} = \frac{14.44\times 2.66}{0.5028}$$

$$= 76.39\%$$

$$\simeq 77\%$$

70. A rigid retaining wall of 6m height has a saturated backfill of soft clay soil. What is the critical height when the properties of the clay soil are:

$\gamma_{sat} = 17.56\ \text{kN/m}^3$ and cohesion C = 18kN/m^2.

(a) 1.1 m (b) 2.1 m

(c) 3.1 m (d) 4.1 m

Ans. (d)

Sol.

$$H_c = 2z_0 = \frac{4C}{\gamma} = \frac{4\times 18}{17.56}$$

$$= 4.1 \text{ m}$$

71. The Engineering News Record Formula,

$Q_a = \frac{Wh}{6(s+0.25)}$ is used for the case of

1. Drop hammer
2. Single acting hammer
3. Double acting hammer

Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. (b)

Sol. Emperical factor 'c' taken as 0.25 cm for single-acting hammer.

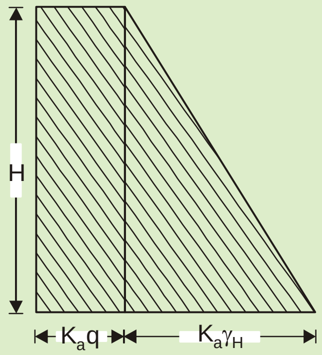
72. In a certain sea shore, the height of a retaining wall with smooth vertical back is 4.4 m. The foundation is over an expansive collapsible soil and has horizontal surace at the level of the top of the wall and carries a udl of 197 kPa. The unit weight and angle of internal friction are 19 kN/m^3 and 30°, respectively. What is the nearest magnitude of the total active pressure per metre length of this sea shore wall?

(a) 270 kN/m (b) 360 kN/m

(c) 450 kN/m (d) 640 kN/m

Ans. (b)

Sol.



$$P_a = K_a\left[\frac{1}{2}\times 19\times 4.4\times 4.4+197\times 4.4\right]$$

where, $K_a = \dfrac{1-\sin 30}{1+\sin 30}=\dfrac{1}{3}$

Hence, P_a = 350.24 kN/m

73. Which of the following statements are rightly associated with the laws of weights in the theory of errors?

1. If an equation is multiplied by its own weight, then the weight of the resulting equation is equal to the reciprocal of the weight of the original equation.
2. The weight of the algebraic sum of two or more quantities is equal to the reciprocal of the sum of the individual weights.
3. If the quantity of a given weight is multiplied with a factor, then the weight of the resulting quantity is obtained by dividing the original weight by the square root of that factor.
4. If the quantity of a given weight is divided by a factor, then the weight of the resulting quantity is obtained by multiplying the original weight by the square of that factor.

(a) 2 and 3 (b) 2 and 4

(c) 1 and 4 (d) 1 and 3

Ans. (c)

Sol. The weight of the algebric sum of two or more quantities is equal to the reciprocal of the sum of the reciprocal of their individual weights.

If the quantity of a given weight is multiplied with a factor, then the weight of resulting quantity is obtained by dividing the original weight by square of that factor.

74. Hypotenusal allowance is given by the expression (adopting standard conventions)

(a) $(1-\sec\theta)\times$ measured distance

(b) $(1-\cos\theta)\times$ measured distance

(c) $(\sec\theta-1)\times$ measured distance

(d) $(\cos\theta-1)\times$ measured distance

Ans. (d)

Sol. Hypotenusal allowance is correction for slope

$$C_g = -L\,(1-\cos\theta)$$

$$\therefore\quad C_g = L\,(\cos\theta-1)$$

75. The clogging of chain rings with mud introduces (with 'error' defined in the standard way)

1. Negative cumulative error
2. Positive cumulative error
3. Compensating error

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

Ans. **(b)**

Sol. Due to clogging of chain rings with mud, actual length of the chain will become less than nominal length of chain.

$\therefore$ M.V > T.V
$\because$ Error = M.V – T.V
$\therefore$ Error = +ve

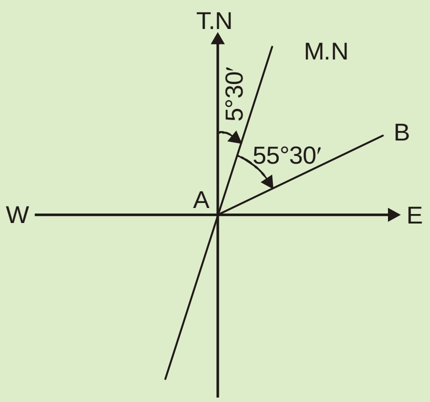
76. The magnetic bearing of a line (on full-circle mensuration basis) is 55° 30′ East. The true magnetic bearing of the line will be.

(a) 61° 00′ (b) 55° 30′
(c) 40° 00′ (d) 50° 00′

Ans. **(a)**

Sol. T.B = 55° 30′ + 5° 30′

T.B = 61°



77. In any closed traverse, if the survey work is error free, then

1. The algerbraic sum of all the latitudes should be equal to zero.
2. The algebraic sum of all the departures should be equal to zero.
3. The sum of the northings should be equal to the sum of the southings.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(a)**

Sol. In a closed traverse, if the survey is error free.

1. $\Sigma L = 0$
2. $\Sigma D = 0$

78. The rise and fall method for obtaining the reduced levels of points provides a check on

1. Foresight
2. Backsight
3. Intermediate sight

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. In rise and fall method R.L of back sight and fore sight sight are checked along with intermediate sight.

79. Turning of the theodolite telescope in vertical plane by 180° about the horizontal axis is known as

(a) Setting (b) Centering
(c) Transiting (d) Swinging

Ans. **(c)**

Sol. Turnning the theodolite telescope in vertical plane by 180° about horizontal axis is called as transiting.

Turnning the theodolite telescope in horizontal plane about vertical axis is called swinging.

80. Which of the following are among the fundamental lines of a theodolite?

1. The vertical and horizontal axes
2. The lines of collimation and axis of the plate levels.
3. The bublle line of the altitude level

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol. Fundamental lines of theodlite are:

(1) Vertical axis

(2) Horizontal axis

(3) Line of collimation

(4) Axis of plate levels

(5) Axis of telescope level

81. Local mean time of a place of longitude of $42°36'$ W is 8h 42 m 15 s AM. The corresponding Greenwich Mean Time is

(a) 10 h 32 m 40 s AM

(b) 11h 32 m 39s PM

(c) 0 h 32 m 39s PM

(d) 11 h 32 m 39s AM

Ans. (d)

Sol. $\text{GMT} = 8\text{h}\ 42\,\text{m}\ 15\text{S} + \dfrac{42°\,30'}{15°}$

GMT = 11 hr 32 m 39 sec AM

82. A vertical photograph of a flat area having an average elevation of 250m above mean sea level was taken with a camera of focal length 25 cm. A section line AB 300 m long in the area measures 15cm on the photograph; a tower BP in the area also appears on the photograph. The distance between images of top and bottom of the tower measures 0.5 cm on the photograph. The distance of the image of the top of the tower is 10 cm. The acutal height of the tower is

(a) 10 m (b) 15 m

(c) 20 m (d) 25 m

Ans. (d)

Sol. h = 250m, f = 25 cm, AB = 300m, ab = 15 cm, d = 0.5 cm, r = 10 cm, height of tower h_2 = ?

$$S = \frac{ab}{AB} = \frac{f}{H-h}$$

$$\frac{15}{300} = \frac{25}{H-250}$$

$$H = 750$$

$$d = \frac{rh_2}{H-h_1}$$

$$0.5 = \frac{10\times h_2}{750-250}$$

$$h_2 = 25\text{ m}$$

83. A tranportation trip survery was undertaken between private car, and public car transportation. The proportion of those using private cars is 0.45. While using the public transport, the further choices available are Metro Rail and Mono Rail, out of which commuting by a Mono Rail has a proportion of 0.55. In such a situation, the choice of interest in using a Metro Rail, Mono Rail and private car would be respectively.

(a) 0.25, 0.3 and 0.45 (b) 0.45, 0.25 and 0.3

(c) 0.25, 0.45 and 0.3 (d) 0.3, 0.25 and 0.45

Ans. (a)

Sol. $P_{metro} = 0.55 \times 0.45 = 0.2475 = 0.25$

$P_{mono} = 0.55 \times 0.55 = 0.3025 = 0.3$

$P_{private\ car} = 0.45$

84. An airfoil of surface area 0.1 m^2 is tested for lift L in a wind tunnel. (Conditions can be considered as incompressible flow.) At an angle of attack of 5°, with standard air density 1.22 kg/m^3, at a speed of 30m/sec, the lift is measured to be 3.2 kgf. What is the lift coefficient? For a prototype wing of area 10 m^2, what is the approximate lift at an air speed of 160 kmph at the same angle of attack of 5°?

(a) 0.572 and 700 kgf

(b) 0.603 and 700 kfg

(c) 0.572 and 570 kgf

(d) 0.603 and 570 kgf

Ans. (a)

Sol.
$$F_L = C_L \frac{\rho U_0^2}{2} A$$

$$3.2 \times 9.81 = \frac{C_L \times 1.22(30)^2 \times 0.1}{2}$$

$$C_L = 0.572$$

$$F_L \propto 3.2 \times \left(\frac{160 \times 0.278}{30}\right)^2 \times \left(\frac{10}{0.1}\right)$$

$$= 702.33 \text{ Kgf}$$

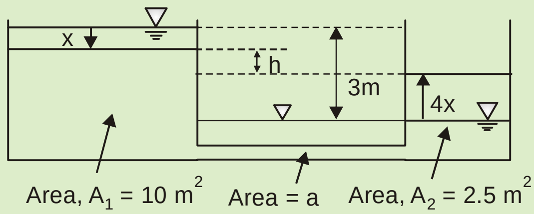
85. Two tanks A and B, of constant cross-sectional areas of 10 m^2 and 2.5 m^2, respectively, are connected by a 5cm pipe, 100 m long, with f = 0.03. If the initial difference of water levels is 3m, how long will it take for 2.5 m^3 of water to flow from A to B? Considering entry and exit losses, it can be grossly assumed that the flow velocity, in m/s, through the pipe is $1.75\sqrt{h}$, where h is in m, taking g = 10 m/sec^2; also, may take area of pipe as 2×10^{-3} m^2.

(a) 535 seconds (b) 516 seconds

(c) 485 seconds (d) 467 seconds

Ans. (d)

Sol.



$$h = 3 - 4x - x$$

$$\Rightarrow \quad h = 3 - 5x$$

$$V = 1.75\sqrt{3 - 5x}$$

If in time dt, water level falls by dx, then

$$V \times a(dt) = Adx$$

$$(1.75\sqrt{3-5x}) \times 2 \times 10^{-3} \times dt = 10.dx$$

For 2.5 m^3 of water to flow, time required = T

$$2.5 \text{ m}^3 = x_0 \times 10$$

$$x_0 = 0.25 \text{ m}$$

$$\Rightarrow \quad \int_0^{0.25} \frac{10}{1.75\sqrt{3-5x}} dx = \int_0^T 2 \times 10^{-3} dt$$

$$\Rightarrow \quad T = 467 \text{ sec}$$

86. The consistency and flow resistance of a sample of bitumen can be determined through which of the following tests?

(a) Viscosity test (b) Penetration test

(c) Ductility test (d) Softening point test

Ans. (a)

87. A pipe of 324 mm diameter, having friction coefficient as 0.04, connects two reservoirs with 15 m difference in their water levels through a 1500 m long pipe. What will be the discharge through the pipe?

(a) 104 lps (b) 134 lps

(c) 165 lps (d) 196 lps

Ans. (a)

Sol.
$$h = \frac{flV^2}{2gd}$$
$$V = 1.26 \text{ m/s}$$
$$Q = \frac{\pi}{4}(0.324)^2 \times 1.26 = 0.1038 \text{m}^3/\text{s}$$
$$= 103.8\, l/\text{sec}$$

88. Flexible concrete is a mix comprising of

(a) Gravel, filler and 30/40 bitumen

(b) Sand, filler and 30/40 bitumen only

(c) Gravel, sand, filler and 60/70 bitumen

(d) Sand, filler and 60/70 bitumen only

Ans. (c)

89. Consider a soil sample, for which tests yield the following results:

Passing 75 micron sieve	62%
Liquid limit	35%
Plasticity Index	14%

As per the group index classification of soil, what is the soil condition of the above soil sample?

(a) Poor (b) Fair

(c) Good (d) Excellent

Ans. (a)

Sol.

$GI = 0.2a + 0.005ac + 0.01bd$

where, $a = 62 - 35 = 27\%$

$b = 62 - 15 = 47\%$

$c = 0$

$d = 21 - 10 = 11$

$\text{P.I.} = \omega_L - \omega_P = 21$

$GI = 0.2a + 0.005ac + 0.01bd = 10.57 \approx 11(\text{Poor})$

90. Consider the following statements regarding ductility of bitumen:

1. Ductility is the property which does not permit bitumen to undergo large deformation without breaking.
2. Bitumens with high ductility are generally adhesive but do not have good cementing properties.
3. Ductility must be ascertained at two different temperatures in order to pronounce on the suitability of the material.

Which of the above statements is/are correct?

(a) 3 only (b) 2 only

(c) 1 only (d) 1, 2 and 3

Ans. (a)

91. A collapsible soil sub-grade sample was tested using Standard California Bearing Ratio apparatus; and the observations are given below

Sl. No.	Load	Penetration
1.	60.55 kg	2.5 mm
2.	80.55 kg	5.0 mm

Taking the standard assumption regarding the load penetration curve, CBR value of the sample will be taken as

(a) 3.9% (b) 4.0%

(c) 4.4% (d) 5.5%

Ans. **(c)**

Sol. $\text{CBR} = \dfrac{\text{Load carreied by specimen}}{\text{load carried by standard specimen}} \times 100$

At 2.5 mm penetration, CBR

$$= \frac{60.55}{1370} \times 100 = 4.4\%$$

At 5 mm penetration, CBR

$$= \frac{80.55}{2055} \times 100 = 3.9\%$$

CBR is the maximum of above two ratio i.e. 4.4%.

92. What is the critical thickness of a prestressed concrete pavement (using Westergaard's Corner Load Formula) to support a maximum wheel load of 4200 kg? Allow 10% for impact. Tyre pressure may be taken as 7 kg/cm^2. Assume flexural strength of concrete as 50 kg/cm^2, factor of safety as 2, subgrade reaction for plastic mix road as 6 kg/cm^3, and modulus of elasticity as 3 × 10^5 kg/cm^2.

(a) 19.6 cm (b) 21.6 cm

(c) 23.6 cm (d) 25.6 cm

Ans. **(*)**

93. At a hydraulic jump, the flow depths are 0.4 m and 5 m at the upstream and downsteam, respectively. The channle is wide rectangular. The discharge per unit width is nearly

(a) 5.8 m^2/s (b) 6.4 m^2/s

(c) 7.3 m^2/s (d) 8.3 m^2/s

Ans. **(c)**

Sol. $$\frac{2q^2}{g} = y_1 y_2 (y_1 + y_2)$$

$$\frac{2 \times q^2}{9.81} = 0.4 \times 5(0.4 + 5)$$

$$q = 7.3\, m^3/s$$

94. Overspeed and delay studies on a preselected section of a Highway are conducted by

(a) Fast moving car method

(b) Enoscope

(c) Radar

(d) Traffic contours

Ans. **(a)**

95. The surface tension of water at 20°C is 75 × 10^{-3} N/m. The difference in water surface within and outside an open-ended capillary tube of 1mm internal bore, inserted at the water surface, would nearly, be

(a) 7 mm (b) 11 mm

(c) 15 mm (d) 19 mm

Ans. **(c)**

Sol. $$h = \frac{4\sigma}{\gamma d}$$

$$= \frac{4 \times 75 \times 10^{-3}}{9.81 \times 10^3 \times 1 \times 10^{-3}} = 30\text{mm}$$

If we take bore as radius then d = 2mm

$\Rightarrow$ h = 15 mm

96. Survey of India was publishing toposheets using a scale of

(a) 1 : 1000 (b) 1 : 5000

(c) 1 : 10000 (d) 1 : 50000

Ans. **(d)**

Sol. Before adaptation of National Mapping Policy – 2005, Survey of India printed Topographical maps on 1 : 2, 50,000, 1 : 50,000 and 1 : 25, 000. Scales.

97. The maximum speed of a train on B.G. track having a curvature of 3° and cant of 10 cm with allowable cant deficiency of 76 mm, for conditions obtaining in India, is

(a) 87.6 km/h (b) 99.6 km/h

(c) 76.6 km/h (d) 65.6 km/h

Ans. (a)

Sol.

$$D = \frac{1720}{R}$$

$$R = 573.33 \text{ m}$$

$$V = \sqrt{\frac{127Re}{G}}$$

$$= \sqrt{\frac{127 \times 573.33 \times 0.176}{1.676}}$$

$$= 87.44 \text{ Km/h}$$

98. The gradient for a B.G railway line such that the grade resistance together with curve resistance due a 4° curve which will be equivalent to a simple ruling gradient of 1 in 150 is

(a) 1 : 180 (b) 1 : 200

(c) 1 : 300 (d) 1 : 400

Ans. (b)

Sol. Grade resistance + Curve resistance

= Ruling gradient resistance

$$\frac{\omega}{x} + 0.0004\omega D = \frac{\omega}{150}$$

$$D = 4°$$

$$x = 197.36 \approx 200$$

Gradient is 1 in 200.

99. A pelton wheel works under a head of 400m. Friction loss through the pipe flow is limited to 10%. The coefficient of velocity for the jet is 0.98. What is the velocity of the jet? Take g = 10 m/s^2.

(a) 83 m/s (b) 71 m/s

(c) 65 m/s (d) 56 m/s

Ans. (a)

Sol. Head available at the nozzle = 0.9 × 400

= 360 m

$$V = C_V\sqrt{2gH}$$

$$= 0.98\sqrt{2 \times 9.81 \times 360}$$

$$= 82.36 \text{ m/s}$$

100. The value of porosity of a soil sample in which the total volume of soil grains is equal to twice the total volume of voids would be

(a) 30% (b) 40%

(c) 50% (d) 60%

Ans. (a)

Sol.

$$V_s = 2V_V$$

$$n = \frac{V_V}{V_V + V_S} = \frac{1}{1 + \frac{V_S}{V_V}}$$

$$= \frac{1}{1+2} = \frac{1}{3} = 33.3\%$$

101. Consider the the following statements:

1. In an Impulse turbine, the pressure of the, flowing water remains unchanged and is equal to atmospheric pressure.
2. In Impulse turbines, the water impinges on the buckets with ‘pressure energy’.

3. In a Reaction turbine, the pressure of the, flowing water remains unchanged and is equal to atmospheric pressure.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

Ans. **(a)**

102. A Pelton wheel with single jet rotates at 600 rmp. The velocity of the jet from the nozzle is 100 m/s. If the ratio of the bucket velocity of jet velocity is 0.44 and the speed ratio is 0.43, what is the coefficient of velocity of the nozzle?

(a) 0·817 (b) 0·882
(c) 0·913 (d) 0.977

Ans. **(d)**

Sol.

$$U_1 = K_{U1}\sqrt{2gH}$$
$$K_{U1} = \text{Speed ratio}$$
$$U_1 = 0.44\times 100 = 44\,m/s$$
$$V = C_V\sqrt{2gH}$$
$$C_V = \frac{V}{\sqrt{2gH}} = \frac{100}{44/0.43} = 0.977$$

Directions:

Each of the next **Eighteen (18)** items consists of two statements, one labelled as the 'Statement (I)' and the other as 'Statement (II)', Examine these two statements carefully and select the answers to 'these items using the codes given below :

Codes:

(a) Both Statement (1) and' Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is ***not*** the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

103. **Statement (I):** : The shear strain graph for a Newtonian fluid is linear.

Statement (II): The coefficient of viscosity μ of the fluid is not a constant.

Ans. **(c)**

104. **Statement (I):** : Reynolds number must be the same for model and the prototype when, both are tested as immersed in a subsonic flow.

Statement (II): A model should be geometlically similar to the prototype.

Ans. **(b)**

105. **Statement (I):** The ogee spillway is a control weir' having an S-shaped crest profile which provides a high discharge coefficient without causing cavitations.

Statement (II): The crest profile of ogee spillway conforms to the lower nappe of flow over a ventilated sharp-crested weir and ensures a constant discharge coefficient for all heads.

Ans. **(c)**

Sol. If head of water over the Ogee spillway is less than design head then falling jet of water will adhere to the crest of the spillway hence an positive hydrostatic pressure will be created which will reduce the discharge coefficient.

106. **Statement (I):** In open channel flow, the maximum velocity does not occur on the free surface.

Statement (II): There is wind drag on the free surface of an open channel.

Ans. **(b)**

107. **Statement (I):** The deeper a lake, the lesser the evaporation in summer and the more in winter.

Statement (II): Heat storage in water bodies affects seasonal evaporation

Ans. (a)

108. **Statement (I):** Flow over sharp-crested weirs, standing wave flumes and abrupt free overfalls at ends of long straight channels are examples of rapidly varied flow.

Statement (II): The above-llsted flows are all essentially local phenomena and can be utilized for flow measurement in open channels.

Ans. (a)

109. **Statement (I):** Negative skin friction will act on the piles of a group in filled-up reclaimed soils or peat soil.

Statement (II): The filled-up' or peat soils' are' not fully consolidated but start consolidating under their own overburden pressure, developing a drag on ,the surface of the piles.

Ans. (a)

110. **Statement (I):** The possibility of quicksand' condition occuring is more on the downstream of a weir on a permeable foundation than on the upstream' end with an upward component of seepage velocity.

Statement (II): Seepage lines end with an upward component of seepage velocity at the downstream reaches of such a weir.

Ans. (a)

Sol. Upward seepage reduces effective stress where as downward seepage increases effective stresses.

111. **Statement (I):** Multistage centrifugal pumps are used to produce very high delivery heads.

Statement (II): Roto-dynamic pumps must have to be centrifugal rather than centripetal, from the very basic principles of hydrodynamics. Also, the stages are in series.

Ans. (a)

112. **Statement (I):** The speed of a hydraulic turbine has to be maintained constant irrespective of the load on the machine for keepirig the electrical power generation frequency constant

Statement (II): Governing of hydraulic turbines can be done by controlling the discharge through the turbines by adjusting the. spear valve in Pelton turbines and the wicket in Francis or Kaplan turbines.

Ans. (a)

113. **Statement (I):** : A channel in alluvium running with constant discharge and constant sediment charge will first from its flow section and then its final longintudinal slope.

Statement (II): If a channel in alluvium has a section too small for a given discharge and slope steeper than required, degradation and aggradation happen and then the flow section attains final regime.

Ans. (d)

Sol. A channel in alluvium running with constant discharge and constant sediment charge will first from its longitudinal slope and then its final flow section.

114. **Statement (I):** The shear stress exerted by the stream flow on the bed is responsible for the movement of bed sediment particles.

Statement (II): The sediment will move when the shear stress crosses a threshold limit designated as a critical shear stress τ_c .

Ans. (a)

115. **Statement (I):** The trap efficiency of a reservoir increases with age as the reservoir capacity is reduced by sediment accumulation

Statement (II): The trap efficiency is a function of the ratio of reservoir capacity to the total inflow. A small reservoir on a,' large stream has a low trap efficiency efficiency.

Ans. (d)

Sol. The trap efficiency of reservoir decreases with the increasing age, as the capacity of reservoir decreases.

Trap efficiency is a function of

1. Ratio of reservoir capacity to mean annual inflow.
2. Sediment characteristics.

116. **Statement (I):** Recarbonation of water softened by lime-soda process results in increased hardness of the water.

Statement (II): : Suspended solids, like $CaSO_4$ and $MgSO_4$, which have not settled in the sedimentation tank, get dissolved due to passage of CO_2.

Ans. (a)

117. **Statement (I):** Pipes carrying water are anchored at bends and other points of unbalanced thrusts

Statement (II): Pipes are anchored by firmly embedding In massive blocks of concrete or masonry to counter side thrusts due to hydrodynamic forces exerted on the joints.

Ans. (a)

118. **Statement (I):** Aerobic condition in composting of refuse can be confirmed by temperature measurements.

Statement (II): Aerobic reactions are exothermic.

Ans. (a)

119. **Statement (I):** For a given soil, optimum moisture content increases with the increase in compactive effort.

Statement (II): Higher the compactive effort, higher is the dry density at the same moisture content.

Ans. (d)

Sol. Optimum moisture contain decreases with compactive effort.

120. **Statement (I):** Rate of settlement of a consolidating layer depends upon its coefficient of consolidation, which is directly proportional to the permeability and number of drainage paths available.

Statement (II): The excess hydrostatic pore pressure is relived fast in soil of higher permeability, in turn, depending on the number or drainage paths available in the consolidating layer.

Ans. (a)