Section - I (Civil Engineering)

One Mark Questions

Q.1 If G_s = 2.7%, n = 40%, w = 20% then the degree of saturation is ________.

Sol.

$$Se = wG$$

and $$e = \frac{n}{1-n} = 0.67$$

$\Rightarrow$ $$S = \frac{2.71 \times 20}{0.67} = \mathbf{81.3\%}$$

End of Solution

Q.2 The determinant of matrix is ________.

$$\begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 3 & 0 & 1 & 2 \end{vmatrix}$$

Sol.

$$\Delta = \begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 3 & 0 & 1 & 2 \end{vmatrix}$$

$R_4 \rightarrow R_4 - R_2 - R_3$

$$\Delta = \begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 0 & -3 & -2 & 1 \end{vmatrix}$$

$R_4 \rightarrow R_4 + 3R_1$

$$\Delta = \begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 0 & 0 & 4 & 10 \end{vmatrix}$$

$R_3 \rightarrow R_3 - 3R_1$

$$\Delta = \begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 0 & -6 & -8 \\ 0 & 0 & 4 & 10 \end{vmatrix}$$

Interchanging column 1 and column 2 and taking transpose

$$\Delta = -\begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 2 & 0 \\ 2 & 3 & -6 & 4 \\ 3 & 0 & -8 & 10 \end{vmatrix}$$

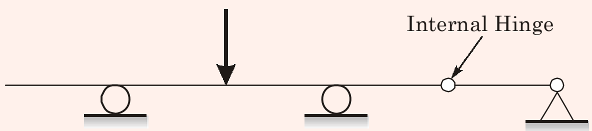
$$= -1 \times \begin{vmatrix} 1 & 2 & 0 \\ 3 & -6 & 4 \\ 0 & -8 & 10 \end{vmatrix}$$

$$= -1 \times \{1(-60 + 32) + 2(0 - 30)\}$$

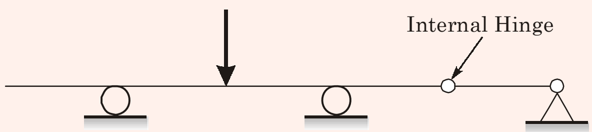
$$= -(-28 - 60) = \mathbf{88}$$

End of Solution

Q.3 The static indeterminacy of two span continuous beam with internal hinge is ________.



Sol.



Number of member, $m = 4$
Number of external reaction, $r_e = 4$
Number of joint, $j = 5$
Number of reaction released, $r_r = 1$
Degree of static indeterminacy,

$$D_s = 3m + r_e - 3j - r_r$$
$$= 3 \times 4 + 4 - 3 \times 5 - 1$$
$$= \mathbf{0}$$

End of Solution

Q.4 A plane blow leak velocity component $u = \frac{x}{T_1}$, $v = -\frac{y}{T_2}$ and $w = 0$ along x, y and z direction respectively where $T_1 (\neq 0)$, $T_2 (\neq 0)$ are constants having dimension of time. The given blow is incompressible if

(a) $T_1 = -T_2$ (b) $T_1 = -\frac{T_2}{2}$

(c) $T_1 = \frac{T_2}{2}$ (d) $T_1 = T_2$

Ans. (d)

For a flow to exist

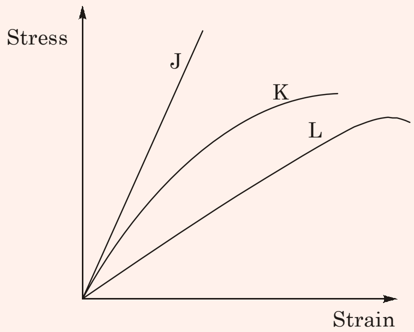
$$\Rightarrow \quad \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\Rightarrow \quad \frac{1}{T_1} - \frac{1}{T_2} = 0$$

$$\Rightarrow \quad T_1 = T_2$$

End of Solution

Q.5 Groups-I contains representative stress-strain curves as shown in figure. While Group-II gives the list of materials. Match the stress-strain curves with corresponding materials.



Group-I	**Group-II**
P. Curve J	**1.** Cement paste
Q. Curve K	**2.** Coarse aggregate
R. Curve L	**3.** Concrete

(a) P-1, Q-3, R-2 (b) P-3, Q-1, R-2

(c) P-2, Q-3, R-1 (d) P-3, Q-2, R-1

Ans. (d)

End of Solution

Q.6 As per IS : 456-2000 in design of concrete target mean strength is taken as

(a) $f_{ck} + 0.825\sigma$ (b) $f_{ck} + 1.64\sigma$

(c) $f_{ck} + 0.50\sigma$ (d) $f_{ck} + 0.725\sigma$

Ans. (b)

End of Solution

Q.7 Modulus of elasticity of concrete is calculated (as per IS 456 : 2000) by

(a) Secent modulus
(b) Tangent modulus
(c) Initial tangent modulus
(d) None of these

Ans. (a)

End of Solution

Q.8 The flexural tensile strength of M 25 grade of concrete in N/mm², as per IS:456-2000, is ________.

Sol.

$$\text{Flexural strength} = 0.7\sqrt{f_{ck}}$$
$$= \mathbf{3.5\ N/mm^2}$$

End of Solution

Q.9 Survey which is conducted for geological features like river, natural resources, building, cities etc. is denoted as

(a) Land survey
(b) Geological survey
(c) Engineering survey
(d) Topographical survey

Ans. (a)

End of Solution

Q.10 The integrating factor for the differential equation $\frac{dP}{dt} + k_2P = k_1L_0e^{-k_1t}$ is

(a) e^{-k_1t}
(b) e^{-k_2t}
(c) e^{k_1t}
(d) e^{k_2t}

Ans. (d)

$$\text{I.P.} = e^{\int k_2 dt}$$

End of Solution

Q.11 Polar moment of inertia (I_p) in cm⁴ at a rectangular section having width b = 2 cm and depth d = 6 cm is __________ .

Sol.

Polar moment of inertia, $I_p = I_x + I_y = \frac{bd^3}{12} + \frac{db^3}{12}$

$$= \frac{bd}{12}\left(b^2 + d^2\right) = \frac{2 \times 6}{12}\left(2^2 + 6^2\right) = 40\ \text{cm}^4$$

End of Solution

Q.12 The average spacing between vehicles in a traffic stream is 50 m, then the density (in veh/km) of stream is ________.

Sol.

$$\text{Capacity} = \frac{1000 \times V}{S} = V \times \text{density}$$

$$\Rightarrow \quad \text{Density} = \frac{1000}{S} = \mathbf{20\ veh/km}$$

End of Solution

Q.13 A fair (unbiased) coin was tossed 4-times in a succession and resulted in the following outcomes (I) H (II) H (III) H (IV) H. The probability of obtaining a "TAIL' when the coin is tossed again is

(a) 0
(b) $\frac{1}{2}$
(c) $\frac{4}{5}$
(d) $\frac{1}{5}$

Ans. (b)

$$P(E) = \frac{n(E)}{n(S)}$$

$$n(s) = [\{H\}, \{T\}] = 2$$

$$n(E) = \{(T)\} = 1$$

$$\therefore \quad P(E) = \frac{1}{2}$$

End of Solution

Q.14 As per ISSCS (IS : 1498 -1970) an expression of A-line is

(a) $I_p = 0.73\ (W_L - 20)$
(b) $I_p = 0.70\ (W_L - 20)$
(c) $I_p = 0.73\ (W_L - 10)$
(d) $I_p = 0.70\ (W_L - 10)$

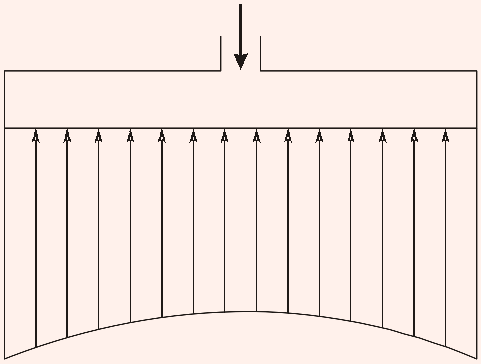
Ans. (a)

End of Solution

Q.15 The contact pressure for a rigid footing resting on clay at the centre and the edges are respectively

(a) maximum and zero
(b) maximum and minimum
(c) zero and maximum
(d) minimum and maximum

Ans. (d)



Stress distribution for cohesive soil

Minimum at centre and maximum at edge.

End of Solution

Q.16 The clay mineral primarly governing the swelling behaviour of black cotton soil is

(a) Halloysite
(b) Illite
(c) Kaolinite
(d) Montmorillonite

Ans. (d)

End of Solution

Q.17 Dominating micro-organisms in Active Sludge Reactor process.

(a) Aerobic heterotrops
(b) Anaerobic heterotrops
(c) Autotrops
(d) Phototrops

Ans. (a)

End of Solution

Two Marks Questions

Q.18 A rectangular channel of 2.5 m width is carrying a discharge of 4 m^3/s. Considering that acceleration due to gravity as 9.81 m/s^2, then velocity of flow (in m/s) corresponding to the critical depth (at which the specific energy is minimum) is ________ .

Sol.

$$Q = 4\ m^3/s,\ B = 2.5\ m$$

$$\Rightarrow \quad q = 4/2.5\ m^3/s/m = 1.6\ m^3/s/m$$

$$y_c^3 = \frac{q^2}{g} \Rightarrow y_c = 0.639\ m$$

$$\text{At critical depth velocity head} = \frac{y_c}{2}$$

$$\Rightarrow \quad \frac{V^2}{2g} = \frac{0.639}{2}$$

$$\Rightarrow \quad V = \sqrt{0.639 \times g}$$

$$= \mathbf{2.504 \ m/s}$$

End of Solution

Q.19 A waste water stream (flow = 2 m^3/s, ultimate BOD = 90 mg/l) is joining a small river (flow = 12 m^3/s, ultimate BOD = 5 mg/l). Both water streams get mixed up instantaneously. Cross-section area of the river is 50 m^2. Assuming the de-oxygenation rate constant, k′ = 0.25/day. The BOD (in mg/l) of the river water 10 km downstream of the mixing point is

(a) 1.68
(b) 2.63
(c) 15.46
(d) 1.37

Ans. (c)

Flow of waste water stream, $Q_w = 2 \ m^3/sec$

Ultimate BOD, $Y_w = 90 \ mg/l = 90 \ gm/m^3$

Flow of river, $Q_R = 12 \ m^3/sec$

Ultimate BOD of river,

$$Y_R = 0.5 \ mg/l = 5 \ gm/m^3$$

BOD of mixture,
$$Y_0 = \frac{(2\times 90)+(12\times 5)}{2+12}$$

$$= \frac{180+60}{14} = \frac{240}{14} = 17.143 \text{ gm/m}^3$$

$$k_D = 0.434 \ K = 0.434 \times 0.25 = 0.1085$$

$$Y_t = Y_0\left[1-(10)^{-k_D t}\right] \quad \text{...(i)}$$

Area of river = 50 m^2

Flow of river = 12 m^3/sec

$$\text{Stream velocity} = \frac{14}{50} = 0.28 \text{ m/sec}$$

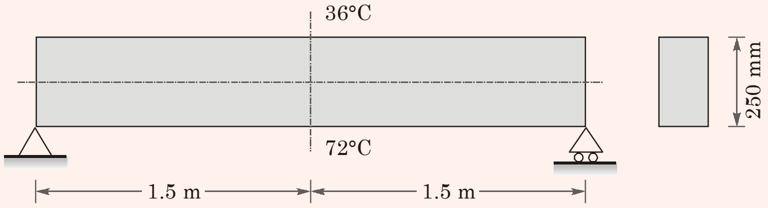
Time taken,
$$t = \frac{10\,\text{km}}{0.28\,\text{m/s}} = 9.921 \text{ days}$$

∴ From eq. (i)
$$Y_t = 17.143\left[1-(10)^{-0.1085\times 9.921}\right]$$

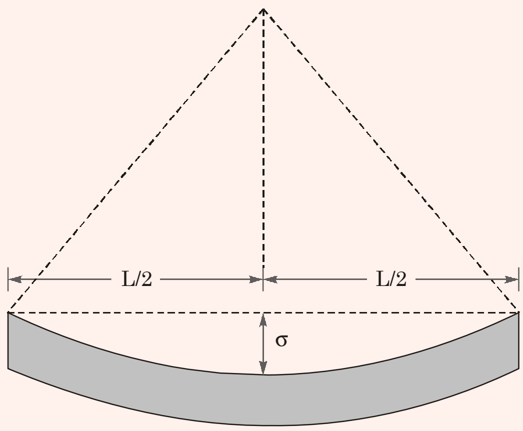
$$= 15.70 \ gm/m^3 = \mathbf{15.70 \ mg/lit}$$

End of Solution

Q.20 The beam of an overall depth 250 mm (shown below) is used in a building subjected to two different thermal environments. The temperature at the top and the bottom surfaces of the beam are 36°C and 72°C respectively. Considering coefficient of thermal expansion (α) as 1.50×10^{-5}/°C, the vertical deflection of the beam (in mm) at its mid span due to temperature gradient is ________.



Sol.



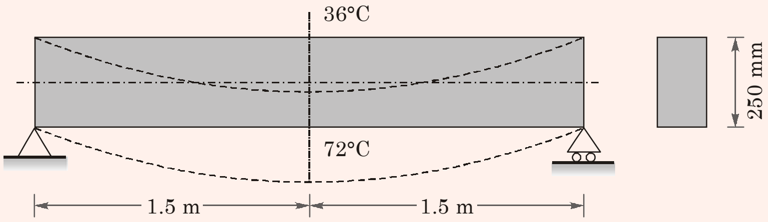
$$R = \frac{h}{\alpha T}$$

From properties of circle

$$(2R - \delta)\delta = \frac{L}{2} \times \frac{L}{2}$$

(Considering 'δ' very small so neglect δ^2)

$$\Rightarrow \qquad \delta = \frac{L^2}{8R} = \frac{L^2 \alpha T}{8h}$$



Given, $\alpha = 1.50 \times 10^{-5}/°C$

$$\Rightarrow \quad \delta = \frac{\alpha T L^2}{8h}$$

$$= \frac{1.50 \times 10^{-5} \times (72° - 36°) \times 3^2}{8 \times (250 \times 10^{-3})}$$

$$= \mathbf{2.43 \ mm}$$

End of Solution

Q.21 The expression $\lim_{\alpha \to 0} \frac{x^\alpha - 1}{\alpha}$ is equal to

(a) log x
(b) 0
(c) x log x
(d) ∞

Ans. (a)

$$\lim_{\alpha \to 0} \frac{x^\alpha - 1}{\alpha} \qquad \left[\frac{0}{0} \text{form}\right]$$

Use L-Hospital Rule

$$\lim_{\alpha \to 0} \frac{e^{\alpha \ln x} - 1}{\alpha}$$

$$\lim_{\alpha \to 0} \frac{e^{\alpha \ln x} \ln x}{1}$$

$$= \mathbf{\ln x}$$

End of Solution

Q.22 Match the **List-I** (Soil exploration) with **List-II** (Parameters of subsoil strength characteristic) and select the correct answer from the codes given below:

	List-I		**List-II**
P.	Pressure meter test (PMT)	**1.**	Menard's method (E_m)
Q.	Static cone penetration (SCPT)	**2.**	Number of blows (N)
R.	Standard penetration (SPT)	**3.**	Skin resistance (f_c)
S.	Vane shear test (VST)	**4.**	Undrained cohesion (C_u)

(a) P-1, Q-3, R-2, S-4
(b) P-1, Q-2, R-3, S-4
(c) P-2, Q-3, R-4, S-1
(d) P-4, Q-1, R-2, S-3

Ans. (a)

End of Solution

Q.23 The suspension of sand like particles in water with particles of diameter 0.10 mm and below is flowing into a settling tank at 0.10 m^3/s. Assume $g = 9.81\ m/s^2$, specific gravity of particles = 2.65, and kinematic viscosity of water = $1.0105 \times 10^{-2}\ cm^2/s$. The minimum surface area (in m^2) required for this settling tank to remove particles of size 0.06 mm and above with 100% efficiency is ________.

Sol.

$$V_s = \frac{(G_s - 1) g d^2}{18\nu}$$

$$= \frac{(2.65-1)\times 9.81 \times \left(6\times 10^{-2}\right)^2}{18 \times 1.0105 \times 10^{-2}}$$

$$= \frac{1.65 \times 9.81 \times 36 \times 10^{-4}}{18 \times 1.0105 \times 10^{-2} \times 10^{2}}$$

$$= 3.204 \times 10^{-3}\ m/s$$

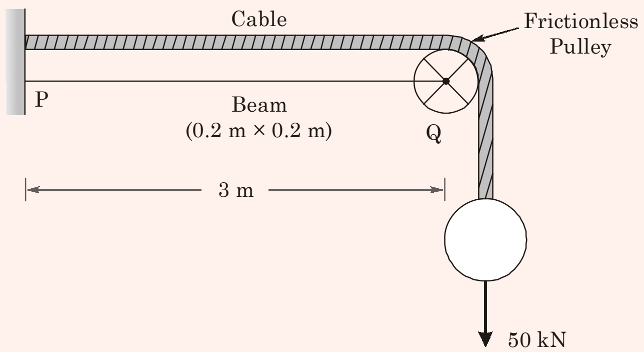
$$V_s = \frac{Q}{BL}$$

$$\Rightarrow \quad BL = \frac{0.1}{3.204 \times 10^{-3}}$$

$$= \mathbf{31.214\ m^2}$$

End of Solution

Q.24 The values of axial stress (σ) in kN/m^2, bending moment (M) in kNm and shear force (V) in kN acting at point P for the arrangement shown in figure are respectively



(a) 1000, 75 and 25
(b) 1250, 150 and 50
(c) 1500, 225 and 75
(d) 1750, 300 and 100

Ans. (b)

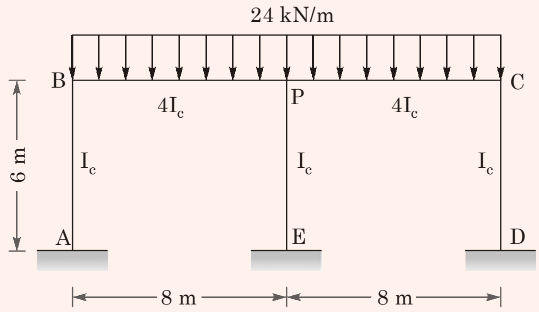
Loading after removing the cable

$$\text{Axial stress} = \frac{50}{0.2\times 0.2} = 1250 \text{ kN/m}^2$$

$$\text{Bending moment} = 50 \times 3 = \mathbf{150 \text{ kNm}}$$

End of Solution

Q.25 Considering the symmetry of a rigid frame as shown, the magnitude of the bending moment (in kNm) at P (Preferably using the moment distribution method) is



(a) 170
(b) 172
(c) 176
(d) 178

Ans. (c)

Distribution Factor

Joint	Member	RS	TRS	D.F.
B	BA	$\frac{I}{6}$	$\frac{2}{3}I$	$\frac{1}{4}$
	BP	$\frac{4I}{8}$		$\frac{3}{4}$
P	PB	$\frac{4I}{8}$	$\frac{7}{6}I$	$\frac{3}{7}$
	PE	$\frac{I}{6}$		$\frac{1}{7}$
	PC	$\frac{4I}{8}$		$\frac{3}{7}$
C	CP	$\frac{4I}{8}$	$\frac{2}{3}I$	$\frac{3}{4}$
	CD	$\frac{I}{6}$		$\frac{1}{4}$

Fixed End Moment

$$\overline{M_{AB}} = \overline{M_{BA}} = \overline{M_{PE}} = \overline{M_{EP}} = \overline{M_{CD}} = \overline{M_{DC}} = 0$$

$$\overline{M_{BP}} = -\frac{24\times(8)^2}{12} = -128 \text{ kNm}$$

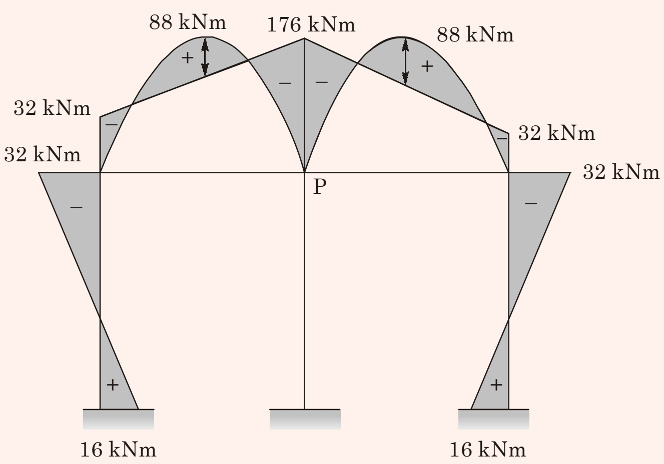
$$\overline{M_{PB}} = +128 \text{ kNm}$$

$$\overline{M_{PC}} = -128 \text{ kNm}$$

$$\overline{M_{CP}} = 128 \text{ kNm}$$

Distribution Table

	A	B	B	P	P	C	C	D	P	E
DF		1/4	3/4	3/7	3/7	3/4	1/4		1/7	
	0	0	−128	128	−128	128	0	0	0	0
		32	96	0	0	−96	−32		0	
	16	32	−32	48	−48	0		−16		0
Final	16	32	−32	176	−176	32		−16	0	0



End of Solution

Q.26 An effluent at a flow rate of 2670 m^3/d from a sewage treatment plant is to be disinfected. The laboratory data at disinfected studies with a chlorine dosage of 15 mg/l yield the model $N_t = N_0 e^{-0.145t}$ where N_t = number of micro organism surviving at time t (in min) and N_0 = number of microorganism, present initially (at t = 0). The volume of disinfection unit (in m^3) required to achieve a 98%. Kill of M.O. is _______ .

Sol. **(50 m^3)**

End of Solution

Q.27 A horizontal nozzle of 30 mm diameter discharges a study Jet of water into the atmosphere at a rate of 15 litres/second. The diameter of inlet to the nozzle is 100 mm. The Jet impinges normal to a flat stationary plate held close to the nozzle end. Neglecting air friction and considering density of water as 1000 kg/m^3, the force exerted by the Jet (in N) on the plate is_________ .

Sol.

$$\text{Force} = \rho a V^2$$

$$Q = aV = 15 \text{ litre/sec} \qquad \text{(given)}$$

$$\Rightarrow \qquad \text{Force} = \rho \frac{Q^2}{a}$$

$$= 100 \times \frac{15^2}{\frac{\pi}{4} \times 30^2} \frac{\text{kg}}{\text{m}^3} \times 10^{-6} \frac{\text{m}^6}{\text{s}^2} \times \frac{1}{10^{-6}} \text{m}^2$$

$$= 100 \times \frac{1}{\pi} \text{N} = \mathbf{31.83 \text{ N}}$$

End of Solution

Q.28 On a section of a highway the speed density relations is linear and is given by $v = \left[80 - \frac{2}{3}k\right]$; where v is in km/hr and k in vehicle/km. The capacity (in veh/hr) of this section of the highway would be

(a) 1200
(b) 2400
(c) 4800
(d) 9600

Ans. **(b)**

$$v = 80 - \frac{2k}{3}$$

Capacity, $$q = v \times k$$

$$= 80k - \frac{2k^2}{3}$$

For q to be maximum $$\frac{dq}{dk} = 0$$

$$\Rightarrow \qquad \frac{dq}{dk} = 80 - \frac{4k}{3} = 0$$

$\Rightarrow$ $k = 60$

Maximum capacity, $q = 80 \times 60 - \frac{2}{3}(60)^2$

$= 4800 - \frac{2}{3} \times 3600$

$= \mathbf{2400}$

End of Solution

Q.29 Irrigation water is to be provided to a crop in a field to bring the moisture content of the soil from the existing 18% to the field capacity of the soil at 28%. The effective root zone of the crop is 70 cm. If the densities of the soil and water are 1.3 g/cm^3 and 1 gm/cm^3 respectively, the depth of the irrigation water (in mm) required for irrigating the crop is ________ .

Sol.

Given,

Root zone depth, $d = 70$ cm

Field capacity, $F_C = 28\%$

Existing moisture content, $w = 18\%$

Density of soil, $\gamma = 1.3$ gm/cm^3

Density of water, $\gamma_w = 1.0$ gm/cm^3

Depth of irrigation water required,

$$d_w = \frac{\gamma}{\gamma_w} d(F_c - w)$$

$$= \frac{1.3}{1.0} \times (70 \times 10)(28\% - 18\%)$$

$$= 1.3 \times (70 \times 10) \times \frac{10}{100}$$

$= \mathbf{91\ mm}$

End of Solution

Q.30 The rank of the matrix $\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14 & -14 & 0 & -10 \end{bmatrix}$ is ______

Sol.

$$\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14 & -14 & 0 & -10 \end{bmatrix}$$

$R_3 \rightarrow R_3 - 2R_1 + R_2$

$$\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14-2(6)+(-2) & -14-2(0)+(14) & 0-2(4)+8 & -10-2(4)+(18) \end{bmatrix}$$

$$\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Determinant of matrix $\begin{bmatrix} 6 & 0 \\ -2 & 14 \end{bmatrix}$ is not zero.

$\therefore$ Rank is **2**.

End of Solution

Q.31 An infinitely long slope is made up of a C-ϕ soil having the properties cohesion (C) = 20 kPa and dry unit weight (γ_d) = 16 kN/m^3. The angle of inclination and critical length of slope are 40° and 5 m respectively. To maintain the limiting equilibrium, the angle of internal friction of soil (in degree) is ________ .

Sol.

As the given slope is in dry condition, therefore, factory of safety should be more than 2.

$$F_s = \frac{\tan\phi}{\tan b} \geq 2 \text{ and } \beta = 40°$$

$\Rightarrow$ $\tan\phi \geq 2\tan(40°)$

$\Rightarrow$ $\tan\phi \geq 1.6782$

$\Rightarrow$ $\phi \geq$ **59.21°**

End of Solution

Q.32 A student riding a bicycle on a 5 km one way street takes 40 minutes to reach home. The student stopped for 15 minutes during this ride. 60 vehicles over took the student (Assume the number of vehicle overtaken by the student is zero) during the ride and 45 vehicles while the student stopped. The speed of vehicle stream on that road (in km/hr) is

(a) 7.5
(b) 12
(c) 40
(d) 60

Ans. (d)

$$\text{Velocity of student} = \frac{5\,\text{km}}{(40-15)\,\text{min}} = 12\,\text{km/hr}$$

$$\left(\frac{\text{Vehicle/min}}{\text{Relative speed of vehicle w.r.t. student}}\right)_{\text{moving}} = \left(\frac{\text{Vehicle/min}}{\text{Relative speed of vehicle w.r.t. student}}\right)_{\text{standing}}$$

$$\Rightarrow \quad \frac{60/25}{x-12} = \frac{4^5/15}{x-0}$$

$$\Rightarrow \quad x = \mathbf{60\ km/hr}$$

End of Solution

Q.33 In a Marshall sample, the bulk specific gravity of mix and aggregates are 2.324 and 2.546 respectively. The sample includes 5% of bitumen (by total wt. of mix) of specific gravity 1.10. The theoretical maximum specific gravity of mix is 2.441. The void filled with bitumen (VFB) in the Marshall sample (in %) is ________.

Sol.

$$V_v = \frac{G_t - G_m}{G_m} \times 100$$

$$= \frac{2.441 - 2.324}{2.324} \times 100 = 5.03\%$$

$$V_b = G_m \frac{w_b}{G_b} = 2.324 \times \frac{5}{1.1} = 10.564$$

$$\text{VMB} = V_v + V_b = 15.594\%$$

$$\text{VFB} = \frac{V_b \times 100}{\text{VMB}} = \frac{10.564}{15.594} \times 100$$

$$= \mathbf{67.74\%}$$

End of Solution

Q.34 With reference to a standard Cartesian (x, y) plane, the parabolic velocity distribution profile of fully developed laminar flow in x-direction between two parallel plates. Stationary and identical plates that are separated by distance, h, is given by the expression

$$u = -\frac{h^2 dP}{8\mu dx}\left[1 - 4\left(\frac{y}{h}\right)^2\right]$$

In this equation the y = 0 axis lies equidistant between the plates at a distance h/2 from the two plates, P is the pressure variable and μ is the dynamic viscosity term, the maximum and average velocities are respectively

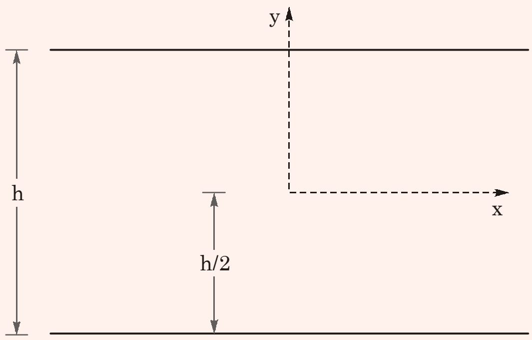
(a) $U_{max} = -\frac{h^2 dP}{8\mu dx}$ and $U_{avg} = \frac{2}{3} U_{max}$

(b) $U_{max} = \frac{h^2 dP}{8\mu dx}$ and $U_{avg} = \frac{2}{3} U_{max}$

(c) $U_{max} = -\frac{h^2 dP}{8\mu dx}$ and $U_{avg} = \frac{3}{8} U_{max}$

(d) $U_{max} = \frac{h^2 dP}{8\mu dx}$ and $U_{avg} = \frac{3}{8} U_{max}$

Ans. (a)



Velocity expression for a laminar flow between two parallel plates is

$$U = -\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)\left[1-4\left(\frac{y}{h}\right)^2\right]$$

End condition, $U = U_{max}$ at $y = 0$

$$\Rightarrow \quad U_{max} = -\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)$$

Discharge, dQ = Area × Velocity

$$\Rightarrow \quad dQ = \left[-\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)\left(1-4\left(\frac{y}{h}\right)^2\right)\right](dy \times 1)$$

$$\Rightarrow \quad Q = -\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)\int_{-h/2}^{h/2}\left(1-\frac{4y^2}{h^2}\right)dy$$

$$= -\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)\left[y-\frac{4y^3}{3h^2}\right]_{-h/2}^{h/2}$$

$$= -\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)\left[\left\{\frac{h}{2}-\left(-\frac{h}{2}\right)\right\}-\left\{\frac{4}{3h^2}\left(\frac{h^3}{8}-\left(-\frac{h^3}{8}\right)\right)\right\}\right]$$

$$= -\frac{h^3}{12\mu}\left(\frac{dP}{dx}\right)$$

$$\because \quad Q = AV$$

$$-\frac{h^3}{12\mu}\left(\frac{dP}{dx}\right) = (h \times 1) \times U_{avg}$$

$$\Rightarrow \quad U_{avg} = -\frac{h^2}{12\mu}\left(\frac{dP}{dx}\right)$$

$$\frac{U_{avg}}{U_{max}} = \frac{-\frac{h^2}{12\mu}\left(\frac{dP}{dx}\right)}{-\frac{h^2}{8\mu}\left(\frac{dP}{dx}\right)} = \frac{8}{12} = \frac{2}{3}$$

$$\therefore \quad U_{avg} = \frac{2}{3}U_{max}$$

End of Solution

Q.35 A venturimeter having a throat diameter of 0.1 m is used to estimate the flow rate of a horizontal pipe having a dia of 0.2 m for an observed pressure difference of 2 m of water head and coefficient of discharge equal to unity, assuming that the energy losses are negligible. The flow rate (in m^3/s) through the pipe is approximately equal to

(a) 0.500 (b) 0.150

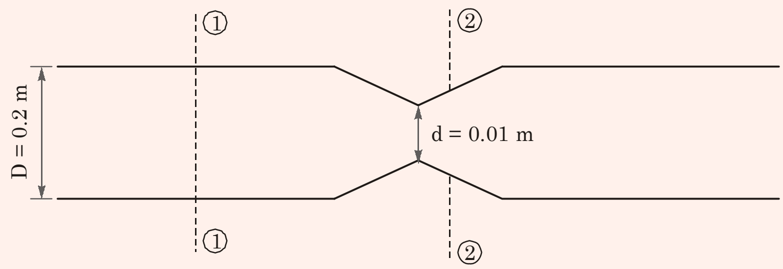
(c) 0.050 (d) 0.015

Ans. (c)

Diameter of throat, $d = 0.1$ m

Diameter of pipe, $D = 0.2$ m

Pressure difference, $\frac{P_1 - P_2}{w} = 2 \text{ m} = h$



Coefficient of discharge, $C_D = 1$

Discharge, $Q = \frac{C_D.A_1A_2\sqrt{rgh}}{\sqrt{A_1^2 - A_2^2}}$

$$A_1 = \frac{\pi}{4}(0.2)^2$$

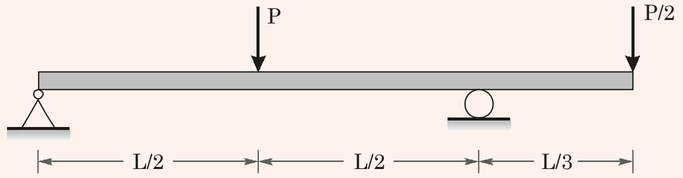
$$A_2 = \frac{\pi}{4}(0.1)^2$$

$$\Rightarrow \quad Q = \frac{1\times\left(\frac{\pi}{4}\right)^2 \times (0.2)^2 (0.1)^2 \sqrt{2\times 9.81\times 2}}{\left(\frac{\pi}{4}\right)\sqrt{(0.2)^4 - (0.1)^4}}$$

$$= 0.0508 \approx 0.050 \text{ m}^3/\text{sec}$$

End of Solution

Q.36 A prismatic beam (shown) has plastic moment capacity of M_p, then the collapse lead P of the beam is



(a) $\frac{2M_p}{L}$ (b) $\frac{4M_p}{L}$

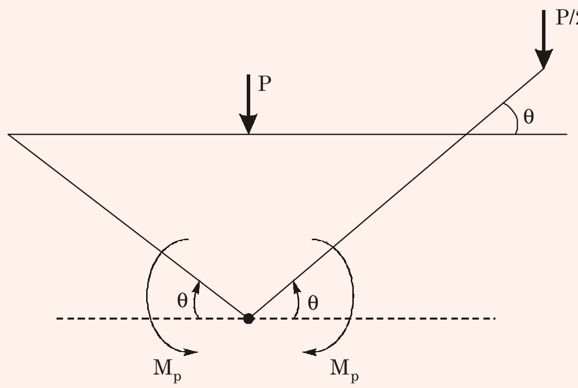
(c) $\frac{6M_p}{L}$ (d) $\frac{8M_p}{L}$

Ans. **(c)**

Here degree of static indeterminacy = 0

∴ Number of plastic hinges required for mechanical

$$= D_s + 1 = 0 + 1 = 1$$



From principal of virtual work

$$-M_p\theta - M_p\theta + P\frac{L}{2}\theta - \frac{P}{2}\times\frac{L}{3}\theta = 0$$

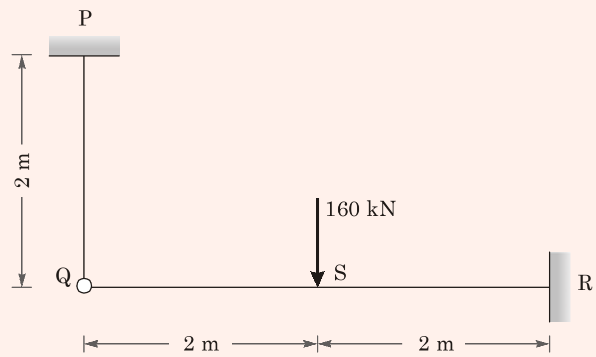
$$\Rightarrow \quad -2M_p\theta + \frac{PL}{2}\theta - \frac{PL}{6}\theta = 0$$

$$\Rightarrow \quad 2M_p = \frac{PL}{2}\times\frac{PL}{6} = \frac{(3-1)PL}{6} = \frac{1}{3}PL$$

$$\Rightarrow \quad P = \frac{6Mp}{L}$$

End of Solution

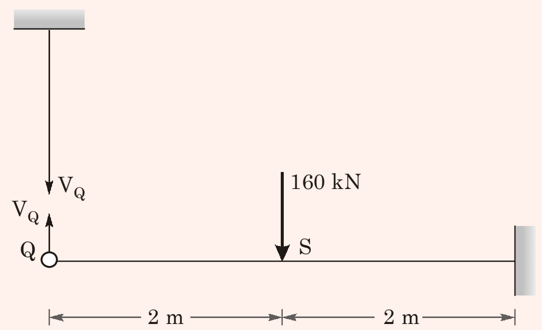
Q.37 The axial load (in kN) in the member PQ for the assembly/arrangement shown in figure given below is ________.



Sol.

Free body diagram

For principle of superposition



$$\frac{160\times 2^3}{3\,EI} + \frac{160\times 2^2}{2\,EI}\times 2 - \frac{V_Q L^3}{3\,EI} = \frac{V_Q L}{AE} \quad ...(i)$$

Deflections due to axial forces will be very less as compared to bending forces.

So we can neglect the axial deformation.

$\therefore$ From equation (i)

$$\frac{160\times 2^3}{3\,EI}+\frac{160\times 2^2}{2\,EI}\times 2-\frac{V_Q 4^3}{3\,EI} = 0$$

$$\Rightarrow \quad \frac{160\times 2^3}{3}+\frac{160\times 2^2\times 2}{2} = \frac{V_Q\times 4^3}{3}$$

$$\Rightarrow \quad V_Q = \mathbf{50\ kN}$$

End of Solution

Q.38 Water is flowing at a steady rate through a homogeneous and saturated horizontal soil strip at 10 meter length. The strip is being subjected to a constant water head (H) of 5 m at the beginning and 1 m at the end. If the governing equation of the flow in the soil strip is $\frac{d^2H}{dx^2}=0$ (where x is the distance along the soil strip), the value of H (in m) at the middle of the strip is ________ .

Sol.

Given, equation of the flow of soil strip is

$$\frac{d^2H}{dx^2} = 0$$

$$\Rightarrow \quad \frac{dH}{dx} = C_1$$

$$\Rightarrow \quad H = C_1 x + C_2$$

at x = 0, H = 5 m

$$\Rightarrow \quad C_2 = 5$$

$$\Rightarrow \quad H = C_1 x + 5$$

at x = 10, H = 1 m

$$\Rightarrow \quad 1 = C_1 \times 10 + 5$$

$$\Rightarrow \quad 10C_1 = -4$$

$$\Rightarrow \quad C_1 = -\frac{2}{5}$$

$$\Rightarrow \quad H = -\frac{2}{5}x+5$$

at x = 5 m

$$H = -\frac{2}{5}\times 5+5$$

$$H = \mathbf{3\ m}$$

End of Solution

Q.39 An observer counts 240 veh/hr at a specific highway location. Assume that the vehicle arrival at the location is Poisson distributed, the probability of having one vehicle arriving over 30 sec time interval is _______.

Sol.

$$P(n,\ t) = \frac{e^{-\lambda t}.(\lambda t)^n}{n!}$$

Here, λ = no. of vehicles = 240 vehicle/km

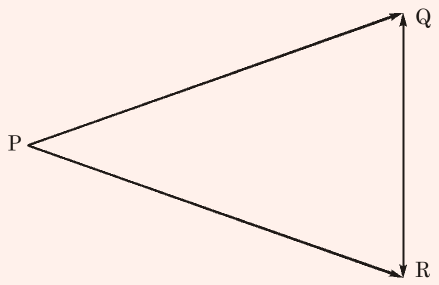
$$P(1,\ 30) = \frac{e^{\frac{-240\times 30}{3600}}\left(\frac{240}{3600}\times 30\right)^1}{1!}$$

$$= 2.e^{-2}$$

$$= \mathbf{0.2707}$$

End of Solution

Q.40 A tachometer was placed at point P to estimate the horizontal distance PQ and PR. The corresponding stadia intercept with the telescope kept horizontal are 0.320 and 0.210 m respectively. The ∠QPR is measured to be 61°30′30″. If the stadia multiplication constant = 100 and stadia addition constant = 0.10 m, the horizontal distance (in m) between the point Q and R is ________.



Sol.

$$PQ = ks + C$$
$$= 100(0.32) + 0.1 = 32.1\ m$$
$$PR = ks + C$$
$$= 100(0.21) + 0.1 = 21.1\ m$$

Applying the cosine rule

$$QR = \sqrt{PQ^2 + PR^2 + 2(PQ)(PR)\cos\theta}$$

Where, $\theta = 61°30'30'' = 61.508°$

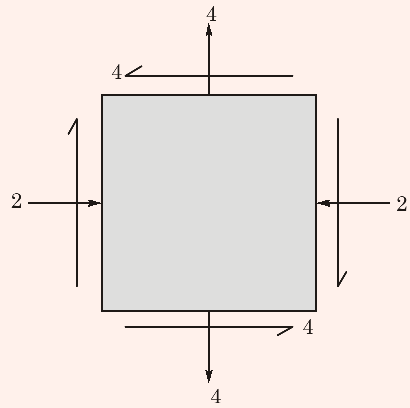
$$= \sqrt{1030.41 + 445.21 + 2(32.1)(21.1)\cos 61.508°}$$

$$= \sqrt{1030.41 + 445.21 + 696.2}$$

$$= \mathbf{46.06 \ m}$$

End of Solution

Q.41 For the state of stresses (in MPa) shown in the figure below, the maximum shear stress (in MPa) is



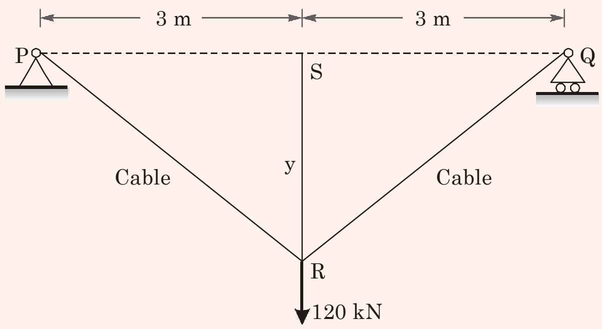
Sol.

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right) + \tau_{xy}^2}$$

$$= \mathbf{5.0 \ MPa}$$

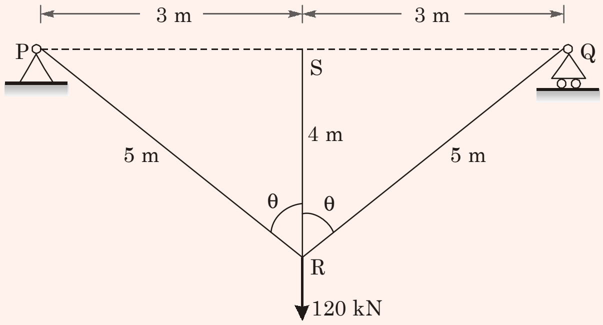
End of Solution

Q.42 The tension (in kN) in a 10 m long cable shown in figure neglecting its self weight is

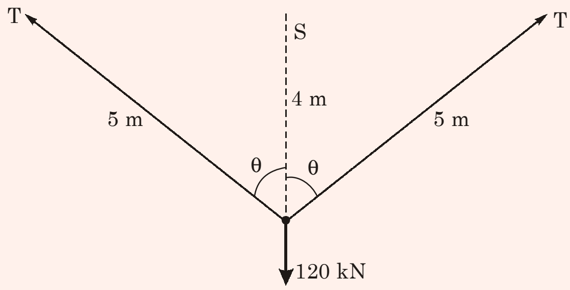


(a) 120 (b) 75
(c) 60 (d) 45

Ans. (b)



Freebody diagram



$$\Sigma F_y = 0$$

$\Rightarrow$ $$2T\cos\theta = 120 \quad \text{...(i)}$$

Here, $$\cos\theta = \frac{4}{5}$$

$$2T \times \frac{4}{5} = 120$$

$\Rightarrow$ $$T = \frac{120 \times 5}{2 \times 4} = 75 \text{ kN}$$

End of Solution

Q.43 A pre-timed four phase signal has critical lane flow rate for the first three phases as 200, 187 and 210 veh/hr with saturation flow rate of 1800 veh/hr/lane for all phases. The lost time is given as 4 seconds for each phase. If the cycle length is 60 seconds. The efficiency gree time of 4th phase is ____________ (in seconds).

Sol.

Flow rates for the first three phase are given as

$$q_1 = 200 \text{ veh/hr}$$

$$q_2 = 187 \text{ veh/hr}$$

and $$q_3 = 210 \text{ veh/hr}$$

Saturation flow rate is 1800 veh/hr/lane

Lost time, $L = 4 \times 4 = 16$ sec

length of the cycle, $C_0 = 60$ sec

Now, $$y_1 = \frac{q_1}{s_1} = \frac{200}{1800}$$

$$y_2 = \frac{q_2}{s_2} = \frac{187}{1800}$$

$$y_3 = \frac{q_3}{s_3} = \frac{210}{1800}$$

$$C_0 = \frac{1.5L+5}{1-y}$$

$$\Rightarrow \quad 60 = \frac{1.5\times 16+5}{1-y}$$

$$\Rightarrow \quad 60 = \frac{24+5}{1-y}$$

$$\Rightarrow \quad 1-y = \frac{29}{60}$$

$$\Rightarrow \quad y = \frac{1-29}{60} = \frac{60-29}{60}$$

$$= 0.517$$

And $$y = y_1 + y_2 + y_3 + y_4$$

$$\Rightarrow \quad 0.517 = \frac{597}{1800} + y_4$$

$$\Rightarrow \quad y_4 = 0.185$$

$$G = \frac{y_4}{y}(C_0 - L)$$

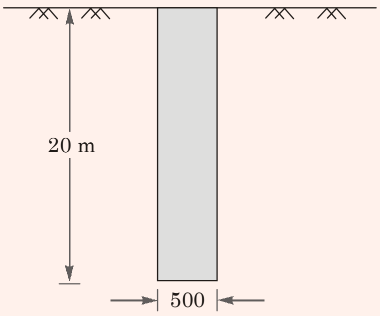
$$= \frac{0.185}{0.517}(60-16)$$

$$= 15.745 \text{ sec}$$

End of Solution

Q.44 A single vertical friction pile of dia 500 mm and length 20 m is subjected to a vertical compressive load. The pile is embedded in a homogeneous sandy stratum where; angle of internal friction (ϕ) = 30°, dry unit weight (γ_d) = 20 kN/m^3 and angle of wall friction (δ) = 2ϕ/3. Considering the coefficient of lateral earth pressure (k) = 2.7 and the bearing capacity factor (N_q) = 25, the ultimate bearing capacity of the pile is ________

Sol.



Homogeneous sandy stratum

$$\phi = 30°$$
$$\gamma_d = 20 \text{ kN/m}^3$$

Wall friction angle, $\delta = \frac{2}{3}\phi = \frac{2}{3} \times 30 = 20°$

Lateral earth pressure coefficient,

$$K = 2.7$$

Bearing capacity factor,

$$N_q = 25$$

Ultimate load capacity,

$$Q_u = ?$$

Vertical effective stress at 20 m,

$$\overline{\sigma_v} = 20 \times 20 = 400 \text{ kN/m}^2$$

From 0 to 20 m, unit point bearing resistance and skin friction resistance remain constant at

$$\overline{\sigma_v} = 400 \text{ kN/m}^2$$

The ultimate load capacity is given by

$$Q_u = q_{up} \cdot A_p + q_s \cdot A_s$$
$$= Q_{up} + f_s$$

where $q_{up} = \overline{\sigma_v} N_q$

$$= 400 \times 25$$
$$= 10000 \text{ kN/m}^2$$

and $q_s = \frac{1}{2} \cdot \overline{\sigma_v} \cdot K \cdot \tan\delta$

$$= \frac{1}{2} \times 400 \times 2.7 \tan 20°$$
$$= 196.54 \text{ kN/m}^2$$

Skin friction resistance,

$$f_s = 196.54 \times \pi \times 0.5 \times 20$$
$$= 6174.49 \text{ kN}$$

$$Q_{up} = q_{up} \times \frac{\pi (0.5)^2}{4}$$
$$= 10{,}000 \times \frac{\pi (0.5)^2}{4}$$
$$= 1963.49 \text{ kN}$$

∴ Ultimate load on the pile

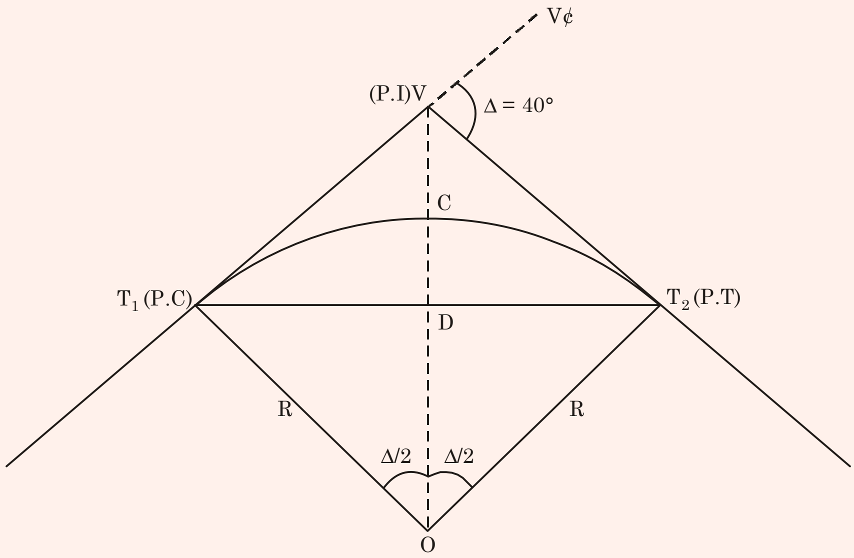
$$= 1963.49 + 6179.49$$
$$= \mathbf{8137.98 \text{ kN}}$$

End of Solution

Q.45 The chainage of the intersection point of two straights is 1585.60 meter and the angle of inter section is 140°. If the radius of a circular curves is 600 meter, the tangent distance (in m) and length of the curve (in m) respectively are

(a) 418.88 and 1466.08
(b) 218.38 and 1648.49
(c) 218.38 and 418.88
(d) 418.88 and 218.38

Ans. (c)



$$\Delta = 180° - 140° = 40°$$

$$\text{Length of the curve} = \frac{\pi R}{180°}\Delta$$

$$= \frac{\pi \times 600}{180} \times 40 = 418.82\,\text{m}$$

Tangent distance (T) is the distance between P-C to P.I (also the distance from P.I to P.T)

$$\Rightarrow \quad T = T_1V = T_2V = OT_1 \tan\frac{\Delta}{2} = R\tan\frac{\Delta}{2}$$

$$= 600 \tan 20°$$

$$= 218.88 \text{ m}$$

End of Solution

Q.46 A surface water treatment plant operates round the clock with a flaw rate of 35 m^3/min. The water temperature is 15°C and Jar testing indicated and alum dosage of 25 mg/*l* with flocculation at a Gt value of 4×10^4 producing optimal results. The alum quantity required for 30 days (in kg) of operation of the plant is ________ .

Sol.

Given data

Flow rate, $Q = 35 \text{ m}^3/\text{min}$

$Gt = 4 \times 10^4$

Alum dosage $= 25$ mg/lit.

Alum quantity (kg) required for 30 days

$= 35 \times 10^3 \times 60 \times 24 \times 30 \times 25 \times 10^{-6}$

$= \mathbf{37,800 \text{ kg}}$

End of Solution

Section - II (General Aptitude)

One Mark Questions

Q.47 The population of a new city is 5 million and is growing at a rate of 20% annually. How many year would it take to double at this growth rate.

(a) 3-4 year
(b) 4-5 year
(c) 5-6 year
(d) 6-7 year

Ans. (a)

$$P_{new} = P_{old}\left(1+\frac{r}{100}\right)^n$$

$$\Rightarrow \quad 10 = 5\left(1+\frac{20}{100}\right)^n$$

$$\Rightarrow \quad 2 = (1.2)^n$$

$$\Rightarrow \quad \frac{\log 2}{\log 1.2} = n$$

$$\Rightarrow \quad n = 3.8 \text{ year}$$

End of Solution

Q.48 A person affected by Alzheimers disease _______ short term memory loss.

(a) experiences
(b) has experienced
(c) is experiencing
(d) experienced

Ans. (a)

End of Solution

Q.49 Select the closest in meaning

"As a women, I have no country"

(a) Women have no country.
(b) Women are not citizens of any country.
(c) Women solidarity knows no national boundary.
(d) Women of all country have equal legal rights.

Ans. (c)

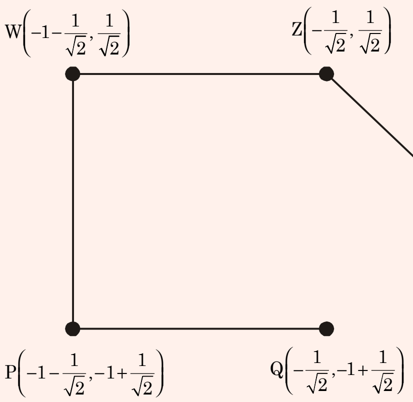
End of Solution

Two Marks Questions

Q.50 If X is 1 km North east of Y, Y is 1 km South east of Z and W is 1 km West of Z. P is 1 km South of W, Q is 1 km East of P. Then find the distance between X and Q.

(a) 1
(b) $\sqrt{2}$
(c) $\sqrt{3}$
(d) 2

Ans. (c)



$$XQ = \sqrt{\left(\frac{1}{\sqrt{2}}+\frac{1}{\sqrt{2}}\right)^2 + (-1)^2} = \sqrt{3}$$

End of Solution

Q.51 In the group of four children. If Som is younger than Riyaz and Shiv is elder than Anshu. Anshu is youngest in the group, so the eldest in the group

1. Shiv is younger than Riyaz.
2. Som is younger than Anshu.

(a) Statement (1) is sufficient to recognize.
(b) Statement (2) is sufficient to recognize.
(c) Statement (1) and statement (2) both are required.
(d) Statement (1) and (2) both are insufficient to find.

Ans. (a)

End of Solution

■■■■