BYJU'S EXAM PREP

GATE 2021

Civil Engineering

Shift-1

Questions & Solutions

SECTION: GENERAL APTITUDE

1. Getting to the top is _____ than staying on top.

A. easier B. much easy

C. more easy D. easiest

Ans. A

Sol. Getting to the top is easier than staying on top.

2. $\oplus$ and $\odot$ are two operators on number p and q such that

$$p \oplus q = \frac{p^2 + q^2}{pq} \text{ and } p \odot q = \frac{p^2}{q};$$

If $x \oplus y = 2 \odot 2$, then x =

A. y B. 3y/2

C. 2y D. y/2

Ans. A

Sol. Given,

$$p \oplus q = \frac{p^2 + q^2}{pq} \text{ and } p \odot q = \frac{p^2}{q}$$

Also, $x \oplus x = z \odot z$

Using the above definitions we get

$$\frac{x^2 + y^2}{xy} = \frac{z^2}{z}$$

$$\Rightarrow \frac{x^2 + y^2}{xy} = 2$$

$$\Rightarrow x^2 + y^2 - 2xy = 0$$

$$\Rightarrow (x - y)^2 = 0$$

x = y

Ans. (1)

3. Consider two rectangular sheets, Sheet M and Sheet N of dimensions 6 cm x 4 cm each.

Folding operation 1: The sheet is folded into half by joining the short edges of the current shape.

Folding operation 2: The sheet is folded into half by joining the long edges of the current shape.

Folding operation 1 is carried out on Sheet M three times.

Folding operation 2 is carried out on Sheet N three times.

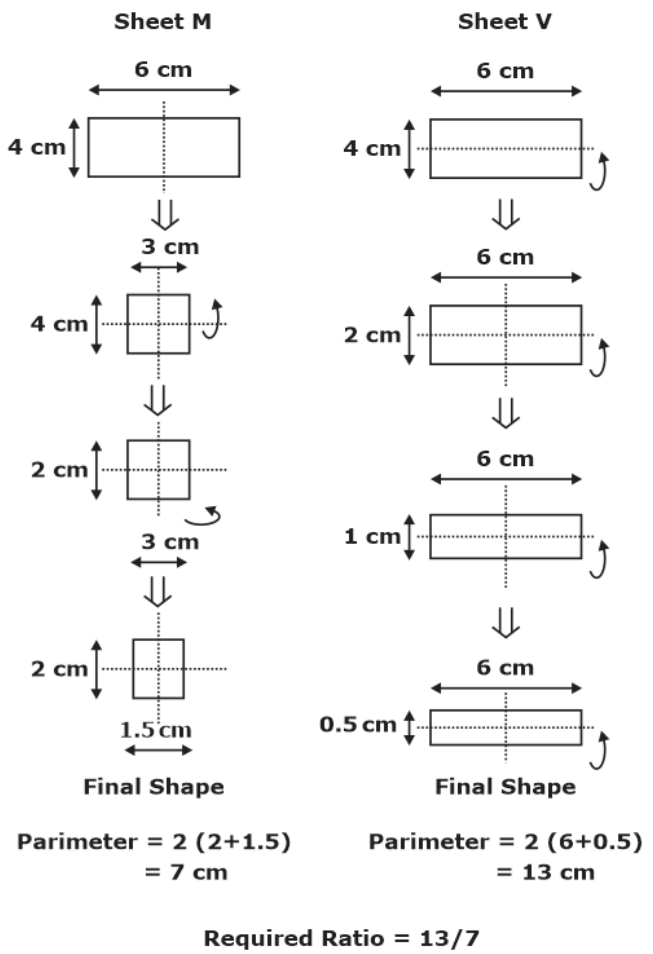
The ratio of perimeters of the final folded shape of Sheet N to the final folded shape of Sheet M is _____.

A. 5 : 13 B. 13 :7

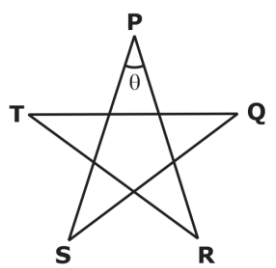
C. 7 : 5 D. 3 : 2

Ans. B

Sol.



4.



Five line segments of equal lengths, PR, PS, QS, QT and RT are used to form a star as shown in the figure above.

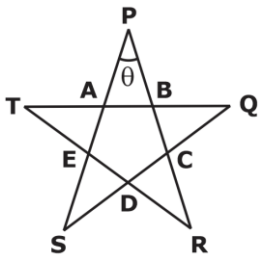
The value of θ, in degrees, is

A. 45 B. 72

C. 36 D. 108

Ans. C

Sol.



Given,

PR = PS = QS = QT = RT

ABCDE will be a regular pentagon

∠PAB = exterior angle for the pentagon

Each exterior angle = $\frac{360^o}{n} = \frac{360^o}{5}$ = 72º

So, ∠PAB = ∠PBA = 72º

In ΔPA, ∠PAB + ∠PBA + θ = 180º

θ = 36º

Ans. (C)

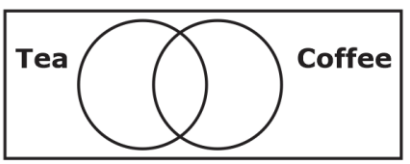
5. In a company, 35% of the employees drink coffee, 40% of the employees drink tea and 10% of the employees drink both tea and coffee. What % of employees drink neither tea nor coffee?

A. 35 B. 25

C. 40 D. 15

Ans. A

Sol.



n(T): No. of employees who drink coffee = 35%

n(T): No. of employees who drink tea = 40%

Then, n(T∩C): No. of employees who drink both tea and coffee = 40%

No. of employees who neither drink tea or, coffee n(∪) – n(T∪C)

= 100 – [n(T) + n(C) –n (T∩C)]

= 100 – (35 + 40 – 10)

= 35%

Ans. (1)

6. A function, λ, is defined by

$$\lambda(p,q) = \begin{cases} (p-q)^2, & \text{if } p \ge q \\ p+q, & \text{if } p < q \end{cases}$$

The value of the expression $\frac{\lambda(-(-3+2),(-2+3))}{(-(-2+1))}$

is:

A. 16 B. – 1

C. 16/3 D. 0

Ans. D

Sol. Given,

$$\lambda(p,q)\begin{cases} (p-q)^2, p \ge q \\ (p+q),\ p < q \end{cases}$$

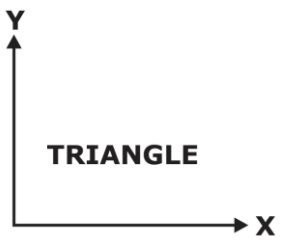
$$\lambda(-(-3+2),(-2+3)) = \lambda(1,\ 1)$$

$= (1 - 2)^2 = 0$

Value of the expression = 0

Ans. (D)

7.



A. 

B. 

C. 

D.

Ans. A

Sol.

Ans. (A)

8. Statement: Either P marries Q or X marries Y.

Among the options below, the logical NEGATION of the above statement is:

A. Neither P marries Q nor X marries Y.

B. X does not marry Y and P marries Q.

C. P marries Q and X marries Y.

D. P does not marry Q and X marries Y.

Ans. A

Sol. The logical negation will be.

Neither P marries Q nor X and marries Y.

9. Four persons P, Q, R and S are to be seated in a row, all facing the same direction, but not necessarily in the same order. P and R cannot sit adjacent to each other. S should be seated to the right of Q. The number of distinct seating arrangements possible is:

A. 6 B. 8

C. 4 D. 2

Ans. D

Sol.

…….. (Not possible)

…….. (Not possible)

RQSP (Possible)

RQSP (Possible)

Ans. (D)

10. Humans have the ability to construct worlds entirely in their minds, which don't exist in the physical world. So far as we know. no other species possesses this ability. This skill is so important that we have different words to refer to its different flavors, such as imagination, invention, and innovation.

Based on the above passage. which one of the following 1s TRUE?

A. We do not know of any species other than humans who possess the ability to construct mental worlds.

B. Imagination, invention, and innovation are unrelated to the ability to construct mental worlds.

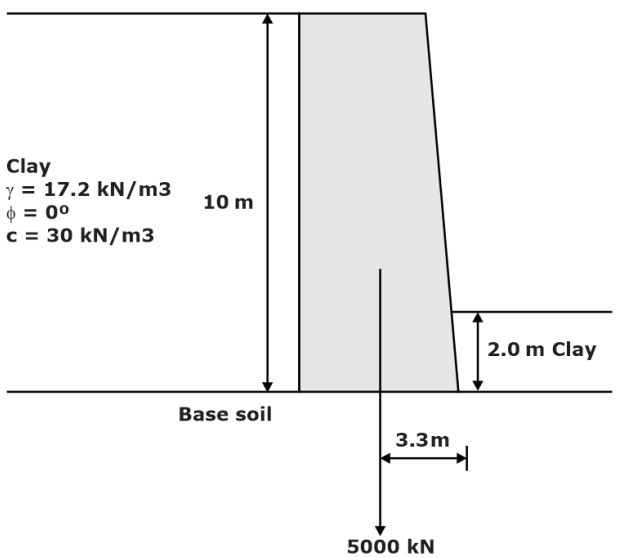
C. The terms imagination, invention and innovation refer to unrelated skills.

D. No species possess the ability to construct worlds in their minds.

Ans. C

TECHNICAL

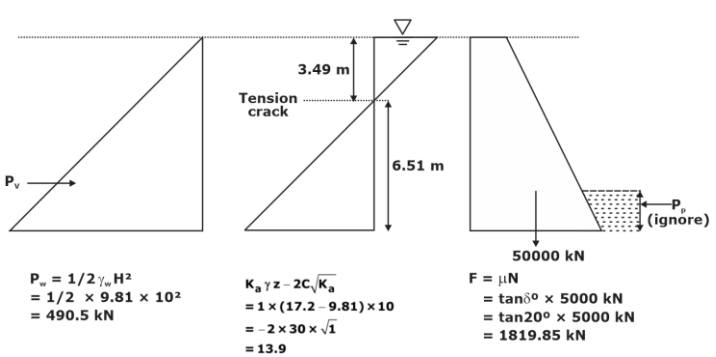
1. A retaining wall of height 10 m with clay backfill is shown in the figure (not to scale). Weight of the retaining wall is 5000 kN per m acting at 3.3 m from the toe of the retaining wall. The interface friction angle between base of the retaining wall and the base soil is 20°. The depth of clay in front of the retaining wall is 2.0 m. The properties of the clay backfill, and the clay placed in front of the retaining wall are the same. Assume that the tension crack is filled with water. Use Rankine's earth pressure theory. Take unit weight of water, λ_w = 9.81 KN/m^3.



The factor of safety (round off to two decimal places) against sliding failure of the retaining wall after ignoring the passive earth pressure will be_____.

Ans. 3.40

Sol.



Depth of tension crack =

$$\frac{2C}{\gamma\sqrt{K_a}} = \frac{2\times 30}{17.2\sqrt{1}} = \frac{60}{17.2\sqrt{1}} = 3.49\,\text{m}$$

K_a = 1 (∴ φ = 0°)

∴ P_a = 1/2 × 13.9 × 6.57 = 45.24 kN

$$\therefore \text{FOS} = \frac{1819.85}{490.5+45.24} = 3.40$$

2. A fluid flowing steadily in a circular pipe of radius R has a velocity that is everywhere parallel to the axis (centerline) of the pipe. The velocity distribution along the radial direction is $V_r = U\left(1-\frac{r^2}{R^2}\right)$, where r is the radial distance as measured from the pipe axis and U is the maximum velocity at r = 0. The average velocity of the fluid in the pipe is.

A. U/2 B. U/4

C. U/3 D. $\left(\frac{5}{6}\right)U$

Ans. A

Sol. It is the constant velocity at a cross section so that the mass flow rate remain same as original.

Mathematically,

$$U = U_{max}\left[1-\frac{r^2}{R^2}\right]$$

$$\overset{o}{m} = \int \partial \overset{o}{m}$$

$$\rho\left(\lambda R^2\right)\bar{U} = \int_o^R \rho\left(2\lambda R\,dr\right)U$$

$$\Rightarrow R^2\bar{U} = 2\int_o^R U_{max}\left[1-\frac{r^2}{R^2}\right]r\,dr$$

$$\Rightarrow R^2\bar{U} = 2\,U_{max}\left[\frac{R}{2}-\frac{R^2}{4}\right]$$

$$\Rightarrow \bar{U} = \frac{U_{max}}{2}$$

3. The solution of the second-order differential equation $\frac{d^2y}{dx^2}+2\frac{dy}{dx}+y=0$ with boundary conditions y(0) = 1 and y(1) = 3 is

A. $e^{-x}+(3e-1)xe^{-x}$

B. $e^{-x}+\left(3e\sin\left(\frac{\pi x}{2}\right)-1\right)xe^{-x}$

C. $e^{-x}-\left(3e\sin\left(\frac{\pi x}{2}\right)-1\right)xe^{-x}$

D. $e^{-x}-(3e-1)xe^{-x}$

Ans. A

Sol. Given differential equation is,

$$\frac{d^2y}{dx^2}+2\cdot\frac{dy}{dx}+y=0$$

with initial conditions y(0) = 1 and y(1) = 3

$\Rightarrow (D^2 + 2D + 1) \cdot y = 0$

The A.E. is,

F(m) = 0

$m^2 + 2m + 1 = 0$

$(m + 1)^2 = 0$

$m_1 = m_2 = -1 = m$ (Let)

Roots are real and equal

C.F. = $(C_1 + C_2x)\, e^{mx}$

C.F. = $(C_1 + C_2x)\, e^{-x}$

$\therefore$ X = 0 $\Rightarrow$ P.I. = 0

$\therefore$ C.S. = C.F. + P.I.

$\Rightarrow$ Y = C.F. + 0

$\Rightarrow Y = (C_1 + C_2x)\, e^{-x}$ .....(i)

$\therefore$ y (0) = 1

(1) $\Rightarrow 1 = (C_1 + 0)e^0$

$\Rightarrow C_1 = 1$

and y(1) = 3

(1) $\Rightarrow 3 = (1 + C_2)e^{-1}$

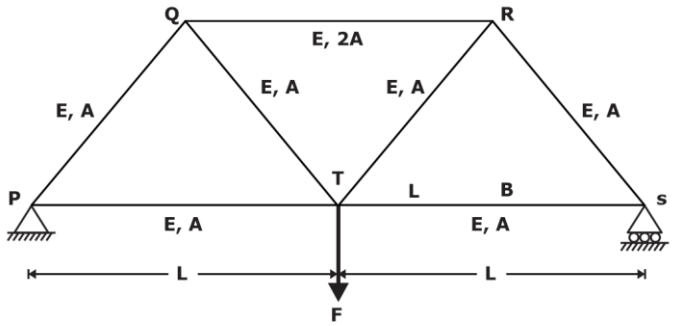
$\Rightarrow (3e - 1) = C_2$

$C_2 = (3e - 1)$

(1) $\Rightarrow y = [1 + (3e - 1)x]\, e^{-x}$

$\Rightarrow y = e^{-x} + (3e - 1)x \cdot e^{-x}$ is the requires solution.

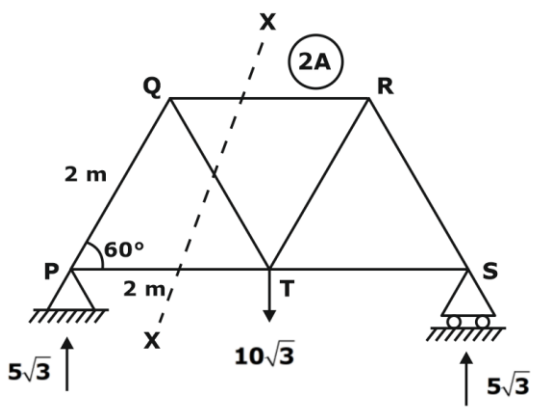
4. Refer the truss as shown in the figure (not to scale).

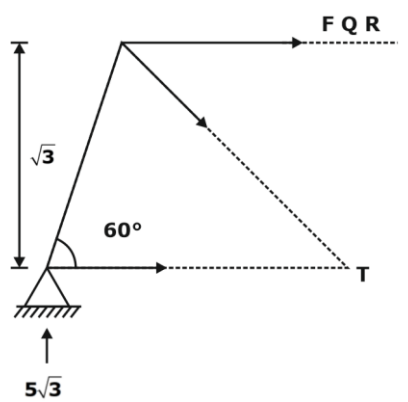


If load, F = 10 $\sqrt{3}$ kN, moment of inertia, I= 8.33 = 10^6 mm^4, area of cross-section, A = 10^4 mm^2 and length, L = 2 m for all the members of the truss, the compressive stress (in kN/m^2, in integer) carried by the member Q-R is _____.

Ans. 0.5 N/mm^2

Sol.





$\Sigma M_T = 0$,

$F_{QR} \times \sqrt{3} + 5\sqrt{3} \times 2 = 0$

$$\therefore F_{QR} = -\frac{10\sqrt{3}}{\sqrt{3}}\text{(Compressive)}$$

$$\therefore F_{QR} = \frac{10}{2\times10^4} = 5\times10^{-4}\text{KN/mm}^2$$

= 0.5 N/mm^2

5. Which of the following is/are correct statement(s)?

A. The boundary of water of a calm water pond will represent contour line.

B. In the case of fixed hair stadia tachometry, the staff intercept will be larger, when the staff is held nearer to the observation point.

C. If the whole circle bearing of a line is 270°, its reduced bearing 1s 90° NW.

D. Back Bearing of a line is equal to Fore Bearing ± 180°.

Ans. A, C and D

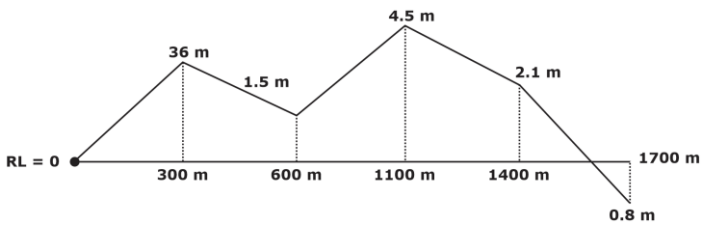
6. The longitudinal section of a runway provides the following data:

End-to-end runway (m)	Gradient (%)
0 to 300	+ 1.2
300 to 600	– 0.7
600 to 1000	+ 0.6
1100 to 1400	– 0.8
1400 to 1700	– 1.0

The effective gradient of the runway (in %, round off to two decimal places) is _____.

Ans. 0.32%

Sol. Assuming RL of start of runway as datum (i.e. RL = 0)



Effective gradient =

$$\left[\frac{\text{Maximum difference in reduced level}}{\text{Total runway length}}\right]$$

$$=\left[\frac{4.5-(-0.9)}{1700}\times 100\right]\%$$

= 0.3176%

= 0.32%

7. Ammonia nitrogen is present in a given wastewater sample as the ammonium ion (NH_4^+) and ammonia (NH_3). If pH is the only deciding factor for the proportion of these two constituents, which of the following is a correct statement?

A. At pH below 9.25. NH_3 will be predominant.

B. At pH 7.0, NH_4^+ and NH_3 will be found in equal measures.

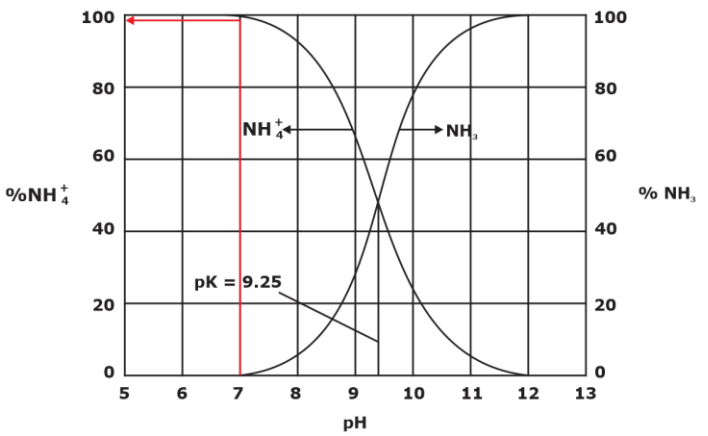
C. At pH above 9.25, only NH_4^+ will be present.

D. At pH 7.0, NH_4^+ will be predominant.

Ans. D

Sol. NH_4 + and NH_3

At pH7, NH_4^+ will be predominant.



If PH below 9.25 then NH_4 + dominant

If PH ↑ below then NH_3 is dominant

If PH ↓ then NH_4^+ is dominant

8. The direct and indirect costs estimated by a contractor for bidding a project is Rs. 160000 and Rs. 20000 respectively. If the mark up applied is 10% of the bid price, the quoted price (in Rs.) of the contractor is

A. 198000 B. 196000

C. 200000 D. 182000

Ans. A

Sol. Direct cost = 160000

Indirect cost = 20000

Total cost = 160000 + 20000 = 180000

Let quoted price by contractor is x.

Mark up applied = 10%

or, $\frac{x-180000}{180000}\times 100 = 10$

hence, quoted price (x) = 198000

9. The rank of matrix $\begin{bmatrix} 1 & 2 & 2 & 3 \\ 3 & 4 & 2 & 5 \\ 5 & 6 & 2 & 7 \\ 7 & 8 & 2 & 9 \end{bmatrix}$ is

A. 2 B. 4

C. 1 D. 3

Ans. A

Sol. Let, $A = \begin{bmatrix} \boxed{1} & 2 & 2 & 3 \\ 3 & \boxed{4} & 2 & 5 \\ 5 & 6 & \boxed{2} & 7 \\ 8 & 8 & 2 & \boxed{9} \end{bmatrix}$

$R_2 \to R_2 - R_1$

$R_3 \to R_3 - R_2$

$R_4 \to R_4 - R_3$

$$\sim A = \begin{bmatrix} \boxed{1} & 2 & 2 & 3 \\ 2 & \boxed{2} & 0 & 2 \\ 2 & 2 & \boxed{0} & 2 \\ 2 & 2 & 0 & \boxed{2} \end{bmatrix}$$

$R_2 \to R_2 - 2R_1$

$R_3 \to R_3 - R_2$

$R_4 \to R_4 - R_2$

$$\sim A = \begin{bmatrix} \boxed{1} & 2 & 2 & 3 \\ 0 & \boxed{-2} & -4 & -4 \\ 0 & 0 & \boxed{0} & 0 \\ 0 & 0 & 0 & \boxed{0} \end{bmatrix}$$

Rank (A) = 2

10. Which one of the following statements is correct?

A. Combustion is an endothermic process, which takes place in the abundance of oxygen.

B. Combustion is an exothermic process, which takes place in the absence of oxygen.

C. Pyrolysis is an endothermic process, which takes place in the absence of oxygen.

D. Pyrolysis is an exothermic process, which takes place in the absence of oxygen.

Ans. C

Sol. Pyrolysis is an endothermic process, which takes place in the absence of oxygen.

11. A signalized intersection operates in two phases. The lost time is 3 seconds per phase. The maximum ratios of approach flow to saturation flow for the two phases are 0.37 and 0.40. The optimum cycle length using the Webster's method (in seconds, round off to one decimal place) is_____.

Ans. 60.9 s

Sol. As per webster method, optimum cycle length is given as

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

here, L = 2 × 3 = 6sec

y = 0.37 + 0.40 = 0.77

$$\therefore C_0 = \frac{1.5 \times 6 + 5}{1 - 0.77} = 60.87 \text{ seconds.}$$

12. 'Kinematic viscosity' is dimensionally represented as

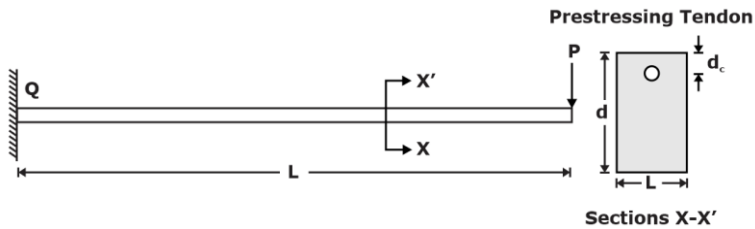
A. T^2/L B. M/L^2T

C. M/LT D. L^2/T

Ans. D

Sol. m^2/sec (L^2/T)

13. A prismatic cantilever prestressed concrete beam of span length, L = 1.5 m has one straight tendon placed in the cross-section as shown in the following figure (not to scale). The total prestressing force of 50 kN in the tendon is applied at d_c = 50 mm from the top in the cross-section of width, b = 200 mm and depth, d = 300 mm.



If the concentrated load, P = 5 kN, the resultant stress (in MPa. in integer) experienced at point 'Q' will be _____.

Ans. 0 MPa

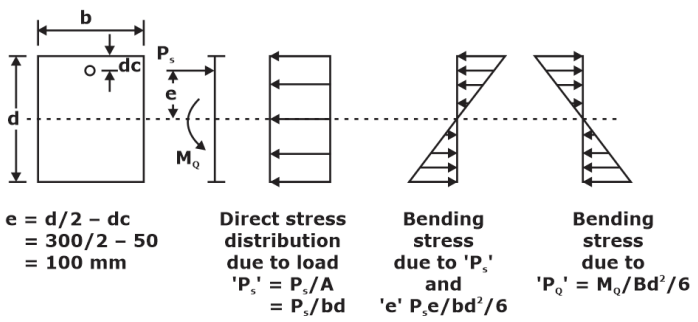
Sol. P_S = 50 KN

dc = 50 mm from to p

b = 200 mm

d = 300 mm

$$\left.\begin{matrix} L = 1.5 \text{ m} \\ P = 5 \text{ kN} \end{matrix}\right\} M_Q = P.L = 5 \times 1.5 = 7.5 \text{ kN (Hogging)}$$



Q point is at top of section

$$\text{So } (\sigma_R)_Q = +\frac{P_C}{A} + \frac{P_S.e}{bd^2/6} - \frac{M_Q}{bd^2/6}$$

$$= \frac{50\times10^3}{200\times300} + \frac{50\times10^3\times100}{200\times300^2/6} - \frac{7.5\times10^6}{200\times300^2/6}$$

$(\sigma_R)_Q = \text{O Mpa}$ Ans

14. Contractor X is developing his bidding strategy against Contractor Y. The ratio of Y's bid price to X's cost for the 30 previous bids in which Contractor X has competed against Contractor Y is given in the Table

Ratio of Y's bid price to X's cost	Number of bids
1.02	6
1.04	12
1.04	3
1.10	6
1.12	3

Based on the bidding behaviour of the Contractor Y. the probability of winning against Contractor Y at a mark up of 8% for the next project is

A. 0%

B. more than 0% but less than 50%

C. 100%

D. more than 50% but less than 100%

Ans. A

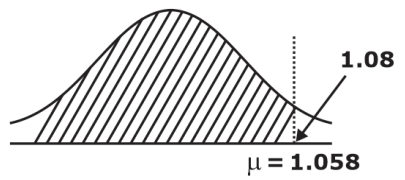
Sol.

Ratio of Y's bid Price to X's cost	Mark-up of Y's bid	Number of bids
1.02	2%	6
1.04	4%	12
1.06	6%	3
1.10	10%	6
1.12	12%	6
		Total (Σn) = 30

(Mean value of ratio of Y's bid price to X's cost)

$$= \left[\frac{1.02\times6+1.04\times12+1.06\times3+1.10\times6+1.12\times3}{30}\right] = 1.058$$

∴ Mean mark-up of Y's bid = 5.8%



∴ Required probability would be more than 50% but less than 10%.

So, correct answer is (a)

15. Spot speeds of vehicles observed at a point on a highway are 40, 55, 60. 65 and 80 km/h. The space-mean speed (in km/h, round off to two decimal places) of the observed vehicles is _____.

Ans. 56.99 kmph

Sol. Given data for spot speed is

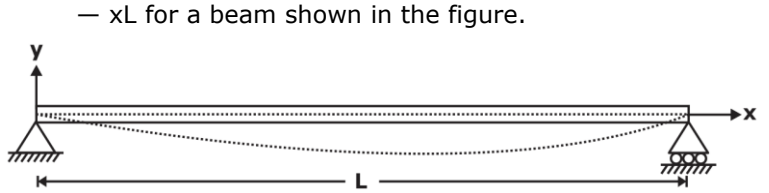
40, 55, 60, 65 and 80 kmph

$$\text{space mean speed} = \frac{m}{\frac{1}{V_1}+\frac{1}{V_2}+\frac{1}{V_3}+\frac{1}{V_4}+\frac{1}{V_5}}$$

$$= \frac{5}{\frac{1}{40}+\frac{1}{55}+\frac{1}{60}+\frac{1}{65}+\frac{1}{80}}$$

= 56.99 kmph

16. The equation of deformation is derived to be $y = x^2 - xL$ for a beam shown in the figure.



The curvature of the beam at the mid-span (in units, in integer) will be _____.

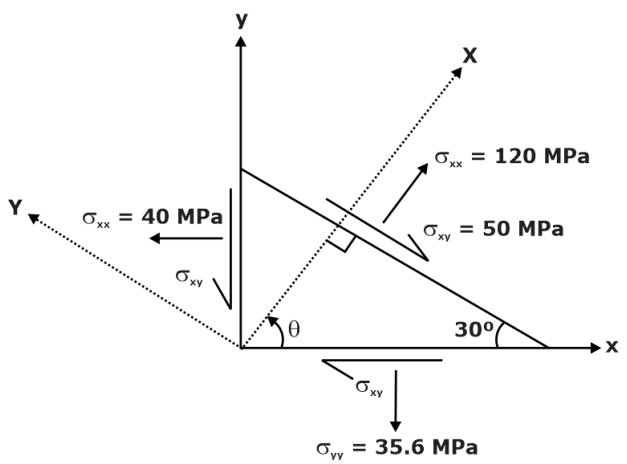
Ans. 2

Sol. $y = x^2 - xL$

$\partial y/\partial x = 2x$

$$\frac{\partial^2 y}{\partial x^2} = \frac{M}{EI} = \frac{1}{R} = \text{Curvature} = 2$$

17. The state of stress in a deformable body is shown in the figure. Consider transformation of the stress from the x-y coordinate system to the X-Y coordinate system. The angle θ, locating the X-axis, is assumed to be positive when measured from the x-axis in counter-clockwise direction.



The absolute magnitude of the shear stress component σ_{xy} (in MPa. round off to one decimal place) in x-y coordinate system is _____.

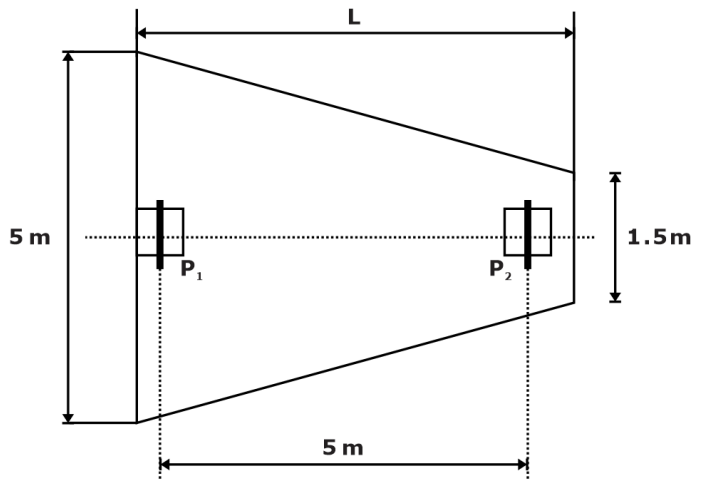
Ans. 96.18 MPa

Sol. $$\sigma'_x = \frac{\sigma_x + \sigma_y}{2} + \left[\frac{\sigma_x - \sigma_y}{2}\right]\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$120 = \frac{40 + 35.6}{2} + \left[\frac{40 - 35.6}{2}\right]\cos(2 \times 60°) + \tau_{xy}\sin(2 \times 60°)$$

τ_{zy} = 96.18 mPa

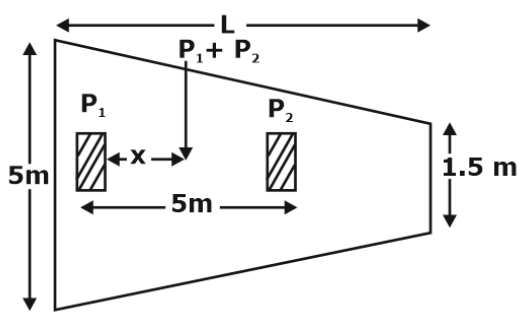
18. A combined trapezoidal footing of length L supports two identical square columns (P_1 and P_2) of size 0.5 m x 0.5 m, as shown in the figure. The columns P_1 and P_2 carry loads of 2000 kN and 1500 kN, respectively.



If the stress beneath the footing is uniform, the length of the combined footing L (in m, round off to two decimal places) is _____.

Ans. 5.22 m

Sol.



P_1 = 2000 kN

P_2 = 1500 kN

∵ Pressure distribution is uniform.

∴ there should not be any eccentricity.

3500 × x = P_2 × 5

x = 2.143 m

Now C.G. should coincide with this.

$$\left[\frac{2 \times 1.5 + 5}{1.5 + 5}\right]\frac{1}{3} = 2.143$$

$$\frac{8}{6.5} \times \frac{L}{3} = 2.143$$

L = 5.22 m

19. Consider the limit:

$$\lim_{x \to \infty}\left(\frac{1}{\ln x} - \frac{1}{x - 1}\right)$$

The limit (correct up to one decimal place) is _____.

Ans. 0.5

Sol. $\lim_{x\to1}\left(\frac{1}{\log_e x}-\frac{1}{x-1}\right)$ $(\infty-\infty)$ from

$=\lim_{x\to1}\frac{(x-1)-\log_e x}{(x-1)\cdot\log_e x}$ $\left(\frac{0}{0}\right)$ from

By L – Hospital's rule

$=\lim_{x\to1}\frac{(1-0)-\frac{1}{x}}{(x-1)\cdot\log_e x\cdot(1-0)}$

$=\lim_{x\to1}\frac{\frac{(x-1)}{x}}{\frac{[(x-1)+x\cdot\log_e x]}{x}}$

$=\lim_{x\to1}\frac{(x-1)}{(x-1)+x\cdot\log_e x}$ $\left(\frac{0}{0}\right)$ from

By L-Hospital's rule

$=\lim_{x\to1}\frac{1}{(1-0)+x\cdot\frac{1}{x}+\log_e x\cdot1}$

$=\frac{1}{1+1+0}=\frac{1}{2}=0.5$

20. Which of the following is NOT a correct statement?

A. Basic principle of surveying is to work from whole to parts.

B. The first reading from a level station is a 'Fore Sight'.

C. Contours of different elevations may intersect each other in case of an overhanging cliff.

D. Planimeter is used for measuring 'area'.

Ans. B

21. The liquid forms of particulate air pollutants are

A. mist and spray

B. dust and mist

C. fly ash and fumes

D. smoke and spray

Ans. A

Sol. Mist and spray are liquid form of particulate air pollutant.

22. On a road, the speed — density relationship of a traffic stream is given by U = 70 — 0.7k (where speed, u, is in km/h and density, k, is in veh/km). At the capacity condition, the average time headway will be

A. 1.0 s B. 0.5 s

C. 1.6 s D. 2.1 s

Ans. D

Sol. Given,

V = 70 – 0.7 K

as per the green shield model, we know that,

$\bar{V}=\bar{V}_{SF}\left[1-\frac{K}{K_j}\right]$ ... (1)

$\therefore \bar{V}=70\left[1-\frac{0.7\,k}{70}\right]=70\left[1-\frac{K}{70/0.7}\right]$ ... (2)

On comparing, we get

$\bar{V}_{SF}=70$ and $k_j=100$

We know, $q_{max}=\frac{\bar{V}_{sf}\times k_j}{4}=\frac{70\times100}{4}=1750$

$1750=\frac{3600}{H_t}$ $_t$ = 2.1 seconds

23. If P = $\begin{bmatrix}1&2\\3&4\end{bmatrix}$ and Q = $\begin{bmatrix}0&1\\1&0\end{bmatrix}$ then Q^TP^T is

A. $\begin{bmatrix}2&4\\1&3\end{bmatrix}$ B. $\begin{bmatrix}1&3\\2&4\end{bmatrix}$

C. $\begin{bmatrix}2&1\\4&3\end{bmatrix}$ D. $\begin{bmatrix}1&2\\3&4\end{bmatrix}$

Ans. A

Sol. $P=\begin{bmatrix}1&2\\3&4\end{bmatrix}$ and $Q=\begin{bmatrix}0&1\\1&0\end{bmatrix}$

Now, $Q^T\cdot P^T=(PQ)^T=\left\{\begin{bmatrix}1&2\\3&4\end{bmatrix}\begin{bmatrix}0&1\\1&0\end{bmatrix}\right\}^T$

$Q^T\cdot P^T=\begin{bmatrix}2&1\\4&3\end{bmatrix}^T$

$Q^T\cdot P^T=\begin{bmatrix}2&4\\1&3\end{bmatrix}$

Option (A)

24. In an Oedometer apparatus. a specimen of fully saturated clay has been consolidated under a vertical pressure of 50 kN/m^2 and is presently at equilibrium. The effective stress and pore water

pressure immediately on increasing the vertical stress to 150 kN/m^2, respectively are

A. 150 kN/m^2 and 0

B. 0 and 150 kN/m^2

C. 100 kN/m^2 and 50 kN/m^2

D. 50 kN/m^2 and 100 kN/m^2

Ans. D

Sol. Additional loading=150-50=100 kN/m^2

Pore water pressure= 100 kN/m^2

Total stress =150 kN/m^2

Effective stress=50 kN/m^2

25. A partially-saturated soil sample has natural moisture content of 25% and bulk unit weight of 18.5 kN/m^3, The specific gravity of soil solids is 2.65 and unit weight of water is 9.81 kN/m^3. The unit weight of the soil sample on full saturation is

A. 19.03 kN/m^3 B. 18.50 kN/m^3

C. 21.12 kN/m^3 D. 20.12 kN/m^3

Ans. A

Sol. $\gamma_{sat} = \left(\frac{G+e}{1+e}\right)\gamma_w$

G = 2.65; δ_w = 9.811 m^3

e = ?

Given,

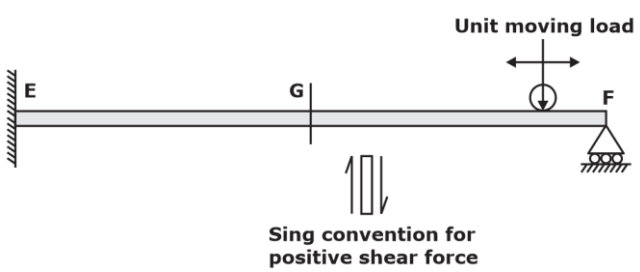
$$\gamma = \left(\frac{G+ec}{1+e}\right)\gamma_w = \left(\frac{G+wG}{1+e}\right)\gamma_w = \frac{G(1+w)}{1+e}\gamma_w$$

$$18.5 = 2.65 \times \frac{(1+0.25)}{1+e} \times 9.81$$

e = 0.756

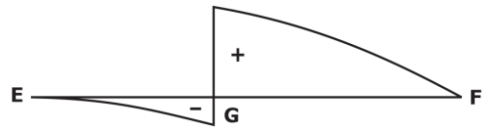
$$\gamma_{sat} = \left(\frac{2.65+0.756}{1+0.756}\right) \times 9.81 = 19.03 \text{ kN/m}^3$$

26. A propped cantilever beam EF is subjected to a unit moving load as shown in the figure (not to scale). The sign convention for positive shear force at the left and right sides of any section is also shown.

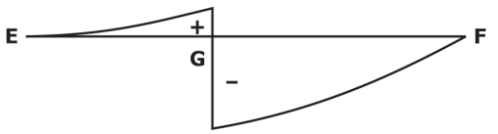


The CORRECT qualitative nature of the influence line diagram for shear force at G is

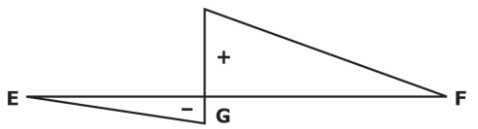
A.



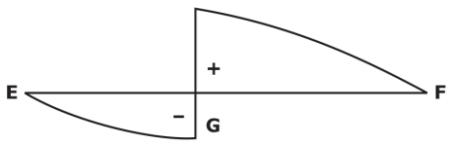
B.



C.



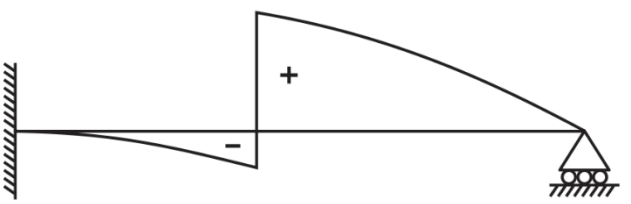
D.



Ans. A

Sol.

Apply Muller-Breslau principle,



27. The value of $\int_0^1 e^x dx$ using the trapezoidal rule with four equal subintervals is

A. 1.718 B. 1.727

C. 2.192 D. 2.718

Ans. B

Sol. $\int_0^1 e^x \cdot dx = \int_a^b f(x)\,dx$

Here, a = 0, b = 1, f(x) = e^x

n = 4 (given)

∴ b = a + nh

1 = 0 + 4h

H = 0.25

X	0	0.25	0.5	0.75	1
$f(x) = e^x$	1 y_0	$e^{0.25}$ Y_1	$e^{0.5}$ y_2	$e^{0.75}$ y_3	e y_4

By trapezoidal rule,

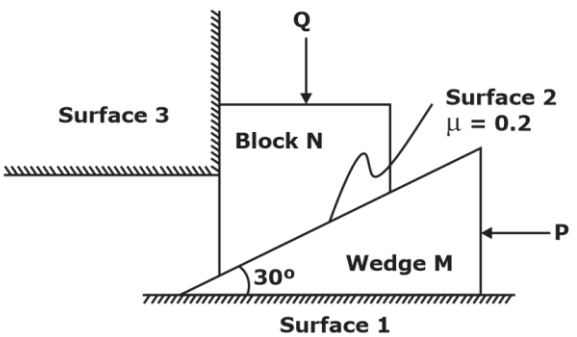
$$\int_a^b f(x)\,dx = \frac{h}{2}\left[(y_0 + y_4) + 2(y_1 + y_2 + y_3)\right]$$

$$\int_0^1 e^x \cdot dx = \frac{0.25}{2}\left[(1 + e) + 2\left(e^{0.25} + e^{0.5} + e^{0.75}\right)\right]$$

= 1.7272

Option (B)

28. A wedge M and a block N are subjected to forces P and Q as shown in the figure. If force P is sufficiently large, then the block N can be raised. The weights of the wedge and the block are negligible compared to the forces P and Q. The coefficient of friction (μ) along the inclined surface between the wedge and the block is 0.2. All other surfaces are frictionless. The wedge angle is 30°.



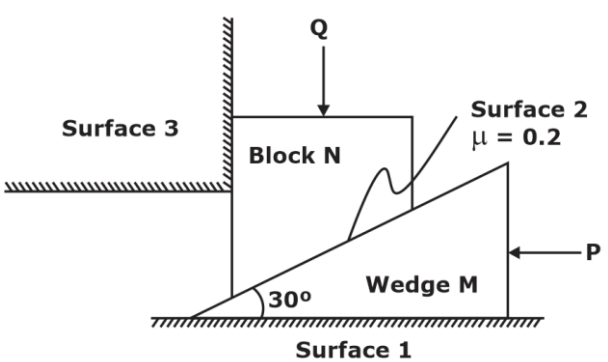
The limiting force P, in terms of Q, required for impending motion of block N to just move it in the upward direction is given as P = αQ. The value of the coefficient 'α' (round off to one decimal place) is

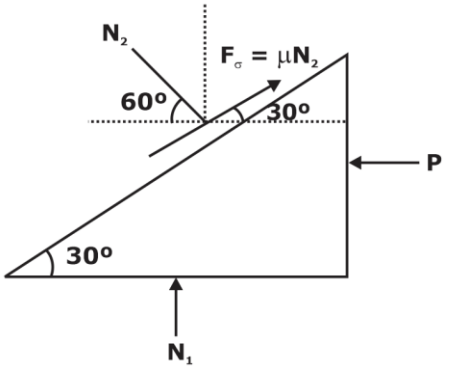
A. 0.5 B. 0.9

C. 0.6 D. 2.0

Ans. B

Sol.



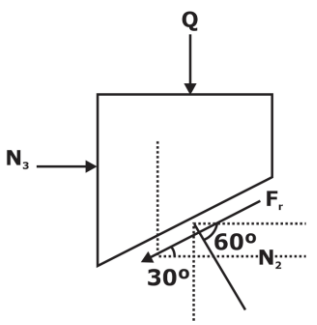


$F_\sigma = 0.2\ N_2$

$\Sigma F_x = 0 \quad N_2 \cos 60^o + F_r \cos 30^o - P = 0$

$N_2 \times \frac{1}{2} + 0.2 N_2 \times \frac{\sqrt{3}}{2} = P$

$P = 0.6732\ N_2$ .....(i)



$\Sigma F_y = 0$

$-Q + N_2 \sin 60^o - F_r \sin 30^o = 0$

$Q = N_2 \times \frac{\sqrt{3}}{2} - 0.2\ N_2 \times \frac{1}{2}$

$Q = 0.7660\ N_2$

$N_2 = 1.30544Q$

From equation (i)

$P = 0.6732 \times 1.30544Q$

$P = 0.8788Q$

$\alpha = 0.8788 = 0.9$

29. A tube-well of 20 cm diameter fully penetrates a horizontal, homogeneous and isotropic confined aquifer of infinite horizontal extent. The aquifer is of 30 m uniform thickness. A steady pumping at the rate of 40 litres/s from the well for a long time results in a steady drawdown of 4 m at the well face. The subsurface flow to the well due to pumping is steady, horizontal and Darcian and the radius of influence of the well is 245 m. The hydraulic conductivity of the aquifer (in m/day, round off to integer) is_____.

Ans. 36 m/day.

Sol. $q = \frac{2\pi k \times 4 \times 30}{\ln(245/.1)}$

q = 40 l/sec

1 equation 1 unknown

k = 35.856 m/day.

30. The shape of the cumulative distribution function of Gaussian distribution is

A. S-shaped

B. Horizontal line

C. Bell-shaped

D. Straight line at 45º angle

Ans. C

31. The values of abscissa (x) and ordinate (y) of a curve are as follows:

X	Y
2.0	5.00
2.5	7.25
3.0	10.00
3.5	13.25
4.0	17.00

By Simpson's 1/3rd rule, the area under the curve (round off to two decimal places) is _____.

Ans. 20.67

Sol.

X	2.0	2.5	3.0	3.5	4.0
Y	5 y_0	7.25 Y_1	10 y_2	13.25 y_3	17 y_4

Here, a = 2, b = 4 area bounded =

$$A = \int_2^4 y \cdot dx$$

h = 0.5, n = 4

by Simpson's 1/3rd rule (n = even)

$$\int_a^b y \cdot dx = \frac{h}{3}\left[(y_0 + y_4) + (y_1 + y_3) + 2(y_2)\right]$$

$$\text{Area} = \int_2^4 y \cdot dx = \frac{0.5}{3}\left[(5+17) + 4(7.25+13.25) + 2\times 10\right]$$

$$= \frac{1}{6}\left[22 + 4\times 20.5 + 20\right]$$

$$= \frac{1}{6}\left[22 + 82 + 20\right]$$

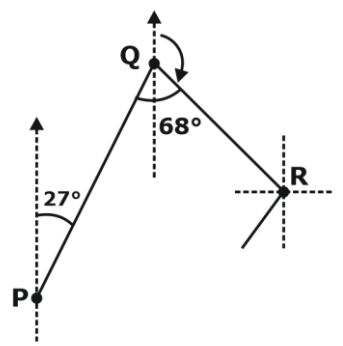
$$= \frac{1}{6}\times 124$$

= 20.667 sq. units

32. Traversing is carried out for a closed traverse PORS. The internal angles at vertices P, Q, R and S are measured as 92°, 68°, 123°, and 77°. respectively. If fore bearing of line PQ is 27°, fore bearing of line RS (in degrees, in integer) is _____.

Ans. 196°

Sol.



Given, FB of PQ = 27°

∴ BB of PQ = 180 + 27 = 207

∴ FB of QR = B.B. of PQ – 68°

= 207 – 68

= 139°

∴ BB of QR = 180 + 139 = 319°

∴ FB of RS = BB of QR – 123°

= 319 – 123

= 196°

33. The shape of the most commonly designed highway vertical curve is

A. circular (multiple radii)

B. circular (single radius)

C. parabolic

D. spiral

Ans. C

Sol. The ideal curve in case of transition curve is spiral whereas for vertical curves parabola is prepared.

34. A 50 mL sample of industrial wastewater is taken into a silica crucible. The empty weight of the crucible is 54.352 g. The crucible with the sample is

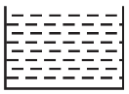
dried in a hot air oven at 104°C till a constant weight of 55.129 g. Thereafter, the crucible with the dried sample is fired at 600°C for 1 h in a muffle furnace, and the weight of the crucible along with residue is determined as 54.783 g. The concentration of total volatile solids is _____.

A. 8620 mg/L B. 1700 mg/L

C. 6920 mg/L D. 15540 mg/L

Ans. C

Sol.

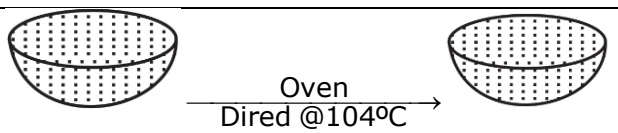


V = Volume of sample

V = some

w′ = Empty weight of the crucible

w′ = 54.352g



w_1 = wt of crucible + w_t of volatile solid + w_t of non volatile solid w_1 = 55.129 g	W_2 = wt of crucible + w_t of non volatile solid w_2 = 54.783 g

Concentration of volatile solids (mgle)

$$= \frac{(w_1 - w_2)}{\left(\frac{V}{1000}\right)} \times 10^3$$

$$= \frac{(55.129 - 54.783)}{\left(\frac{50}{1000}\right)} \times 10^3 = 6920 \text{ mg/l}$$

35. Vehicular arrival at an isolated intersection follows the Poisson distribution. The mean vehicular arrival rate is 2 vehicle per minute. The probability (round off to two decimal places) that at least 2 vehicles will arrive in any given 1-minute interval is _____.

Ans. 0.59 s

Sol. Given λ = 2 veh / min

Probability of passing of at least 2 veh / min

$$= 1 - \begin{bmatrix} \text{probability of having 0 vehicle} \\ + \text{probability of having 1 vehicle} \end{bmatrix}$$

$$= 1 - \left[\frac{2^{\circ} e^{-2}}{01} + \frac{2^{1} e^{-2}}{11}\right]$$

=0.59

36. Gypsum is typically added in cement to

A. increase workability

B. prevent quick setting

C. decrease heat of hydration

D. enhance hardening

Ans. B

Sol. Calcium Sulphate is added in the form of Gypsum ($CaSO_4.2H_2O$) to the cement clinkers to slow down the hydration of cement which results in prevention of the quick setting of the cement.

37. The volume determined from $\iiint_V 8xyz\, dV$ for $V = [2,3] \times [1,2] \times [0,1]$ will be (in integer) _____.

Ans. 15

Sol. $\iiint_V 8xyz\, dv$

$$= 8 \int_{z_1=0}^{z_2=1} z \int_{y_1=1}^{y_2=2} y \int_{x_1=2}^{x_2=3} x \quad dx \cdot dy \cdot dz$$

$$= 8 \int_{z_1}^{z_2} z \int_{y_1}^{y_2} y \cdot \left[\frac{x^2}{2}\right]_{x_1=2}^{x_2=3} \cdot dy \cdot dz$$

$$= 4 \int_{z_1}^{z_2} z \int_{y_1}^{y_2} y(9-4)\, dy \cdot dz$$

$$= 4 \times 5 \int_{z_1}^{z_2} z \int_{y_1}^{y_2} y \cdot dy\, dz$$

$$= 20 \int_{z_1}^{z_2} z \left[\frac{y^2}{2}\right]_{y_1=1}^{y_2=2}$$

$$= \frac{20}{2} \int_{z_1}^{z_2} z[4-1] \cdot dz$$

$$= 10 \times 3 \int_{z_1}^{z_2} z \cdot dz$$

$$= 30\left[\frac{z^2}{z}\right]_0^1$$

$= 15\,[1 - 0]$

$= 15$

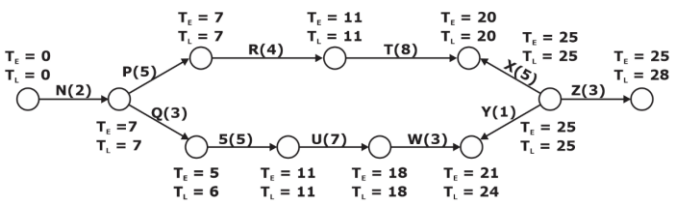
38. A small project has 12 activities -N, P, Q, R, S, T, U, V, W, X, Y, and Z. The relationship among these activities and the duration of these activities are given in the Table.

Activity	Duration (in weeks)	Depends upon
N	2	—
P	5	N
Q	3	N
R	4	P
S	5	Q
T	8	R
U	7	R, S
V	2	U
W	3	U
X	5	T, V
Y	1	W
Z	3	X, Y

The total float of the activity "V" (in weeks, in integer) is _____.

Ans. 0

Sol.



Activity	t_{ij}	EST	EFT	LFT	LST	F_T
N	2	0	2	2	0	0
P	5	2	7	7	2	0
Q	3	2	5	6	3	1
R	4	7	11	11	7	0
S	5	5	10	11	6	1
T	8	11	19	20	12	1
U	7	11	18	18	11	0
V	2	18	20	20	18	0
W	3	18	21	24	21	3
X	5	20	25	25	20	0
Y	1	21	22	25	24	3
Z	3	25	28	28	25	0

So, total float of activity V = 0

39. Which one of the following is correct?

A. The most important type of species involved in the degradation of organic matter in the case of activated sludge process based wastewater treatment is chemoheterotrophs.

B. The partially treated effluent from a food processing industry, containing high concentration of biodegradable organics, is being discharged into a flowing river at a point P. If the rate of degradation of the organics is higher than the rate of aeration. then dissolved oxygen of the river water will be lowest at point P.

C. A young lake characterized by low nutrient content and low plant productivity is called eutrophic lake.

D. For an effluent sample of a sewage treatment plant. the ratio $BOD_{5\text{-day, }20^\circ C}$ upon ultimate BOD is more than 1.

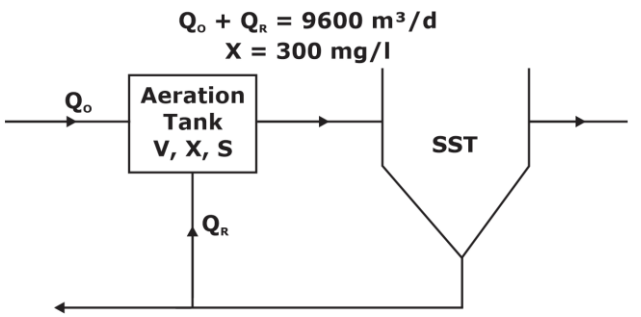
Ans. A

Sol. Chemoheterotrophs microorganisms are mostly used in Biological Treatment.

40. A secondary clarifier handles a total flow of 9600 m^3/d from the aeration tank of a conventional activated-sludge treatment system. The concentration of solids in the flow from the aeration tank is 3000 mg/L. The clarifier is required to thicken the solids to 12000 mg/L. and hence it is to be designed for a solid flux of $3.2\,\frac{kg}{m^2 \cdot h}$. The surface area of the designed clarifier for thickening (in m^2, in integer) is _____.

Ans. 375 m^2

Sol.



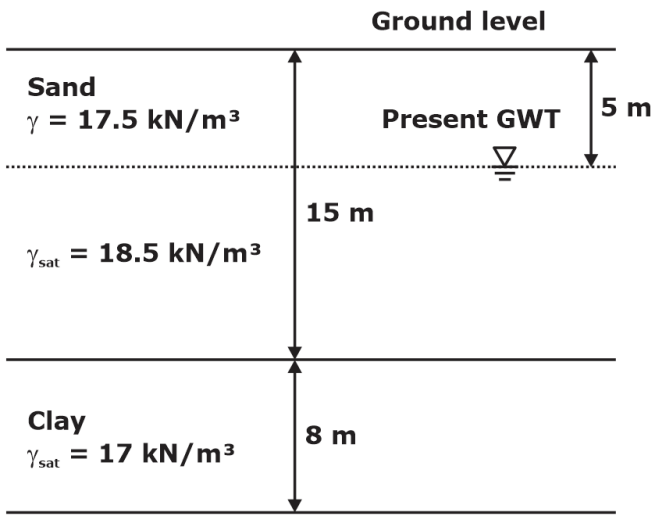
Solid loading to SST = (Q_O + Q_R) x =

$$\frac{6900}{24}\frac{m^3}{h} \times \frac{3000 \times 10^{-6}}{10^{-3}}\frac{kg}{m^3}$$

Solid flux = 3.2 kg/m^2.h = 1200 kg/h

Surface area of SST = $\frac{1200\ kg/h}{3.2\ kg/m^2.g} = 375\,m^2$

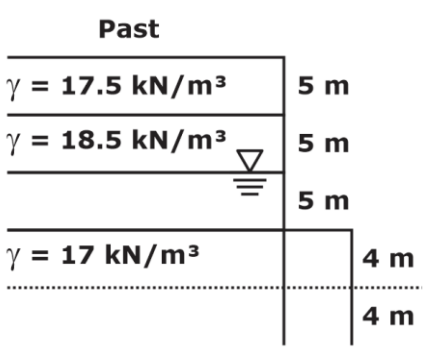
41. The soil profile at a construction site is shown in the figure (not to scale). Ground water table (GWT) is at 5 m below the ground level at present. An old well data shows that the ground water table was as low as 10 m below the ground level in the past. Take unit weight of water, γ_w = 9.81 kN/m^3.



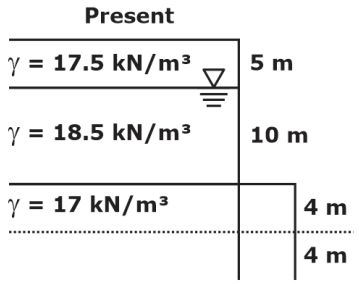
The overconsolidation ratio (OCR) (round off to two decimal places) at the mid-point of the clay layer is _____.

Ans. 1.24

Sol.



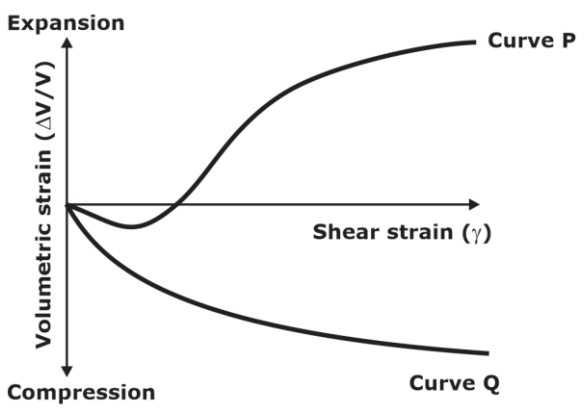
$\bar{\sigma}_{Past}$ = 17.5× 5 + 18.5 × 5 + 5 × (18.5 – 9.81) + 4 × (17 – 9.81) = 252.21 kPa



$\bar{\sigma}_{Present}$ = 17.5× 5 + 10 × (18.5 – 9.81) + 4 × (17 – 9.81) = 203.16 kPa

$\therefore$ OCR = $\frac{\bar{\sigma}_{Past}}{\bar{\sigma}_{Present}} = \frac{252.21}{203.16} = 1.24$

42. Based on drained triaxial shear tests on sands and clays, the representative variations of volumetric strain (ΔV/V) with the shear strain (γ) is shown in the figure.



Choose the CORRECT option regarding the representative behaviour exhibited by Curve P and Curve Q.

A. Curve P represents dense sand and overconsolidated clay, while Curve Q represents loose sand and normally consolidated clay.

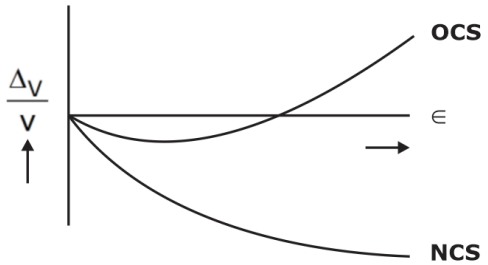
B. Curve P represents loose sand and normally consolidated clay, while Curve Q represents dense sand and overconsolidated clay.

C. Curve P represents dense sand and normally consolidated clay, while Curve Q represents loose sand and overconsolidated clay.

D. Curve P represents loose sand and overconsolidated clay, while Curve Q represents dense sand and normally consolidated clay.

Ans. A

Sol. This is the required relation between volumetric strain and axial strain for over consolidated and normally consolidated soils respectively.



43. The cohesion (c), angle of internal friction (φ) and unit weight (γ) of a soil are 15 kPa, 20° and 17.5 kN/m3, respectively. The maximum depth of unsupported excavation in the soil (in m, round off to two decimal places) is _____.

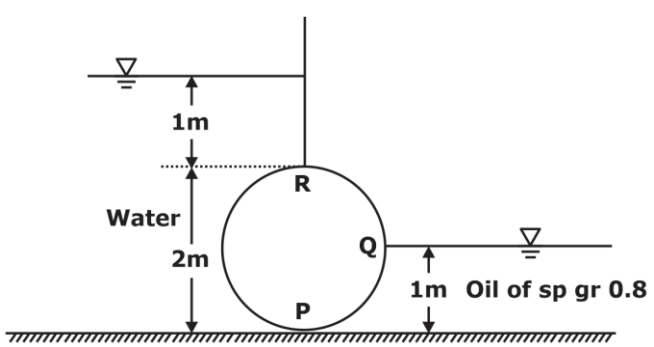
Ans. 4.896 m

Sol. $K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 20^o}{1+\sin 20^o} = 0.4903$

Depth of unsupported cut

$$2Z_0 = \frac{4C}{\gamma\sqrt{K_a}} = \frac{4\times 15}{17.5\times\sqrt{0.4903}} = 4.896 \text{ m}$$

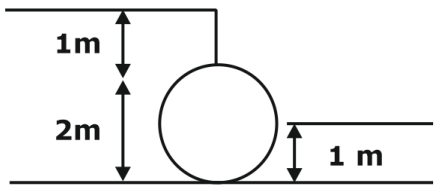
44. A cylinder (2.0 m diameter, 3.0 m long and 25 kN weight) is acted upon by water on one side and oil (specific gravity = 0.8) on other side as shown in the figure.



The absolute ratio of the net magnitude of vertical forces to the net magnitude of horizontal forces (round off to two decimal places) is _____.

Ans. 0.37

Sol.



$$\frac{F_V}{F_H} = \frac{39719.9}{105948} = 0.37$$

$$FH_2 \delta g \bar{h} A\big|_{ril} = 1000\times 0.8\times 9.81\times 0.5\times 1\times 3$$

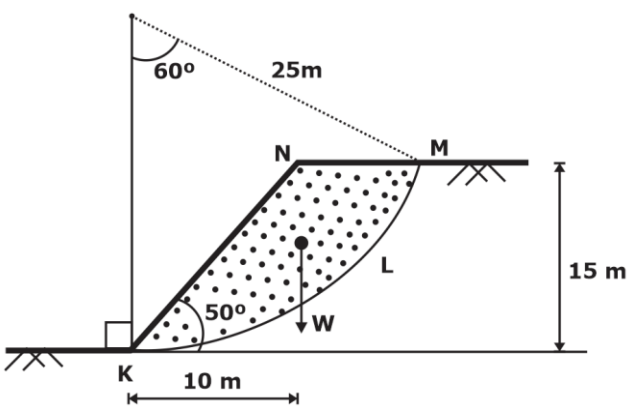
$F_{net} = FH_1 - FH_2 = 105948N$

$$FV_1 \delta g V = 1000\times 9.81\times\frac{\pi}{2}\times 1^2\times 3 = 13791.4N$$

$FV_{net} = 64719.91 - 25000 = 3971.9$ N

$$\frac{F_V}{F_H} = \frac{39719.9}{105948} = 0.37$$

45. An unsupported slope of height 15 m is shown in the figure (not to scale), in which the slope face makes an angle 50° with the horizontal. The slope material comprises purely cohesive soil having undrained cohesion 75 kPa. A trial slip circle KLM. with a radius 25 m, passes through the crest and toe of the slope and it subtends an angle 60° at its center O. The weight of the active soil mass (W, bounded by KLMN) is 2500 kN/m, which is acting at a horizontal distance of 10 m from the toe of the slope. Consider the water table to be present at a very large depth from the ground surface.



Considering the trial slip circle KLM, the factor of safety against the failure of slope under undrained condition (round off to two decimal places) is _____.

Ans. 1.96

Sol. $FOS = \frac{\text{Resisting moment}}{\text{Overturning moment}}$

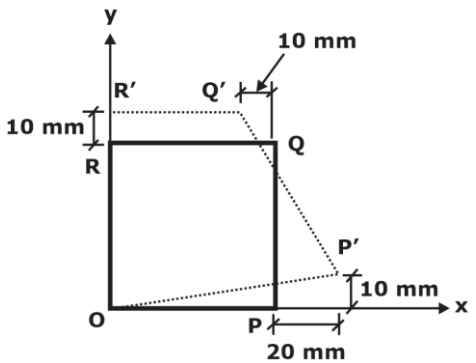
Resisting moment $= 75 \times \left(25 \times 60 \times \frac{\pi}{180}\right) \times 25 =$

49087.39 kNm/m

Overturning moment $= 2500 \times 10 = 25000$ kNm/m

$\therefore$ FOS $= \frac{49087.39}{25000} = 1.96$

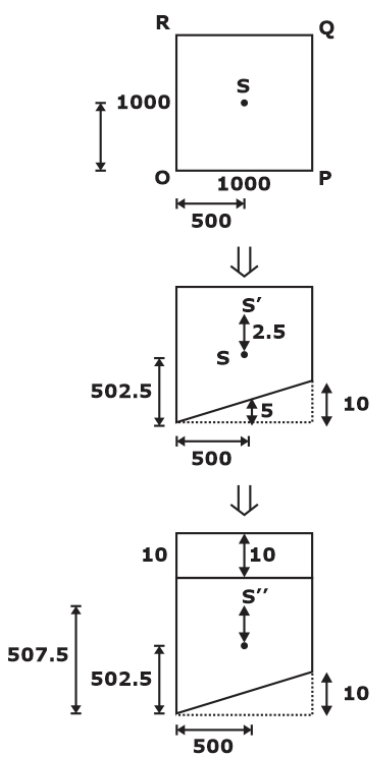
46. A square plate O-P-Q-R of a linear elastic material with sides 1.0 m is loaded in a state of plane stress. Under a given stress condition, the plate deforms to a new configuration O-P-Q'-R' as shown in the figure (not to scale). Under the given deformation, the edges of the plate remain straight.

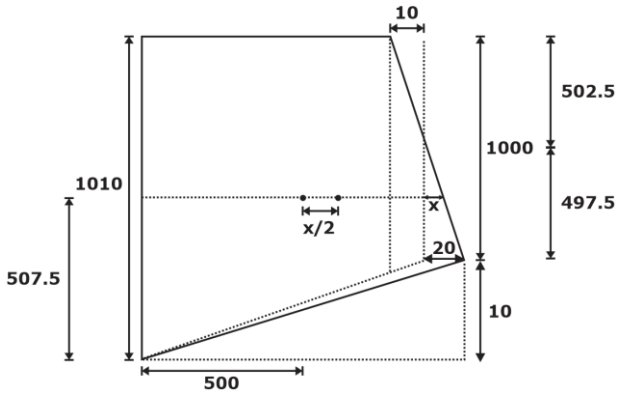


The horizontal displacement of the point (0.5 m, 0.5 m) in the plate O-P-Q-R (in mm, round off to one decimal place) is _____.

Ans. 2.5 mm

Sol.

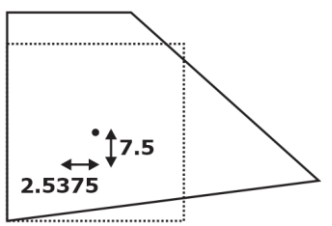




$\frac{30}{1000} = \frac{10 + x}{502.5}$

$\frac{x}{2} = 2.5375$

Final



Horizontal of displacement

= 2.5375 mm

= 2.5 mm upto 1 decimal place

47. A water sample is analyzed for coliform organisms by the multiple-tube fermentation method. The results of confirmed test are as follows:

Sample size (mL)	Number of positive results out of 5 tubes	Number of negative results out of 5 tubes
0.01	5	0
0.001	3	2
0.0001	1	4

The most probable number (MPN) of coliform organisms of the above results is to be obtained using the following MPN Index.

MPN Index for Various Combinations of Positive Results when Five Tubes used per Dilution of 10.0 mL, 1.0 mL and 0.1 mL	
Combination of positive tubes	**MPN Index per 100 mL**
0-2-4	11
1-3-5	19
4-2-0	22
5-3-1	110

The MPN of coliform organisms per 100 mL is

A. 110000 B. 1100000

C. 110 D. 1100

Ans. A

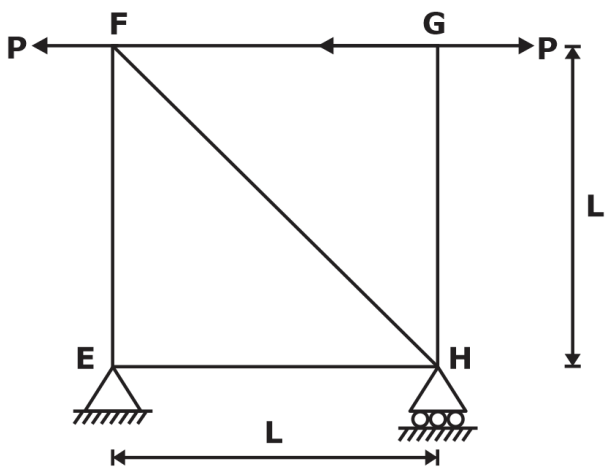
Sol.

+ve Test	0.01 ml	0.001 ml	0.0001 ml
Result	5	3	1

As per standard table

10 ml	1 ml	0.1 ml	MPN/100 ml
5	3	1	10

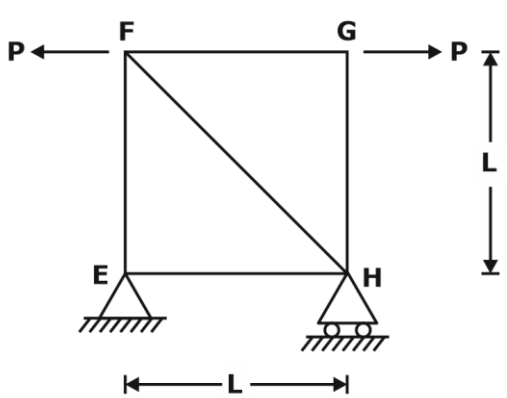
48. A truss EFGH is shown in the figure, in which all the members have the same axial rigidity R. In the figure, P is the magnitude of external horizontal forces acting at joints F and G.



If R = 500 × 10^3 kN, P= 150 kN and L = 3 m, the magnitude of the horizontal displacement of joint G (in mm. round off to one decimal place) is _____.

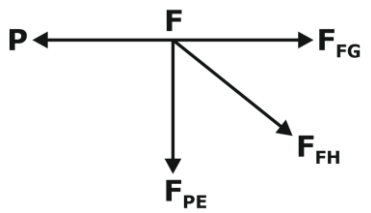
Ans. 0.9 mm

Sol.



member force in F_{FG} = P

Consider joint F



$\Sigma F_x = 0$, $P - F_{FG} - F_{FH} \sin 45° = 0$

$F_{FH} = 0$

$\therefore F_{PE} = 0$

and all sections = 0

$\therefore F_{PE} = 0$

As per Castigliano's

$$\text{Total SE} = \frac{P^2L}{2AE}$$

$$(\text{Horizontal deflection})\,\Delta_G = \frac{\partial U}{\partial P} = \frac{2PL}{2AE} = \frac{PL}{AE}$$

$$= \frac{450 \times 10^3}{500 \times 1000} = 0.9 \text{ mm}$$

49. If water is flowing at the same depth in most hydraulically efficient triangular and rectangular channel sections then the ratio of hydraulic rads of triangular section to that of rectangular section is

A. 1 B. $\sqrt{2}$

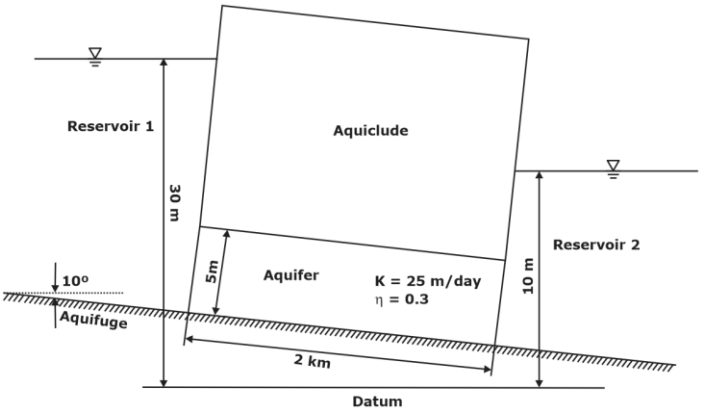
C. $\frac{1}{\sqrt{2}}$ D. 2

Ans. C

Sol. Hydraulic radius for triangular channel section of most economical section is $\frac{y}{2\sqrt{2}}$ whereas for rectangular channel section it is given as $\frac{y}{2}$

$$\therefore \frac{R_{triangle}}{R_{rectangular}} = \frac{\frac{y}{2\sqrt{2}}}{\frac{y}{\sqrt{2}}} = \frac{1}{\sqrt{2}} = 0.70$$

50. Two reservoirs are connected through a homogeneous and isotropic aquifer having hydraulic conductivity (K) of 25 m/day and effective porosity (η) of 0.3 as shown in the figure (not to scale). Ground water is flowing in the aquifer at the steady state.



If water in Reservoir 1 is contaminated then the time (in days. round off to one decimal place) taken by the contaminated water to reach to Reservoir 2 will be _____.

Ans. 2400 days

Sol. $V_s = \frac{v}{n} = \frac{K_i}{n} = \frac{25 \times \frac{20}{2000}}{0.3} = \frac{L}{t} = \frac{2000}{t}$

$t = \frac{2000 \times 0.3 \times 2000}{25 \times 20} = 2400$ days

51. A baghouse filter has to treat 12 m^3/s of waste gas continuously. The baghouse is to be divided into 5 sections of equal cloth area such that one section can be shut down for cleaning and/or repairing. while the other 4 sections continue to operate. An air-to-cloth ratio of 6.0 $m^3/min\text{-}m^2$ cloth will provide sufficient treatment to the gas. The individual bags are of 32 cm in diameter and 5 m in length. The total number of bags (in integer') required in the baghouse is _____.

Ans. 30

Sol. Given data,

Gas flow rate = 12 m^3/s

Airto cloth ratio = 6 $m^3/min.m^2$

Cloth area =

$$\frac{\text{Gas flow rate}}{\text{Air to cloth ratio}} = \frac{12\ m^3/s}{6\frac{m^3}{S \cdot m^2} \times \frac{1}{60}} = 120\,m^2$$

Area of one filter bag = π. D.L. =

$$\pi \times \left(\frac{32}{100}\right) m \times 5 = 5.0265\,m^2$$

D – Diameter of filter bag

L – Length of filter bag

Cloth area per operating section =

$$\frac{120\,m^2}{4} = 30\,m^2 / \text{section}$$

No. of filter bag per section (N) =

$$\frac{30\,m^2}{\text{Area of one filter bag}}$$

$$N = \frac{30\,m^2}{5.0265\,m^2}$$

$N = 5.968 \approx 6$ filter bag

Total number of operating = No. of operating section × N

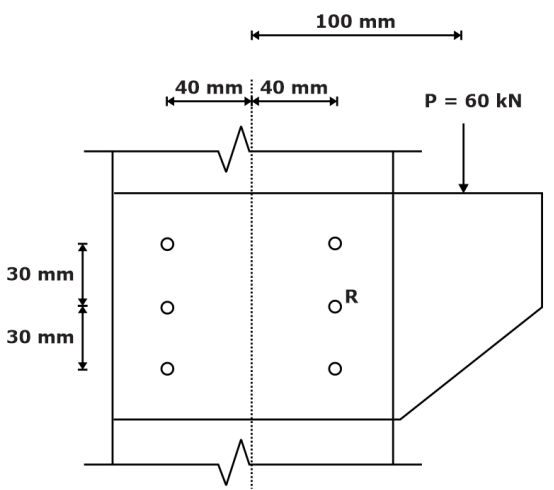
= 4 × 6 = 24

Total number of in non-operating section = 1 × 6 = 6

Total number of filter bag (Operating + Non-operating)

= 24 + 6 = 30

52. A column is subjected to a total load (P) of 60 KN supported through a bracket connection, as shown in the figure (not to scale).



The resultant force in bolt R (in kN, round off to one decimal place) is _____.

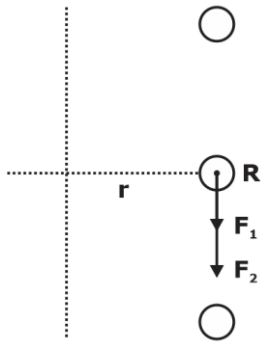
Ans. 28.18 kN

Sol. F_1 = Direct shear force = $\frac{60}{6}$ = 10 kN

F_2 = Force, coming due to moment (eccentricity)

= $\frac{P \times e \times r}{\Sigma r^2}$ [for the bolt 'R', r = 40 mm]

$$= \frac{60 \times 100 \times 40}{50^2 \times 4 + 40^2 \times 2} = 18.18 \text{ kN}$$



$$F = \sqrt{F_1^2 + F_2^2 + 2 + F_1F_2 \cos}$$

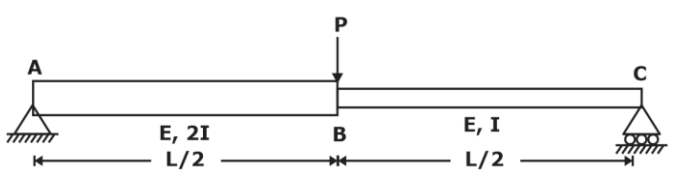
Since here θ = 0°

∴ $F_R = F_1 + F_2$

= 10 + 18.18

28.18 kN

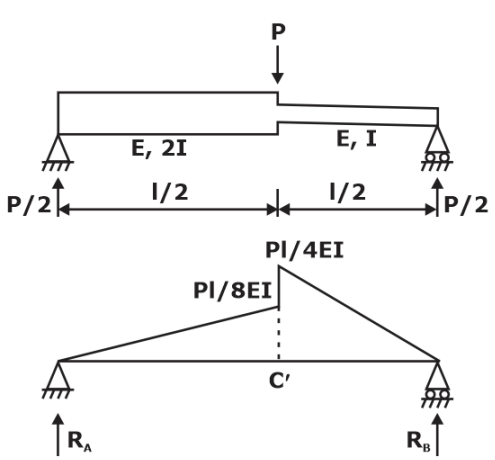
53. Employ stiffness matrix approach for the simply supported beam as shown in the figure to calculate unknown displacements/rotations. Take length, L = 8 m; modulus of elasticity, E = 3 × 10^4 N/mm²; moment of inertia, I = 225 × 10^6 mm⁴.



The mid-span deflection of the beam (in mm, round off to integer) under P = 100 KN in downward direction will be _____.

Ans. 119 mm

Sol.



Calculate reaction,

$$R_A + R_B = \frac{1}{2} \times \frac{l}{2} \times \frac{Dl}{8EI} + \frac{1}{2} \times \frac{l}{2} \times \frac{\rho l}{4EI}$$

$$= \frac{\rho l^2}{32EI} + \frac{\rho l^2}{16EI} = \frac{3\rho l^2}{32EI}$$

Taken $\Sigma M_A = 0$,

$$R_B \times L - \left(\frac{\rho l^2}{16EI}\right) \times \left(\frac{l}{2} + \frac{l}{3} \times \frac{l}{2}\right) - \left(\frac{\rho l^2}{32EI}\right) \times \frac{2}{3} \times \frac{l}{2} = 0$$

$$\therefore R_B L = \frac{2\rho l^3}{48EI} + \frac{\rho l^3}{96EI}$$

$$\therefore R_B = \frac{5\rho l^3}{96EI \times L} = \frac{5\rho l^2}{96EI}$$

$$\therefore R_A = \frac{3\rho l^2}{32EI} - \frac{5\rho l^2}{96EI} = \frac{4\rho l^2}{96EI}$$

$$\therefore BM_C = \frac{5\rho l^2}{96EI} \times \frac{l}{2} - \left(\frac{\rho l^2}{16EI}\right) \times \frac{l}{3} \times \frac{l}{2}$$

$$= \frac{5\rho l^3}{96 \times 2EI} - \frac{\rho l^3}{96EI}$$

$$= \frac{5\rho l^3 - 2\rho l^3}{96 \times 2} = \frac{3\rho l^3}{96 \times 2EI} = \frac{\rho l^3}{64EI}$$

$$\therefore \Delta_C = \frac{\rho l^3}{64EI} = \frac{100 \times 10^3 \times (8 \times 1000)^3}{64 \times 3 \times 10^4 \times 225 \times 10^6}$$

$$= \frac{10^{14} \times 8 \times 8 \times 8}{10^{10} \times 64 \times 3 \times 225} = 118.5 \text{ mm} = 119 \text{ mm}$$

54. A highway designed for 80 km/h speed has a horizontal curve section with radius 250 m. If the design lateral friction is assumed to develop fully, the required super elevation is

A. 0.02 B. 0.07

C. 0.09 D. 0.05

Ans. D

Sol. Given V = 80 kmph

Radius = R = 250 m

lateral friction has been developed.

$$\therefore e + f = \frac{V^2}{127R} \Rightarrow e = \frac{80^2}{127 \times 250} - 0.15$$

e = 0.051 = 5.1%

55. An unlined canal under regime conditions along with a silt factor of 1 has a width of flow 71.25 m. Assuming the unlined canal as a wide channel, the corresponding average depth of flow (in m, round off to two decimal places) in the canal will be _____.

Ans. 2.92 m

Sol. $P \simeq b = 71.25 = 4.75\sqrt{Q}$

$\therefore$ $Q \equiv 225$ cumec; f = 1

$$V = \left(\frac{Qf^2}{1h_0}\right)^{1/6} = \left(\frac{225 \times 1^2}{1h_0}\right)^{1/6} = 1.08$$

$$\therefore \frac{Q}{V} = A = \frac{225}{1.08} = 207.89 = 71.25 \times \gamma$$

$\therefore \gamma = 2.92$ m

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