



GATE 2026

Civil Engineering-2

Afternoon Session

**Memory Based
Questions & Solutions**

Exam held on 14-02-2026

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SECTION - A

GENERAL APTITUDE

1. $\log_2 x + \log_{\sqrt{2}} x = 48$

the value of x is _____.

Ans. (2^{16})

$$\log_2 x + \log_{\sqrt{2}} x = 48$$

$$\frac{\log x}{\log 2} = \frac{\log x}{\log \sqrt{2}} = \log(48) \Rightarrow x = 2^{16}$$

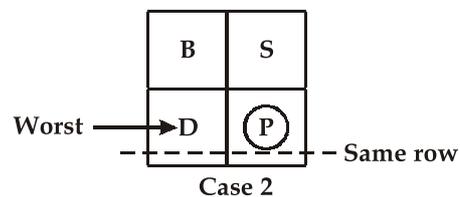
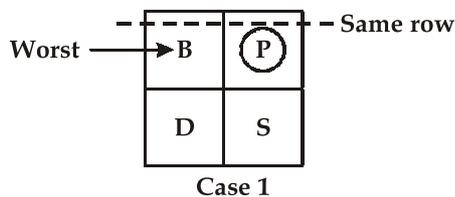
End of Solution

2. A person, his brother, his daughter and his son have oratory skill but not of the same level. They sat in a 2×2 matrix arrangement in such a way that
- I. His brother and daughter sat in same column.
 - II. His son sat diagonally across sibling of the worst orator.
 - III. Best orator and worst orator sit in the same row.

Who is the best orator?

- (a) Person (b) His brother
(c) His daughter (d) His son

Ans. (a)



End of Solution



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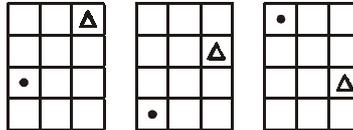


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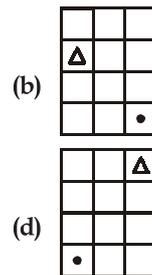
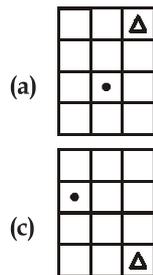


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3. Consider the below diagram:



The next figure in the sequence is



Ans. (c)
 • Moving down
 △ Moving down

End of Solution

4. The incident that happened is that an animal has fallen into _____ pit, and the animal is _____ elephant. It is very surprising to see that the elephant is in pain _____ miserable as it has to look _____ the crowd.
 (a) a, an, and, at (b) a, a, and, for
 (c) an, a, at, and (d) and, a, an, at

Ans. (a)
 an elephant

End of Solution

5. Choose the correct option to complete the sentence:
 The team __ 250 runs in 20 overs __ the rainy day.
 (a) scored, despite (b) scoring, in spite of
 (c) scoring, despite (d) score, despite

Ans. (a)
 Scored, Despite

End of Solution

SECTION - B

TECHNICAL

11. $\frac{dy}{dx} + yx = x$
 $y(x = 0) = 0, y(x = 1) = ?$

Ans. (0.39346)

$$\frac{dy}{dx} + xy = x$$

$$P = x, \quad q = x$$

$$I.F. = e^{\int p dx} = e^{\int x dx}$$

$$\Rightarrow I.F. = e^{x^2/2}$$

$$y \cdot e^{x^2/2} = \int x \cdot e^{x^2/2} dx + c$$

$$\text{Put, } \frac{x^2}{2} = t$$

$$x dx = dt$$

$$y \cdot e^{x^2/2} = \int e^t dt$$

$$y \cdot e^{x^2/2} = e^t + c$$

$$y \cdot e^{x^2/2} = e^{x^2/2} + c$$

$$y(0) = 0 \Rightarrow x = 0, \quad y = 0$$

$$0 \times 1 = 1 + c$$

$$\Rightarrow c = -1$$

$$\text{At } x = 1,$$

$$y(1)e^{1/2} = e^{1/2} - 1$$

$$y = 1 - \frac{1}{e^{1/2}} = 1 - \frac{1}{\sqrt{e}} = 1 - \frac{1}{1.6487} = 0.39346$$

End of Solution

12. $\log_2 x + \log_{\sqrt{2}} x = 48$, then $x = ?$

Ans. (2^{16})

$$\log_2 x + \log_{\sqrt{2}} x = 48$$

$$\log_2 x + \frac{\log_2 x}{\log_2 \sqrt{2}} = 48$$

$$\log_2 x + \frac{\log_2 x}{\log_2 2^{1/2}} = 48$$

$$\left[\log_b a + \frac{\log_k a}{\log_k b} \right]$$

$$\log_2 x + \frac{\log_2 x}{\frac{1}{2}} = 48$$

$$\log_2 x + 2\log_2 x = 48$$

$$3\log_2 x = 48$$

$$\log_2 x = 16$$

$$x = 2^{16}$$

End of Solution

13. If the Eigen values of matrix A are 1, 2, 3, then trace of matrix A^2 is?

Ans. (14)

Eigen values of matrix A are 1, 2, 3

Eigen values of matrix $A^2 = (1)^2, (2)^2, (3)^2$
 $= 1, 4, 9$

$$\begin{aligned} \text{Tr}(A^2) &= 1 + 4 + 9 \\ &= 14 \end{aligned}$$

End of Solution

14. Find the Fourier series for the given function $f(x) = \begin{cases} -1, & \pi < x < 0 \\ 1, & 0 < x < -\pi \end{cases}$

(a) $\frac{4}{\pi} \left[\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots \right]$

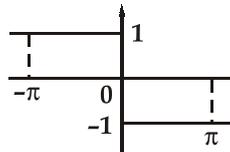
(b) $-\frac{4}{\pi} \left[\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots \right]$

(c) $1 + \frac{4}{\pi} \left[\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots \right]$

(d) $1 - \frac{4}{\pi} \left[\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots \right]$

Ans. (a)

$$f(x) = \begin{cases} -1, & \pi < x < 0 \\ 1, & 0 < x < -\pi \end{cases}$$



$f(x) =$ Odd function

Since $f(x)$ is odd function

So $a_0 = 0$ and $a_n = 0$

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cdot \sin(nx) dx$$

$$\Rightarrow b_n = \frac{2}{\pi} \int_0^{\pi} 1 \times \sin(nx) dx$$

$$\Rightarrow b_n = \frac{2}{\pi} \int_0^{\pi} \sin(nx) dx$$

$$\Rightarrow b_n = \frac{2}{\pi} \left[\frac{-\cos nx}{n} \right]_0^{\pi}$$

$$\Rightarrow b_n = \frac{-2}{n\pi} [\cos n\pi - \cos 0]$$

$$\Rightarrow b_n = \frac{-2}{n\pi} [(-1)^n - 1]$$

$$\Rightarrow b_n = \begin{cases} 0 & \text{if } n = \text{even} \\ +\frac{4}{n\pi} & \text{if } n = \text{odd} \end{cases}$$

$$f(x) = \sum_{n=1}^{\infty} b_n \sin(nx)$$

$$\Rightarrow f(x) = \frac{4}{\pi} \sin x + \frac{4}{3\pi} \sin 3x + \frac{4}{5\pi} \sin 5x + \dots$$

$$\Rightarrow f(x) = \frac{4}{\pi} \left[\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots \right]$$

End of Solution

15. The age (in years) of a population is normally distributed with a mean of 36 years and a standard deviation of 12 years.

The height (in cm) of the same population is also normally distributed with a mean of 160 cm and a variance of 10 cm².

If the probability that a person's age is greater than 50 years is equal to the probability that the person's height is greater than h cm, determine the value of h .

(Give the numerical answer in cm, correct to two decimal places.)

Ans. (163.68)

Normal distribution
 x (age)

$$\mu_x = 36, \quad \sigma_x = 12$$

$$P(x > 50)$$

$$P\left(\frac{x - \mu}{\sigma}\right) = \frac{50 - 36}{12} = \frac{14}{12}$$

Normal distribution
 y (height)



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18. One third of solid matter in a sludge containing 90% water is composed of fixed mineral solids with $G_s = 2.5$ and two-third is composed of volatile solids with SG of all solids lies between

Ans. (1.25)

$$G_s = \frac{1}{\frac{(1/3)}{2.5} + \frac{(2/3)}{1}} = 1.25$$

End of Solution

19. Match the column
Column-I : Air Pollutant
1. Dust ($5 - 25 \mu\text{g}/\text{m}^3$)
 2. CO
 3. SO_2
 4. Fly ash ($< 2.5 \mu\text{g}/\text{m}^3$)

- Column-II : Treatment
- P. Cyclone separator
 - Q. Wet lime scrubber
 - R. Electrostatic precipitator (ESP)
 - S. Catalytic converter

Ans. (1 - P, 2 - S, 3 - Q, 4 - R)

End of Solution

20. In which of the following wastewater treatment units are grown algae primarily utilized as an essential component of the treatment process?
Select the correct answer.

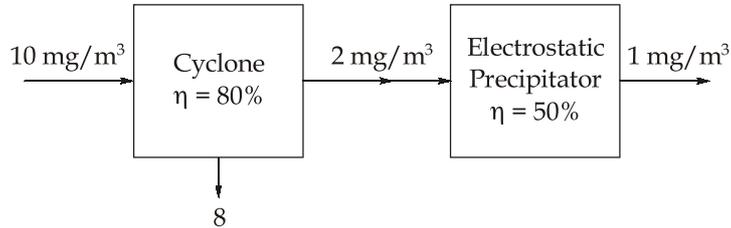
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|----------------------|----------------------|
| (a) Septic tank | (b) Oxidation pond |
| (c) Slow sand filter | (d) Trickling filter |

Ans. (b)

End of Solution

21. A gas stream containing particulate matter has an initial particle concentration of $10 \text{ mg}/\text{m}^3$.
The gas first passes through a cyclone separator having an efficiency of 80%, and then through an electrostatic precipitator (ESP) having an efficiency of 50%.
Assuming efficiencies are based on the inlet concentration to each device, determine the final outlet particle concentration (in mg/m^3).

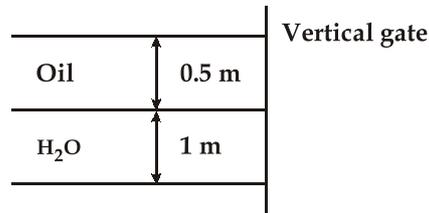
Ans. (1)



Particle concentration in final outlet = 1 mg/m^3

End of Solution

22. The cross-section of a 0.5 m wide vertical gate holding water and oil is shown in the figure. The unit weights of water and oil are 10 kN/m^3 and 7.5 kN/m^3 respectively.



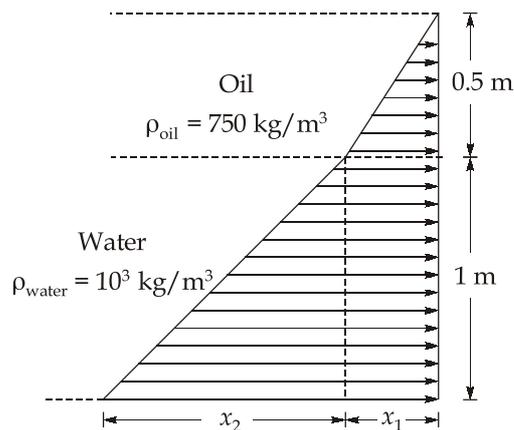
The horizontal component of hydrostatic force on vertical gate is ____ kN.

Ans. (4.844)

Given: width of gate = 0.5 m

$$\rho_{\text{water}} = 10 \text{ kN/m}^3, \rho_{\text{oil}} = 7.5 \text{ kN/m}^3$$

Pressure diagram:



$$x_1 = \rho_{\text{oil}} gh = 750 \times 10 \times 0.5 = 3.75 \text{ kPa}$$

$$x_2 = \rho_{\text{water}} gh = 10^3 \times 10 \times 1 = 10 \text{ kPa}$$

Hydrostatic force on gate

$$F = \text{volume of pressure diagram}$$

\Rightarrow

$$F = (\text{Area}) \text{ width}$$

$$\Rightarrow F = \left[\frac{1}{2} \times 3.75 \times 0.5 + 3.75 \times 1 + \frac{1}{2} \times 10 \times 1 \right] \times 0.5$$

$$\Rightarrow F = 4.844 \text{ kN/m of width}$$

End of Solution

23. A centrifugal pump is delivering water from an underground tank to an overhead reservoir against a static head of 35 m through a 2 km long, 250 mm diameter pipe. The head-discharge characteristic of the pump is given by $[H = 140 - 9000Q^2]$ where H is the head generated by the pump and Q is the discharge of the pump. Neglecting all minor losses, the head generated by the pump is _____. (in m)
 Take friction factor, $f = 0.04$.

Ans. (80.07)

$$\therefore H = H_{\text{static}} + H_f$$

$$H = H_{\text{static}} + \frac{8Q^2}{\pi^2 g} \left(\frac{fL}{D^5} \right)$$

Now,

$$\Rightarrow 140 - 9000 Q^2 = 35 + \frac{8Q^2}{\pi^2 \times 9.81} \times \frac{0.04 \times 2000}{(0.25)^5}$$

$$\Rightarrow 15768.792 Q^2 = 105$$

$$\Rightarrow Q = 0.0816 \text{ m}^3/\text{sec}$$

Head generated by pump.

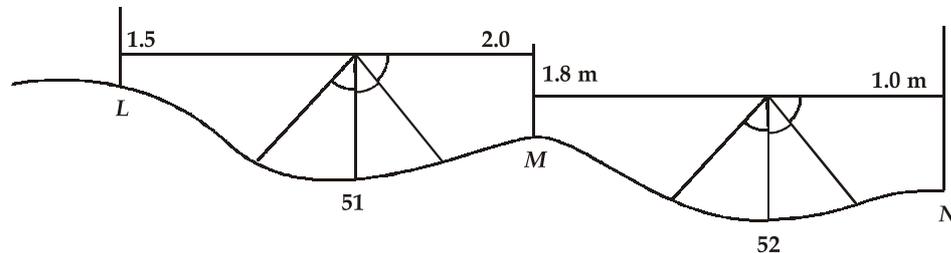
$$H = 140 - 9000 Q^2$$

$$\Rightarrow H = 140 - 9000 \times 0.0816^2$$

$$H = 80.07 \text{ m}$$

End of Solution

24. Observe the following levelling diagram and Match the list using suitable codes



List-I

1. Sum of back sights
2. Sum of fore sights
3. RL of point N

List-II

- P. 3.300 m
- Q. 2.500 m
- R. 150.300 m
- S. 3.000 m
- T. 150.500 m

Ans. (#)

$$H_2 = BM + BS$$

$$= 150 + 1.5 = 151.5 \text{ m}$$

$$RL_N = 151.5 - 2 + 1.8 - 1 = 150.3 \text{ m}$$

$$\text{Sum of Back sight, } \Sigma(BS) = 1.5 + 1.5 + 1.8 = 3.3 \text{ m}$$

$$\text{Sum of fore sight, } \Sigma(FS) = 2 + 1 = 3 \text{ m}$$

End of Solution

25. A map has a Representative Fraction (R.F.) of 1 : 25,000.
 If the distance measured on the map is 20 cm, determine the corresponding distance on the ground in kilometers.
 (Give the numerical answer only.)

Ans. (3)

Given: $RF = \frac{1}{25,000}$

$$1 \text{ cm on map} = 25000 \text{ cm on ground}$$

$$= 0.25 \text{ km on ground}$$

$$20 \text{ cm on map} = 20 \times 0.025$$

$$= 5 \text{ km on ground}$$

If Distance = 12 cm

$$12 \text{ cm on map} = 12 \times 0.25$$

$$= 3 \text{ km on ground.}$$

End of Solution



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29. A soil deposit is fully saturated. The water content of the soil is 20%, and the specific gravity of soil solids is 2.65.
 The critical hydraulic gradient for piping (quick condition) in the soil.

Ans. (1.078)

Given: Water content, $w = 20\%$ (Fully saturated soil)

Specific gravity, $G = 2.65$

Critical hydraulic gradient, $i_c = ?$

$$\therefore i_c = \frac{G-1}{1+e}$$

$$\Rightarrow i_c = \frac{G-1}{\left(1 + \frac{Gw}{S}\right)} \quad (\because es = Gw)$$

$$\Rightarrow i_c = \frac{2.65-1}{\left(1 + \frac{2.65 \times 0.20}{1}\right)}$$

$$\Rightarrow i_c = 1.078$$

End of Solution

30. A soil has a liquidity index of 0.50 and a plasticity index of 40%. The natural water content of the soil is 30%.
 The plastic limit of the soil (in percent).
 (Enter the numerical value only, without units.)

Ans. (10%)

Given: liquidity index, $I_L = 0.5$

Plasticity index, $I_p = 40\%$

Natural water content, $w_n = 30\%$

Plastic limit, $w_p = ?$

$$\therefore I_L = \frac{w_n - w_p}{I_p}$$

$$\Rightarrow 0.5 = \frac{30 - w_p}{40}$$

$$\Rightarrow w_p = 10\%$$

End of Solution

31. For a clayey soil stratum, the time required for the degree of consolidation to increase from 25% to 50% is 30 days.
 Determine the total time required for the same soil stratum to reach 90% degree of consolidation.
 Assume one-dimensional consolidation.

Ans. (173.06)

Given: $U_1 = 25\%$
 $U_2 = 50\%$
 $t_2 - t_1 = 30$ days

$$\therefore T_v = \frac{C_v t}{d^2}$$

$$\therefore \frac{\pi}{4}(0.25)^2 = \frac{C_v t_1}{d^2}$$

and $\frac{\pi}{4}(0.50) = \frac{C_v t_2}{d^2}$

Now, $\frac{\pi}{4}(0.5^2 - 0.25^2) = \frac{C_v}{d^2}(t_2 - t_1)$

$$\Rightarrow 0.1473 = \frac{C_v}{d^2} \times 30$$

$$\Rightarrow \frac{C_v}{d^2} = 4.9 \times 10^{-3}$$

Time required for 90% degrees of consolidation,

$$(T_v)_{90} = \frac{C_v t}{d^2}$$

$$\Rightarrow 0.848 = 4.9 \times 10^{-3} t$$

$$\Rightarrow t = 173.06 \text{ days}$$

End of Solution

32. The water table is at the ground surface.

Unit weight of water, saturated unit weight of soil, $\gamma_{\text{sat}} = 18 \text{ kN/m}^3$.

A point load $P = 2000 \text{ kN}$ is applied at the ground surface.

At a depth z directly below the load, the effective vertical stress due to the applied load is equal to 10% of the effective overburden stress at that depth.

Determine the depth z (in metres).

Ans. (10.525)

Given: $\gamma_{\text{sat}} = 18 \text{ kN/m}^3$, $Q = 2000 \text{ kN}$

From Boussinesq's equation. Stress below the point load at depth z is given by

$$\sigma_z = \frac{3}{2\pi} \left(\frac{Q}{z^2} \right)$$

$$\therefore \sigma_z = 10\% \text{ of } (\gamma' z)$$

$$\therefore \frac{3}{2\pi} \times \frac{2000}{z^2} = 0.1 \times (18 - 9.81)z$$

$$\Rightarrow z^3 = 1165.97$$

$$\Rightarrow z = 10.525 \text{ m below the ground level.}$$

End of Solution

33. A square footing of width 1 m is founded on a cohesionless soil. The net ultimate bearing capacity at a depth of foundation $D_f = 1$ m is found to be 582.8 kPa, $\gamma = 18$ kN/m³, $C = 0$. When the depth of foundation is increased to $D_f = 2$ m, the net ultimate bearing capacity becomes 864 kPa. Assuming Terzaghi's bearing capacity equation and neglecting the cohesion term, determine the bearing capacity factor N_q of the soil.

Ans. (15.62)

$$\gamma = 18 \text{ kN/m}^3$$

Ultimate bearing capacity,

$$(q_u)_{D_f=1 \text{ m}} = 582.8 \text{ kPa}$$

$$(q_u)_{D_f=2 \text{ m}} = 864 \text{ kPa}$$

As per Terzaghi's bearing capacity equation ultimate bearing capacity of footing is given by (For square footing)

$$q_u = 1.3 CN_C + \gamma D_f N_q + 0.4 B \gamma N_r$$

For $D_f = 1$ m,

$$582.8 = \gamma \times 1 \times N_q + 0.4 B \gamma N_r \quad \dots(i)$$

For $D_f = 2$ m,

$$864 = \gamma \times 2 \times N_q + 0.4 B \gamma N_r \quad \dots(ii)$$

From equation (i) and (ii)

$$864 - 582.8 = \gamma N_q$$

$$\Rightarrow N_q = 15.62$$

End of Solution

34. Match Column I with the correct description in Column II.

Column I

- A. Skempton
- B. Newmark
- C. Hiley
- D. Converse-Labarre formula

Column II

- 1. Increase in vertical stress below footing
- 2. Pile driving formula for capacity
- 3. Bearing capacity factor for saturated clay
- 4. Pile group efficiency

Ans. (A - 3, B - 1, C - 2, D - 4)

End of Solution



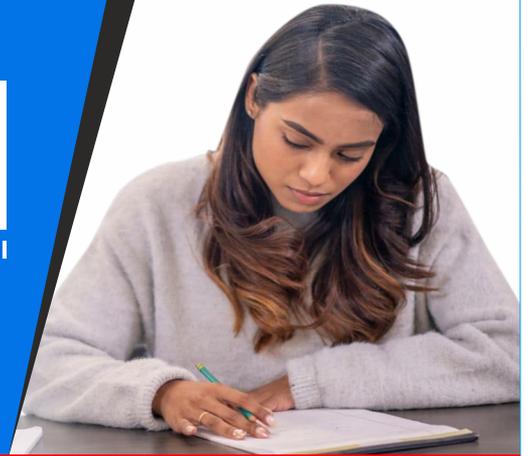
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35. The probability (in %) that a storm having return period of 15 years may occur at least one in the next 10 years is :

Ans. (49.84)

Given: Return period, $T = 15$ years

Exactly one time

$$P(r) = {}^n C_r p^r q^{n-r}$$

$$P(r = 1) = {}^{10} C_1 \left(\frac{1}{15}\right)^1 \left(\frac{14}{15}\right)^9$$

$$= 0.358 = 35.8\%$$

At least one

$$P(r \geq 1) = 1 - P(r = 0)$$

$$= 1 - q^n$$

$$= 1 - \left(\frac{14}{15}\right)^{10}$$

$$= 0.4984 = 49.84\%$$

End of Solution

36. Consider the mass curve of rainfall.

I. The slope at a point on the mass curve can be positive.

II. The slope at a point on the mass curve can be zero.

Which of the following is correct?

(a) I-False; II - True

(b) I-True; II - False

(c) I-True; II - True

(d) I-False; II - False

Ans. (c)

End of Solution

37. The CCA for a canal is 10000 ha. The base period for a crop in the CCA is 140 days. Watering depth is 40 cm The outlet discharge (in m³/s) lies between _____ .

Ans. (3.31)

Given: CCA, $A = 10000$ ha

Base period, $B = 140$ days

Depth of watering, $\Delta = 40$ cm

$$\therefore D = \frac{8.64 B}{\Delta}$$

$$\Rightarrow \frac{A}{Q} = \frac{8.64 B}{\Delta}$$

$$\Rightarrow \frac{10,000}{Q} = \frac{8.64 \times 140}{0.4}$$

$$\Rightarrow Q = 3.31 \text{ m}^3/\text{sec}$$

End of Solution

38. Width of rectangular channel required to carry a discharge = 96 m³/s at a critical depth of 9.8 m is _____ m.

Ans. (1)

Given: Discharge, $Q = 96 \text{ m}^3/\text{sec}$

Critical depth, $y_c = 9.8 \text{ m}$

Width, $B = ?$

$$\therefore \frac{Q^2}{g} = \frac{A^3}{T}$$

$$\Rightarrow \frac{96^2}{9.81} = B_2 y_c^3$$

$$\Rightarrow 939.45 = B^2 \times 9.8^3$$

$$B = 0.999 \text{ m} \simeq 1 \text{ m}$$

End of Solution

39. The flow depth for a discharge of 10 m³/s in a wide rectangular channel is 2.0 m. Assume that the flow is uniform. If the discharge is doubled. The flow depth in this channel is _____ m.

Ans. (3.03)

Given: $Q_1 = 10 \text{ m}^3/\text{sec}$, $y_1 = 2 \text{ m}$

$Q_2 = 2 Q_1$ $y_2 = ?$

For wide rectangular channel, $R = y$

$$\therefore Q = \frac{A}{n} R^{2/3} S^{1/2}$$

$$\Rightarrow Q = \frac{By}{n} y^{2/3} S^{1/2}$$

$$\Rightarrow Q \propto y^{5/3}$$

Now,
$$\frac{Q_1}{Q_2} = \left(\frac{y_1}{y_2} \right)^{5/3}$$

$$\frac{10}{20} = \left(\frac{2}{y_2} \right)^{5/3}$$

$$y_2 = 3.03 \text{ m}$$

End of Solution

40. Cant excess and cant deficiency are used for:

- (a) Cant excess for main track and cant deficiency for branch track
- (b) Cant excess for branch track and cant deficiency for main track
- (c) Cant excess for the fast moving train and cant deficiency for slow moving train
- (d) Cant excess for the slow moving train and cant deficiency for fast moving train

Ans. (d)

To understand why this is the case, we look at the relationship between equilibrium speed (the speed for which the track is actually banked) and the actual speed of the train.

- **Cant Deficiency (Fast Trains):** When a train travels faster than the equilibrium speed, the centrifugal force is greater than what the track banking (cant) can counteract. The train "needs" more banking than is provided. This shortage is called Cant Deficiency.
- **Cant Excess (Slow Trains):** When a train travels slower than the equilibrium speed (such as a freight train on a track designed for high-speed expresses), the banking is steeper than necessary for that speed. The train "has" more banking than it needs, leading to more pressure on the inner rail. This surplus is called Cant Excess.

End of Solution

41. Primary purpose of windrose diagrams for:

- (a) Gradient of runway (b) Length of runway
 (c) Elevation of runway (d) Orientation of runway

Ans. (d)

The primary purpose of a windrose diagram is to determine the most effective orientation for a runway at an airport. It is a graphical tool that displays the direction, intensity, and duration of winds at a specific location over a long period (typically 5-10 years). By analyzing this data, planners can align the runway with prevailing winds to ensure aircraft experience favorable headwinds during takeoff and landing, which increases safety by minimizing dangerous crosswinds.

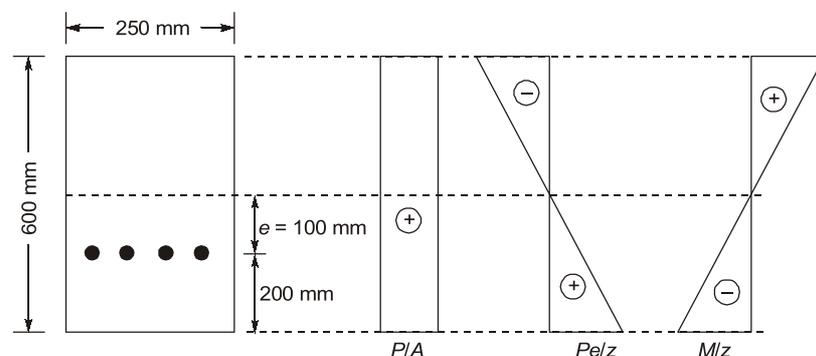
End of Solution

42. A 250 mm × 600 mm rectangular section of concrete beam is prestressed by 4 high stress tendons each of 14 mm ϕ . The centreline of the tendons is 200 mm from the soffit of the beam.

If the prestress in each tendon is 700 N/mm²

Determine the bending moment (in kNm) that must be applied such that the stress at the extreme top fibre become zero.

Ans. (0 or 86.205)



$$\text{Eccentricity, } e = \frac{D}{2} - 200 = \frac{600}{2} - 200 = 100 \text{ mm}$$

$$P = 4 \times \frac{\pi}{4} (14)^2 \times \frac{700}{1000}$$

$$P = 431.026 \text{ kN}$$

If the stress at top fibre = 0

$$\frac{P}{A} - \frac{Pe}{z} + \frac{M}{Z} = 0$$

$$\Rightarrow \frac{M}{z} = \frac{Pe}{z} - \frac{P}{A}$$

$$\Rightarrow M = P \left(e - \frac{z}{A} \right) \quad \left(\because z = \frac{BD^2}{6} \right)$$

$$\Rightarrow M = P \left(e - \frac{D}{6} \right)$$

$$\Rightarrow M = P \left(100 - \frac{600}{6} \right)$$

$$M = 0 \text{ kNm}$$

For stress at bottom fibre = 0

$$\Rightarrow \frac{P}{A} + \frac{Pe}{z} - \frac{M}{Z} = 0$$

$$\Rightarrow \frac{M}{Z} = \frac{P}{A} + \frac{Pe}{Z}$$

$$\Rightarrow M = P \left(e + \frac{Z}{A} \right)$$

$$\Rightarrow M = P \left(e + \frac{D}{6} \right)$$

$$\Rightarrow M = 431.026 \left(100 + \frac{600}{6} \right)$$

$$M = 86.205 \text{ kNm}$$

End of Solution



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$$\Delta_{AB} + \Delta_{BC} + \Delta_{CD} = 2 \text{ mm}$$

$$\Rightarrow \frac{R_A l_{AB}}{AE} + \frac{(R_A - P) l_{BC}}{AE} + \frac{(-R_D) l_{CD}}{AE} = 2 \text{ mm}$$

$$\Rightarrow R_A \times 5000 + (R_A - 20) \times 5000 - R_D \times 5000 = 2 \times 20000$$

$$\Rightarrow R_A + (R_A - 20) - R_D = 8$$

$$\Rightarrow 2R_A - R_D = 28 \quad \dots(i)$$

$$\Sigma F_x = 0 \Rightarrow R_A + R_D = 20 \quad \dots(ii)$$

On solving equation (i) and (ii),

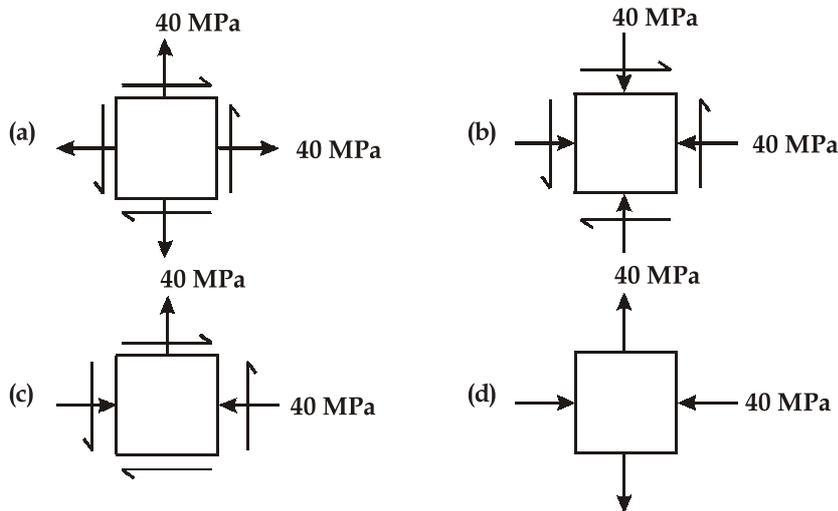
$$3 R_A = 48$$

$$R_A = 16 \text{ kN } (\leftarrow)$$

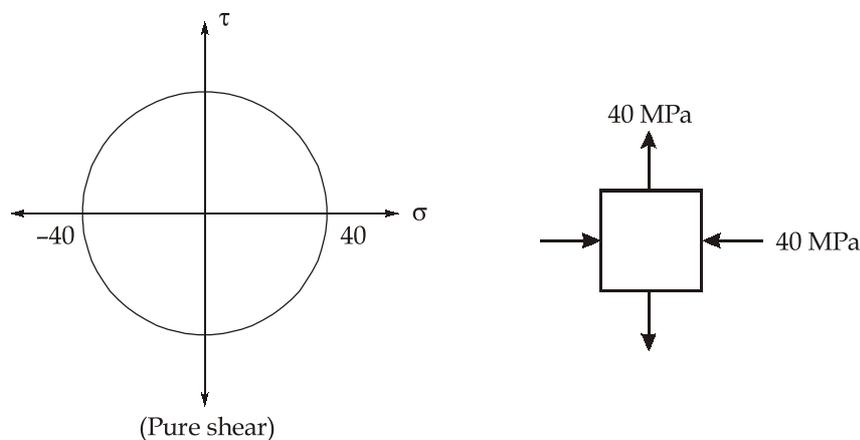
$$R_D = 4 \text{ kN } (\leftarrow)$$

End of Solution

45. Which one of the condition for pure shear?



Ans. (d)



End of Solution

46. At a point in a three-dimensional body, the strain components are represented by the strain tensor:

The body is subjected to plane strain condition in the x - y plane.

Determine the values of the following strain components:

$$\begin{bmatrix} \epsilon_{xx} & \frac{\gamma_{xy}}{2} & \frac{\gamma_{xz}}{2} \\ \frac{\gamma_{yx}}{2} & \epsilon_{yy} & \frac{\gamma_{yz}}{2} \\ \frac{\gamma_{zx}}{2} & \frac{\gamma_{zy}}{2} & \epsilon_{zz} \end{bmatrix}$$

Ans. (*)

Given strain matrix =

$$\begin{bmatrix} \epsilon_{xx} & \frac{\gamma_{xy}}{2} & \frac{\gamma_{xz}}{2} \\ \frac{\gamma_{yx}}{2} & \epsilon_{yy} & \frac{\gamma_{yz}}{2} \\ \frac{\gamma_{zx}}{2} & \frac{\gamma_{zy}}{2} & \epsilon_{zz} \end{bmatrix}$$

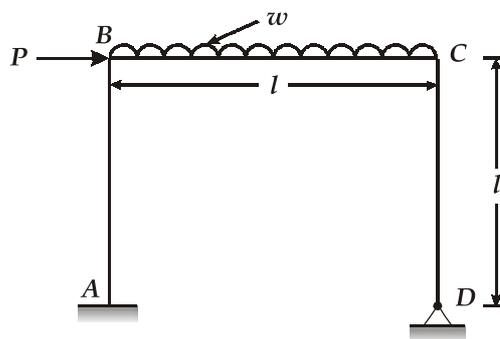
For plain strain condition,

$$\begin{aligned} \epsilon_{zz} &= 0 \\ \gamma_{zy} &= \gamma_{yz} = 0 \\ \gamma_{xz} &= \gamma_{zx} = 0 \end{aligned}$$

End of Solution

47. For the frame shown in figure, $M_p = C_1 Pl + C_2 w l^2$ using combined mechanism. Ratio

of $\frac{C_1}{C_2}$ approximately is _____.



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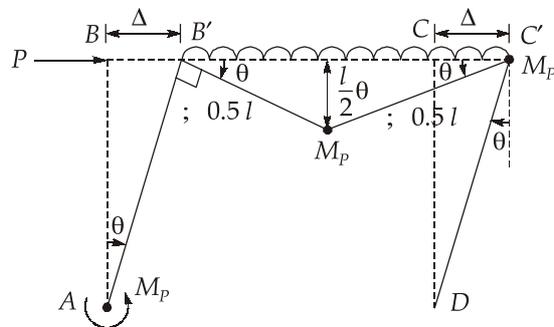
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Ans. (4)



(Combined mechanism)

\therefore External workdone = Internal workdone

$$\Rightarrow P\Delta + w\left(\frac{1}{2} \times l \times \frac{l}{2}\theta\right) = M_p\theta + M_p(\theta + \theta) + M_p(\theta + \theta)$$

$$\Rightarrow P(l\theta) + \frac{wl^2\theta}{4} = 5 M_p\theta$$

$$\Rightarrow M_p = \frac{Pl}{5} + \frac{wl^2}{20}$$

Given: $M_p = C_1Pl + C_2wl^2$

$$\therefore C_1 = \frac{1}{5} \text{ and } C_2 = \frac{1}{20}$$

$$\text{ratio} = \frac{C_1}{C_2} = \frac{1}{5} \times 20 = 4$$

End of Solution

48. For cantilever beams, $M_d \leq 1.5 Z_e \frac{f_y}{\gamma_{mo}}$,

- (a)
- (b)
- (c) to avoid plastic deformation under working loads
- (d)

Ans. (c)

Design moment capacity, $M_d \leq 1.5 Z_e \left(\frac{f_y}{\gamma_{mo}}\right)$ for cantilever beam to avoid plastic deformation under working loads.

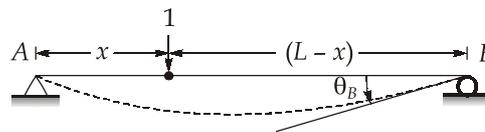
End of Solution

49. A simply supported beam AB of span L and constant flexural rigidity EI is subjected to a unit load moving across the span.

The influence line ordinate for the slope at support B (x measure from the left support)

- (a) $\frac{x}{6EI} (L^2 + x^2)$ (b) $\frac{x}{3EI} (L^2 + x^2)$
 (c) $\frac{x}{6EI} (L^2 - x^2)$ (d) $\frac{x}{3EI} (L^2 - x^2)$

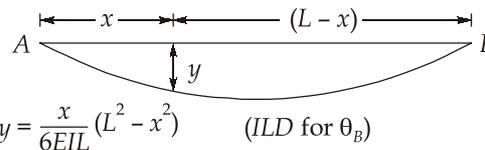
Ans. (c)



Slope at support B,

$$\theta_B = \frac{wa}{6EI} (L^2 - a^2)$$

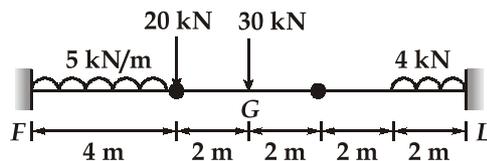
$$\theta_B = \frac{1 \times x}{6EI} (L^2 - x^2) = \frac{x}{6EI} (L^2 - x^2)$$



$$y = \frac{x}{6EI} (L^2 - x^2) \quad (\text{ILD for } \theta_B)$$

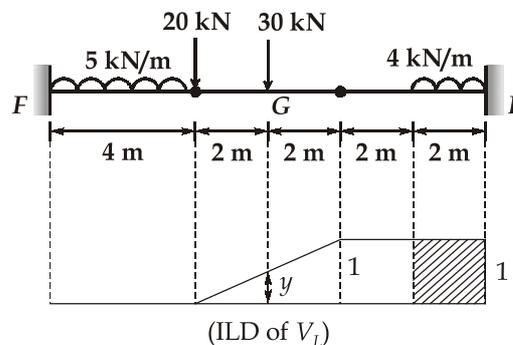
End of Solution

- 50.



The vertical reaction at support L is ____ kN.

Ans. (23)



From ILD, $\frac{y}{2} = \frac{1}{4}$
 $\Rightarrow y = 0.5$
 Vertical reaction at support L ,
 $V_L = 30 \times 0.5 + 4(2 \times 1)$
 $\Rightarrow V_L = 23 \text{ kN}$

End of Solution

51. An incident occurred on one side of a median on a 4-lane dual carriageway road section. The incident disrupted the traffic movement in one direction. Traffic police diverted the traffic from disrupted side to other side through an opening in a median. The desired SD on 4-lane dual way is 360 m under normal conditions. The SSD, which shall be available on operating road section after Incident is:

- (a) 180 m (b) 360 m
 (c) 720 m (d) 240 m

Ans. (b)

End of Solution

52. A down grade of 1 in 100 meets an upgrade of 1 in 125 on a road. If the rate of change of grade is 0.1% per 30 m, the length (in m) of the vertical change between the two grades is _____.

Ans. (540)

Given: $n_1 = \frac{-1}{100}$, $n_2 = +\frac{1}{125}$
 $N = \left| \frac{-1}{100} - \frac{1}{125} \right| = 0.018 = 1.8\%$
 Rate of change of gradient = $\frac{N}{L_v}$
 $\Rightarrow \frac{0.1\%}{30} = \frac{1.8\%}{L_v}$
 $L_v = 540 \text{ m}$

End of Solution

53. A downward gradient of $-1/40$ meets an upward gradient of $1/50$. If the safe stopping sight distance is 90 m, the height of headlight is 0.75 m and the angle of beam is 1.2° , determine the length of vertical curve.

Ans. (62.878)

Given: $n_1 = \frac{-1}{40}$, $n_2 = \frac{1}{50}$, $h = 0.75 \text{ m}$, $\beta = 1.2^\circ$
 Sight distance, $S = 90 \text{ m}$

Assume: $L_v > HSD$

$$L_v = \frac{NS^2}{(2h + 2S \tan \beta)}$$

$$\Rightarrow L_v = \frac{\frac{9}{200}(90)^2}{2 \times 0.75 + 2 \times 90 \tan 1.2^\circ}$$

$$\Rightarrow L_v = 69.159 \text{ m} < HSD \text{ (Assumption is wrong)}$$

Assume: $L_v < HSD$

$$L_v = 2S - \frac{(2h + 2S \tan \beta)}{N}$$

$$\Rightarrow L_v = 2 \times 90 - \frac{(2 \times 0.75 + 2 \times 90 \tan 1.2^\circ)}{\left(\frac{9}{200}\right)}$$

$$\Rightarrow L_v = 62.878 \text{ m} < HSD \text{ (Assumption is right)}$$

End of Solution

54. The speed-density relationship of a highway is given as

$$u = u_0 \ln \left(\frac{k_j}{k} \right)$$

If the free mean speed is 45 km/hr and jam density is 200 veh per km, determine the maximum capacity of the road.

Ans. (3311)

Given: $u_0 = 45 \text{ km/hr}$, $K_j = 200 \text{ veh/km}$

Speed-density relationship

$$u = u_0 \log_e \left(\frac{K_j}{K} \right) \quad \dots(i)$$

For maximum flow,

$$\frac{dq}{dk} = 0$$

$$\Rightarrow u_0 \left[K \times \frac{1}{(K_j/k)} \times K_j \left(\frac{-1}{K^2} \right) + \log_e \left(\frac{K_j}{K} \right) \times 1 \right] = 0$$

$$\Rightarrow -1 + \log_e \left(\frac{K_j}{K} \right) = 0$$

$$\frac{K_j}{K} = e$$

$$K = \frac{1}{e} K_j$$

From equation (i)

Maximum capacity of road,

$$q_{\max} = u_0 \left(\frac{K_j}{e} \right) \log_e \left(\frac{K_j}{K_j/e} \right)$$

$$\Rightarrow q_{\max} = \frac{1}{e} u_0 K_j$$

$$\Rightarrow q_{\max} = \frac{1}{e} \times 45 \times 200$$

$$q_{\max} = 3310.9 \text{ veh/hr}$$
$$\simeq 3311 \text{ veh/hr}$$

○○○○