GATE Civil Engineering

Sample Paper – 7

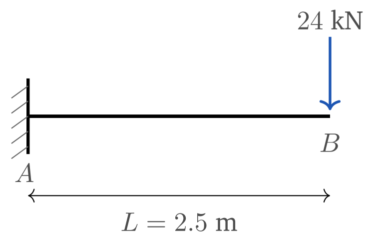
Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Civil Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Take $g = 9.81$ m/s^2 and unit weight of water $\gamma_w = 9.81$ kN/m^3 unless stated otherwise.

Structural Engineering

Q1. A cantilever beam AB of length 2.5 m is fixed at A and carries a single vertical point load of 24 kN at its free end B, as shown. The magnitude of the maximum bending moment in the beam is: **[1 mark]**



(A) 24 kN·m

(B) 60 kN·m

(C) 120 kN·m

(D) 30 kN·m

Q2. A steel rail of length 20 m is initially unstressed and is then subjected to a uniform temperature rise of 25°C. The rail is free to expand. Taking the coefficient of thermal expansion $\alpha = 12 \times 10^{-6}$ /°C, the free elongation of the rail is: **[1 mark]**

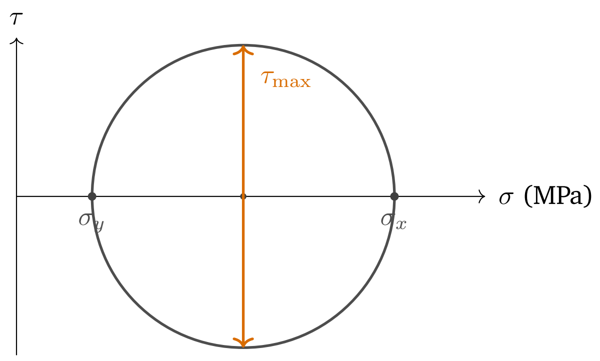
(A) 3 mm

(B) 12 mm

(C) 1.5 mm

(D) 6 mm

Q3. At a point in a stressed body the normal stresses on two mutually perpendicular planes are $\sigma_x = 100$ MPa and $\sigma_y = 20$ MPa, with no shear stress on these planes, as represented by the Mohr circle shown. The maximum in-plane shear stress at the point is: **[1 mark]**



(A) 40 MPa

(B) 60 MPa

(C) 80 MPa

(D) 20 MPa

Q4. A structural member has a solid rectangular cross-section 100 mm wide and 200 mm deep. The least radius of gyration of the section (about the centroidal axis parallel to the 100 mm side) is nearest to: **[1 mark]**

(A) 100 mm

(B) 200 mm

(C) 50 mm

(D) 57.7 mm

Q5. A solid circular shaft of diameter 60 mm transmits a torque of 2 kN·m. The maximum torsional shear stress developed on the outer surface of the shaft is nearest to: **[1 mark]**

(A) 94.3 MPa

(B) 23.6 MPa

(C) 141.5 MPa

(D) 47.2 MPa

Q6. A pin-ended (hinged at both ends) straight column is 4 m long, made of steel with modulus of elasticity $E = 200$ GPa, and has a least moment of inertia $I = 4 \times 10^6$ mm^4. Using Euler's theory, the critical buckling load of the column is nearest to: **[1 mark]**

(A) 246.7 kN

(B) 493.5 kN

(C) 987.0 kN

(D) 123.4 kN

Q7. A cantilever beam of length L and flexural rigidity EI carries a uniformly distributed load w per unit length over its entire span. The slope (rotation) of the beam at its free end is: **[1 mark]**

(A) $\dfrac{wL^3}{8EI}$

(B) $\dfrac{wL^4}{8EI}$

(C) $\dfrac{wL^3}{6EI}$

(D) $\dfrac{wL^3}{24EI}$

Q8. A steel column has an effective length of 3 m and its least radius of gyration is 30 mm. The slenderness ratio of the column is: **[1 mark]**

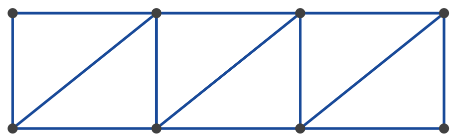
(A) 100

(B) 10

(C) 50

(D) 300

Q9. The plane truss shown below has $m = 16$ members and $j = 8$ joints, and is supported by $r = 3$ external reaction components. The degree of static indeterminacy of the truss is: **[1 mark]**



(A) 0

(B) 1

(C) 3

(D) 2

Q10. For a simply supported beam AB of span L, the influence line for the *shear force* at the midspan section is drawn. The maximum ordinate (magnitude) of this influence line is: **[1 mark]**

(A) 1.0

(B) 0.25

(C) 0.5

(D) $L/2$

Q11. A prismatic beam is fully fixed (built in against rotation and translation) at both ends and carries a single concentrated load W at its midspan. The magnitude of the fixed-end moment developed at each support is: **[1 mark]**

(A) $\dfrac{WL}{8}$

(B) $\dfrac{WL}{12}$

(C) $\dfrac{wL^2}{12}$

(D) $\dfrac{WL}{4}$

Q12. In the limit state design of a singly reinforced rectangular section to IS 456:2000, the limiting moment of resistance is written as $M_{u,\text{lim}} = k\, f_{ck}\, b\, d^2$. For a section reinforced with **Fe415** steel, the coefficient k is: **[1 mark]**

(A) 0.148

(B) 0.138

(C) 0.133

(D) 0.360

Q13. As per IS 800:2007, for a member normally carrying compressive loads resulting from dead loads and imposed (live) loads, the maximum permissible effective slenderness ratio (KL/r) is: **[1 mark]**

(A) 250

(B) 400

(C) 350

(D) 180

Q14. In a PERT network, an activity has an optimistic time $t_o = 6$ days and a pessimistic time $t_p = 18$ days. The standard deviation of the activity duration is: **[1 mark]**

(A) 2 days

(B) 12 days

(C) 4 days

(D) 6 days

Geotechnical Engineering

Q15. A soil sample has a void ratio of 0.75 and a water content of 20%. The specific gravity of the soil solids is 2.70. The degree of saturation of the sample is: **[1 mark]**

(A) 54%

(B) 100%

(C) 72%

(D) 37.5%

Q16. A fine-grained soil has a liquid limit of 40% and a plastic limit of 20%. A sample of this soil has a natural (in-situ) water content of 25%. The liquidity index of the soil is: **[1 mark]**

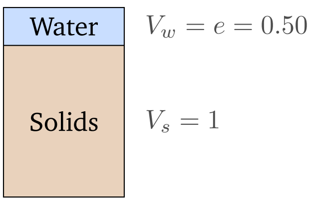
(A) 0.75

(B) 0.25

(C) 0.20

(D) 0.50

Q17. A fully saturated soil has a void ratio of 0.50 and a specific gravity of solids of 2.70. Using the two-phase (solids + water) diagram shown, the saturated unit weight of the soil is nearest to: **[1 mark]**



(A) 26.49 kN/m^3

(B) $17.66\ \text{kN/m}^3$

(C) $11.12\ \text{kN/m}^3$

(D) $20.93\ \text{kN/m}^3$

Q18. A sand deposit has its water table at a depth of 2 m below the ground surface. Above the water table the unit weight is $16\ \text{kN/m}^3$ and below it the saturated unit weight is $20\ \text{kN/m}^3$. The effective vertical stress at a depth of 6 m below the ground surface is nearest to: **[1 mark]**

(A) $112.0\ \text{kN/m}^2$

(B) $72.76\ \text{kN/m}^2$

(C) $39.24\ \text{kN/m}^2$

(D) $60.0\ \text{kN/m}^2$

Q19. A soil has a coefficient of permeability of 5×10^{-4} m/s. At a section within the soil the hydraulic gradient of the seeping water is 0.40. The Darcy (discharge) velocity of flow is: **[1 mark]**

(A) 1.25×10^{-3} m/s

(B) 2.0×10^{-4} m/s

(C) 8.0×10^{-4} m/s

(D) 5.0×10^{-4} m/s

Q20. In a compaction test, the dry unit weight of a soil corresponding to zero air voids (the theoretical maximum) is required at a water content of 20%. The specific gravity of the solids is 2.70. The zero-air-void dry unit weight of the soil is nearest to: **[1 mark]**

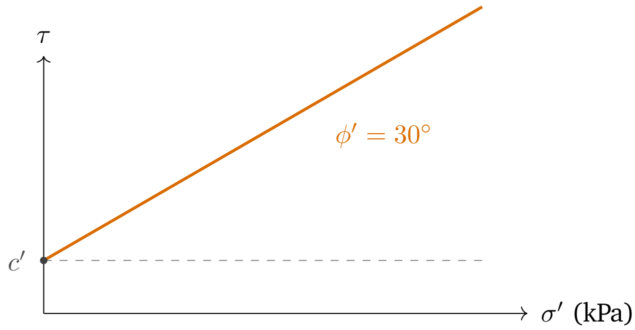
(A) $26.49\ \text{kN/m}^3$

(B) $22.09\ \text{kN/m}^3$

(C) $17.20\ \text{kN/m}^3$

(D) $13.70\ \text{kN/m}^3$

Q21. A direct shear test is carried out on a soil that has an effective cohesion $c' = 10$ kPa and an effective angle of internal friction $\phi' = 30°$. The Mohr–Coulomb strength envelope is shown. Under a normal effective stress of 60 kPa on the failure plane, the shear strength of the soil is nearest to: **[2 marks]**



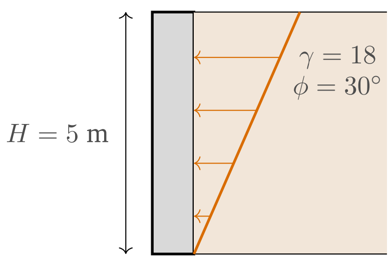
(A) 34.64 kPa

(B) 44.64 kPa

(C) 30.0 kPa

(D) 60.0 kPa

Q22. A smooth vertical retaining wall 5 m high retains a dry cohesionless backfill with a horizontal top surface, unit weight 18 kN/m^3 and friction angle $\phi = 30°$, as shown. Using Rankine's theory, the total *passive* earth thrust per metre run of the wall is: **[2 marks]**



(A) 225 kN/m

(B) 108 kN/m

(C) 675 kN/m

(D) 337.5 kN/m

Q23. A normally consolidated saturated clay layer 3 m thick has an initial void ratio $e_0 = 0.90$ and a compression index $C_c = 0.30$. The initial effective vertical stress at mid-depth is 100 kPa, and a wide loading increases it by 100 kPa. The consolidation settlement of the layer is nearest to: **[2 marks]**

(A) 142.6 mm

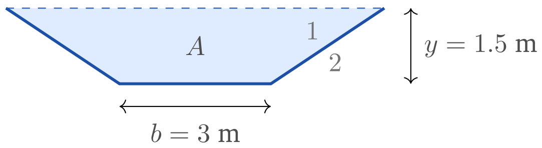
(B) 90.0 mm

(C) 285.0 mm

(D) 47.5 mm

Water Resources Engineering

Q24. A trapezoidal channel has a bottom width of 3 m and side slopes of 2 horizontal to 1 vertical, and carries water at a depth of 1.5 m, as shown. The wetted perimeter of the flow section is nearest to: **[2 marks]**



(A) 6.71 m

(B) 9.71 m

(C) 12.0 m

(D) 8.5 m

Q25. A vertical rectangular gate 2 m wide and 3 m deep has its top edge coinciding with the free surface of the water on one side. Measured from the free surface, the depth of the centre of pressure of the hydrostatic force on the gate is: **[2 marks]**

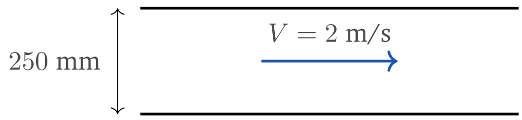
(A) 1.5 m

(B) 2.0 m

(C) 2.25 m

(D) 3.0 m

Q26. Water flows steadily through a straight pipe of diameter 250 mm at a mean velocity of 2 m/s, as shown. The volumetric discharge through the pipe is nearest to: **[2 marks]**



(A) $0.157 \text{ m}^3/\text{s}$

(B) $0.049 \text{ m}^3/\text{s}$

(C) $0.0982 \text{ m}^3/\text{s}$

(D) $0.196 \text{ m}^3/\text{s}$

Q27. Water of kinematic viscosity $\nu = 1.0 \times 10^{-6}$ m^2/s flows through a pipe of diameter 150 mm at a mean velocity of 2 m/s. The Reynolds number of the flow is: **[2 marks]**

(A) 3.0×10^5

(B) 3.0×10^4

(C) 3.0×10^6

(D) 1.5×10^5

Q28. Water flows in a rectangular channel at a mean velocity of 3 m/s and a flow depth of 0.9 m. The Froude number of the flow is nearest to: **[2 marks]**

(A) 1.01

(B) 0.50

(C) 2.02

(D) 3.03

Q29. In a rectangular channel, water flows at a depth of 1.5 m with a mean velocity of 2 m/s. The specific energy of the flow is nearest to: **[2 marks]**

(A) 1.50 m

(B) 2.00 m

(C) 0.204 m

(D) 1.70 m

Q30. A storm produces 4 cm of direct (effective) runoff uniformly over a catchment of area 50 km^2. The total volume of direct runoff generated is: **[2 marks]**

(A) 2.0×10^6 m^3

(B) 2.0×10^5 m^3

(C) 2.0×10^7 m^3

(D) 2.0×10^4 m^3

Q31. A 4-hour unit hydrograph of a catchment has a peak discharge of 25 m^3/s. A 4-hour storm produces 3 cm of effective (excess) rainfall over the catchment, and the base flow is constant at 5 m^3/s. The peak of the resulting total flood hydrograph is: **[2 marks]**

(A) 80 m^3/s

(B) 75 m^3/s

(C) 25 m^3/s

(D) 30 m^3/s

Q32. An irrigation canal is required to supply water to a culturable command area of 5000 hectares for a crop whose duty at the head of the field is 1000 hectares per cumec. The discharge that the canal must carry is: **[2 marks]**

(A) 50 m^3/s

(B) 0.2 m^3/s

(C) 2 m^3/s

(D) 5 m^3/s

Q33. A canal system serves a culturable command area (CCA) of 8000 hectares. For a particular crop, the intensity of irrigation is 40%. The area actually irrigated for this crop in the season is: **[2 marks]**

(A) 4000 ha

(B) 3200 ha

(C) 8000 ha

(D) 2000 ha

Q34. A small hydraulic structure has a design (service) life of 2 years. It is exposed to floods, and a flood of the design magnitude has a return period of 10 years. The hydrologic risk, that is the probability that the design flood is equalled or exceeded at least once during the life of the structure, is: **[2 marks]**

(A) 0.19

(B) 0.10

(C) 0.20

(D) 0.81

Environmental Engineering

Q35. A wastewater sample has a measured 5-day BOD of 150 mg/L. The first-order deoxygenation rate constant is $k = 0.23$ day^{-1} (to base e). Using $\text{BOD}_t = L_0(1 - e^{-kt})$, the ultimate (first-stage) BOD L_0 of the sample is nearest to: **[2 marks]**

(A) 150 mg/L

(B) 95 mg/L

(C) 300 mg/L

(D) 219.5 mg/L

Q36. A sedimentation tank has an effective liquid volume of 600 m^3 and treats a continuous flow of 3600 m^3/day. The theoretical detention (retention) time of the tank is: **[2 marks]**

(A) 6 hours

(B) 2 hours

(C) 8 hours

(D) 4 hours

Q37. A town has a population of 50,000 and an average per-capita water demand of 150 litres per capita per day. Taking the maximum daily demand as 1.8 times the average daily demand, the maximum daily water demand of the town is: **[2 marks]**

(A) 7500 m^3/day

(B) 13500 m^3/day

(C) 27000 m^3/day

(D) 4167 m^3/day

Q38. A discrete spherical particle of diameter 0.01 mm and specific gravity 2.65 settles under gravity in still water at 20°C, for which the dynamic viscosity is $\mu = 1.0 \times 10^{-3}$ Pa · s. Assuming laminar (Stokes) settling, the terminal settling velocity of the particle is nearest to: **[2 marks]**

(A) 4.5×10^{-5} m/s

(B) 1.8×10^{-4} m/s

(C) 9.0×10^{-5} m/s

(D) 8.99×10^{-4} m/s

Q39. Municipal solid waste is stored loosely at a density of 100 kg/m^3 and is then mechanically compacted to a density of 500 kg/m^3. The percentage reduction in the volume of the waste achieved by the compaction is: **[2 marks]**

(A) 20%

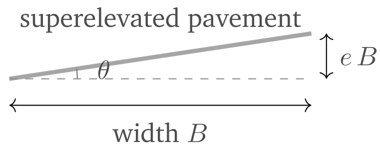
(B) 500%

(C) 80%

(D) 5%

Transportation & Geomatics Engineering

Q40. A horizontal highway curve is to be designed for a speed of 100 km/h. The maximum allowable value of the sum of superelevation and side-friction factor is $e+f = 0.15$, and the design follows $R = V^2/\big(127(e+f)\big)$ with the superelevated cross-section shown. The minimum radius of the curve is nearest to: **[2 marks]**



(A) 262.5 m

(B) 1050 m

(C) 350 m

(D) 524.9 m

Q41. A vehicle travels at 60 km/h on a road with a descending gradient of 2%. The driver's total reaction (perception–brake) time is 2.5 s and the longitudinal friction coefficient is 0.35. Taking $g = 9.81$ m/s^2, the stopping sight distance required is nearest to: **[2 marks]**

(A) 41.7 m

(B) 84.6 m

(C) 42.9 m

(D) 120 m

Q42. A traffic stream follows Greenshields' linear speed–density model with a free-flow speed of 80 km/h and a jam density of 100 veh/km. The speed of the stream at which the flow (volume) is a maximum is: **[2 marks]**

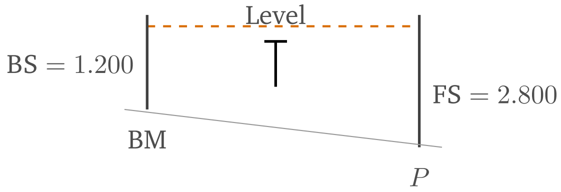
(A) 80 km/h

(B) 100 km/h

(C) 50 km/h

(D) 40 km/h

Q43. In differential levelling by the rise-and-fall method, a back sight of 1.200 m is taken on a benchmark of reduced level 50.000 m, and a fore sight of 2.800 m is taken on a point P, as shown. The reduced level of P is: [2 marks]



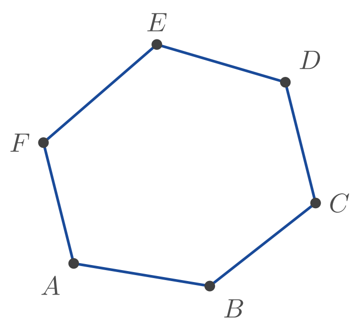
(A) 48.400 m

(B) 51.600 m

(C) 54.000 m

(D) 46.800 m

Q44. A closed traverse has the shape of a six-sided polygon (hexagon), as shown. For the traverse to close correctly, the theoretical sum of its interior angles should be: [2 marks]



(A) $540°$

(B) $900°$

(C) $720°$

(D) $360°$

Q45. A simple circular curve of radius 200 m connects two straights that meet at a deflection (intersection) angle of $60°$. The tangent length of the curve is nearest to: [2 marks]

(A) 115.47 m

(B) 200 m

(C) 173.2 m

(D) 100 m

Q46. A survey map is drawn to a representative fraction of $1 : 5000$. On this map, a road is plotted as a straight line of length 8 cm. The corresponding actual length of the road on the ground is: **[2 marks]**

(A) 40 m

(B) 4000 m

(C) 400 m

(D) 250 m

Detailed Solutions

Q1.

Solution

Concept – bending moment in a cantilever under an end load: For a cantilever carrying a single point load at the free end, the bending moment is largest at the fixed support and equals the load times the distance to the support.

Step 1 – list the data: Load $W = 24$ kN, lever arm $L = 2.5$ m.

Step 2 – write the maximum-moment expression: $M_{\max} = W \times L$

Step 3 – substitute the values: $M_{\max} = 24 \times 2.5$

Step 4 – evaluate: $M_{\max} = 60$ kN·m

Step 5 – locate it: The moment is zero at the free end and grows linearly to its peak at the fixed end A.

Final Answer: $M_{\max} = 60$ kN·m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q1

Q2.

Solution

Concept – free thermal expansion of a bar: A bar free to expand elongates by $\delta = \alpha\, L\, \Delta T$, with no stress developed.

Step 1 – convert the length to millimetres: $L = 20 \text{ m} = 20000 \text{ mm}$

Step 2 – write the expansion formula: $\delta = \alpha\, L\, \Delta T$

Step 3 – substitute the values: $\delta = 12 \times 10^{-6} \times 20000 \times 25$

Step 4 – multiply the length and temperature terms: $20000 \times 25 = 500000$

Step 5 – complete the arithmetic: $\delta = 12 \times 10^{-6} \times 500000$

$\delta = 6$ mm

Final Answer: $\delta = 6$ mm $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – maximum in-plane shear stress from Mohr's circle: With no shear on the given planes, the two normal stresses are the principal stresses, and $\tau_{\max}$ equals the radius of the Mohr circle, $\tau_{\max} = \dfrac{\sigma_x - \sigma_y}{2}$.

Step 1 – identify the principal stresses: $\sigma_1 = 100$ MPa, $\sigma_2 = 20$ MPa (since $\tau_{xy} = 0$).

Step 2 – form the difference: $\sigma_1 - \sigma_2 = 100 - 20 = 80$ MPa

Step 3 – halve it: $\tau_{\max} = \dfrac{80}{2}$

$\tau_{\max} = 40$ MPa

Step 4 – check with the circle: The centre is at $\frac{100+20}{2} = 60$ MPa and the radius is 40 MPa, so the top of the circle sits at $\tau = 40$ MPa. Consistent.

Final Answer: $\tau_{\max} = 40$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q3**

Q4.

Solution

Concept – radius of gyration of a section: $r = \sqrt{\dfrac{I}{A}}$, using the least moment of inertia and the area.

Step 1 – compute the least moment of inertia: About the axis parallel to the 100 mm side, $I = \dfrac{b\,d^3}{12} = \dfrac{100 \times 200^3}{12}$

Step 2 – evaluate d^3: $200^3 = 8{,}000{,}000$

Step 3 – finish the moment of inertia: $I = \dfrac{100 \times 8{,}000{,}000}{12} = \dfrac{800{,}000{,}000}{12}$

$I = 66.667 \times 10^6 \text{ mm}^4$

Step 4 – compute the area: $A = 100 \times 200 = 20000 \text{ mm}^2$

Step 5 – form I/A: $\dfrac{I}{A} = \dfrac{66.667 \times 10^6}{20000} = 3333.3 \text{ mm}^2$

Step 6 – take the square root: $r = \sqrt{3333.3}$

$r = 57.7$ mm

Final Answer: $r = 57.7$ mm $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q4**

Q5.

Solution

Concept – torsion formula for a solid circular shaft: $\tau_{\max} = \dfrac{16\,T}{\pi D^3}$.

Step 1 – convert the torque to N·mm: $T = 2\ \mathrm{kN \cdot m} = 2 \times 10^6\ \mathrm{N \cdot mm}$

Step 2 – evaluate D^3: $D^3 = 60^3 = 216000\ \mathrm{mm}^3$

Step 3 – compute the denominator πD^3: $\pi \times 216000 = 678584$

Step 4 – form the numerator $16T$: $16 \times 2 \times 10^6 = 32 \times 10^6$

Step 5 – divide: $\tau_{\max} = \dfrac{32 \times 10^6}{678584}$

$\tau_{\max} = 47.2\ \mathrm{MPa}$

Final Answer: $\tau_{\max} = 47.2\ \mathrm{MPa} \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – Euler buckling load of a pin-ended column: $P_{cr} = \dfrac{\pi^2 EI}{L^2}$, with the effective length equal to L for hinged ends.

Step 1 – express E in consistent units: $E = 200\ \mathrm{GPa} = 200000\ \mathrm{N/mm^2}$

Step 2 – form the product EI: $EI = 200000 \times 4 \times 10^6 = 8 \times 10^{11}\ \mathrm{N \cdot mm^2}$

Step 3 – convert the length and square it: $L = 4000$ mm, so $L^2 = 16 \times 10^6\ \mathrm{mm^2}$

Step 4 – substitute into Euler's formula: $P_{cr} = \dfrac{\pi^2 \times 8 \times 10^{11}}{16 \times 10^6}$

Step 5 – put in $\pi^2 = 9.8696$: $P_{cr} = \dfrac{9.8696 \times 8 \times 10^{11}}{16 \times 10^6} = \dfrac{7.8957 \times 10^{12}}{16 \times 10^6}$

Step 6 – evaluate: $P_{cr} = 493480\ \mathrm{N} \approx 493.5\ \mathrm{kN}$

Final Answer: $P_{cr} \approx 493.5\ \mathrm{kN} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – slope at the free end of a cantilever under UDL: For a cantilever of length L carrying a full-span UDL w, the end rotation is $\theta = \dfrac{wL^3}{6EI}$.

Step 1 – recall the standard result: The end deflection is $\dfrac{wL^4}{8EI}$ and the end slope is $\dfrac{wL^3}{6EI}$.

Step 2 – confirm the dependence: The slope has one fewer power of L than the deflection, so it must vary as L^3, matching option C.

Why the other options are wrong:

- A, $wL^3/8EI$: uses the deflection coefficient $1/8$ for a slope; the slope coefficient is $1/6$.
- B, $wL^4/8EI$: is the free-end **deflection**, not the slope, and carries L^4.
- D, $wL^3/24EI$: is not the cantilever end slope.

Final Answer: $\theta = \dfrac{wL^3}{6EI} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept – slenderness ratio of a column: $\lambda = \dfrac{L_e}{r}$, the ratio of effective length to least radius of gyration.

Step 1 – put both lengths in the same unit: $L_e = 3$ m $= 3000$ mm, $r = 30$ mm.

Step 2 – form the ratio: $\lambda = \dfrac{3000}{30}$

Step 3 – evaluate: $\lambda = 100$

Step 4 – note the meaning: This is a dimensionless number; a value of 100 indicates a fairly slender column.

Final Answer: $\lambda = 100 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – degree of static indeterminacy of a plane truss: $D_s = (m + r) - 2j$, where m is the number of members, r the reaction components and j the joints.

Step 1 – list the data: $m = 16$, $r = 3$, $j = 8$.

Step 2 – form $m + r$: $m + r = 16 + 3 = 19$

Step 3 – form $2j$: $2j = 2 \times 8 = 16$

Step 4 – subtract: $D_s = 19 - 16$

$D_s = 3$

Step 5 – interpret: Since $D_s > 0$, the truss is statically indeterminate to the third degree.

Final Answer: $D_s = 3 \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – influence line for shear at a mid-section: For the shear at a section of a simply supported beam, the influence line has two straight branches; at the section itself it jumps, with ordinates of opposite sign just to the left and right.

Step 1 – write the ordinate values at midspan: Just left of midspan the ordinate is $-a/L$ and just right it is $+b/L$, where a and b are the distances to the supports.

Step 2 – put the section at midspan: $a = b = L/2$, so each ordinate has magnitude $\dfrac{L/2}{L} = 0.5$.

Step 3 – identify the maximum magnitude: The largest ordinate magnitude on the influence line is 0.5, a dimensionless number.

Why the other options are wrong:

- A, 1.0: is the peak of a *reaction* influence line, not a mid-section shear line.
- D, $L/2$: is a length; a shear influence-line ordinate is dimensionless.

Final Answer: maximum ordinate $= 0.5 \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – fixed-end moment for a central point load: For a prismatic fixed–fixed beam carrying a concentrated load W at midspan, the fixed-end moment at each support is $\dfrac{WL}{8}$.

Step 1 – recall the standard fixed-end moment table: Central point load W: FEM $= \dfrac{WL}{8}$; full UDL w: FEM $= \dfrac{wL^2}{12}$.

Step 2 – pick the case that applies: The load here is a single central point load, so FEM $= \dfrac{WL}{8}$.

Why the other options are wrong:

- B, $WL/12$: is not a standard fixed-end moment for this case.
- C, $wL^2/12$: is the fixed-end moment for a **uniformly distributed** load, not a point load.
- D, $WL/4$: is the simply supported midspan moment, not a fixed-end moment.

Final Answer: FEM $= \dfrac{WL}{8} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – limiting moment of resistance coefficient in RCC: $M_{u,\text{lim}} = k\, f_{ck}\, b\, d^2$, where k depends on the limiting neutral-axis depth ratio, which is fixed by the steel grade.

Step 1 – recall the standard coefficients (IS 456): $k = 0.148$ for Fe250, 0.138 for Fe415, and 0.133 for Fe500.

Step 2 – pick the value for the stated grade: For **Fe415**, $k = 0.138$.

Why the other options are wrong:

- A, 0.148: is the coefficient for **Fe250** (mild steel).
- C, 0.133: is the coefficient for **Fe500**.
- D, 0.360: is the stress-block depth factor (x_u related), not the moment coefficient.

Final Answer: $k = 0.138 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – limiting slenderness ratios in IS 800:2007: The code caps KL/r at different values depending on the load type carried by the member.

Step 1 – recall the relevant limit: For a member carrying compressive loads resulting from dead and imposed (live) loads, the maximum KL/r is 180.

Step 2 – distinguish it from the others: A value of 250 applies to members carrying loads only from wind or seismic actions, and 350/400 apply to tension members in various situations.

Why the other options are wrong:

- A, 250: is the cap for compression members whose forces arise only from wind/seismic effects.
- B, 400: is the cap for tension members that may be subject to load reversal from wind/seismic.
- C, 350: is the cap for tension members in this reversal category under other combinations.

Final Answer: $KL/r = 180 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept – PERT standard deviation of an activity: $\sigma = \dfrac{t_p - t_o}{6}$, based on the beta-distribution assumption.

Step 1 – list the two extreme estimates: $t_o = 6$ days, $t_p = 18$ days.

Step 2 – form the range: $t_p - t_o = 18 - 6 = 12$

Step 3 – divide by 6: $\sigma = \dfrac{12}{6}$

$\sigma = 2$ days

Final Answer: $\sigma = 2$ days $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept – weight–volume identity: $S\,e = w\,G$, so $S = \dfrac{w\,G}{e}$.

Step 1 – list the data: $e = 0.75$, $w = 0.20$, $G = 2.70$.

Step 2 – form the product wG: $w\,G = 0.20 \times 2.70 = 0.54$

Step 3 – divide by the void ratio: $S = \dfrac{0.54}{0.75}$

Step 4 – evaluate: $S = 0.72$

Step 5 – express as a percentage: $S = 72\%$

Final Answer: $S = 72\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept – liquidity index: $I_L = \dfrac{w - \text{PL}}{\text{LL} - \text{PL}}$, locating the natural water content within the plastic range.

Step 1 – list the data: $w = 25\%$, $\text{PL} = 20\%$, $\text{LL} = 40\%$.

Step 2 – compute the numerator: $w - \text{PL} = 25 - 20 = 5$

Step 3 – compute the denominator (plasticity index): $\text{LL} - \text{PL} = 40 - 20 = 20$

Step 4 – divide: $I_L = \dfrac{5}{20}$

$I_L = 0.25$

Why the other options are wrong:

- A, 0.75: is the *consistency index* $\dfrac{\text{LL} - w}{\text{LL} - \text{PL}}$, the complement of I_L.

Final Answer: $I_L = 0.25 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – saturated unit weight from void ratio: $\gamma_{sat} = \dfrac{(G+e)}{1+e}\gamma_w$ for a fully saturated soil.

Step 1 – list the data: $G = 2.70$, $e = 0.50$, $\gamma_w = 9.81$ kN/m^3.

Step 2 – form the numerator $G + e$**:** $G + e = 2.70 + 0.50 = 3.20$

Step 3 – form the denominator $1 + e$**:** $1 + e = 1.50$

Step 4 – take the ratio: $\dfrac{3.20}{1.50} = 2.1333$

Step 5 – multiply by γ_w**:** $\gamma_{sat} = 2.1333 \times 9.81$

$\gamma_{sat} = 20.93$ kN/m^3

Step 6 – read the phase diagram as a check: With $V_s = 1$ and $V_w = e = 0.50$, the weight of solids is $G\gamma_w = 26.49$ and the weight of water is $e\gamma_w = 4.905$; dividing the total 31.40 by the total volume 1.5 gives 20.93 kN/m^3. Consistent.

Final Answer: $\gamma_{sat} = 20.93$ kN/m$^3 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q17**

Q18.

Solution

Concept – effective stress in a layered profile: $\sigma' = \sigma - u$, where the total stress accumulates layer by layer and the pore pressure is measured below the water table.

Step 1 – total stress from the upper (moist) layer: 0 to 2 m: $\sigma_1 = 16 \times 2 = 32$ kPa

Step 2 – total stress from the lower (saturated) layer: 2 to 6 m: $\sigma_2 = 20 \times 4 = 80$ kPa

Step 3 – total vertical stress at 6 **m:** $\sigma = 32 + 80 = 112$ kPa

Step 4 – pore water pressure at 6 **m:** The water table is at 2 m, so the water column is $6 - 2 = 4$ m; $u = 9.81 \times 4 = 39.24$ kPa

Step 5 – effective stress: $\sigma' = 112 - 39.24$

$\sigma' = 72.76$ kN/m^2

Why the other options are wrong:

- A, 112: is the **total** stress, not the effective stress.
- C, 39.24: is the pore water pressure.

Final Answer: $\sigma' = 72.76 \text{ kN/m}^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – Darcy's law: The discharge (Darcy) velocity is $v = k\,i$, the product of permeability and hydraulic gradient.

Step 1 – list the data: $k = 5 \times 10^{-4}$ m/s, $i = 0.40$.

Step 2 – substitute into Darcy's law: $v = 5 \times 10^{-4} \times 0.40$

Step 3 – multiply: $v = 2.0 \times 10^{-4}$ m/s

Why the other options are wrong:

- D, 5×10^{-4}: is the permeability k itself, obtained by forgetting the gradient.
- A, 1.25×10^{-3}: divides k by i instead of multiplying.

Final Answer: $v = 2.0 \times 10^{-4} \text{ m/s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – zero-air-void dry unit weight: At complete saturation ($S = 1$) the dry unit weight is $\gamma_d = \dfrac{G\,\gamma_w}{1 + w\,G}$.

Step 1 – list the data: $G = 2.70$, $w = 0.20$, $\gamma_w = 9.81 \text{ kN/m}^3$.

Step 2 – compute the numerator $G\gamma_w$: $G\,\gamma_w = 2.70 \times 9.81 = 26.487$

Step 3 – compute the denominator $1 + wG$: $w\,G = 0.20 \times 2.70 = 0.54$

$1 + w\,G = 1 + 0.54 = 1.54$

Step 4 – divide: $\gamma_d = \dfrac{26.487}{1.54}$

$\gamma_d = 17.20 \text{ kN/m}^3$

Why the other options are wrong:

- A, 26.49: is $G\gamma_w$ without dividing by $(1 + wG)$.

Final Answer: $\gamma_d = 17.20 \text{ kN/m}^3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – Mohr–Coulomb shear strength: $\tau_f = c' + \sigma'_n \tan\phi'$, the cohesion intercept plus the frictional contribution.

Step 1 – list the data: $c' = 10$ kPa, $\phi' = 30°$, $\sigma'_n = 60$ kPa.

Step 2 – evaluate the friction term $\tan\phi'$**:** $\tan 30° = 0.5774$

Step 3 – compute the frictional shear: $\sigma'_n \tan\phi' = 60 \times 0.5774 = 34.64$ kPa

Step 4 – add the cohesion intercept: $\tau_f = 10 + 34.64$

$\tau_f = 44.64$ kPa

Why the other options are wrong:

- A, 34.64: keeps only the frictional part and drops the cohesion c'.

Final Answer: $\tau_f = 44.64$ kPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – Rankine passive thrust on a wall with cohesionless backfill: $P_p = \frac{1}{2}K_p\gamma H^2$, with $K_p = \dfrac{1+\sin\phi}{1-\sin\phi}$.

Step 1 – compute the passive earth-pressure coefficient: $K_p = \dfrac{1+\sin 30°}{1-\sin 30°} = \dfrac{1+0.5}{1-0.5}$

$K_p = \dfrac{1.5}{0.5} = 3$

Step 2 – evaluate H^2**:** $H^2 = 5^2 = 25$ m^2

Step 3 – substitute into the thrust formula: $P_p = \frac{1}{2} \times 3 \times 18 \times 25$

Step 4 – simplify step by step: $3 \times 18 = 54$

$54 \times 25 = 1350$

$P_p = \frac{1}{2} \times 1350$

$P_p = 675$ kN/m

Why the other options are wrong:

- B, 108: uses the *active* coefficient $K_a = 1/3$ instead of $K_p = 3$.

Final Answer: $P_p = 675$ kN/m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – one-dimensional consolidation settlement (normally consolidated clay): $S_c = \dfrac{C_c H}{1+e_0}\log_{10}\left(\dfrac{\sigma_0' + \Delta\sigma'}{\sigma_0'}\right)$.

Step 1 – list the data: $C_c = 0.30$, $H = 3$ m, $e_0 = 0.90$, $\sigma_0' = 100$ kPa, $\Delta\sigma' = 100$ kPa.

Step 2 – form the leading factor: $\dfrac{C_c H}{1+e_0} = \dfrac{0.30 \times 3}{1.90} = \dfrac{0.90}{1.90} = 0.4737$ m

Step 3 – form the stress ratio: $\dfrac{\sigma_0' + \Delta\sigma'}{\sigma_0'} = \dfrac{100+100}{100} = 2$

Step 4 – take the logarithm: $\log_{10} 2 = 0.30103$

Step 5 – multiply the two parts: $S_c = 0.4737 \times 0.30103$

$S_c = 0.1426$ m

Step 6 – convert to millimetres: $S_c = 0.1426 \times 1000 = 142.6$ mm

Final Answer: $S_c = 142.6$ mm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept – wetted perimeter of a trapezoidal channel: $P = b + 2y\sqrt{1+m^2}$, where b is the bottom width, y the depth and m the side slope (horizontal per vertical).

Step 1 – list the data: $b = 3$ m, $y = 1.5$ m, $m = 2$.

Step 2 – evaluate $\sqrt{1+m^2}$: $1 + m^2 = 1 + 4 = 5$

$\sqrt{5} = 2.2361$

Step 3 – compute the sloping-side length term $2y\sqrt{1+m^2}$: $2 \times 1.5 \times 2.2361 = 3 \times 2.2361 = 6.7082$ m

Step 4 – add the bottom width: $P = 3 + 6.7082$

$P = 9.71$ m

Why the other options are wrong:

- A, 6.71: is only the two sloping sides, forgetting the bottom width b.

Final Answer: $P = 9.71 \text{ m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept – depth of centre of pressure for a surface-topped vertical plate: For a vertical rectangle with its top edge at the free surface, the centre of pressure lies at $h^* = \dfrac{2H}{3}$ below the surface.

Step 1 – recall the general result: $h^* = \bar{h} + \dfrac{I_G}{A\,\bar{h}}$, with $\bar{h} = H/2$ and $I_G = \dfrac{bH^3}{12}$.

Step 2 – substitute for a surface-top rectangle: $h^* = \dfrac{H}{2} + \dfrac{bH^3/12}{(bH)(H/2)} = \dfrac{H}{2} + \dfrac{H}{6}$

Step 3 – add the fractions: $h^* = \dfrac{3H + H}{6} = \dfrac{4H}{6} = \dfrac{2H}{3}$

Step 4 – put in $H = 3$ m: $h^* = \dfrac{2 \times 3}{3} = 2$ m

Why the other options are wrong:

- A, 1.5: is the depth of the *centroid*, where the average pressure acts, not the centre of pressure.

Final Answer: $h^* = 2 \text{ m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – discharge as area times mean velocity: $Q = AV$, with $A = \dfrac{\pi}{4}D^2$ for a circular pipe.

Step 1 – convert the diameter: $D = 250 \text{ mm} = 0.25$ m

Step 2 – compute the flow area: $A = \frac{\pi}{4}(0.25)^2 = \frac{\pi}{4} \times 0.0625$

$A = 0.04909\ \mathrm{m}^2$

Step 3 – multiply by the velocity: $Q = 0.04909 \times 2$

Step 4 – evaluate: $Q = 0.0982\ \mathrm{m}^3/\mathrm{s}$

Why the other options are wrong:

- B, 0.049: is the area alone (velocity omitted).

Final Answer: $Q = 0.0982\ \mathrm{m}^3/\mathrm{s} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept – Reynolds number for pipe flow: $Re = \frac{VD}{\nu}$, a dimensionless ratio of inertial to viscous effects.

Step 1 – convert the diameter: $D = 150\ \mathrm{mm} = 0.15\ \mathrm{m}$

Step 2 – form the numerator VD**:** $VD = 2 \times 0.15 = 0.30$

Step 3 – divide by the kinematic viscosity: $Re = \frac{0.30}{1.0 \times 10^{-6}}$

Step 4 – evaluate: $Re = 3.0 \times 10^5$

Step 5 – classify: Since $Re > 4000$, the flow is turbulent.

Final Answer: $Re = 3.0 \times 10^5 \Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – Froude number in open-channel flow: $Fr = \frac{V}{\sqrt{g\,y}}$, comparing flow velocity with the wave celerity.

Step 1 – list the data: $V = 3$ m/s, $y = 0.9$ m, $g = 9.81$ m/s^2.

Step 2 – form the product $g\,y$**:** $g\,y = 9.81 \times 0.9 = 8.829$

Step 3 – take the square root: $\sqrt{8.829} = 2.9714$

Step 4 – divide: $Fr = \frac{3}{2.9714}$

$Fr = 1.01$

Step 5 – interpret: $Fr \approx 1$ means the flow is essentially at the critical state.

Final Answer: $Fr \approx 1.01 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – specific energy of open-channel flow: $E = y + \frac{V^2}{2g}$, the sum of depth and velocity head measured from the channel bed.

Step 1 – list the data: $y = 1.5$ m, $V = 2$ m/s, $g = 9.81$ m/s^2.

Step 2 – compute the velocity head: $\frac{V^2}{2g} = \frac{2^2}{2 \times 9.81} = \frac{4}{19.62}$

$= 0.2039$ m

Step 3 – add the flow depth: $E = 1.5 + 0.2039$

$E = 1.70$ m

Final Answer: $E \approx 1.70$ m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept – runoff volume as depth times area: Volume $= d \times A$, once the depth and area are in consistent units.

Step 1 – convert the runoff depth to metres: $d = 4$ cm $= 0.04$ m

Step 2 – convert the area to square metres: $A = 50$ km^2 $= 50 \times 10^6$ m^2

Step 3 – multiply: Volume $= 0.04 \times 50 \times 10^6$

Step 4 – evaluate: Volume $= 2.0 \times 10^6$ m^3

Final Answer: Volume $= 2.0 \times 10^6$ m^3 $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – linear scaling of a unit hydrograph plus base flow: Direct-runoff ordinates scale in proportion to the depth of excess rainfall; the total hydrograph is the direct runoff plus the base flow.

Step 1 – scale the unit-hydrograph peak by the rainfall depth: Excess rainfall $= 3$ cm, so direct-runoff peak $= 3 \times 25 = 75\ \text{m}^3/\text{s}$

Step 2 – add the constant base flow: Total peak $= 75 + 5$

Step 3 – evaluate: Total peak $= 80\ \text{m}^3/\text{s}$

Why the other options are wrong:

- B, 75: is the direct-runoff peak alone, ignoring base flow.
- C, 25: forgets to scale by the rainfall depth.

Final Answer: total peak $= 80\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q31

Q32.

Solution

Concept – discharge from duty and command area: Duty D (ha/cumec) is the area a unit discharge can irrigate, so $Q = \dfrac{A}{D}$.

Step 1 – list the data: $A = 5000$ ha, $D = 1000$ ha/cumec.

Step 2 – substitute: $Q = \dfrac{5000}{1000}$

Step 3 – evaluate: $Q = 5\ \text{m}^3/\text{s}$

Why the other options are wrong:

- B, 0.2: divides the duty by the area (reciprocal error).
- A, 50: misplaces the decimal by a factor of ten.

Final Answer: $Q = 5\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – intensity of irrigation: The area actually irrigated for a crop = (intensity of irrigation) $\times$ culturable command area.

Step 1 – list the data: CCA $= 8000$ ha, intensity $= 40\% = 0.40$.

Step 2 – multiply: Area $= 0.40 \times 8000$

Step 3 – evaluate: Area $= 3200$ ha

Why the other options are wrong:

- C, 8000: is the full CCA, as if every hectare grew this crop.
- A, 4000: applies a 50% intensity rather than 40%.

Final Answer: Area $= 3200$ ha $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q33

Q34.

Solution

Concept – hydrologic risk over a design life: Risk $= 1 - \left(1 - \frac{1}{T}\right)^n$, where T is the return period and n the life in years.

Step 1 – list the data: $T = 10$ years, $n = 2$ years.

Step 2 – compute the single-year non-exceedance probability: $1 - \frac{1}{T} = 1 - 0.1 = 0.9$

Step 3 – raise to the power n: $(0.9)^2 = 0.81$

Step 4 – subtract from one: Risk $= 1 - 0.81$

Risk $= 0.19$

Why the other options are wrong:

- B, 0.10: is the single-year exceedance probability, not the two-year risk.
- D, 0.81: is the probability of *no* exceedance in two years.

Final Answer: Risk $= 0.19 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – first-order BOD progression (base e): $\text{BOD}_t = L_0\left(1 - e^{-kt}\right)$, so $L_0 = \dfrac{\text{BOD}_t}{1 - e^{-kt}}$.

Step 1 – form the exponent: $k\,t = 0.23 \times 5 = 1.15$

Step 2 – evaluate the exponential: $e^{-1.15} = 0.3166$

Step 3 – form the bracket: $1 - 0.3166 = 0.6834$

Step 4 – divide the measured BOD by the bracket: $L_0 = \dfrac{150}{0.6834}$

$L_0 = 219.5\ \text{mg/L}$

Why the other options are wrong:

- A, 150: takes the 5-day BOD itself as the ultimate value.

Final Answer: $L_0 \approx 219.5\ \text{mg/L} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – detention time of a tank: $t_d = \dfrac{V}{Q}$, the volume divided by the flow rate.

Step 1 – list the data: $V = 600\ \text{m}^3$, $Q = 3600\ \text{m}^3/\text{day}$.

Step 2 – form the ratio (in days): $t_d = \dfrac{600}{3600} = 0.1667\ \text{day}$

Step 3 – convert to hours: $t_d = 0.1667 \times 24$

$t_d = 4$ hours

Final Answer: $t_d = 4$ hours $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – maximum daily demand from average demand: Average daily demand = per-capita rate × population; the maximum daily demand applies a peak factor.

Step 1 – compute the average daily demand (litres): $Q_{avg} = 150 \times 50000 = 7{,}500{,}000$ litres/day

Step 2 – convert to cubic metres: $Q_{avg} = \dfrac{7{,}500{,}000}{1000} = 7500\ \text{m}^3/\text{day}$

Step 3 – apply the peak factor: $Q_{\max} = 1.8 \times 7500$

Step 4 – evaluate: $Q_{\max} = 13500\ \text{m}^3/\text{day}$

Why the other options are wrong:

- A, 7500: is the *average* demand, without the peak factor.

Final Answer: $Q_{\max} = 13500\ \text{m}^3/\text{day} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – Stokes' law settling velocity: $v_s = \dfrac{g\,(\rho_s - \rho_w)\,d^2}{18\,\mu}$ for a small sphere in laminar settling.

Step 1 – convert the diameter to metres: $d = 0.01$ mm $= 1 \times 10^{-5}$ m, so $d^2 = 1 \times 10^{-10}\ \text{m}^2$

Step 2 – form the density difference: $\rho_s - \rho_w = 2650 - 1000 = 1650\ \text{kg/m}^3$

Step 3 – compute the numerator: $g(\rho_s - \rho_w)d^2 = 9.81 \times 1650 \times 1 \times 10^{-10}$

$= 1.6187 \times 10^{-6}$

Step 4 – compute the denominator: $18\,\mu = 18 \times 1.0 \times 10^{-3} = 0.018$

Step 5 – divide: $v_s = \dfrac{1.6187 \times 10^{-6}}{0.018}$

$v_s = 8.99 \times 10^{-5}\ \text{m/s} \approx 9.0 \times 10^{-5}\ \text{m/s}$

Final Answer: $v_s \approx 9.0 \times 10^{-5}\ \text{m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – volume reduction on compaction: Since mass is conserved, volume is inversely proportional to density; the fractional reduction is $1 - \frac{\rho_{loose}}{\rho_{comp}}$.

Step 1 – form the density ratio: $\frac{\rho_{loose}}{\rho_{comp}} = \frac{100}{500} = 0.20$

Step 2 – this is the fraction of the original volume that remains: Compacted volume $= 0.20\times$ loose volume.

Step 3 – fractional reduction: $1 - 0.20 = 0.80$

Step 4 – express as a percentage: Reduction $= 80\%$

Why the other options are wrong:

- A, 20%: is the fraction of volume that *remains*, not the reduction.

Final Answer: reduction $= 80\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – minimum radius of a horizontal curve: $R = \dfrac{V^2}{127\,(e+f)}$, with V in km/h and R in m.

Step 1 – list the data: $V = 100$ km/h, $e + f = 0.15$.

Step 2 – square the speed: $V^2 = 100^2 = 10000$

Step 3 – compute the denominator: $127 \times 0.15 = 19.05$

Step 4 – divide: $R = \dfrac{10000}{19.05}$

$R = 524.9$ m

Why the other options are wrong:

- A, 262.5: doubles $(e + f)$ in the denominator.

Final Answer: $R \approx 524.9$ m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – stopping sight distance on a gradient: $\text{SSD} = v\,t + \dfrac{v^2}{2g\,(f \pm n)}$; on a descending gradient the grade n is subtracted from f.

Step 1 – convert the speed to m/s: $v = 60\text{ km/h} = \dfrac{60}{3.6} = 16.667\text{ m/s}$

Step 2 – compute the lag (reaction) distance: $v\,t = 16.667 \times 2.5 = 41.667\text{ m}$

Step 3 – adjust the friction for the down-grade: $f - n = 0.35 - 0.02 = 0.33$

Step 4 – compute the braking distance: Numerator: $v^2 = 16.667^2 = 277.78$

Denominator: $2g(f - n) = 2 \times 9.81 \times 0.33 = 6.4746$

$\dfrac{v^2}{2g(f-n)} = \dfrac{277.78}{6.4746} = 42.90\text{ m}$

Step 5 – add the two parts: $\text{SSD} = 41.667 + 42.90$

$\text{SSD} = 84.6\text{ m}$

Final Answer: $\text{SSD} \approx 84.6\text{ m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – optimum speed in Greenshields' model: The flow is maximum at half the free-flow speed, $v_{opt} = \dfrac{v_f}{2}$.

Step 1 – recall the parabolic flow–speed relation: Flow peaks where $v = v_f/2$ and density $k = k_j/2$.

Step 2 – substitute the free-flow speed: $v_{opt} = \dfrac{80}{2}$

Step 3 – evaluate: $v_{opt} = 40\text{ km/h}$

Why the other options are wrong:

- A, 80: is the free-flow speed, where the flow is actually zero (density $\to 0$).
- C, 50: does not follow from the half-of-free-speed result.

Final Answer: $v_{opt} = 40\text{ km/h} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q42

Q43.

Solution

Concept – rise-and-fall levelling: A fore sight larger than the back sight is a fall; the reduced level of the point is the benchmark level minus the fall.

Step 1 – compare the sights: BS $= 1.200$ m, FS $= 2.800$ m; since FS $>$ BS, there is a fall.

Step 2 – compute the fall: Fall $=$ FS $-$ BS $= 2.800 - 1.200 = 1.600$ m

Step 3 – subtract the fall from the benchmark RL: $\text{RL}_P = 50.000 - 1.600$

$\text{RL}_P = 48.400$ m

Step 4 – cross-check by the height-of-instrument method: HI $= 50.000 + 1.200 = 51.200$; then $\text{RL}_P = 51.200 - 2.800 = 48.400$ m. Consistent.

Why the other options are wrong:

- B, 51.600: adds the fall instead of subtracting it.

Final Answer: $\text{RL}_P = 48.400 \text{ m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q43

Q44.

Solution

Concept – sum of interior angles of a closed traverse: For a closed polygon of n sides, $\sum$ interior angles $= (2n - 4) \times 90°$.

Step 1 – count the sides: The traverse is a hexagon, so $n = 6$.

Step 2 – form $(2n - 4)$: $2(6) - 4 = 12 - 4 = 8$

Step 3 – multiply by $90°$: $\sum = 8 \times 90°$

$\sum = 720°$

Step 4 – cross-check: The equivalent form $(n-2) \times 180° = 4 \times 180° = 720°$ agrees.

Why the other options are wrong:

- A, 540: is the value for a pentagon ($n = 5$).

Final Answer: $\sum = 720° \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – tangent length of a simple circular curve: $T = R\tan\frac{\Delta}{2}$, where Δ is the deflection angle.

Step 1 – list the data: $R = 200$ m, $\Delta = 60°$.

Step 2 – halve the deflection angle: $\frac{\Delta}{2} = \frac{60°}{2} = 30°$

Step 3 – evaluate the tangent: $\tan 30° = 0.5774$

Step 4 – multiply by the radius: $T = 200 \times 0.5774$

$T = 115.47$ m

Why the other options are wrong:

- C, 173.2: uses $\tan 60°$ instead of $\tan(\Delta/2) = \tan 30°$.

Final Answer: $T = 115.47$ m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – map scale (representative fraction): Ground distance = map distance $\times$ scale denominator.

Step 1 – read the representative fraction: $1 : 5000$ means 1 unit on the map equals 5000 units on the ground.

Step 2 – multiply the map length by the denominator: Ground distance = 8 cm $\times\ 5000 = 40000$ cm

Step 3 – convert to metres: 40000 cm $= \frac{40000}{100} = 400$ m

Why the other options are wrong:

- A, 40: divides by an extra factor of ten in the cm-to-m conversion.
- B, 4000: keeps the length in centimetres numerically as metres.

Final Answer: ground distance $= 400$ m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	D	5	D
6	B	7	C	8	A	9	C	10	C
11	A	12	B	13	D	14	A	15	C
16	B	17	D	18	B	19	B	20	C
21	B	22	C	23	A	24	B	25	B
26	C	27	A	28	A	29	D	30	A
31	A	32	D	33	B	34	A	35	D
36	D	37	B	38	C	39	C	40	D
41	B	42	D	43	A	44	C	45	A
46	C								