# GATE Civil Engineering

## Sample Paper – 1

**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 simply supported beam $AB$ of span $8$ m carries a single point load of $40$ kN acting at $2$ m from the support $A$. The vertical reaction developed at support $B$ is: **[1 mark]**

(A) $30$ kN

(B) $20$ kN

(C) $10$ kN

(D) $40$ kN

**Q2.** A steel bar of circular cross-section, diameter 20 mm, carries an axial tensile pull of 60 kN. The normal (axial) stress in the bar is nearest to: **[1 mark]**

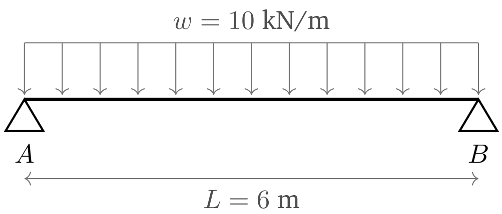
(A) 300 MPa

(B) 150 MPa

(C) 191 MPa

(D) 95.5 MPa

**Q3.** A simply supported beam of span 6 m carries a uniformly distributed load of 10 kN/m over its entire length, as shown. The maximum bending moment in the beam is: **[1 mark]**



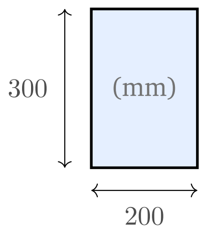

(A) 45 kN·m

(B) 30 kN·m

(C) 90 kN·m

(D) 22.5 kN·m

**Q4.** A beam has the solid rectangular cross-section shown below (width 200 mm, depth 300 mm). At a section the bending moment is 60 kN·m. The maximum bending (flexural) stress at that section is: **[1 mark]**




(A) 5 MPa

(B) 10 MPa

(C) 40 MPa

(D) 20 MPa

**Q5.** A beam of solid rectangular section 100 mm wide and 150 mm deep carries a transverse shear force of 90 kN at a section. The maximum shear stress at that section is: **[1 mark]**

(A) 6 MPa

(B) 4.5 MPa

(C) 9 MPa

(D) 12 MPa

**Q6.** A solid circular shaft of diameter $D$ transmits a torque $T$. The maximum torsional shear stress developed on the outer surface of the shaft is: **[1 mark]**

(A) $\dfrac{32T}{\pi D^3}$

(B) $\dfrac{16T}{\pi D^4}$

(C) $\dfrac{16T}{\pi D^3}$

(D) $\dfrac{64T}{\pi D^3}$

**Q7.** A simply supported beam of span $L$, flexural rigidity $EI$, carries a single concentrated load $W$ at midspan. The maximum vertical deflection of the beam is: **[1 mark]**

(A) $\dfrac{WL^3}{48EI}$

(B) $\dfrac{WL^3}{3EI}$

(C) $\dfrac{5wL^4}{384EI}$

(D) $\dfrac{WL^3}{192EI}$

**Q8.** A straight column is fixed (restrained against rotation and translation) at both of its ends. For use in the Euler buckling formula, the effective length of this column is: **[1 mark]**

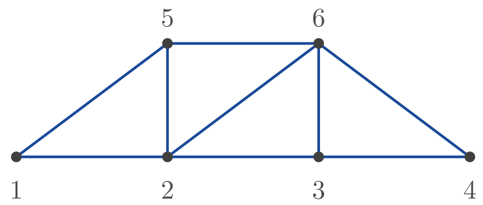
(A) $0.5\,L$

(B) $1.0\,L$

(C) $2.0\,L$

(D) $0.707\,L$

**Q9.** The plane truss shown below has $6$ joints. For the truss to be a *perfect* (just-rigid, statically determinate) truss, the number of members it must contain is: **[1 mark]**




(A) $12$

(B) $9$

(C) $6$

(D) $15$

**Q10.** For a simply supported beam $AB$ of span $L$, the influence line for the vertical reaction at support $A$ is a straight line. Its maximum ordinate (which occurs when the unit load stands directly over $A$) is: **[1 mark]**

(A) $0.5$

(B) $L$

(C) $L/2$

(D) $1.0$

**Q11.** At a rigid joint of a frame, two members meet. Their relative rotational stiffnesses at the joint are in the ratio $3 : 1$. In the moment-distribution method, the distribution factor for the *stiffer* of the two members is: **[1 mark]**

(A) 0.25

(B) 0.75

(C) 0.50

(D) 1.00

**Q12.** In the limit state design of reinforced concrete to IS 456:2000, the limiting ratio of the depth of the neutral axis to the effective depth, $x_{u,\max}/d$, for a section reinforced with **Fe415** steel is: **[1 mark]**

(A) 0.48

(B) 0.46

(C) 0.53

(D) 0.42

**Q13.** As per the limit state method of IS 800:2007 for steel structures, the partial safety factor for the yield/buckling resistance of a member governed by yielding, $\gamma_{m0}$, is: **[1 mark]**

(A) 1.25

(B) 1.10

(C) 1.15

(D) 1.50

**Q14.** In a PERT network, an activity has an optimistic time $t_o = 3$ days, a most-likely time $t_m = 6$ days and a pessimistic time $t_p = 15$ days. The expected duration of the activity is: **[1 mark]**

(A) 7 days

(B) 6 days

(C) 8 days

(D) 9 days

## Geotechnical Engineering

**Q15.** A soil has a void ratio of $0.60$. The corresponding porosity of the soil is: **[1 mark]**

(A) $37.5\%$

(B) $60.0\%$

(C) $40.0\%$

(D) $62.5\%$

**Q16.** A fine-grained soil has a liquid limit of $45\%$ and a plastic limit of $25\%$. Its plasticity index is: **[1 mark]**

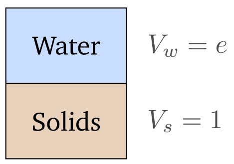
(A) $70\%$

(B) $45\%$

(C) $25\%$

(D) $20\%$

**Q17.** A fully saturated soil sample has a water content of $30\%$ and a specific gravity of solids of $2.70$. Using the two-phase (solids + water) diagram shown, the void ratio of the sample is: **[1 mark]**




(A) $0.81$

(B) $0.30$

(C) $2.70$

(D) $0.11$

**Q18.** A homogeneous soil deposit has its water table at the ground surface and a saturated unit weight of $19$ kN/m$^3$. The effective vertical stress at a depth of $5$ m below the surface is nearest to: **[1 mark]**

(A) $95.0\ \text{kN/m}^2$

(B) $90.0\ \text{kN/m}^2$

(C) $49.05\ \text{kN/m}^2$

(D) $45.95\ \text{kN/m}^2$

**Q19.** Water seeps through a soil of porosity $0.40$. At a section the discharge (Darcy) velocity is $2$ mm/s. The seepage (actual) velocity of water through the voids is: **[1 mark]**

(A) $0.8$ mm/s

(B) $2.0$ mm/s

(C) $8.0$ mm/s

(D) $5.0$ mm/s

**Q20.** In a laboratory compaction (Proctor) test on a given soil, the compactive effort is increased from the standard to the modified level. Compared with the standard test, the modified test generally gives: **[1 mark]**

(A) a lower optimum moisture content and a higher maximum dry density

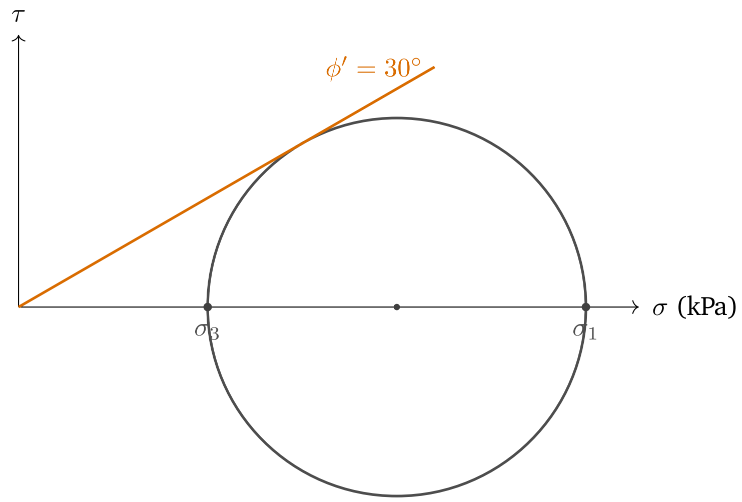
(B) a higher optimum moisture content and a higher maximum dry density

(C) a lower optimum moisture content and a lower maximum dry density

(D) a higher optimum moisture content and a lower maximum dry density

## Geotechnical Engineering (continued)

**Q21.** A consolidated-drained triaxial test is carried out on a cohesionless soil with effective cohesion $c' = 0$ and effective friction angle $\phi' = 30°$. The cell (confining) pressure is $\sigma_3 = 100$ kPa. Using the Mohr–Coulomb failure geometry shown, the major principal stress at failure, $\sigma_1$, is: **[2 marks]**



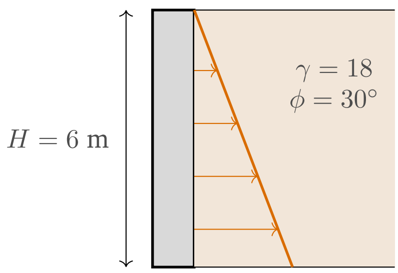

(A) 200 kPa

(B) 100 kPa

(C) 300 kPa

(D) 173 kPa

**Q22.** A vertical retaining wall 6 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 active earth thrust per metre run of the wall is: **[2 marks]**




(A) 216 kN/m

(B) 54 kN/m

(C) 108 kN/m

(D) 324 kN/m

**Q23.** A long strip footing rests at the ground surface on a saturated clay under undrained ($\phi_u = 0$) conditions with undrained cohesion $c_u = 50$ kPa. Using Terzaghi's bearing-capacity theory with $N_c = 5.7$ (and $N_q = 1$,

$N_\gamma = 0$ for $\phi = 0$), the ultimate bearing capacity of the footing is: **[2 marks]**

(A) 570 kPa

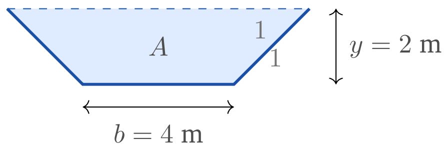
(B) 285 kPa

(C) 142.5 kPa

(D) 250 kPa

## Water Resources Engineering

**Q24.** A trapezoidal channel has a bottom width of 4 m and side slopes of 1 horizontal to 1 vertical, and carries water at a depth of 2 m, as shown. The cross-sectional area of flow is: **[2 marks]**




(A) 8 $m^2$

(B) 16 $m^2$

(C) 12 $m^2$

(D) 10 $m^2$

**Q25.** A vertical rectangular gate 2 m wide and 3 m deep has its top edge coinciding with the free surface of water on one side. The total hydrostatic force acting on the gate is nearest to: **[2 marks]**

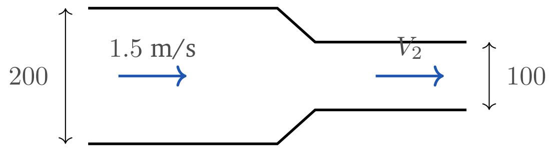
(A) 88.29 kN

(B) 176.58 kN

(C) 44.15 kN

(D) 58.86 kN

**Q26.** Water flows steadily through a pipe that contracts from a diameter of 200 mm to a diameter of 100 mm, as shown. The mean velocity in the 200 mm section is 1.5 m/s. By continuity, the mean velocity in the 100 mm section is: **[2 marks]**




(A) 3.0 m/s

(B) 1.5 m/s

(C) 0.375 m/s

(D) 6.0 m/s

**Q27.** Water flows through a straight pipeline of length 500 m and diameter 0.30 m at a mean velocity of 2 m/s. Taking the Darcy–Weisbach friction factor $f = 0.02$, the head loss due to friction is nearest to: [2 marks]

(A) 3.4 m

(B) 6.8 m

(C) 13.6 m

(D) 1.7 m

**Q28.** A rectangular channel 3 m wide carries a steady discharge of 12 $m^3/s$. The critical depth of flow in the channel is nearest to: [2 marks]

(A) 0.79 m

(B) 1.18 m

(C) 1.63 m

(D) 2.00 m

**Q29.** A horizontal jet of water of diameter 50 mm moving at 20 m/s strikes a large stationary flat plate normal to the jet. The force exerted by the jet on the plate is nearest to (take $\rho_w = 1000$ kg/$m^3$): [2 marks]

(A) 39.3 N

(B) 1570.8 N

(C) 392.7 N

(D) 785.4 N

**Q30.** A catchment of area 2 km$^2$ has a runoff coefficient of 0.60. For a design rainfall intensity of 50 mm/hr, the peak runoff estimated by the rational method $(Q = CiA/3.6)$ is: **[2 marks]**

(A) 60.0 m$^3$/s

(B) 6.0 m$^3$/s

(C) 30.0 m$^3$/s

(D) 16.67 m$^3$/s

**Q31.** A 4-hour unit hydrograph of a catchment has a peak discharge of 40 m$^3$/s. A 4-hour storm produces 3 cm of effective (excess) rainfall over the catchment. Assuming a negligible base flow, the peak of the resulting direct-runoff hydrograph is: **[2 marks]**

(A) 120 m$^3$/s

(B) 40 m$^3$/s

(C) 13.3 m$^3$/s

(D) 160 m$^3$/s

**Q32.** For a certain crop, the duty of irrigation water at the field is 1728 hectares per cumec and the base period is 120 days. The corresponding delta (total depth of water) for the crop is: **[2 marks]**

(A) 120 cm

(B) 60 cm

(C) 86.4 cm

(D) 100 cm

**Q33.** A crop requires a total depth of water (delta) of 80 cm applied over a base period of 100 days. The duty of irrigation water for this crop is: **[2 marks]**

(A) 8640 ha/cumec

(B) 640 ha/cumec

(C) 108 ha/cumec

(D) 1080 ha/cumec

**Q34.** The return period of a particular flood magnitude is 25 years. The probability that a flood of this magnitude (or greater) occurs in any one given year is: **[2 marks]**

(A) 25

(B) 0.25

(C) 0.04

(D) 0.40

## Environmental Engineering

**Q35.** A wastewater sample has an ultimate (first-stage) BOD of 300 mg/L. The deoxygenation rate constant is $k_D = 0.10$ day$^{-1}$ (to base 10). Using $\text{BOD}_t = L_0(1 - 10^{-k_D t})$, the 5-day BOD of the sample is nearest to: **[2 marks]**

(A) 300 mg/L

(B) 205 mg/L

(C) 95 mg/L

(D) 150 mg/L

**Q36.** A circular primary sedimentation tank of diameter 20 m treats a flow of 4000 $m^3$/day. The surface overflow rate (surface loading rate) of the tank is nearest to: **[2 marks]**

(A) 200 $m^3/m^2$/day

(B) 12.73 $m^3/m^2$/day

(C) 25.46 $m^3/m^2$/day

(D) 6.37 $m^3/m^2$/day

**Q37.** A town has a population of $50{,}000$. The rate of sewage generation is taken as $135$ litres per capita per day. The average daily sewage flow from the town is: **[2 marks]**

(A) $6.75$ m$^3$/day

(B) $675$ m$^3$/day

(C) $6750$ m$^3$/day

(D) $67500$ m$^3$/day

**Q38.** At a place, the observed environmental lapse rate is *greater* in magnitude than the dry adiabatic lapse rate (that is, temperature falls with height faster than the adiabatic rate). With respect to the dispersion of air pollutants, such an atmosphere is said to be: **[2 marks]**

(A) stable (weak dispersion)

(B) neutral

(C) unstable (superadiabatic, strong dispersion)

(D) under a temperature inversion

**Q39.** A city generates $500$ tonnes per day of municipal solid waste. The average compacted density of the waste in the collection vehicles is $400$ kg/m$^3$. The daily volume of waste to be transported is: **[2 marks]**

(A) $200000$ m$^3$/day

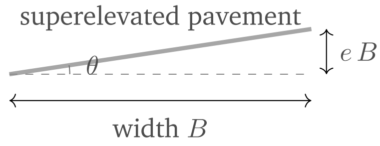
(B) $2000$ m$^3$/day

(C) $125$ m$^3$/day

(D) $1250$ m$^3$/day

## Transportation & Geomatics Engineering

**Q40.** A horizontal highway curve of radius $250$ m is designed for a speed of $80$ km/h. The pavement cross-section is superelevated as shown. The sum of the superelevation and the side-friction factor $(e + f)$ required to balance the centrifugal effect, using $e + f = V^2/(127R)$, is: **[2 marks]**




(A) 0.10

(B) 0.20

(C) 0.40

(D) 0.05

**Q41.** A vehicle travels at a design speed of $54$ km/h on a level road. The driver's reaction (perception–brake) time is $2.5$ s and the longitudinal friction coefficient is $0.35$ (take $g = 9.81$ m/s$^2$). The stopping sight distance required is nearest to: **[2 marks]**

(A) $37.5$ m

(B) $32.8$ m

(C) $108$ m

(D) $70.3$ m

**Q42.** A traffic stream is described by Greenshields' linear speed–density model with a free-flow speed of $60$ km/h and a jam density of $120$ veh/km. The maximum flow (capacity) of the stream is: **[2 marks]**

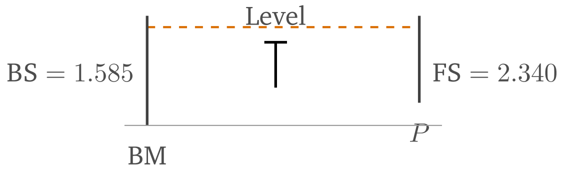
(A) $1800$ veh/hr

(B) $7200$ veh/hr

(C) $3600$ veh/hr

(D) $900$ veh/hr

**Q43.** In differential levelling, a level is set up between a benchmark and a point $P$, as shown. The reduced level of the benchmark is $100.000$ m, the back sight reading on it is $1.585$ m, and the fore sight reading on $P$ is $2.340$ m. The reduced level of $P$ is: **[2 marks]**



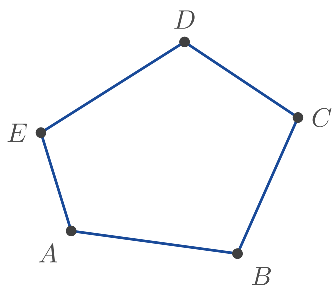

(A) 99.245 m

(B) 100.755 m

(C) 103.925 m

(D) 98.075 m

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




(A) $360^\circ$

(B) $540^\circ$

(C) $720^\circ$

(D) $900^\circ$

**Q45.** A simple circular curve of radius $300$ m has a deflection (intersection) angle of $60^\circ$. The length of the circular curve is nearest to: **[2 marks]**

(A) $300$ m

(B) $600$ m

(C) $314.16$ m

(D) $157.08$ m

**Q46.** A tacheometer with a multiplying (stadia) constant of $100$ and an additive constant of $0$ is used with the line of sight horizontal and the staff held vertical. The observed staff intercept is $1.250$ m. The horizontal distance from the instrument to the staff is: **[2 marks]**

(A) $12.5$ m

(B) $125$ m

(C) $1250$ m

(D) $250$ m

# Detailed Solutions

## Q1.

**Solution**

**Concept – take moments about a support to find the far reaction:** For a beam under a single point load, the reaction at a support equals the load times the distance of the load from the *other* support, divided by the span.

**Step 1 – list the data:** Span $L = 8$ m, load $W = 40$ kN acting at $a = 2$ m from $A$.

**Step 2 – take moments about $A$ (clockwise positive):** $R_B \times 8 = 40 \times 2$

**Step 3 – solve for $R_B$:** $R_B = \dfrac{40 \times 2}{8}$

$R_B = \dfrac{80}{8}$

$R_B = 10$ kN

**Step 4 – check with vertical equilibrium:** $R_A = 40 - 10 = 30$ kN, and the load lies nearer to $A$, so $A$ should carry more. It does, which confirms the result.

**Final Answer:** $R_B = 10$ kN $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

## Q2.

**Solution**

**Concept – axial stress is load divided by cross-sectional area:** $\sigma = P/A$, with $A$ the area of the circular section.

**Step 1 – compute the area of the section:** $A = \dfrac{\pi}{4}d^2 = \dfrac{\pi}{4}(20)^2$

$A = \dfrac{\pi}{4} \times 400$

$A = 314.16 \text{ mm}^2$

**Step 2 – convert the load to newtons:** $P = 60$ kN $= 60000$ N

**Step 3 – compute the stress:** $\sigma = \dfrac{P}{A} = \dfrac{60000}{314.16}$

$\sigma = 190.99 \text{ N/mm}^2$

$\sigma \approx 191$ MPa

**Final Answer:** $\sigma \approx 191$ MPa $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

## Q3.

**Solution**

**Concept – for a simply supported beam under a full-span UDL the maximum moment is at midspan:** $M_{\max} = \dfrac{wL^2}{8}$.

**Step 1 – list the data:** $w = 10$ kN/m, $L = 6$ m.

**Step 2 – substitute into the formula:** $M_{\max} = \dfrac{10 \times 6^2}{8}$

**Step 3 – evaluate $L^2$:** $6^2 = 36$

**Step 4 – complete the arithmetic:** $M_{\max} = \dfrac{10 \times 36}{8} = \dfrac{360}{8}$

$M_{\max} = 45$ kN·m

**Step 5 – sanity check:** Total load $= 10 \times 6 = 60$ kN and each reaction is 30 kN. The midspan moment $= 30 \times 3 - 10 \times 3 \times 1.5 = 90 - 45 = 45$ kN·m, which agrees.

**Final Answer:** $M_{\max} = 45$ kN·m $\Rightarrow \boxed{\text{A}}$

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

## Q4.

**Solution**

**Concept – flexural stress is bending moment divided by section modulus:** $\sigma = M/Z$, where for a rectangle $Z = bd^2/6$.

**Step 1 – compute the section modulus:** $Z = \dfrac{b\,d^2}{6} = \dfrac{200 \times 300^2}{6}$

**Step 2 – evaluate $d^2$:** $300^2 = 90000$

**Step 3 – finish the section modulus:** $Z = \dfrac{200 \times 90000}{6} = \dfrac{18{,}000{,}000}{6}$

$Z = 3.0 \times 10^6$ mm$^3$

**Step 4 – convert the moment to N·mm:** $M = 60\ \text{kN} \cdot \text{m} = 60 \times 10^6\ \text{N} \cdot \text{mm}$

**Step 5 – compute the stress:** $\sigma = \dfrac{M}{Z} = \dfrac{60 \times 10^6}{3.0 \times 10^6}$

$\sigma = 20$ MPa

**Final Answer:** $\sigma = 20$ MPa $\Rightarrow \boxed{\text{D}}$

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

## Q5.

### Solution

**Concept – for a rectangular section the maximum shear stress is** $1.5$ **times the average:** The shear stress varies parabolically over the depth and peaks at the neutral axis, where $\tau_{\max} = 1.5\,\tau_{\text{avg}}$.

**Step 1 – compute the cross-sectional area:** $A = b \times d = 100 \times 150 = 15000\ \text{mm}^2$

**Step 2 – compute the average shear stress:** $\tau_{\text{avg}} = \dfrac{V}{A} = \dfrac{90000}{15000}$

$\tau_{\text{avg}} = 6\ \text{MPa}$

**Step 3 – apply the rectangular-section factor:** $\tau_{\max} = 1.5 \times \tau_{\text{avg}} = 1.5 \times 6$

$\tau_{\max} = 9\ \text{MPa}$

**Final Answer:** $\tau_{\max} = 9\ \text{MPa} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

## Q6.

### Solution

**Concept – torsion formula for a solid circular shaft:** $\dfrac{T}{J} = \dfrac{\tau}{r}$, so $\tau_{\max} = \dfrac{T\,r}{J}$ with $r = D/2$ and $J = \dfrac{\pi D^4}{32}$.

**Step 1 – write the polar moment of inertia:** $J = \dfrac{\pi D^4}{32}$

**Step 2 – put the radius at the surface:** $r = \dfrac{D}{2}$

**Step 3 – substitute into** $\tau_{\max} = Tr/J$**:** $\tau_{\max} = \dfrac{T \times \frac{D}{2}}{\frac{\pi D^4}{32}}$

**Step 4 – simplify:** $\tau_{\max} = T \times \dfrac{D}{2} \times \dfrac{32}{\pi D^4} = \dfrac{32\,T\,D}{2\,\pi D^4}$

$\tau_{\max} = \dfrac{16\,T}{\pi D^3}$

**Final Answer:** $\tau_{\max} = \dfrac{16T}{\pi D^3} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

## Q7.

**Solution**

**Concept – standard deflection result for a central point load:** For a simply supported beam with a concentrated load $W$ at midspan, the maximum deflection occurs at midspan.

**Step 1 – recall the standard formula:** $\delta_{\max} = \dfrac{WL^3}{48EI}$

**Step 2 – confirm the dependence:** The deflection grows with the cube of the span $L^3$ and falls with the flexural rigidity $EI$, which matches option A.

**Why the other options are wrong:**

- B, $WL^3/3EI$: is the tip deflection of a **cantilever** with an end load, not a simply supported beam.
- C, $5wL^4/384EI$: is the midspan deflection under a **uniformly distributed** load $w$, not a point load.
- D, $WL^3/192EI$: is the midspan deflection of a **fixed–fixed** beam under a central point load.

**Final Answer:** $\delta_{\max} = \dfrac{WL^3}{48EI} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q7

## Q8.

**Solution**

**Concept – effective length depends on the end restraints:** $L_e = k\,L$, where $k$ is the effective-length factor set by how the two ends are held.

**Step 1 – identify the end conditions:** Both ends are **fixed** (no rotation, no translation).

**Step 2 – recall the factor for fixed–fixed:** $k = 0.5$

**Step 3 – write the effective length:** $L_e = 0.5\,L$

**Why the other options are wrong:**

- B, $1.0L$: applies to a column **hinged at both ends.**
- C, $2.0L$: applies to a column **fixed at one end and free at the other** (a flagpole).
- D, $0.707L$: applies to a column **fixed at one end and hinged at the other.**

**Final Answer:** $L_e = 0.5L \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

## Q9.

### Solution

**Concept – perfect-truss (statical-determinacy) relation:** A plane truss is just-rigid when $m = 2j - 3$, where $m$ is the number of members and $j$ the number of joints.

**Step 1 – read the joint count:** $j = 6$.

**Step 2 – substitute into $m = 2j - 3$:** $m = 2(6) - 3$

**Step 3 – evaluate:** $m = 12 - 3 = 9$

**Step 4 – confirm against the figure:** Counting the members drawn (three in the bottom chord, one in the top chord, and five inclined/vertical web members) gives $3 + 1 + 5 = 9$, which matches.

**Why the other options are wrong:**

- A, $12$: uses $2j = 12$ and forgets to subtract the $3$ for the reactions/rigid-body constraints; the truss would then be redundant.
- C, $6$: is fewer members than needed; the frame would be a mechanism (deficient).
- D, $15$: badly over-counts and would make the truss internally indeterminate.

**Final Answer:** $m = 9 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

## Q10.

### Solution

**Concept – influence line for a support reaction:** For a reaction, the influence-line ordinate is the reaction produced by a *unit* moving load; it is dimensionless.

**Step 1 – place the unit load over $A$:** When the unit load sits directly over support $A$, the entire load is carried by $A$.

**Step 2 – find the reaction there:** $R_A = 1$ (the whole unit load), so the ordinate is $1.0$.

**Step 3 – place the unit load over $B$:** Then $R_A = 0$, so the influence line falls linearly from $1.0$ at $A$ to $0$ at $B$.

**Step 4 – identify the maximum:** The largest ordinate is at $A$ and equals $1.0$ (a pure number, not a length).

**Why the other options are wrong:**

- A, $0.5$: is the ordinate at midspan, not the maximum.
- B, $L$ and C, $L/2$: are lengths; a reaction influence line is dimensionless and cannot have units of length.

**Final Answer:** maximum ordinate $= 1.0 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q10

## Q11.

### Solution

**Concept – distribution factor is a member's share of the joint stiffness:** $\text{DF}_i = \dfrac{k_i}{\sum k}$, where $k_i$ is the stiffness of member $i$ at the joint.

**Step 1 – assign the stiffnesses:** Ratio $3:1$, so take $k_1 = 3$ (stiffer) and $k_2 = 1$.

**Step 2 – sum the stiffnesses at the joint:** $\sum k = 3 + 1 = 4$

**Step 3 – distribution factor of the stiffer member:** $\text{DF}_1 = \dfrac{3}{4} = 0.75$

**Step 4 – check the total:** $\text{DF}_2 = \dfrac{1}{4} = 0.25$, and $0.75 + 0.25 = 1.00$, as the distribution factors at a joint must sum to unity.

**Final Answer:** $\text{DF} = 0.75 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q11

## Q12.

### Solution

**Concept – limiting neutral-axis depth in RCC limit-state design:** The value of $x_{u,\max}/d$ is fixed by the grade of steel because it is set by the strain compatibility at the balanced (limiting) condition.

**Step 1 – recall the IS 456 values:** $x_{u,\max}/d = 0.53$ for Fe250, $0.48$ for Fe415, and $0.46$ for Fe500.

**Step 2 – pick the value for the stated grade:** For **Fe415**, $x_{u,\max}/d = 0.48$.

**Why the other options are wrong:**

- B, $0.46$: is the value for **Fe500**.
- C, $0.53$: is the value for **Fe250** (mild steel).

- D, $0.42$: does not correspond to any standard grade in IS 456.

**Final Answer:** $x_{u,\max}/d = 0.48 \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q12

## Q13.

**Solution**

**Concept – partial safety factors for steel in IS 800:2007:** Different failure modes carry different $\gamma_m$ values; yielding of the gross section uses $\gamma_{m0}$.

**Step 1 – recall the standard value:** For resistance governed by yielding, $\gamma_{m0} = 1.10$.

**Step 2 – distinguish it from the others:** The factor for resistance governed by *ultimate stress* (for example net-section rupture or bolt/weld failure) is $\gamma_{m1} = 1.25$, which is a different case.

**Why the other options are wrong:**

- A, $1.25$: is $\gamma_{m1}$, used for rupture at the ultimate stress, not for yielding.
- C, $1.15$: is the partial safety factor for reinforcing steel in RCC (IS 456), not for structural steel.
- D, $1.50$: is the partial safety factor for concrete in RCC, not for steel.

**Final Answer:** $\gamma_{m0} = 1.10 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q13

## Q14.

**Solution**

**Concept – PERT expected time uses a weighted (beta-distribution) average:** $t_e = \dfrac{t_o + 4t_m + t_p}{6}$.

**Step 1 – list the three time estimates:** $t_o = 3$, $t_m = 6$, $t_p = 15$ days.

**Step 2 – form the weighted sum in the numerator:** $t_o + 4t_m + t_p = 3 + 4(6) + 15$

$= 3 + 24 + 15$

$= 42$

**Step 3 – divide by** $6$**:** $t_e = \dfrac{42}{6}$

$t_e = 7$ days

**Final Answer:** $t_e = 7$ days $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q14

## Q15.

### Solution

**Concept – porosity from void ratio:** $n = \dfrac{e}{1+e}$, since $n$ is voids per total volume and $e$ is voids per solids.

**Step 1 – list the data:** $e = 0.60$.

**Step 2 – substitute:** $n = \dfrac{0.60}{1+0.60}$

**Step 3 – evaluate the denominator:** $1 + 0.60 = 1.60$

**Step 4 – divide:** $n = \dfrac{0.60}{1.60} = 0.375$

$n = 37.5\%$

**Final Answer:** $n = 37.5\% \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q15

## Q16.

### Solution

**Concept – plasticity index is the width of the plastic range:** $I_p = \text{LL} - \text{PL}$.

**Step 1 – list the limits:** $\text{LL} = 45\%$, $\text{PL} = 25\%$.

**Step 2 – subtract:** $I_p = 45 - 25$

$I_p = 20\%$

**Final Answer:** $I_p = 20\% \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q16

## Q17.

### Solution

**Concept – the basic weight–volume identity:** $S\,e = w\,G$, where $S$ is the degree of saturation, $e$ the void ratio, $w$ the water content and $G$ the specific gravity of solids.

**Step 1 – set the saturation:** The sample is fully saturated, so $S = 1$.

**Step 2 – reduce the identity:** $e = \dfrac{w\,G}{S} = w\,G$ (with $S = 1$).

**Step 3 – substitute the values:** $e = 0.30 \times 2.70$

**Step 4 – evaluate:** $e = 0.81$

**Step 5 – read the two-phase diagram as a check:** Taking $V_s = 1$, the mass of solids is $G = 2.70$; the mass of water is $w \times 2.70 = 0.81$, which (at unit water density) is also its volume $V_w = 0.81 = e$. Consistent.

**Final Answer:** $e = 0.81 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

## Q18.

### Solution

**Concept – effective stress is total stress minus pore pressure:** $\sigma' = \sigma - u$. With the water table at the surface, the effective unit weight is the submerged unit weight $\gamma' = \gamma_{sat} - \gamma_w$.

**Step 1 – compute the submerged unit weight:** $\gamma' = \gamma_{sat} - \gamma_w = 19 - 9.81$

$\gamma' = 9.19\ \text{kN/m}^3$

**Step 2 – multiply by depth:** $\sigma' = \gamma' \times z = 9.19 \times 5$

$\sigma' = 45.95\ \text{kN/m}^2$

**Step 3 – cross-check with $\sigma - u$:** Total stress $\sigma = 19 \times 5 = 95$ kPa; pore pressure $u = 9.81 \times 5 = 49.05$ kPa; so $\sigma' = 95 - 49.05 = 45.95$ kPa. It agrees.

**Why the other options are wrong:**

- A, $95$: is the **total** vertical stress, not the effective stress.
- C, $49.05$: is the **pore water pressure**, not the effective stress.

**Final Answer:** $\sigma' = 45.95\ \text{kN/m}^2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q18

## Q19.

### Solution

**Concept – seepage velocity flows only through the void area:** The Darcy (discharge) velocity is defined over the whole area, but water actually moves only through the pores, so $v_s = v/n$.

**Step 1 – list the data:** Discharge velocity $v = 2$ mm/s, porosity $n = 0.40$.

**Step 2 – apply the relation:** $v_s = \dfrac{v}{n} = \dfrac{2}{0.40}$

**Step 3 – evaluate:** $v_s = 5$ mm/s

**Step 4 – note the direction of the inequality:** Since $n < 1$, the seepage velocity is always *larger* than the discharge velocity, which agrees with $5 > 2$.

**Why the other options are wrong:**

- A, $0.8$: multiplies by $n$ instead of dividing, giving a value smaller than $v$, which is physically impossible here.
- B, 2: is the discharge velocity itself, ignoring the porosity correction.

**Final Answer:** $v_s = 5$ mm/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

## Q20.

### Solution

**Concept – effect of compactive effort on the compaction curve:** Increasing the compactive energy pushes the whole compaction curve up and to the left.

**Step 1 – effect on maximum dry density:** More energy packs the grains more tightly, so the **maximum dry density increases**.

**Step 2 – effect on optimum moisture content:** Because the soil can now reach a denser state with less lubricating water, the **optimum moisture content decreases**.

**Step 3 – combine:** Higher MDD together with lower OMC, which is option A.

**Why the other options are wrong:**

- B, both increase: gets the density right but the OMC wrong; OMC falls, it does not rise.
- C, both decrease: gets the OMC right but wrongly lowers the density; more effort cannot reduce the peak density.
- D, OMC up and MDD down: reverses both trends and describes a *reduction* in compactive effort.

**Final Answer:** lower OMC, higher MDD $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

## Q21.

**Solution**

**Concept – Mohr–Coulomb failure relation for principal stresses:** For $c' = 0$, $\sigma_1 = \sigma_3 \tan^2\left(45^\circ + \dfrac{\phi'}{2}\right)$, where the bracket term $\tan^2(45 + \phi/2)$ is the flow factor.

**Step 1 – form the angle inside the tangent:** $45^\circ + \dfrac{\phi'}{2} = 45^\circ + \dfrac{30^\circ}{2} = 45^\circ + 15^\circ = 60^\circ$

**Step 2 – evaluate the tangent:** $\tan 60^\circ = \sqrt{3} = 1.732$

**Step 3 – square it:** $\tan^2 60^\circ = (\sqrt{3})^2 = 3$

**Step 4 – multiply by the confining pressure:** $\sigma_1 = 100 \times 3$

$\sigma_1 = 300$ kPa

**Step 5 – check with the Mohr circle:** The circle has centre $\frac{\sigma_1+\sigma_3}{2} = 200$ kPa and radius $\frac{\sigma_1-\sigma_3}{2} = 100$ kPa. Then $\sin\phi' = \frac{100}{200} = 0.5$, giving $\phi' = 30^\circ$, exactly as specified. Consistent.

**Final Answer:** $\sigma_1 = 300$ kPa $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q21

## Q22.

**Solution**

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

**Step 1 – compute the active earth-pressure coefficient:** $K_a = \dfrac{1 - \sin 30^\circ}{1 + \sin 30^\circ} = \dfrac{1 - 0.5}{1 + 0.5}$

$$K_a = \frac{0.5}{1.5} = \frac{1}{3}$$

**Step 2 – evaluate $H^2$:** $H^2 = 6^2 = 36$ m$^2$

**Step 3 – substitute into the thrust formula:** $P_a = \frac{1}{2} \times \frac{1}{3} \times 18 \times 36$

**Step 4 – simplify step by step:** $\frac{1}{3} \times 18 = 6$

$P_a = \frac{1}{2} \times 6 \times 36$

$P_a = \frac{1}{2} \times 216$

$P_a = 108$ kN/m

**Final Answer:** $P_a = 108$ kN/m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

## Q23.

### Solution

**Concept – Terzaghi bearing capacity for a strip footing:** $q_u = cN_c + \gamma D_f N_q + 0.5\,\gamma B N_\gamma$. For a saturated clay under undrained conditions, $\phi = 0$, so $N_q = 1$ and $N_\gamma = 0$.

**Step 1 – drop the vanishing terms:** The footing is at the surface, so $D_f = 0$, which kills the $\gamma D_f N_q$ term; and $N_\gamma = 0$ kills the last term.

**Step 2 – what remains:** $q_u = c\,N_c$

**Step 3 – substitute the values:** $q_u = 50 \times 5.7$

**Step 4 – evaluate:** $q_u = 285$ kPa

**Why the other options are wrong:**

- A, $570$: doubles the correct value, as if $N_c = 11.4$.
- C, $142.5$: halves the correct value.

**Final Answer:** $q_u = 285$ kPa $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** **Go Back to Q23**

## Q24.

### Solution

**Concept – area of a trapezoidal channel section:** $A = (b + my)\,y$, where $b$ is the bottom width, $y$ the depth and $m$ the side slope (horizontal per vertical).

**Step 1 – list the data:** $b = 4$ m, $y = 2$ m, side slope $1 : 1$ so $m = 1$.

**Step 2 – compute the term $my$:** $my = 1 \times 2 = 2$

**Step 3 – form $(b + my)$:** $b + my = 4 + 2 = 6$

**Step 4 – multiply by the depth:** $A = 6 \times 2$

$A = 12$ m$^2$

**Step 5 – check geometrically:** The section is a rectangle $4 \times 2 = 8$ m$^2$ plus two side triangles each $\frac{1}{2}(2)(2) = 2$ m$^2$, giving $8 + 2 + 2 = 12$ m$^2$. Consistent.

**Final Answer:** $A = 12$ m$^2$ $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** **Go Back to Q24**

## Q25.

**Solution**

**Concept – total hydrostatic force on a plane surface:** $F = \gamma_w \bar{h} A$, where $\bar{h}$ is the depth of the centroid of the surface below the free surface.

**Step 1 – locate the centroid depth:** The gate is 3 m deep with its top at the surface, so the centroid is at $\bar{h} = 3/2 = 1.5$ m.

**Step 2 – compute the area:** $A = 2 \times 3 = 6 \text{ m}^2$

**Step 3 – substitute into the force equation:** $F = 9.81 \times 1.5 \times 6$

**Step 4 – multiply in steps:** $9.81 \times 1.5 = 14.715$

$F = 14.715 \times 6$

$F = 88.29$ kN

**Final Answer:** $F = 88.29 \text{ kN} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

## Q26.

**Solution**

**Concept – continuity for incompressible flow:** $A_1V_1 = A_2V_2$, so $V_2 = V_1(A_1/A_2) = V_1(D_1/D_2)^2$ for circular sections.

**Step 1 – form the diameter ratio:** $\dfrac{D_1}{D_2} = \dfrac{200}{100} = 2$

**Step 2 – square it (area ratio):** $\left(\dfrac{D_1}{D_2}\right)^2 = 2^2 = 4$

**Step 3 – multiply by the upstream velocity:** $V_2 = V_1 \times 4 = 1.5 \times 4$

$V_2 = 6$ m/s

**Step 4 – sanity check:** Halving the diameter quarters the area, so the velocity must rise fourfold. $1.5 \to 6$ m/s is exactly fourfold. Consistent.

**Final Answer:** $V_2 = 6 \text{ m/s} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

## Q27.

### Solution

**Concept – Darcy–Weisbach head loss:** $h_f = \dfrac{fLV^2}{2gD}$.

**Step 1 – list the data:** $f = 0.02,\ L = 500\ \text{m},\ V = 2\ \text{m/s},\ D = 0.30\ \text{m},\ g = 9.81\ \text{m/s}^2$.

**Step 2 – compute the numerator:** $fLV^2 = 0.02 \times 500 \times 2^2$

$= 0.02 \times 500 \times 4$

$= 40$

**Step 3 – compute the denominator:** $2gD = 2 \times 9.81 \times 0.30$

$= 5.886$

**Step 4 – divide:** $h_f = \dfrac{40}{5.886}$

$h_f = 6.79 \approx 6.8\ \text{m}$

**Final Answer:** $h_f \approx 6.8\ \text{m} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q27

## Q28.

### Solution

**Concept – critical depth in a rectangular channel:** $y_c = \left(\dfrac{q^2}{g}\right)^{1/3}$, where $q = Q/b$ is the discharge per unit width.

**Step 1 – compute the unit discharge:** $q = \dfrac{Q}{b} = \dfrac{12}{3} = 4\ \text{m}^2/\text{s}$

**Step 2 – form $q^2/g$:** $\dfrac{q^2}{g} = \dfrac{4^2}{9.81} = \dfrac{16}{9.81}$

$= 1.6310$

**Step 3 – take the cube root:** $y_c = (1.6310)^{1/3}$

$y_c = 1.177 \approx 1.18\ \text{m}$

**Step 4 – verify by cubing:** $1.177^3 \approx 1.63$, which recovers $q^2/g$. Consistent.

**Final Answer:** $y_c \approx 1.18\ \text{m} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q28

## Q29.

### Solution

**Concept – force of a jet striking a stationary normal plate:** $F = \rho A V^2$, the rate of change of the jet's momentum brought to rest in the direction of flow.

**Step 1 – compute the jet area:** $A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.05)^2$

$= \frac{\pi}{4} \times 0.0025$

$= 1.9635 \times 10^{-3}\ \text{m}^2$

**Step 2 – square the velocity:** $V^2 = 20^2 = 400\ \text{m}^2/\text{s}^2$

**Step 3 – substitute into $F = \rho AV^2$:** $F = 1000 \times 1.9635 \times 10^{-3} \times 400$

**Step 4 – multiply step by step:** $1000 \times 1.9635 \times 10^{-3} = 1.9635$

$F = 1.9635 \times 400$

$F = 785.4\ \text{N}$

**Final Answer:** $F = 785.4\ \text{N} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q29**

## Q30.

### Solution

**Concept – rational method for peak runoff:** $Q = \dfrac{C\,i\,A}{3.6}$, with $Q$ in m$^3$/s, $i$ in mm/hr and $A$ in km$^2$; the 3.6 converts the units.

**Step 1 – list the data:** $C = 0.60$, $i = 50$ mm/hr, $A = 2$ km$^2$.

**Step 2 – compute the numerator:** $C\,i\,A = 0.60 \times 50 \times 2$

$= 60$

**Step 3 – divide by 3.6:** $Q = \dfrac{60}{3.6}$

$Q = 16.67\ \text{m}^3/\text{s}$

**Final Answer:** $Q = 16.67\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q30**

## Q31.

### Solution

**Concept – linearity (proportionality) of the unit hydrograph:** A unit hydrograph is the direct-runoff response to $1$ cm of effective rainfall over its duration; runoff ordinates scale in proportion to the depth of excess rainfall.

**Step 1 – state the scaling factor:** Effective rainfall $= 3$ cm, so every ordinate is multiplied by $3$.

**Step 2 – scale the peak:** Peak $= 3 \times$ (unit-hydrograph peak) $= 3 \times 40$

**Step 3 – evaluate:** Peak $= 120\ \text{m}^3/\text{s}$

**Step 4 – note base flow:** Base flow is negligible, so the direct-runoff peak equals the total peak.

**Why the other options are wrong:**

- B, $40$: forgets to scale by the rainfall depth.
- C, $13.3$: *divides* by $3$ instead of multiplying.

**Final Answer:** peak $= 120\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q31

## Q32.

### Solution

**Concept – delta–duty relation:** $\Delta = \dfrac{8.64\,B}{D}$, with $\Delta$ in metres, base period $B$ in days and duty $D$ in ha/cumec.

**Step 1 – list the data:** $B = 120$ days, $D = 1728$ ha/cumec.

**Step 2 – compute the numerator:** $8.64 \times B = 8.64 \times 120 = 1036.8$

**Step 3 – divide by the duty:** $\Delta = \dfrac{1036.8}{1728}$

$\Delta = 0.60$ m

**Step 4 – convert to centimetres:** $\Delta = 0.60 \times 100 = 60$ cm

**Final Answer:** $\Delta = 60$ cm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

## Q33.

### Solution

**Concept – duty from delta and base period:** Rearranging $\Delta = \dfrac{8.64\,B}{D}$ gives $D = \dfrac{8.64\,B}{\Delta}$, with $\Delta$ in metres.

**Step 1 – convert delta to metres:** $\Delta = 80$ cm $= 0.80$ m.

**Step 2 – list the base period:** $B = 100$ days.

**Step 3 – compute the numerator:** $8.64 \times B = 8.64 \times 100 = 864$

**Step 4 – divide by delta:** $D = \dfrac{864}{0.80}$

$D = 1080$ ha/cumec

**Final Answer:** $D = 1080$ ha/cumec $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q33

## Q34.

### Solution

**Concept – return period and annual exceedance probability:** The probability that an event of return period $T$ is equalled or exceeded in any single year is $P = \dfrac{1}{T}$.

**Step 1 – list the return period:** $T = 25$ years.

**Step 2 – take the reciprocal:** $P = \dfrac{1}{25}$

**Step 3 – evaluate:** $P = 0.04$

**Step 4 – interpret:** There is a $4\%$ chance of this flood magnitude being reached or exceeded in any given year.

**Why the other options are wrong:**

- A, $25$: is the return period itself; a probability cannot exceed $1$.
- B, $0.25$: would be $1/4$, corresponding to a $4$-year return period, not $25$.

**Final Answer:** $P = 0.04 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q34

## Q35.

### Solution

**Concept – first-order BOD progression:** $\text{BOD}_t = L_0\left(1 - 10^{-k_D t}\right)$, where $L_0$ is the ultimate BOD and $k_D$ the base-10 rate constant.

**Step 1 – form the exponent:** $k_D\, t = 0.10 \times 5 = 0.5$

**Step 2 – evaluate the power of ten:** $10^{-0.5} = \dfrac{1}{\sqrt{10}} = 0.3162$

**Step 3 – form the bracket:** $1 - 0.3162 = 0.6838$

**Step 4 – multiply by the ultimate BOD:** $\text{BOD}_5 = 300 \times 0.6838$

$\text{BOD}_5 = 205.1 \approx 205$ mg/L

**Final Answer:** $\text{BOD}_5 \approx 205$ mg/L $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q35

## Q36.

### Solution

**Concept – surface overflow rate is flow per unit plan area:** $\text{SOR} = \dfrac{Q}{A_{\text{surface}}}$.

**Step 1 – compute the surface area of the circular tank:** $A = \dfrac{\pi}{4} D^2 = \dfrac{\pi}{4}(20)^2$

$= \dfrac{\pi}{4} \times 400$

$= 314.16 \text{ m}^2$

**Step 2 – divide the flow by the area:** $\text{SOR} = \dfrac{4000}{314.16}$

**Step 3 – evaluate:** $\text{SOR} = 12.73 \text{ m}^3/\text{m}^2/\text{day}$

**Final Answer:** $\text{SOR} = 12.73 \text{ m}^3/\text{m}^2/\text{day} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q36

## Q37.

### Solution

**Concept – total flow is per-capita rate times population:** $Q = q \times$ population, then convert litres to cubic metres.

**Step 1 – multiply the per-capita rate by the population:** $Q = 135 \times 50000$

$= 6{,}750{,}000$ litres/day

**Step 2 – convert litres to cubic metres ($1000$ L $= 1$ m$^3$):** $Q = \dfrac{6{,}750{,}000}{1000}$

$Q = 6750\ \text{m}^3/\text{day}$

**Why the other options are wrong:**

- A and B: misplace the decimal in the litres-to-$\text{m}^3$ conversion.
- D, $67500$: divides by $100$ instead of $1000$.

**Final Answer:** $Q = 6750\ \text{m}^3/\text{day} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q37

## Q38.

### Solution

**Concept – atmospheric stability from the lapse-rate comparison:** When the environmental lapse rate exceeds the dry adiabatic lapse rate (superadiabatic), a rising parcel stays warmer than its surroundings and keeps rising, so the atmosphere is *unstable*.

**Step 1 – compare the two lapse rates:** Environmental lapse rate $>$ dry adiabatic lapse rate (about $9.8$°C/km).

**Step 2 – reason about a displaced parcel:** A parcel lifted adiabatically cools at $9.8$°C/km, but the surrounding air cools faster, so the parcel is warmer, lighter and buoyant: it accelerates upward.

**Step 3 – classify:** This runaway vertical motion is the **unstable (superadiabatic)** condition, which gives strong mixing and good pollutant dispersion.

**Why the other options are wrong:**

- A, stable: needs the environmental lapse rate *less* than the adiabatic rate, the opposite of what is given.
- B, neutral: needs the two rates to be equal.
- D, inversion: needs temperature to *rise* with height, a strongly stable case, not this one.

**Final Answer:** unstable (superadiabatic) $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q38

## Q39.

### Solution

**Concept – volume is mass divided by density:** $V = \dfrac{M}{\rho}$, after making the mass and density units consistent.

**Step 1 – convert the daily mass to kilograms:** $M = 500 \text{ tonnes} = 500 \times 1000 = 500{,}000 \text{ kg}$

**Step 2 – divide by the compacted density:** $V = \dfrac{500000}{400}$

**Step 3 – evaluate:** $V = 1250 \text{ m}^3/\text{day}$

**Why the other options are wrong:**

- A, $200000$: multiplies mass by density instead of dividing.
- C, $125$: is off by a factor of ten in the tonne-to-kilogram conversion.

**Final Answer:** $V = 1250 \text{ m}^3/\text{day} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** **Go Back to Q39**

## Q40.

### Solution

**Concept – superelevation design equation:** $e + f = \dfrac{V^2}{127\,R}$, with $V$ in km/h and $R$ in m; the 127 absorbs the unit conversion in $V^2/(gR)$.

**Step 1 – list the data:** $V = 80$ km/h, $R = 250$ m.

**Step 2 – square the speed:** $V^2 = 80^2 = 6400$

**Step 3 – compute the denominator:** $127 \times R = 127 \times 250 = 31750$

**Step 4 – divide:** $e + f = \dfrac{6400}{31750}$

$e + f = 0.2016 \approx 0.20$

**Final Answer:** $e + f \approx 0.20 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** **Go Back to Q40**

## Q41.

**Solution**

**Concept – stopping sight distance is lag distance plus braking distance:** SSD $= v\,t + \dfrac{v^2}{2gf}$, with $v$ the speed in m/s.

**Step 1 – convert the speed to m/s:** $v = 54\text{ km/h} = \dfrac{54}{3.6} = 15\text{ m/s}$

**Step 2 – compute the lag (reaction) distance:** $v\,t = 15 \times 2.5 = 37.5\text{ m}$

**Step 3 – compute the braking distance:** $\dfrac{v^2}{2gf} = \dfrac{15^2}{2 \times 9.81 \times 0.35}$

Numerator: $15^2 = 225$

Denominator: $2 \times 9.81 \times 0.35 = 6.867$

$= \dfrac{225}{6.867} = 32.77\text{ m}$

**Step 4 – add the two parts:** SSD $= 37.5 + 32.77$

SSD $= 70.27 \approx 70.3\text{ m}$

**Final Answer:** SSD $\approx 70.3\text{ m} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** **Go Back to Q41**

## Q42.

**Solution**

**Concept – Greenshields' model gives capacity at half the free speed:** The maximum flow is $q_{\max} = \dfrac{v_f\,k_j}{4}$, occurring at $v = v_f/2$ and $k = k_j/2$.

**Step 1 – list the data:** Free speed $v_f = 60$ km/h, jam density $k_j = 120$ veh/km.

**Step 2 – multiply the two:** $v_f\,k_j = 60 \times 120 = 7200$

**Step 3 – divide by** $4$**:** $q_{\max} = \dfrac{7200}{4}$

$q_{\max} = 1800\text{ veh/hr}$

**Why the other options are wrong:**

- B, $7200$: is the product $v_f k_j$ without the factor $1/4$.
- C, $3600$: uses a factor of $1/2$ instead of $1/4$.

**Final Answer:** $q_{\max} = 1800\text{ veh/hr} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** **Go Back to Q42**

## Q43.

**Solution**

**Concept – height-of-instrument method of levelling:** $\text{HI} = \text{RL}_{\text{BM}} + \text{BS}$, and $\text{RL}_{\text{point}} = \text{HI} - \text{FS}$.

**Step 1 – compute the height of instrument:** $\text{HI} = 100.000 + 1.585$

$\text{HI} = 101.585$ m

**Step 2 – subtract the fore sight to get the RL of $P$:** $\text{RL}_P = 101.585 - 2.340$

$\text{RL}_P = 99.245$ m

**Step 3 – interpret:** The fore sight (2.340) is larger than the back sight (1.585), so $P$ is lower than the benchmark, and indeed $99.245 < 100.000$. Consistent.

**Why the other options are wrong:**

- B, 100.755: adds the fore sight instead of subtracting it.
- C, 103.925: adds both readings to the benchmark.

**Final Answer:** $\text{RL}_P = 99.245 \text{ m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q43

## Q44.

**Solution**

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

**Step 1 – count the sides:** The traverse is a pentagon, so $n = 5$.

**Step 2 – form $(2n - 4)$:** $2(5) - 4 = 10 - 4 = 6$

**Step 3 – multiply by $90°$:** $\sum = 6 \times 90°$

$\sum = 540°$

**Step 4 – cross-check:** The formula also reads $(n - 2) \times 180° = 3 \times 180° = 540°$, which agrees.

**Final Answer:** $\sum = 540° \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

## Q45.

**Solution**

**Concept – length of a circular curve from its radius and deflection angle:** $L = \dfrac{\pi R \Delta}{180^\circ}$, where $\Delta$ is the deflection (central) angle in degrees.

**Step 1 – list the data:** $R = 300$ m, $\Delta = 60^\circ$.

**Step 2 – substitute:** $L = \dfrac{\pi \times 300 \times 60}{180}$

**Step 3 – simplify the angle fraction:** $\dfrac{60}{180} = \dfrac{1}{3}$

$L = \pi \times 300 \times \dfrac{1}{3}$

**Step 4 – evaluate:** $L = \pi \times 100 = 314.16$ m

**Final Answer:** $L = 314.16 \text{ m} \Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q45

## Q46.

**Solution**

**Concept – tacheometric distance formula (horizontal sight, vertical staff):** $D = k\,s + c$, where $k$ is the multiplying constant, $s$ the staff intercept and $c$ the additive constant.

**Step 1 – list the data:** $k = 100$, $s = 1.250$ m, $c = 0$.

**Step 2 – substitute:** $D = 100 \times 1.250 + 0$

**Step 3 – evaluate:** $D = 125$ m

**Why the other options are wrong:**

- A, $12.5$: misplaces the decimal by a factor of ten.
- C, $1250$: over-scales by a factor of ten.

**Final Answer:** $D = 125 \text{ m} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q46

# Answer Key

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