# GATE Civil Engineering

## Sample Paper – 8

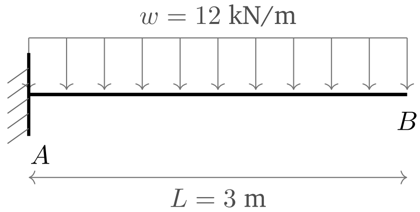
**Duration: 128 Minutes** **Maximum Marks: 72**

### 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 $AB$ is fixed at $A$ and free at $B$, with a span of 3 m. It carries a uniformly distributed load of 12 kN/m over its full length, as shown. The magnitude of the maximum bending moment (at the fixed end) is: **[1 mark]**



(A) $54$ kN·m

(B) $27$ kN·m

(C) $108$ kN·m

(D) $18$ kN·m

**Q2.** A straight steel bar of length $2$ m and cross-sectional area $500$ mm$^2$ carries an axial tensile load of $50$ kN. Taking the modulus of elasticity as $E = 200$ GPa, the axial elongation of the bar is: **[1 mark]**

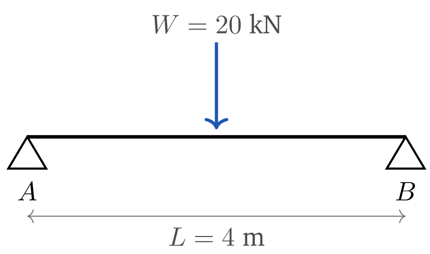
(A) $1.0$ mm

(B) $2.0$ mm

(C) $0.5$ mm

(D) $4.0$ mm

**Q3.** A simply supported beam of span $4$ m carries a single concentrated load of $20$ kN acting at its midspan, as shown. The maximum bending moment in the beam is: **[1 mark]**



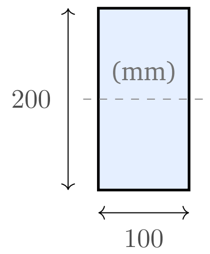

(A) $10$ kN·m

(B) $40$ kN·m

(C) $20$ kN·m

(D) $80$ kN·m

**Q4.** A solid rectangular cross-section is $100$ mm wide and $200$ mm deep, as shown. Its second moment of area (moment of inertia) about the centroidal axis parallel to the width is: **[1 mark]**




(A) $66.67 \times 10^6$ mm$^4$

(B) $33.33 \times 10^6$ mm$^4$

(C) $133.3 \times 10^6$ mm$^4$

(D) $6.667 \times 10^6$ mm$^4$

**Q5.** In the plastic analysis of beams, the shape factor of a cross-section is the ratio of its plastic moment capacity to its yield moment. For a solid rectangular cross-section this shape factor is: **[1 mark]**

(A) 1.70

(B) 1.00

(C) 1.12

(D) 1.50

**Q6.** A solid circular shaft of diameter 50 mm transmits a torque of 1.5 kN·m. The maximum torsional shear stress developed on the outer surface of the shaft is nearest to: **[1 mark]**

(A) 61.1 MPa

(B) 30.6 MPa

(C) 122.2 MPa

(D) 15.3 MPa

**Q7.** A cantilever beam of length $L$ and flexural rigidity $EI$ carries a single concentrated load $W$ at its free end. 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) $\dfrac{WL^3}{8EI}$

**Q8.** A straight column is fixed (restrained against rotation and translation) at one end and completely free at the other end, like a flagpole. For use in the Euler buckling formula, the effective length of this column is: **[1 mark]**

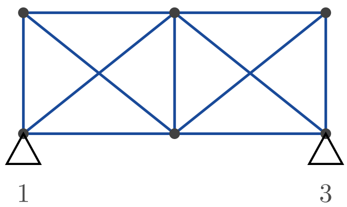
(A) $0.5\,L$

(B) $1.0\,L$

(C) $2.0\,L$

(D) $0.707\,L$

**Q9.** The plane truss shown below has $6$ joints and $11$ members, and is supported by a hinge and a roller (three reaction components in all). The degree of static indeterminacy of the truss is: **[1 mark]**




(A) $0$

(B) $1$

(C) $2$

(D) $3$

**Q10.** A propped cantilever beam is fixed at one end and simply supported (propped) at the other. Considering only the vertical reactions and the moment reaction, the degree of static indeterminacy of this beam is: **[1 mark]**

(A) 1

(B) 2

(C) 0

(D) 3

**Q11.** In the moment-distribution method applied to a prismatic member with the far end fixed, the fraction of a balancing moment applied at the near joint that is carried over to the fixed far end is: **[1 mark]**

(A) 0.25

(B) 0.50

(C) 1.00

(D) 0.75

**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 mild steel of grade **Fe250** is: **[1 mark]**

(A) 0.48

(B) 0.46

(C) 0.42

(D) 0.53

**Q13.** In the limit state design of reinforced concrete to IS 456:2000, the partial safety factor applied to the characteristic compressive strength of **concrete**, $\gamma_{mc}$, is: **[1 mark]**

(A) 1.50

(B) 1.15

(C) 1.10

(D) 1.25

**Q14.** In a PERT network, an activity has an optimistic time $t_o = 4$ days and a pessimistic time $t_p = 16$ days. The standard deviation of the activity duration is: **[1 mark]**

(A) 12 days

(B) 6 days

(C) 4 days

(D) 2 days

## Geotechnical Engineering

**Q15.** A soil has a porosity of $0.40$. The corresponding void ratio of the soil is: **[1 mark]**

(A) $0.40$

(B) $0.667$

(C) $0.60$

(D) $0.25$

**Q16.** A soil sample has a bulk (moist) unit weight of $20$ kN/m$^3$ at a water content of $25\%$. The dry unit weight of the soil is: **[1 mark]**

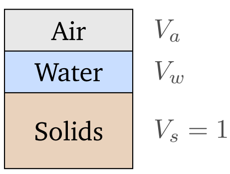
(A) $15$ kN/m$^3$

(B) $16$ kN/m$^3$

(C) $25$ kN/m$^3$

(D) $20$ kN/m$^3$

**Q17.** A partially saturated soil has a void ratio of $0.70$, a water content of $20\%$ and a specific gravity of solids of $2.70$. Using the three-phase (air–water–solids) diagram shown, the degree of saturation of the soil is nearest to: **[1 mark]**



(A) $54.0\%$

(B) $70.0\%$

(C) $77.1\%$

(D) $100.0\%$

**Q18.** A homogeneous dry sand deposit has a bulk unit weight of $18$ kN/m$^3$, and the water table lies well below the depth of interest. The total vertical stress at a depth of $4$ m below the ground surface is: **[1 mark]**

(A) $72$ kN/m$^2$

(B) $54$ kN/m$^2$

(C) $36$ kN/m$^2$

(D) $90$ kN/m$^2$

**Q19.** In a soil with a coefficient of permeability $k = 2 \times 10^{-3}$ m/s, water flows under a hydraulic gradient of $i = 0.5$. Using Darcy's law, the discharge (Darcy) velocity of flow is: **[1 mark]**

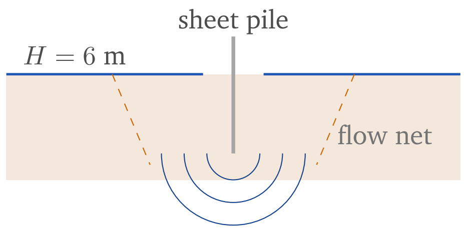
(A) $4 \times 10^{-3}$ m/s

(B) $2 \times 10^{-3}$ m/s

(C) $0.5 \times 10^{-3}$ m/s

(D) $1 \times 10^{-3}$ m/s

**Q20.** Water seeps under a sheet pile through a soil of permeability $k = 1 \times 10^{-4}$ m/s under a total head of $6$ m. From the flow net shown, the number of flow channels is $N_f = 4$ and the number of equipotential drops is $N_d = 12$. The seepage discharge per metre run, $q = k\,H\,(N_f/N_d)$, is: **[1 mark]**



(A) $2 \times 10^{-4}$ m$^3$/s per m

(B) $6 \times 10^{-4}$ m$^3$/s per m

(C) $1 \times 10^{-4}$ m$^3$/s per m

(D) $8 \times 10^{-4}$ m$^3$/s per m

## Geotechnical Engineering (continued)

**Q21.** A normally consolidated clay layer is $4$ m thick with an initial void ratio of $0.80$ and a compression index of $0.30$. The initial effective vertical stress at the middle of the layer is $100$ kPa, and a wide surcharge raises it by a further $100$ kPa. The primary consolidation settlement of the layer is nearest to: **[2 marks]**

(A) $100$ mm

(B) $150$ mm

(C) $200$ mm

(D) $301$ mm

**Q22.** A cohesionless soil has an angle of internal friction of $\phi = 30°$. According to Rankine's theory, the coefficient of passive earth pressure, $K_p = \dfrac{1+\sin\phi}{1-\sin\phi}$, for this soil is: **[2 marks]**

(A) $\dfrac{1}{3}$

(B) $1$

(C) $3$

(D) $2$

**Q23.** A square 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 theory for a square footing, $q_u = 1.3\,c\,N_c$ with $N_c = 5.7$ (the surcharge and self-weight terms vanish at the surface for $\phi = 0$). The ultimate bearing capacity is: **[2 marks]**

(A) $285.0$ kPa

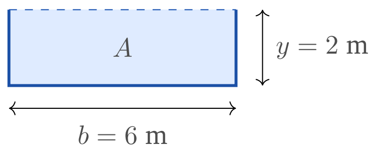
(B) 370.5 kPa

(C) 456.0 kPa

(D) 740.0 kPa

## Water Resources Engineering

**Q24.** A rectangular open channel of bottom width 6 m carries water at a uniform depth of 2 m, as shown. The hydraulic radius (hydraulic mean depth) of the flow section is: **[2 marks]**




(A) 2.0 m

(B) 1.2 m

(C) 6.0 m

(D) 0.6 m

**Q25.** Water flows uniformly in a wide channel where the hydraulic radius is 1.0 m and the bed slope is 0.0004. Taking Manning's roughness coefficient as $n = 0.02$, the mean velocity from Manning's equation $V = \frac{1}{n}R^{2/3}S^{1/2}$ is: **[2 marks]**

(A) 1.0 m/s

(B) 2.0 m/s

(C) 0.5 m/s

(D) 4.0 m/s

**Q26.** Water ($\rho = 1000$ kg/m$^3$, dynamic viscosity $\mu = 1 \times 10^{-3}$ Pa·s) flows at a mean velocity of 2 m/s through a pipe of diameter 0.10 m. The Reynolds number of the flow is: **[2 marks]**

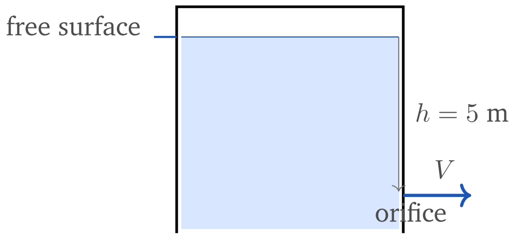
(A) $2 \times 10^3$

(B) $2 \times 10^4$

(C) $2 \times 10^6$

(D) $2 \times 10^5$

**Q27.** Water discharges through a small sharp-edged orifice in the side of a large tank, with the centre of the orifice $5$ m below the free surface, as shown. Neglecting all losses (coefficient of velocity $= 1$), the theoretical velocity of the jet at the orifice, $V = \sqrt{2gh}$, is nearest to: **[2 marks]**




(A) $5.0$ m/s

(B) $49.0$ m/s

(C) $3.13$ m/s

(D) $9.9$ m/s

**Q28.** Water flows in a rectangular channel at a depth of $1.0$ m with a mean velocity of $2$ m/s. The Froude number of the flow, $Fr = \dfrac{V}{\sqrt{g\,y}}$, is nearest to (and the flow is therefore): **[2 marks]**

(A) $0.64$ (subcritical)

(B) $1.00$ (critical)

(C) $2.00$ (supercritical)

(D) $0.32$ (subcritical)

**Q29.** A pump lifts water at a discharge of $0.05$ m$^3$/s against a total head of $20$ m. Assuming $100\%$ efficiency, the water power delivered, $P = \rho\, g\, Q\, H$, is: **[2 marks]**

(A) $98.1$ kW

(B) $4.9$ kW

(C) $9.81$ kW

(D) $19.62$ kW

**Q30.** A rainfall of $10$ cm depth falls uniformly over a catchment of area $100$ km$^2$. If the runoff coefficient is $0.40$, the total volume of direct runoff produced is: **[2 marks]**

(A) $1 \times 10^7$ m$^3$

(B) $1 \times 10^6$ m$^3$

(C) $1 \times 10^8$ m$^3$

(D) $4 \times 10^6$ m$^3$

**Q31.** An isolated storm deposits rainfall of $3$ cm, $5$ cm and $2$ cm in three successive one-hour intervals over a catchment, and produces $5.8$ cm of direct runoff. Assuming the loss rate is uniform and every interval contributes to runoff, the $\phi$-index of the catchment is: **[2 marks]**

(A) $1.4$ cm/hr

(B) $2.0$ cm/hr

(C) $0.6$ cm/hr

(D) $4.2$ cm/hr

**Q32.** Groundwater flows through a confined aquifer of cross-sectional area $50$ m$^2$ under a hydraulic gradient of $0.02$. Taking the coefficient of permeability as $k = 1 \times 10^{-3}$ m/s, the seepage discharge through the aquifer, $Q = k\,i\,A$, is: **[2 marks]**

(A) $2 \times 10^{-3}$ m$^3$/s

(B) $1 \times 10^{-3}$ m$^3$/s

(C) $0.5 \times 10^{-3}$ m$^3$/s

(D) $5 \times 10^{-3}$ m$^3$/s

**Q33.** A hydrological analysis shows that the probability of a particular flood magnitude being equalled or exceeded in any one year is $0.02$. The return period of this flood is: **[2 marks]**

(A) 20 years

(B) 50 years

(C) 100 years

(D) 25 years

**Q34.** A hydraulic structure with a design life of 2 years is built to withstand a flood of return period 10 years. The hydrological risk (probability that the design flood is equalled or exceeded at least once during the design life), $R = 1 - (1 - 1/T)^n$, is nearest to: **[2 marks]**

(A) 0.10

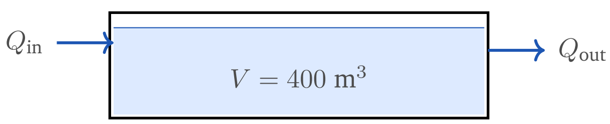
(B) 0.20

(C) 0.19

(D) 0.81

## Environmental Engineering

**Q35.** A rectangular primary sedimentation tank has a volume of 400 $m^3$ and treats a steady flow of 1600 $m^3$/day, as shown schematically. The theoretical detention (retention) time of the tank, $t = V/Q$, is: **[2 marks]**




(A) 2 hours

(B) 4 hours

(C) 6 hours

(D) 12 hours

**Q36.** A wastewater sample is found to have a 5-day BOD of 136.8 mg/L. The deoxygenation rate constant is $k_D = 0.10$ day$^{-1}$ (to base 10). Using $\text{BOD}_t = L_0\left(1 - 10^{-k_D t}\right)$, the ultimate (first-stage) BOD $L_0$ of the sample is nearest to: **[2 marks]**

(A) 200 mg/L

(B) 137 mg/L

(C) 300 mg/L

(D) 411 mg/L

**Q37.** A water treatment plant treats a flow of 4 million litres per day (MLD) and applies a chlorine dose of 2 mg/L. The mass of chlorine required per day is: **[2 marks]**

(A) 0.8 kg/day

(B) 8 kg/day

(C) 80 kg/day

(D) 800 kg/day

**Q38.** Near the ground on a calm clear night, the air temperature is observed to *increase* with height instead of decreasing. This condition, which strongly suppresses vertical mixing and traps air pollutants near the surface, is called: **[2 marks]**

(A) a superadiabatic (unstable) condition

(B) a neutral condition

(C) a temperature inversion

(D) a dry adiabatic condition

**Q39.** A town has a population of 200,000. The per-capita generation rate of municipal solid waste is 0.5 kg per person per day. The total mass of solid waste generated by the town per day is: **[2 marks]**

(A) 400 tonnes/day

(B) 1000 tonnes/day

(C) 40 tonnes/day

(D) 100 tonnes/day

## Transportation & Geomatics Engineering

**Q40.** A horizontal highway curve of radius $100$ m is provided with a superelevation of $e = 0.07$ and is designed for a side-friction factor of $f = 0.15$. The maximum safe speed on this curve, from $V = \sqrt{127\,R\,(e+f)}$ (with $V$ in km/h and $R$ in m), is nearest to: **[2 marks]**

(A) $100$ km/h

(B) $25$ km/h

(C) $75$ km/h

(D) $52.9$ km/h

**Q41.** A vehicle moving at $72$ km/h on a level road brakes to a stop. Taking the longitudinal friction coefficient as $0.35$ and $g = 9.81$ m/s$^2$, the braking distance $\dfrac{v^2}{2gf}$ (the distance travelled while the brakes act, excluding reaction distance) is nearest to: **[2 marks]**

(A) $37.5$ m

(B) $58.25$ m

(C) $108$ m

(D) $70.3$ m

**Q42.** On a highway lane the traffic flow is $1200$ vehicles per hour and the space-mean speed is $40$ km/h. Using the fundamental relation $q = k\,v$, the traffic density $k$ is: **[2 marks]**

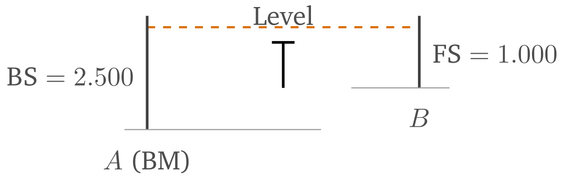
(A) $48000$ veh/km

(B) $60$ veh/km

(C) $15$ veh/km

(D) $30$ veh/km

**Q43.** In differential levelling by the height-of-instrument method, a level is set up between a benchmark $A$ and a point $B$, as shown. The reduced level of $A$ is $50.000$ m, the back sight on $A$ is $2.500$ m, and the fore sight on $B$ is $1.000$ m. The reduced level of $B$ is: **[2 marks]**



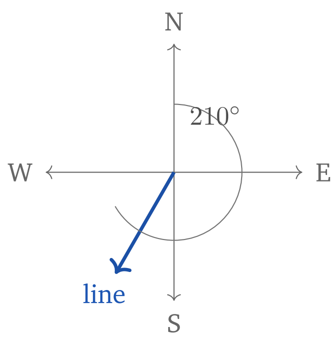

(A) 48.500 m

(B) 51.500 m

(C) 53.500 m

(D) 46.500 m

**Q44.** The whole-circle bearing of a survey line is $210°$, measured clockwise from north, as indicated on the compass diagram. Its equivalent reduced (quadrantal) bearing is: **[2 marks]**



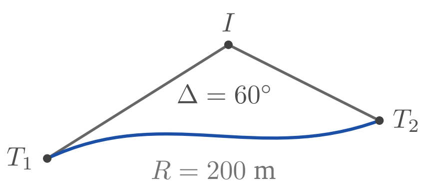

(A) N30°E

(B) N30°W

(C) S30°E

(D) S30°W

**Q45.** A simple circular curve of radius 200 m has a deflection (intersection) angle of $60°$ between its two tangents, as shown. The tangent length of the curve, $T = R\tan(\Delta/2)$, is nearest to: **[2 marks]**




(A) 100 m

(B) 115.5 m

(C) 200 m

(D) 57.7 m

**Q46.** On a survey map, a horizontal ground distance of 200 m is drawn as a line 10 cm long. The representative fraction (scale) of the map is: **[2 marks]**

(A) $1/1000$

(B) $1/500$

(C) $1/2000$

(D) $1/4000$

# Detailed Solutions

## Q1.

**Solution**

**Concept – maximum moment in a cantilever under a full-span UDL:** For a cantilever carrying a uniform load $w$ over its whole length $L$, the largest bending moment occurs at the fixed end and equals $M_{\max} = \dfrac{wL^2}{2}$.

**Step 1 – list the data:** $w = 12$ kN/m, $L = 3$ m.

**Step 2 – substitute into the formula:** $M_{\max} = \dfrac{12 \times 3^2}{2}$

**Step 3 – evaluate $L^2$:** $3^2 = 9$

**Step 4 – complete the arithmetic:** $M_{\max} = \dfrac{12 \times 9}{2} = \dfrac{108}{2}$

$M_{\max} = 54$ kN·m

**Step 5 – sanity check:** The total load is $12 \times 3 = 36$ kN acting at the mid-length $1.5$ m from the fixed end, so $M = 36 \times 1.5 = 54$ kN·m, which agrees.

**Final Answer:** $M_{\max} = 54$ kN·m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

## Q2.

**Solution**

**Concept – axial elongation of a bar:** $\delta = \dfrac{PL}{AE}$, with all quantities in consistent units.

**Step 1 – convert the data to N and mm:** $P = 50$ kN $= 50000$ N, $L = 2$ m $= 2000$ mm, $A = 500$ mm$^2$, $E = 200$ GPa $= 200000$ N/mm$^2$.

**Step 2 – compute the numerator:** $PL = 50000 \times 2000 = 1.0 \times 10^8$

**Step 3 – compute the denominator:** $AE = 500 \times 200000 = 1.0 \times 10^8$

**Step 4 – divide:** $\delta = \dfrac{1.0 \times 10^8}{1.0 \times 10^8}$

$\delta = 1.0$ mm

**Final Answer:** $\delta = 1.0$ mm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

## Q3.

**Solution**

**Concept – maximum moment for a central point load on a simple beam:** For a simply supported beam of span $L$ with a load $W$ at midspan, $M_{\max} = \dfrac{WL}{4}$, occurring under the load.

**Step 1 – list the data:** $W = 20$ kN, $L = 4$ m.

**Step 2 – substitute:** $M_{\max} = \dfrac{20 \times 4}{4}$

**Step 3 – multiply the numerator:** $20 \times 4 = 80$

**Step 4 – divide:** $M_{\max} = \dfrac{80}{4} = 20$ kN·m

**Step 5 – cross-check with reactions:** Each reaction is $W/2 = 10$ kN; the moment at midspan is $10 \times 2 = 20$ kN·m, which agrees.

**Final Answer:** $M_{\max} = 20$ kN·m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

## Q4.

**Solution**

**Concept – moment of inertia of a rectangle about its centroidal axis:** $I = \dfrac{b\,d^3}{12}$, where $b$ is the width and $d$ the depth measured perpendicular to the axis.

**Step 1 – list the data:** $b = 100$ mm, $d = 200$ mm.

**Step 2 – evaluate $d^3$:** $200^3 = 8{,}000{,}000 = 8 \times 10^6$

**Step 3 – multiply by the width:** $b\,d^3 = 100 \times 8 \times 10^6 = 8 \times 10^8$

**Step 4 – divide by 12:** $I = \dfrac{8 \times 10^8}{12}$

$I = 66.67 \times 10^6$ mm$^4$

**Final Answer:** $I = 66.67 \times 10^6$ mm$^4$ $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

## Q5.

**Solution**

**Concept – shape factor in plastic analysis:** The shape factor is $S = \dfrac{M_p}{M_y} = \dfrac{Z_p}{Z_e}$, the ratio of the plastic section modulus to the elastic section modulus.

**Step 1 – write the elastic section modulus of a rectangle:** $Z_e = \dfrac{b\,d^2}{6}$

**Step 2 – write the plastic section modulus of a rectangle:** $Z_p = \dfrac{b\,d^2}{4}$

**Step 3 – form the ratio:** $S = \dfrac{Z_p}{Z_e} = \dfrac{bd^2/4}{bd^2/6}$

**Step 4 – simplify:** $S = \dfrac{6}{4} = 1.5$

**Why the other options are wrong:**

- A, $1.70$: is close to the shape factor of a solid circular section (1.7), not a rectangle.
- B, $1.00$: would mean the plastic and elastic moduli are equal, which is never true for a solid section.
- C, $1.12$: is roughly the shape factor of a typical rolled I-section, not a rectangle.

**Final Answer:** $S = 1.5 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q5

## Q6.

**Solution**

**Concept – torsional shear stress in a solid circular shaft:** $\tau_{\max} = \dfrac{16\,T}{\pi D^3}$, obtained from $\tau = Tr/J$ with $r = D/2$ and $J = \pi D^4/32$.

**Step 1 – convert the data to N and mm:** $T = 1.5\ \text{kN}\cdot\text{m} = 1.5 \times 10^6\ \text{N}\cdot\text{mm}$, $D = 50$ mm.

**Step 2 – evaluate $D^3$:** $50^3 = 125000$

**Step 3 – compute the numerator:** $16 \times T = 16 \times 1.5 \times 10^6 = 24 \times 10^6$

**Step 4 – compute the denominator:** $\pi D^3 = \pi \times 125000 = 392699$

**Step 5 – divide:** $\tau_{\max} = \dfrac{24 \times 10^6}{392699}$

$\tau_{\max} = 61.1\ \text{N/mm}^2 = 61.1$ MPa

**Final Answer:** $\tau_{\max} \approx 61.1\ \text{MPa} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q6

## Q7.

### Solution

**Concept – deflection of a cantilever with an end point load:** For a cantilever of length $L$ and rigidity $EI$ carrying a load $W$ at the free end, the maximum deflection is at the free tip.

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

**Step 2 – confirm the dependence:** The deflection grows with $L^3$ and falls with $EI$; the coefficient $1/3$ is fixed by the cantilever's boundary conditions.

**Why the other options are wrong:**

- A, $WL^3/48EI$: is the midspan deflection of a **simply supported** beam under a central point load.
- C, $5wL^4/384EI$: is a deflection under a **uniformly distributed** load, not a tip point load.
- D, $WL^3/8EI$: is the tip deflection of a cantilever under a **uniformly distributed** load (written with $w$ as $wL^4/8EI$), not an end point load.

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

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

## Q8.

### Solution

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

**Step 1 – identify the end conditions:** One end is **fixed**, the other is **free** (a flagpole/cantilever column).

**Step 2 – recall the factor for fixed–free:** $k = 2.0$

**Step 3 – write the effective length:** $L_e = 2.0\,L$

**Why the other options are wrong:**

- A, $0.5L$: applies to a column **fixed at both ends**.
- B, $1.0L$: applies to a column **hinged at both ends**.
- D, $0.707L$: applies to a column **fixed at one end and hinged at the other**.

**Final Answer:** $L_e = 2.0L \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

## Q9.

### Solution

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

**Step 1 – read the data:** $m = 11$, $r = 3$ (a hinge gives 2 and a roller gives 1), $j = 6$.

**Step 2 – compute $2j$:** $2 \times 6 = 12$

**Step 3 – substitute into the formula:** $D_s = 11 + 3 - 12$

**Step 4 – evaluate:** $D_s = 14 - 12 = 2$

**Step 5 – interpret:** A positive value means the truss is statically indeterminate; here two members (the extra diagonals of the cross-braced panels) are redundant.

**Final Answer:** $D_s = 2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

## Q10.

### Solution

**Concept – static indeterminacy of a beam:** $D_s = r - 3$ for a plane beam, where $r$ is the number of independent support reactions and 3 is the number of equilibrium equations available.

**Step 1 – count the reactions of a propped cantilever:** The fixed end supplies a vertical reaction, a horizontal reaction and a moment (3); the propped (simple) end supplies one vertical reaction (1). So $r = 3 + 1 = 4$.

**Step 2 – subtract the equilibrium equations:** $D_s = r - 3 = 4 - 3$

**Step 3 – evaluate:** $D_s = 1$

**Step 4 – interpret:** The beam has one reaction more than can be found from statics alone, so it is indeterminate to the first degree.

**Final Answer:** $D_s = 1 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

## Q11.

### Solution

**Concept – carry-over factor in moment distribution:** When a moment is applied at the near end of a prismatic member whose far end is fixed, a fraction of it is transmitted (carried over) to the far end.

**Step 1 – recall the standard result:** For a prismatic (constant $EI$) member with the far end fixed, the carry-over factor is $\frac{1}{2}$.

**Step 2 – express as a decimal:** COF $= 0.50$

**Why the other options are wrong:**

- A, $0.25$: no standard prismatic case gives a quarter.
- C, $1.00$: would mean the whole moment is carried over, which is not the case for a fixed far end.
- D, $0.75$: is not a carry-over factor; it is a common distribution factor value.

**Final Answer:** COF $= 0.50 \Rightarrow \boxed{\text{B}}$

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

## Q12.

### Solution

**Concept – limiting neutral-axis depth in RCC limit-state design:** The ratio $x_{u,\max}/d$ is fixed by the grade of steel through 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 **Fe250** (mild steel), $x_{u,\max}/d = 0.53$.

**Why the other options are wrong:**

- A, $0.48$: is the value for **Fe415**.
- B, $0.46$: is the value for **Fe500**.
- C, $0.42$: does not correspond to any standard grade in IS 456.

**Final Answer:** $x_{u,\max}/d = 0.53 \Rightarrow \boxed{\text{D}}$

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

## Q13.

### Solution

**Concept – partial safety factors for materials in IS 456:2000:** Each material's characteristic strength is divided by its own partial safety factor $\gamma_m$ to obtain the design strength.

**Step 1 – recall the value for concrete:** For concrete, $\gamma_{mc} = 1.50$.

**Step 2 – distinguish it from steel:** For reinforcing steel the factor is $\gamma_{ms} = 1.15$, a different value.

**Why the other options are wrong:**

- B, $1.15$: is the factor for reinforcing **steel**, not concrete.
- C, $1.10$: is $\gamma_{m0}$ for structural steel in IS 800, not a concrete factor.
- D, $1.25$: is $\gamma_{m1}$ for structural steel (ultimate stress) in IS 800.

**Final Answer:** $\gamma_{mc} = 1.50 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

## Q14.

### Solution

**Concept – standard deviation of a PERT activity:** The spread of an activity time is $\sigma = \dfrac{t_p - t_o}{6}$, one-sixth of the range from optimistic to pessimistic.

**Step 1 – list the estimates:** $t_o = 4$ days, $t_p = 16$ days.

**Step 2 – form the range:** $t_p - t_o = 16 - 4 = 12$

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

$\sigma = 2$ days

**Why the other options are wrong:**

- A, $12$: is the range itself, not divided by $6$.
- C, $4$: is the **variance** $\sigma^2 = 2^2 = 4$, not the standard deviation.

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

Answer: (D) Go Back to Q14

## Q15.

**Solution**

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

**Step 1 – list the data:** $n = 0.40$.

**Step 2 – form the denominator:** $1 - n = 1 - 0.40 = 0.60$

**Step 3 – divide:** $e = \frac{0.40}{0.60}$

$e = 0.667$

**Step 4 – cross-check:** Back-substituting, $n = e/(1+e) = 0.667/1.667 = 0.40$, which recovers the given porosity.

**Final Answer:** $e = 0.667 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q15

## Q16.

**Solution**

**Concept – dry unit weight from bulk unit weight and water content:** $\gamma_d = \frac{\gamma}{1+w}$, where $w$ is expressed as a fraction.

**Step 1 – convert the water content:** $w = 25\% = 0.25$.

**Step 2 – form the denominator:** $1 + w = 1 + 0.25 = 1.25$

**Step 3 – divide the bulk unit weight:** $\gamma_d = \frac{20}{1.25}$

$\gamma_d = 16 \text{ kN/m}^3$

**Why the other options are wrong:**

- D, 20: is the bulk unit weight, ignoring the moisture correction.
- C, 25: mistakenly multiplies rather than divides, and is physically impossible ($\gamma_d < \gamma$).

**Final Answer:** $\gamma_d = 16 \text{ kN/m}^3 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q16

## Q17.

**Solution**

**Concept – 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 – rearrange for the degree of saturation:** $S = \dfrac{w\,G}{e}$

**Step 2 – list the data:** $w = 0.20$, $G = 2.70$, $e = 0.70$.

**Step 3 – compute the numerator:** $w\,G = 0.20 \times 2.70 = 0.54$

**Step 4 – divide by the void ratio:** $S = \dfrac{0.54}{0.70}$

$S = 0.771 = 77.1\%$

**Step 5 – read the three-phase diagram as a check:** With $V_s = 1$, the volume of voids is $e = 0.70$; the water occupies $wG = 0.54$ of that, and $0.54/0.70 = 77.1\%$ of the voids are filled, the rest being air.

**Final Answer:** $S = 77.1\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q17

## Q18.

**Solution**

**Concept – total vertical stress in a dry soil:** With no water present, the total vertical stress at depth $z$ is $\sigma = \gamma\,z$.

**Step 1 – list the data:** $\gamma = 18$ kN/m$^3$, $z = 4$ m.

**Step 2 – multiply:** $\sigma = 18 \times 4$

$\sigma = 72$ kN/m$^2$

**Step 3 – note the pore pressure:** The water table is well below this depth, so the pore pressure is zero and the effective stress equals the total stress ($\sigma' = 72$ kPa as well).

**Final Answer:** $\sigma = 72\ \text{kN/m}^2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

## Q19.

**Solution**

**Concept – Darcy's law for discharge velocity:** $v = k\,i$, where $k$ is the coefficient of permeability and $i$ the hydraulic gradient.

**Step 1 – list the data:** $k = 2 \times 10^{-3}$ m/s, $i = 0.5$.

**Step 2 – multiply:** $v = 2 \times 10^{-3} \times 0.5$

**Step 3 – evaluate:** $v = 1 \times 10^{-3}$ m/s

**Why the other options are wrong:**

- A, $4 \times 10^{-3}$: divides by the gradient instead of multiplying.
- B, $2 \times 10^{-3}$: is $k$ itself, forgetting the gradient factor.

**Final Answer:** $v = 1 \times 10^{-3}$ m/s $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q19

## Q20.

**Solution**

**Concept – seepage discharge from a flow net:** $q = k\,H\,\dfrac{N_f}{N_d}$, where $N_f$ is the number of flow channels and $N_d$ the number of equipotential drops.

**Step 1 – list the data:** $k = 1 \times 10^{-4}$ m/s, $H = 6$ m, $N_f = 4$, $N_d = 12$.

**Step 2 – form the flow-net shape factor:** $\dfrac{N_f}{N_d} = \dfrac{4}{12} = \dfrac{1}{3}$

**Step 3 – multiply $k$ and $H$:** $k\,H = 1 \times 10^{-4} \times 6 = 6 \times 10^{-4}$

**Step 4 – apply the shape factor:** $q = 6 \times 10^{-4} \times \dfrac{1}{3}$

$q = 2 \times 10^{-4}$ m$^3$/s per m

**Final Answer:** $q = 2 \times 10^{-4}$ m$^3$/s per m $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q20

## Q21.

**Solution**

**Concept – primary consolidation settlement of a normally consolidated clay:** $S_c = \dfrac{C_c\,H}{1 + e_0}\,\log_{10}\dfrac{\sigma_0' + \Delta\sigma'}{\sigma_0'}$.

**Step 1 – list the data:** $C_c = 0.30$, $H = 4$ m $= 4000$ mm, $e_0 = 0.80$, $\sigma_0' = 100$ kPa,

$\Delta\sigma' = 100$ kPa.

**Step 2 – form the stress ratio:** $\dfrac{\sigma_0' + \Delta\sigma'}{\sigma_0'} = \dfrac{100+100}{100} = \dfrac{200}{100} = 2$

**Step 3 – take the logarithm:** $\log_{10} 2 = 0.30103$

**Step 4 – form the leading coefficient:** $\dfrac{C_c\,H}{1+e_0} = \dfrac{0.30 \times 4000}{1+0.80} = \dfrac{1200}{1.80} = 666.7$ mm

**Step 5 – multiply by the log term:** $S_c = 666.7 \times 0.30103$

$S_c = 200.7 \approx 200$ mm

**Final Answer:** $S_c \approx 200$ mm $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q21

## Q22.

### Solution

**Concept – Rankine passive earth-pressure coefficient:** $K_p = \dfrac{1+\sin\phi}{1-\sin\phi}$, the reciprocal of the active coefficient $K_a$.

**Step 1 – evaluate $\sin\phi$:** $\sin 30° = 0.5$

**Step 2 – form the numerator:** $1+\sin\phi = 1+0.5 = 1.5$

**Step 3 – form the denominator:** $1-\sin\phi = 1-0.5 = 0.5$

**Step 4 – divide:** $K_p = \dfrac{1.5}{0.5} = 3$

**Step 5 – cross-check with the active coefficient:** $K_a = \dfrac{0.5}{1.5} = \dfrac{1}{3}$, and $K_p = 1/K_a = 3$, as expected.

**Final Answer:** $K_p = 3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

## Q23.

### Solution

**Concept – Terzaghi bearing capacity for a square footing on clay:** For a square footing, $q_u = 1.3\,c\,N_c + \gamma D_f N_q + 0.4\,\gamma B N_\gamma$. For $\phi = 0$: $N_q = 1$, $N_\gamma = 0$, and at the surface $D_f = 0$.

**Step 1 – drop the vanishing terms:** With $D_f = 0$ and $N_\gamma = 0$, only the cohesion term remains.

**Step 2 – write what is left:** $q_u = 1.3\,c\,N_c$

**Step 3 – substitute the values:** $q_u = 1.3 \times 50 \times 5.7$

**Step 4 – multiply step by step:** $1.3 \times 50 = 65$

$q_u = 65 \times 5.7$

$q_u = 370.5$ kPa

**Why the other options are wrong:**

- A, 285: is the *strip*-footing value $cN_c$ without the 1.3 shape factor.
- C, 456: applies a 1.6 shape factor that belongs to no standard case here.

**Final Answer:** $q_u = 370.5$ kPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

## Q24.

**Solution**

**Concept – hydraulic radius of a channel:** $R = \frac{A}{P}$, the flow area divided by the wetted perimeter.

**Step 1 – compute the flow area:** $A = b\,y = 6 \times 2 = 12$ m$^2$

**Step 2 – compute the wetted perimeter:** For a rectangular channel, $P = b + 2y = 6 + 2(2) = 6 + 4 = 10$ m

**Step 3 – divide:** $R = \frac{12}{10}$

$R = 1.2$ m

**Why the other options are wrong:**

- A, 2.0: is the flow depth, not the hydraulic radius.
- C, 6.0: is the bottom width, not the hydraulic radius.

**Final Answer:** $R = 1.2$ m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

## Q25.

**Solution**

**Concept – Manning's uniform-flow equation:** $V = \frac{1}{n} R^{2/3} S^{1/2}$.

**Step 1 – list the data:** $n = 0.02$, $R = 1.0$ m, $S = 0.0004$.

**Step 2 – evaluate $R^{2/3}$:** $R^{2/3} = 1.0^{2/3} = 1.0$

**Step 3 – evaluate $S^{1/2}$:** $S^{1/2} = \sqrt{0.0004} = 0.02$

**Step 4 – form $1/n$:** $\frac{1}{n} = \frac{1}{0.02} = 50$

**Step 5 – multiply the three factors:** $V = 50 \times 1.0 \times 0.02$

$V = 1.0$ m/s

**Final Answer:** $V = 1.0$ m/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

## Q26.

### Solution

**Concept – Reynolds number for pipe flow:** $Re = \frac{\rho V D}{\mu}$, a dimensionless ratio of inertial to viscous forces.

**Step 1 – list the data:** $\rho = 1000$ kg/m$^3$, $V = 2$ m/s, $D = 0.10$ m, $\mu = 1 \times 10^{-3}$ Pa·s.

**Step 2 – compute the numerator:** $\rho V D = 1000 \times 2 \times 0.10 = 200$

**Step 3 – divide by the viscosity:** $Re = \frac{200}{1 \times 10^{-3}}$

$Re = 2 \times 10^5$

**Step 4 – interpret:** Since $Re \gg 4000$, the flow is turbulent.

**Final Answer:** $Re = 2 \times 10^5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

## Q27.

### Solution

**Concept – Torricelli's theorem for orifice velocity:** $V = \sqrt{2gh}$, where $h$ is the head of water above the centre of the orifice.

**Step 1 – list the data:** $g = 9.81$ m/s$^2$, $h = 5$ m.

**Step 2 – form the product under the root:** $2gh = 2 \times 9.81 \times 5$

**Step 3 – evaluate:** $2 \times 9.81 = 19.62$

$19.62 \times 5 = 98.1$

**Step 4 – take the square root:** $V = \sqrt{98.1}$

$V = 9.9$ m/s

**Why the other options are wrong:**

- B, 49.0: is $2gh/2$-type mis-arithmetic; a velocity of 49 m/s is far too high for a 5 m head.
- C, 3.13: takes $\sqrt{gh/2}$ or similar, dropping the factor of 2.

**Final Answer:** $V \approx 9.9$ m/s $\Rightarrow \boxed{\text{D}}$

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

## Q28.

### Solution

**Concept – Froude number of open-channel flow:** $Fr = \dfrac{V}{\sqrt{g\,y}}$; $Fr < 1$ is subcritical, $Fr = 1$ critical and $Fr > 1$ supercritical.

**Step 1 – list the data:** $V = 2$ m/s, $y = 1.0$ m, $g = 9.81$ m/s$^2$.

**Step 2 – compute the denominator:** $g\,y = 9.81 \times 1.0 = 9.81$

$\sqrt{9.81} = 3.132$

**Step 3 – divide:** $Fr = \dfrac{2}{3.132}$

$Fr = 0.639 \approx 0.64$

**Step 4 – classify:** Since $Fr = 0.64 < 1$, the flow is subcritical.

**Final Answer:** $Fr \approx 0.64$, subcritical $\Rightarrow \boxed{\text{A}}$

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

## Q29.

### Solution

**Concept – water power delivered by a pump:** $P = \rho\,g\,Q\,H$, the rate of doing work against gravity on the pumped water.

**Step 1 – list the data:** $\rho = 1000$ kg/m$^3$, $g = 9.81$ m/s$^2$, $Q = 0.05$ m$^3$/s, $H = 20$ m.

**Step 2 – multiply $\rho$ and $g$:** $\rho\,g = 1000 \times 9.81 = 9810$

**Step 3 – multiply by the discharge:** $9810 \times 0.05 = 490.5$

**Step 4 – multiply by the head:** $P = 490.5 \times 20 = 9810$ W

**Step 5 – convert to kilowatts:** $P = 9.81$ kW

**Final Answer:** $P = 9.81$ kW $\Rightarrow \boxed{\text{C}}$

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

## Q30.

**Solution**

**Concept – runoff volume from rainfall depth, area and runoff coefficient:** Volume $= C \times$ (rainfall depth) $\times$ (area), all in consistent units.

**Step 1 – convert the quantities to metres and square metres:** Rainfall depth $= 10$ cm $= 0.10$ m; area $= 100$ km$^2$ $= 100 \times 10^6 = 1 \times 10^8$ m$^2$; $C = 0.40$.

**Step 2 – multiply depth by area:** $0.10 \times 1 \times 10^8 = 1 \times 10^7$ m$^3$

**Step 3 – apply the runoff coefficient:** Volume $= 0.40 \times 1 \times 10^7$

Volume $= 4 \times 10^6$ m$^3$

**Why the other options are wrong:**

- A, $1 \times 10^7$: is the total rainfall volume, before applying the runoff coefficient.
- C, $1 \times 10^8$: mishandles the km$^2$-to-m$^2$ conversion.

**Final Answer:** Volume $= 4 \times 10^6$ m$^3$ $\Rightarrow \boxed{\text{D}}$

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

## Q31.

**Solution**

**Concept – $\phi$-index (uniform loss rate):** Runoff depth $= \sum(P_i - \phi\,\Delta t)$ over the intervals in which rainfall exceeds the loss. Here each interval is 1 hour.

**Step 1 – total the rainfall:** $P = 3 + 5 + 2 = 10$ cm

**Step 2 – write the runoff equation (all three hours contribute):** Runoff $= (3 - \phi) + (5 - \phi) + (2 - \phi)$

**Step 3 – simplify:** Runoff $= 10 - 3\phi$

**Step 4 – set equal to the observed runoff and solve:** $5.8 = 10 - 3\phi$

$3\phi = 10 - 5.8 = 4.2$

$\phi = \dfrac{4.2}{3} = 1.4$ cm/hr

**Step 5 – verify the assumption:** Each hourly depth (3, 5, 2 cm) exceeds $\phi = 1.4$ cm, so all three intervals indeed contribute. Consistent.

**Final Answer:** $\phi = 1.4$ cm/hr $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q31

## Q32.

**Solution**

**Concept – Darcy discharge through an aquifer:** $Q = k\,i\,A$, the product of permeability, hydraulic gradient and cross-sectional area.

**Step 1 – list the data:** $k = 1 \times 10^{-3}$ m/s, $i = 0.02$, $A = 50$ m$^2$.

**Step 2 – multiply $k$ and $i$:** $k\,i = 1 \times 10^{-3} \times 0.02 = 2 \times 10^{-5}$

**Step 3 – multiply by the area:** $Q = 2 \times 10^{-5} \times 50$

$Q = 1 \times 10^{-3}\ \text{m}^3/\text{s}$

**Final Answer:** $Q = 1 \times 10^{-3}\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

## Q33.

**Solution**

**Concept – return period and annual exceedance probability:** $T = \dfrac{1}{P}$, the reciprocal of the probability of exceedance in any one year.

**Step 1 – list the probability:** $P = 0.02$.

**Step 2 – take the reciprocal:** $T = \dfrac{1}{0.02}$

**Step 3 – evaluate:** $T = 50$ years

**Step 4 – interpret:** On average this flood is equalled or exceeded once every 50 years.

**Why the other options are wrong:**

- A, 20: would correspond to $P = 0.05$, not 0.02.
- C, 100: would correspond to $P = 0.01$, not 0.02.

**Final Answer:** $T = 50$ years $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q33

## Q34.

**Solution**

**Concept – hydrological risk over a design life:** $R = 1-\left(1-\frac{1}{T}\right)^n$, the probability that the design event is equalled or exceeded at least once in $n$ years.

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

**Step 2 – compute the annual non-exceedance probability:** $1-\frac{1}{T} = 1-\frac{1}{10} = 0.90$

**Step 3 – raise it to the power $n$:** $(0.90)^2 = 0.81$

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

$R = 0.19$

**Why the other options are wrong:**

- A, $0.10$: is the single-year exceedance probability $1/T$, ignoring the two-year life.
- D, $0.81$: is the survival (non-exceedance) probability, not the risk.

**Final Answer:** $R = 0.19 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q34

## Q35.

**Solution**

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

**Step 1 – list the data:** $V = 400$ m$^3$, $Q = 1600$ m$^3$/day.

**Step 2 – divide:** $t = \frac{400}{1600} = 0.25$ day

**Step 3 – convert days to hours:** $t = 0.25 \times 24$

$t = 6$ hours

**Final Answer:** $t = 6$ hours $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

## Q36.

**Solution**

**Concept – ultimate BOD from the 5-day BOD:** Rearranging $\text{BOD}_t = L_0(1 - 10^{-k_D t})$ gives $L_0 = \dfrac{\text{BOD}_t}{1 - 10^{-k_D t}}$.

**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 – divide the given $\text{BOD}_5$ by the bracket:** $L_0 = \dfrac{136.8}{0.6838}$

$L_0 = 200.0 \approx 200$ mg/L

**Step 5 – check by going forward:** $\text{BOD}_5 = 200 \times 0.6838 = 136.8$ mg/L, which recovers the given value.

**Final Answer:** $L_0 \approx 200$ mg/L $\Rightarrow \boxed{\text{A}}$

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

## Q37.

**Solution**

**Concept – chlorine mass from dose and flow:** Mass = dose × flow, treating a dose in mg/L as g/m$^3$.

**Step 1 – convert the flow to cubic metres:** $4$ MLD $= 4 \times 10^6$ L/day $= 4000$ m$^3$/day

**Step 2 – express the dose per cubic metre:** $2$ mg/L $= 2$ g/m$^3$

**Step 3 – multiply dose by flow:** Mass $= 2 \times 4000 = 8000$ g/day

**Step 4 – convert grams to kilograms:** Mass $= \dfrac{8000}{1000} = 8$ kg/day

**Final Answer:** Mass $= 8$ kg/day $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q37

## Q38.

**Solution**

**Concept – atmospheric stability and inversion:** Normally temperature falls with height; when instead it *rises* with height, a stable lid forms that suppresses vertical mixing.

**Step 1 – describe the observed profile:** Temperature increases with height near the ground.

**Step 2 – reason about a displaced parcel:** A parcel lifted from the surface cools adiabatically and becomes colder (denser) than the warmer air above it, so it sinks back: vertical motion is choked off.

**Step 3 – name the condition:** This is a **temperature inversion**, which traps pollutants near the ground.

**Why the other options are wrong:**

- A, superadiabatic (unstable): needs temperature to *fall* with height faster than the adiabatic rate, the opposite trend.
- B, neutral: needs the environmental and adiabatic lapse rates to be equal.
- D, dry adiabatic: is a reference lapse rate, not a trapping condition.

**Final Answer:** temperature inversion $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q38

## Q39.

**Solution**

**Concept – total waste mass from population and per-capita rate:** Mass $=$ (per-capita rate) $\times$ (population), then convert to tonnes.

**Step 1 – multiply the rate by the population:** Mass $= 0.5 \times 200000$

$= 100000$ kg/day

**Step 2 – convert kilograms to tonnes ($1000$ kg $= 1$ tonne):** Mass $= \dfrac{100000}{1000}$

Mass $= 100$ tonnes/day

**Why the other options are wrong:**

- A, $400$ and B, $1000$: misplace the decimal in the kg-to-tonne conversion or misread the rate.
- C, $40$: is off by a factor in the arithmetic.

**Final Answer:** Mass $= 100$ tonnes/day $\Rightarrow \boxed{\text{D}}$

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

## Q40.

### Solution

**Concept – safe speed on a superelevated curve:** Solving $e + f = \dfrac{V^2}{127\,R}$ for the speed gives $V = \sqrt{127\,R\,(e+f)}$, with $V$ in km/h and $R$ in m.

**Step 1 – add the superelevation and friction:** $e + f = 0.07 + 0.15 = 0.22$

**Step 2 – form the product** $127\,R\,(e+f)$**:** $127 \times 100 \times 0.22$

**Step 3 – multiply step by step:** $127 \times 100 = 12700$

$12700 \times 0.22 = 2794$

**Step 4 – take the square root:** $V = \sqrt{2794}$

$V = 52.9$ km/h

**Final Answer:** $V \approx 52.9$ km/h $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q40**

## Q41.

### Solution

**Concept – braking distance on a level road:** $d_b = \dfrac{v^2}{2\,g\,f}$, with $v$ the speed in m/s.

**Step 1 – convert the speed to m/s:** $v = 72$ km/h $= \dfrac{72}{3.6} = 20$ m/s

**Step 2 – square the speed:** $v^2 = 20^2 = 400$

**Step 3 – compute the denominator:** $2\,g\,f = 2 \times 9.81 \times 0.35 = 6.867$

**Step 4 – divide:** $d_b = \dfrac{400}{6.867}$

$d_b = 58.25$ m

**Final Answer:** $d_b \approx 58.25$ m $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q41**

## Q42.

### Solution

**Concept – fundamental traffic-flow relation:** $q = k\,v$, so density $k = \dfrac{q}{v}$, where $q$ is flow, $k$ density and $v$ the space-mean speed.

**Step 1 – list the data:** $q = 1200$ veh/hr, $v = 40$ km/h.

**Step 2 – divide flow by speed:** $k = \dfrac{1200}{40}$

**Step 3 – evaluate:** $k = 30$ veh/km

**Step 4 – check the units:** $\dfrac{\text{veh/hr}}{\text{km/hr}} = \text{veh/km}$, which is a density, confirming the calculation.

**Final Answer:** $k = 30$ veh/km $\Rightarrow \boxed{\text{D}}$

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

## Q43.

### Solution

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

**Step 1 – compute the height of instrument:** $\text{HI} = 50.000 + 2.500$

$\text{HI} = 52.500$ m

**Step 2 – subtract the fore sight to get the RL of $B$:** $\text{RL}_B = 52.500 - 1.000$

$\text{RL}_B = 51.500$ m

**Step 3 – interpret:** The fore sight $(1.000)$ is smaller than the back sight $(2.500)$, so $B$ is higher than $A$, and indeed $51.500 > 50.000$. Consistent.

**Why the other options are wrong:**

- A, $48.500$: subtracts the back sight instead of adding it.
- C, $53.500$: adds both readings to the RL of $A$.

**Final Answer:** $\text{RL}_B = 51.500$ m $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q43

## Q44.

### Solution

**Concept – converting whole-circle bearing to reduced bearing:** A whole-circle bearing (WCB) between $180°$ and $270°$ lies in the third (SW) quadrant, and the reduced bearing is $\text{RB} = \text{WCB} - 180°$, measured from south towards west.

**Step 1 – identify the quadrant:** $\text{WCB} = 210°$, which is between $180°$ and $270°$, so the line points into the south-west quadrant.

**Step 2 – compute the angle from south:** $\text{RB} = 210° - 180° = 30°$

**Step 3 – write the quadrantal bearing:** The line is $30°$ measured from south towards west, i.e. S $30°$ W.

**Why the other options are wrong:**

- A, N30°E: corresponds to a WCB of $30°$ (first quadrant).
- B, N30°W: corresponds to a WCB of $330°$ (fourth quadrant).
- C, S30°E: corresponds to a WCB of $150°$ (second quadrant).

**Final Answer:** $\text{S}\,30°\,\text{W} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q44

## Q45.

### Solution

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

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

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

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

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

$T = 115.5$ m

**Why the other options are wrong:**

- C, $200$: is the radius, not the tangent length.
- D, $57.7$: uses $R = 100$ m or drops a factor, halving the correct value.

**Final Answer:** $T \approx 115.5 \text{ m} \Rightarrow \boxed{\text{B}}$

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

## Q46.

### Solution

**Concept – representative fraction (scale) of a map:** $\text{RF} = \dfrac{\text{map distance}}{\text{ground distance}}$, expressed in the same units.

**Step 1 – convert both lengths to centimetres:** Map distance $= 10$ cm; ground distance $= 200$ m $= 200 \times 100 = 20000$ cm.

**Step 2 – form the ratio:** $\text{RF} = \dfrac{10}{20000}$

**Step 3 – simplify:** $\mathrm{RF} = \dfrac{1}{2000}$

**Step 4 – interpret:** One unit on the map represents $2000$ of the same units on the ground.

**Why the other options are wrong:**

- A, $1/1000$: would need the $10$ cm to represent only $100$ m.
- D, $1/4000$: doubles the ground distance in error.

**Final Answer:** $\mathrm{RF} = \dfrac{1}{2000} \Rightarrow \boxed{\mathrm{C}}$

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

## Answer Key

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