MADE EASY

GATE 2026

Civil Engineering-1

Forenoon Session

Detailed Solutions

Exam held on 14-02-2026

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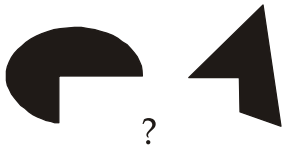
SECTION - A GENERAL APTITUDE

Q.1 'The shopkeeper sells lemons.'
In this sentence, the word 'lemons' is the
(a) object (b) subject
(c) predicate (d) verb

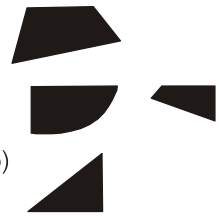
Ans. (a)
A shopkeeper sells lemons
Subject Verb Object

End of Solution

Q.2 The figure below is supposed to show three non-overlapping shapes - one oval and two triangles. Which one of the following figures P, Q, R, or S fits the missing portion indicated by '?' and completes the oval and the two triangles?



(a) 
P

(b) 
Q

(c) 
R

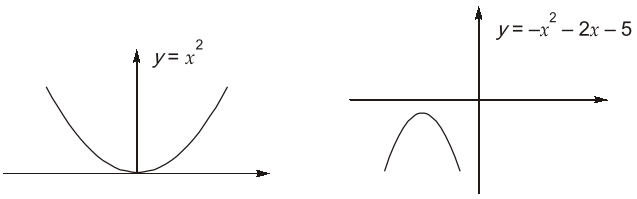
(d) 
S

Ans. (a)

End of Solution

Q.3 At how many points will the curves $y = x^2$ and $y = -x^2 - 2x - 1$ intersect in the real $(x,.y)$ plane?
(a) 0 (b) 1
(c) 2 (d) 3

Ans. (a)



No intersection points,

$y = x^2$ Always positive

$y = -x^2 - 2x - 5$ Always negative

End of Solution

Q.4 'If Anish had scored hundred runs in today's match, he would have been made the captain of his team. He would have then become the youngest captain in his team's history. Unfortunately, he got out without scoring any runs. Hence, there won't be any change in the captaincy for now.'

Based on the paragraph above, which one of the following statements is true?

(a) Anish made hundred runs but was denied captaincy.
(b) Anish was the captain of his team before the game today.
(c) The current captain is older than Anish.
(d) Anish is the youngest player in his team.

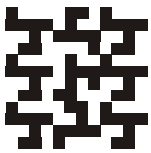
Ans. (c)

As in question it is mentioned.

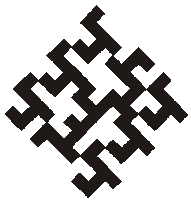
He would have become the youngest captain, so the current captain is older than Anish.

End of Solution

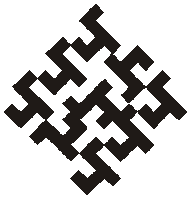
Q.5 Which one of the following figures P, Q, R, or S, correctly shows the 45° clockwise-rotated version of figure (I)?



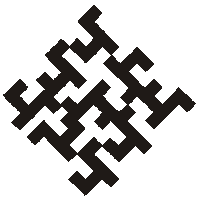
(I)

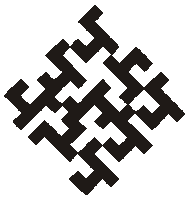
(a) 

P

(b) 

Q

(c) 
R

(d) 
S

Ans. (b)

End of Solution

Q.6 Match the words in **Column I** with their synonyms in **Column II**.

Column I	Column II
(i) Lonely	(p) Verbatim
(ii) Literal	(q) Solitary
(iii) Lousy	(r) Deadly
(iv) Lethal	(s) Terrible

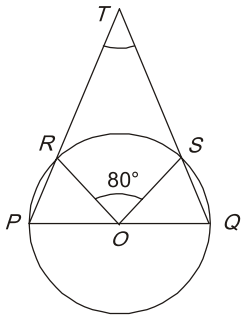
(a) (i)-(q); (ii)-(p); (iii)-(s); (iv)-(r)
(b) (i)-(q); (ii)-(s); (iii)-(r); (iv)-(p)
(c) (i)-(s); (ii)-(p); (iii)-(q); (iv)-(r)
(d) (i)-(r); (ii)-(s); (iii)-(p); (iv)-(q)

Ans. (a)

Lonely → Solitary
Literal → Verbatim
Lousy → Terrible
Lethal → Deadly

End of Solution

Q.7 In the given figure, $\overline{PQ}$ is the diameter of a circle with center 0. Two points R and S are chosen on the circle such that $\angle ROS = 80°$. When $\overline{PR}$ and $\overline{QS}$ are extended, they meet at T. The value of $\angle RTS$ is _____.



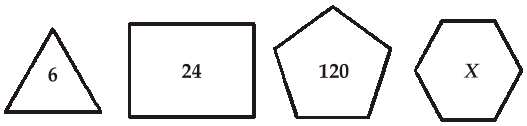
(a) 40°
(b) 50°
(c) 60°
(d) 80°

Ans. (b)

$$\frac{1}{2}(180^\circ - 80^\circ) = 50^\circ$$

End of Solution

Q.8 Based on the relationship between each polygon and the number inside it, the value of 'X' is _____



(a) 720
(b) 596
(c) 24
(d) 240

Ans. (a)

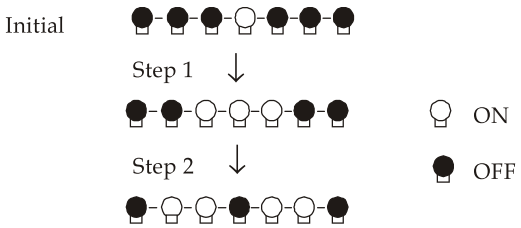
No. of sides = 3
3! = 6
No. of sides = 4
4! = 24
No. of sides = 5! = 120
No. of sides = 6! = 720

End of Solution

Q.9 Consider a linear arrangement of seven bulbs, each of which can be in the ON or OFF states. The initial configuration of the bulbs is shown in the figure. In every Step, the states of the bulbs are changed based on the following rules:

- Any OFF bulb with exactly one ON neighbor at the end of the previous Step is turned ON.
- Any ON bulb with both neighbors ON at the end of the previous Step is turned OFF.
- The state of any bulb not meeting the conditions above is left unchanged.

The state of bulbs at the end of Step 1 and Step 2 are also shown in the figure. The number of bulbs which are ON at the end of Step 8 is _____



(a) 5
(b) 4
(c) 3
(d) 0

Ans. (b)

Step (1) OFF, OFF, ON, ON, ON, OFF, OFF
Step (2) OFF, ON, ON, OFF, ON, ON, OFF
Step (3) ON, ON, ON, OFF, ON, ON, ON
Step (4) ON, OFF, ON, OFF, ON, OFF, OFF
No change possible.

End of Solution

Q.10 P and Q are two positive integers such that $P^2 = Q^2 + 13$.

The product of the numbers P and Q is _____

(a) 13 (b) 26
(c) 39 (d) 42

Ans. (d)

$$[P^2 - Q^2] = 13$$
$$(P - Q)(P + Q) = 13 = 1 \times 13$$
$$P - Q = 1$$
$$P + Q = 13$$
$$P = 7$$

and

$$Q = 6$$
$$P \times Q = 42$$

End of Solution

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SECTION - B TECHNICAL

Q.11 Matrix P is given as

$$P = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

The TRUE option is

(a) Trace of P is equal to the sum of the Eigen values of P.

(b) $P^T P$ is an identity matrix.

(c) P is a skew-symmetric matrix.

(d) Absolute magnitude of each Eigen value is 1.

Ans. (a)

$$P^T = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

$$P^T P = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 2 \\ 0 & 1 & 0 \\ 2 & 0 & 2 \end{bmatrix}$$

$P^T P \neq I$ ($\therefore$ Not on identity matrix)

$P^T = P$ ($\therefore$ Symmetric and not skew symmetric)

$$|A - \lambda I| = 0$$

$$\begin{vmatrix} 1-\lambda & 0 & 1 \\ 0 & 1-\lambda & 0 \\ 1 & 0 & 1-\lambda \end{vmatrix} = (1-\lambda)\lambda(\lambda - 2) = 0$$

$$\lambda = 0,\ 1,\ 2$$

End of Solution

Q.12 Given

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 2 \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

The above system of equations represents a

(a) plane (b) line

(c) volume (d) point

Ans. (b)

$$x_1 + x_2 + x_3 = 0$$
$$x_1 + 2x_3 = 0$$

Let, $x_2 = \alpha$

$$x_1 + x_3 = -\alpha$$
$$x_1 + 2x_3 = 0$$
$$x_3 = \alpha$$
$$x_1 = -2\alpha$$

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -2\alpha \\ \alpha \\ \alpha \end{bmatrix} = \alpha \begin{bmatrix} -2 \\ 1 \\ 1 \end{bmatrix}$$

It represents a line.

End of Solution

Q.13 A thin-walled spherical gas balloon of radius R and wall thickness t (t << R) is subjected to an internal (gauge) pressure *p*. The maximum tensile and shear stresses in the balloon wall are, respectively:

(a) Zero and $pR/2t$
(b) $pR/2t$ and Zero
(c) $pR/2t$ and $pR/4t$
(d) $pR/4t$ and Zero

Ans. (c)

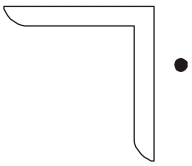
$$\text{Hoop stress} = \text{longitudinal stress} = \frac{pD}{4t}$$

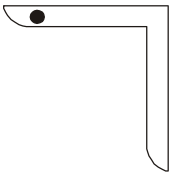
$$\therefore \quad \text{Tensile stress} = \frac{p \times (2R)}{4t} = \frac{pR}{2t}$$

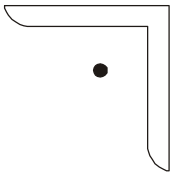
$$\text{Maximum shear stress} = \frac{\frac{pR}{2t}}{2} = \frac{pR}{4t}$$

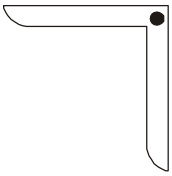
End of Solution

Q.14 Black dot shown in the figure qualitatively represents the shear centre of the angle section. The option which represents the position of the shear centre is:

(a) 

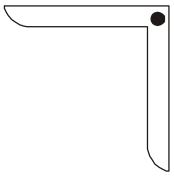
(b) 

(c) 

(d) 

Ans. **(d)**

Shear center will lie on the axis of symmetry and at the point of intersection of axis of legs.



End of Solution

Q.15 Which one of the following is utilized to determine the long-term deformation of concrete under sustained loading?

(a) Creep
(b) Shrinkage
(c) Modulus of rupture
(d) Split tensile strength

Ans. **(a)**

Creep is the gradual, time–dependent deformation of a material under a constant sustained stress.

End of Solution

Q.16 Two reservoirs having different water levels are connected by two long parallel pipelines of same length and same material but having diameters of 600 mm and 400 mm. Using Darcy-Weisbach equation, the ratio of flowrate of water in the bigger diameter pipe to that in the smaller diameter pipe is

(a) 0.54
(b) 1.22
(c) 1.84
(d) 2.76

Ans. **(d)**

Given:

Diameter of larger pipe, D_1 = 600 mm

Diameter of smaller pipe, D_2 = 400 mm

$\because$ Pipes are connected in parallel,

$\therefore$ Headloss in both the pipes will be same.

$$h_{f1} = h_{f2}$$

$$\frac{8Q_1^2 f L_1}{\pi^2 g D_1^5} = \frac{8Q_2^2 f L_2}{\pi^2 g D_2^5}$$

$$\Rightarrow \quad \left(\frac{Q_1}{Q_2}\right)^2 = \left(\frac{D_1}{D_2}\right)^5 \qquad [\because \ L_1 = L_2]$$

$$\Rightarrow \quad \frac{Q_1}{Q_2} = \left(\frac{600}{400}\right)^{5/2} = 2.755 \simeq 2.76$$

End of Solution

Q.17 An irrigation canal is to be designed to deliver 10 cumec to meet the peak demand of 7500 hectare of cropped area. The estimated canal losses are 50 % of the head discharge. The duty (in hectare/cumec) on capacity of this canal is

(a) 375 (b) 1125

(c) 1500 (d) 1875

Ans. (a)

$$\text{Duty} = \frac{\text{Area}}{\text{Discharge}} = \frac{7500}{10} = 750 \text{ ha/cumec}$$

Duty at head of canal = $750 \times 0.5 = 375$ ha/cumec

End of Solution

Q.18 The name of a person in Column 1 is to be matched with the test mentioned in Column 2.

Column 1	Column 2
(I) Menard	(P) Dilatometer test
(II) Marchetti	(Q) Pressuremeter test
(III) Casagrande	(R) Compaction test
(IV) Proctor	(S) Liquid limit test

Option giving the CORRECT match between Column 1 and Column 2 is:

(a) (I) – (Q); (II) – (P); (III) – (S); (IV) – (R)

(b) (I) – (R); (II) – (S); (III) – (Q); (IV) – (P)

(c) (I) – (P); (II) – (Q); (III) – (S); (IV) – (R)

(d) (I) – (R); (II) – (S); (III) – (P); (IV) – (Q)

Ans. (a)

Menard → Pressuremeter Test

Marchetti → Dilatometer Test

Casagrande → Liquid Limit Test

Proctor → Compaction Test

End of Solution

Q.19 Corrections are applied to the basic length of the runway strip considering:
(i) The elevation H (in m) of the airport above Mean Sea Level (MSL)
(ii) Corrected air temperature T (in °C) with respect to the standard temperature at elevation H
(iii) The effective gradient G (in %) along the length of the runway
Respective correction applied to the basic length of the runway is:

(a) $0.07\times\frac{H}{300}; 0.01\times T; 0.10\times G$
(b) $0.01\times\frac{H}{300}; 0.07\times T; 0.10\times G$
(c) $0.07\times\frac{H}{300}; 0.10\times T; 0.01\times G$
(d) $0.10\times\frac{H}{300}; 0.07\times T; 0.01\times G$

Ans. (a)

$$\text{Elevation correction} = 7\% \text{ per } 300 \text{ of height} = \frac{0.07}{300}\times H$$

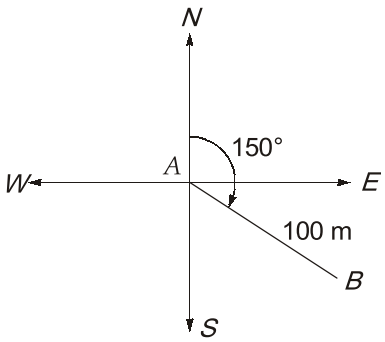
$$\text{Temperature correction} = 1\% \text{ per degree rise in temperature} = 0.01T$$

$$\text{Gradient correction} = 20\% \text{ per } 1\% \text{ of effective gradient} = 0.20G$$

End of Solution

Q.20 The Whole Circle Bearing (WCB) of line AB is 150°. The length of AB is 100 m. The latitude and departure values, respectively, for this line are:
(a) +86.60 ; +50.00
(b) +86.60 ; – 50.00
(c) –86.60 ; +50.00
(d) – 86.60 ; – 50.00

Ans. (c)



Given, $WCB = 150,\ AB = 100 \text{ m} = l$

$$\text{Latitude} = l\cos\theta = 100 \times \cos(150°) = -86.60 \text{ m}$$

$$\text{Departure} = l\sin\theta = 100 \times \sin(150°) = +50 \text{ m}$$

End of Solution

Q.21 A rapid sand filter bed of depth 0.8 m has 40 % porosity during service cycle. It is recommended that during backwash operation, the expanded filter bed should have 70 % porosity. The uniform expanded depth (in m) of the filter bed during backwash is

(a) 1.0 (b) 1.2
(c) 1.4 (d) 1.6

Ans. **(d)**

Given, $n_i = 0.4,\ n_e = 0.7$

$D = 0.8$ m, $D_e = ?$

$D(1 - n)(G_s - 1) = \text{Constant}$

$\Rightarrow \quad 0.8 \times (1 - 0.4) = D_e \times (1 - 0.7)$

$\Rightarrow \quad D_e = \dfrac{0.8 \times 0.6}{0.3} = 1.6$ m

End of Solution

Q.22 The settling velocity of inorganic particles in the sedimentation tank of a water treatment plant is governed by

(a) Darcy's law (b) Stokes' law
(c) Dupuit's law (d) Bernoulli's law

Ans. **(b)**

Settling velocity of discrete inorganic particles under laminar flow conditions is determine by stoke's law.

$$V_s = \frac{\rho g (G_s - 1) d^2}{18\mu}$$

End of Solution

Q.23 Gradually Varied Flow (GVF) profiles in open channels given in Column 1 are to be matched with the water surface slopes in Column 2 in the table below.

Column 1 (GVF Profile)	Column 2 (Water Surface Slope)
(P) M1	(I) Positive
(Q) M2	(II) Negative
(R) M3	(III) Zero

Which of the following options is/are NOT correct?

(a) (P) – (I) ; (Q) – (II) ; (R) – (I)
(b) (P) – (I) ; (Q) – (II) ; (R) – (III)
(c) (P) – (II) ; (Q) – (I) ; (R) – (I)
(d) (P) – (I) ; (Q) – (III) ; (R) – (II)

Ans. **(b, c, d)**

M_1 – Positive
M_2 – Negative
M_3 – Positive

End of Solution

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Q.24 Cant C on a Broad Gauge railway track is calculated for an equilibrium speed V (in km/h), dynamic gauge G (in mm) and radius of curve R (in m) using formula/ formulae:

(a) $C = \frac{GV^2}{127R}$

(b) $C = \frac{13.76V^2}{R}$

(c) $C = \frac{13.20V^2}{R}$

(d) $C = \frac{8.33V^2}{R}$

Ans. **(a, b)**

For B.G. $e = \frac{GV^2}{127R}$

$= \frac{(1.75 \times 10^3)V^2}{127R} = 13.78\frac{V^2}{R}$

End of Solution

Q.25 Which of the following components is/are NOT removed in the secondary treatment of sewage?

(a) Suspended settleable organic solids
(b) Colloids including dissolved organic matter
(c) Pathogens
(d) Fat and grease

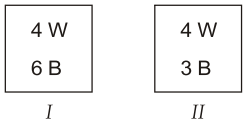
Ans. **(a, c, d)**

- Fat and grease remove in skimming tank.
- Pathogen remove in tertiary treatment.
- Suspended settleable solids are removed in primary treatment in sedimentation.

End of Solution

Q.26 Bag I contains 4 white and 6 black balls.
Bag II contains 4 white and 3 black balls.
One ball is drawn at random from any one of the two bags and it is found to be a black ball. The probability that the black ball was drawn from Bag I is _____ (rounded off to two decimal places).

Ans. **(0.583)(0.50 to 0.66)**



Drawn ball is black.
P (that it was drawn from bag I),

$$P\left(\frac{I}{B}\right) = \frac{P(I)P\left(\frac{B}{I}\right)}{P(I)P\left(\frac{B}{I}\right)+P(II)P\left(\frac{B}{II}\right)}$$

$$P\left(\frac{I}{B}\right) = \frac{\frac{6}{10}\times\frac{1}{2}}{\frac{1}{2}\times\frac{6}{10}+\frac{1}{2}\times\frac{3}{7}} = 0.583$$

End of Solution

Q.27 A matrix is given as:

$$\begin{bmatrix} 9 & 15 \\ 15 & 50 \end{bmatrix}$$

By performing Cholesky decomposition, $|l_{22}|$ of the lower triangular matrix is _____ (in integer).

Ans. **(5)(5 to 5)**

$$A = LL^T$$

$$= \begin{bmatrix} L_{11} & 0 \\ L_{21} & L_{22} \end{bmatrix}\begin{bmatrix} L_{11} & L_{21} \\ L_0 & L_{22} \end{bmatrix}$$

$$\begin{bmatrix} 9 & 15 \\ 15 & 50 \end{bmatrix} = \begin{bmatrix} L_{11}^2 & L_{11}L_{21} \\ L_{11}L_{21} & L_{21}^2+L_{22}^2 \end{bmatrix}$$

$$L_{11} = 3$$
$$L_{11}L_{21} = 15$$
$$L_{21} = 5$$
$$L_{21}^2+L_{22}^2 = 50$$
$$5^2 + L_{22}^2 = 50$$
$$L_{22}^2 = 25$$
$$L_{22} = 5$$

End of Solution

Q.28 It is given that x and y are integers in the following equation:

$(x + y - 7)^2 + (y + 3x - 13)^2 = 0$

The value of $(x^3 + y^3)$ is _____ (in integer).

Ans. **(91)(91 to 91)**

$(y + 3x - 13)^2 + (x + y - 7)^2 = 0$

Now, for sum to be 0,

$$y + 3x - 13 = 0$$

and $$x + y - 7 = 0$$

$\Rightarrow$ $$y + 3x = 13$$

$$x + y = 7$$

$$2x = 6$$

$$x = 3,\ x = 4$$

Now, $$x^3 + y^3 = (3)^3 + (4)^3$$

$$= 27 + 64 = 91$$

End of Solution

Q.29 The required centre-to-centre spacing of 10 mm diameter bars is 150 mm to resist the design moment in a concrete slab. Instead of 10 mm diameter bars, if 12 mm diameter bars of the same grade are used, the required centre-to-centre spacing (in mm) to resist the same design moment becomes _____ (rounded off to the nearest integer).

Ans. (216)(214 to 218)

Given, $S_{10\ mm} = 150$ mm, $\phi = 10$ mm

$S_{12\ mm} = ?$, $\phi = 12$ mm

$\therefore$ Spacing $\propto \phi^2$

$$\frac{S_{12mm}}{S_{10mm}} = \left(\frac{12}{10}\right)^2$$

$$S_{12\ mm} = 150 \times \left(\frac{12}{10}\right)^2$$

$$S_{12\ mm} = 216 \text{ mm}$$

End of Solution

Q.30 Two steel plates are to be connected together by a 5 mm fillet weld of length 150 mm to transfer a design load. If the size of the fillet weld used to connect the same two plates is changed to 6 mm, the weld length (in mm) needed for transferring the same design load is _____ (in integer).

Ans. (125)(120 to 130)

Here, $$\text{Length of weld} = \frac{1}{\text{Size of weld}}$$

$\therefore$ $$l_1 S_1 = l_2 S_2$$

$\Rightarrow$ $$5 \times 150 = l_2 \times 6$$

$$S_2 = 125 \text{ mm}$$

End of Solution

Q.31 For a liquid, the permeability of a sandy soil having a void ratio of 0.60 was determined as 0.14 cm/s. Considering the same liquid and by using Taylor's equation, the permeability (in cm/s) of this soil corresponding to the void ratio of 0.80 is _____ (rounded off to two decimal places).

Ans. **(0.30)(0.28 to 0.32)**

By Taylor's equation, $k = C_k \dfrac{e^3}{1+e}$

Given: $k_1 = 0.14$ cm/s, $e_1 = 0.60$; $e_2 = 0.80$

$$\frac{k_2}{k_1} = \frac{\left(e_2^3/1+e_2\right)}{\left(e_1^3+1+e_1\right)}$$

$$\frac{k_2}{0.14} = \frac{\left(0.80^3/1+0.80\right)}{\left(0.60^3/1+0.60\right)}$$

$\Rightarrow$ $k_2 = 0.295$ cm/s $\simeq 0.30$ cm/s

End of Solution

Q.32 To obtain undisturbed clay soil sample, an Area Ratio of 10 % needs to be achieved for a thin walled sampling tube. If the outer diameter of the tube is 50.8 mm, the inner diameter (in mm) is _____ (rounded off to one decimal place).

Ans. **(48.4)(48.2 to 48.6)**

$$\text{Area ratio} = \frac{D_2^2 - D_1^2}{D_1^2} \times 100$$

$\Rightarrow$ $$10 = \frac{50.8^2 - D_1^2}{D_1^2} \times 100$$

$\Rightarrow$ $D_1 = 48.436$ mm $\simeq 48.4$ mm

End of Solution

Q.33 The travel times of three vehicles on a 2 km stretch of road are 4, 5, and 8 minutes. Assuming the speed of each vehicle to be constant in this stretch, the Space Mean Speed (in km/h) of the vehicles is _____ (rounded off to two decimal places).

Ans. **(21.2)(20.0 to 21.9)**

Given: 3 vehicles

$$V_1 = \frac{\text{distance}}{\text{time}} = \frac{2}{4}\text{km/min} = 30\text{kmph}$$

$$V_2 = \frac{2}{5} \times 60 = 24 \text{ kmph}$$

$$V_3 = \frac{2}{8} \times 60 = 15 \text{ kmph}$$

$$\text{Space mean speed} = \frac{n}{\frac{1}{V_1}+\frac{1}{V_2}+\frac{1}{V_3}} = \frac{3}{\frac{1}{30}+\frac{1}{24}+\frac{1}{15}}$$

$$= 21.176 \text{ kmph} \simeq 21.2 \text{ kmph}$$

End of Solution

Q.34 A 30 m long tape is standardized at 25°C. It was used to measure the length of a line which came out to be 200 m. The temperature during the measurement was 35°C. The coefficient of expansion of the tape was 11×10^{-6} per °C. The correction in the measured length (in mm) due to change in temperature is _____ (in integer).

Ans. **(22)(22 to 22)**

Given: $T_0 = 25°C,\ T_m = 35°C$

$l_0 = 200 \text{ m},\ \alpha = 11 \times 10^{-6}\ /°C$

Temperature correction, $C_T = l_o\alpha(T_m - T_o)$

$= 200 \times 11 \times 10^{-6} \times 10$

$C_T = 0.022 \text{ m} = 22 \text{ mm}$

End of Solution

Q.35 The height of the plane of collimation of a levelling instrument is 100.000 m from a datum. The levelling instrument measures a Back Sight of 1.500 m on a vertically held staff at a ground point P. The reduced level (in m) of the ground point P with respect to the datum is _____ (rounded off to three decimal places).

Ans. **(98.5)(98.5 to 98.5)**

Given: Level of line = 100 m (above datum)

B.S reading = 1.5 m

$\therefore$ Reduced level of P = 100 – 1.5 = 98.5 m

End of Solution

Q.36 Let $f(x)$ be a continuous function defined in $[0,2] \to \mathbb{R}$. and satisfying the equation $\int_0^2 f(x)[x - f(x)]dx = \frac{2}{3}$.

The value of $f(1)$ is

(a) 1 (b) 2

(c) $\frac{1}{2}$ (d) 0

Ans. **(c)**

$$\int_0^2 f(x)[x - f(x)]dx = \frac{2}{3}$$

$$\int_0^2 [xf(x) - f(x)^2]dx$$

$$\int_0^2\left[\frac{x^2}{4}-\left(\frac{x}{2}-f(x)\right)^2\right]dx=\frac{2}{3}$$

$$\int_0^2\frac{x^2}{4}dx-\int_0^2\left(\frac{x}{2}-f(x)\right)^2dx=\frac{2}{3}$$

$$\left[\frac{x^3}{3\times4}\right]_0^2-\int_0^2\left[\frac{x}{2}-f(x)\right]^2dx=\frac{2}{3}$$

$$\frac{2}{3}-\int_0^2\left[\frac{x}{2}-f(x)\right]^2dx=\frac{2}{3}$$

$$\int_0^2\left(\frac{x}{2}-f(x)\right)^2dx=0 \qquad x=[0,\ 2]$$

$$f(x)-\frac{x}{2}=0$$

$$f(x)=\frac{x}{2}$$

at $x=1$, $\quad f(1)=\frac{1}{2}$

End of Solution

Q.37 An ordinary differential equation is given below.

$$x^2\frac{d^2y}{dx^2}=6y$$

Considering a and b as arbitrary constants, the general solution of the equation is

(a) $y(x)=ax^3+\frac{b}{x^2}$ (b) $y(x)=ax^2+\frac{b}{x^3}$

(c) $y(x)=ax^2+b\ln x$ (d) $y(x)=ax^3+b\ln x$

Ans. **(a)**

Given: Differential equation

$$x^2\frac{d^2y}{dx^2}-6y=0$$

Let $x=e^z$

$$x^2D^2y-6y=0$$

$$(x^2D^2-6)y=0$$

$$(D^2-D-6)y=0$$

Auxiliary equation,

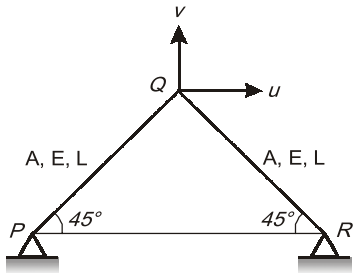
$$m^2-m-6=0$$

$$m=-2 \text{ and } 3$$

$$y = c_1 e^{-2t} + c_2 e^{+3t}$$
$$y = c_1 e^{-2z} + c_2 e^{3z}$$
$$y = \frac{c_1}{x^2} + c_2 x^3$$

End of Solution

Q.38 A plane truss consists of two linearly elastic, homogeneous, identical members, namely PQ and QR. Both members have length (L), cross-sectional area (A), and modulus of elasticity (E). The members are inclined at 45° as shown in the figure. The truss has hinge supports at P and R. The translational degrees-of-freedom (u and v) are shown at joint Q.



(Figure not to scale)

After application of the boundary conditions, the stiffness matrix of the truss becomes:

(a) $\frac{AE}{L}\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix}$

(b) $\frac{AE}{L}\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix}$

(c) $\frac{AE}{L}\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}$

(d) $\frac{AE}{L}\begin{bmatrix}1 & -1\\ -1 & 1\end{bmatrix}$

Ans. (c)

Stiffness matrix, $[k] = \begin{bmatrix}k_{11} & k_{12}\\ k_{21} & k_{22}\end{bmatrix}$

Here, $k_{11} = \Sigma\left(\frac{AE}{L}\cos^2\theta\right)$

$$k_{11} = \frac{AE}{L}\left(\cos^2 225° + \cos^2 315°\right) = \frac{AE}{L}$$

$$k_{22} = \Sigma\left(\frac{AE}{L}\sin^2\theta\right)$$

$$k_{22} = \frac{AE}{L}\left(\sin^2 225° + \sin^2 315°\right) = \frac{AE}{L}$$

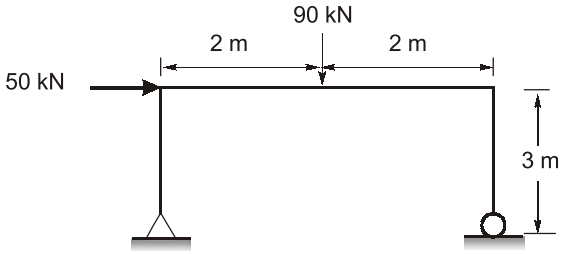
$$k_{12} = k_{21} = \Sigma\left(\frac{AE}{L}\cos\theta\sin\theta\right)$$

$$= \frac{AE}{L}(\cos 225^\circ \sin 225^\circ + \cos 315^\circ \sin 315^\circ) = 0$$

$$\text{Stiffness matrix, } [k] = \frac{AE}{L}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

End of Solution

Q.39 The plane frame has a hinge and a roller support, and is loaded as shown in the figure. Both the columns have same height.



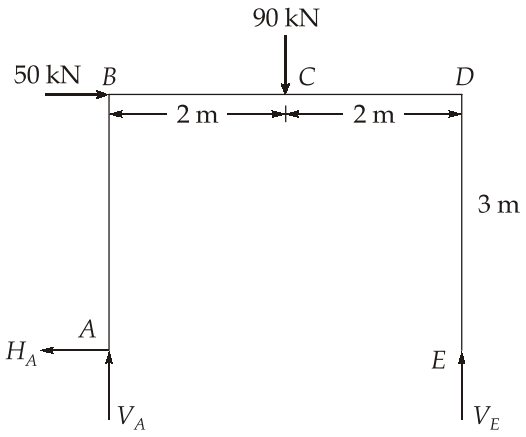
(Figure not to scale)

What is the absolute value of the maximum bending moment (in kN-m) in the frame?

(a) 165 (b) 150

(c) 240 (d) 195

Ans. (a)



$\Sigma F_x = 0 \Rightarrow H_A = 50$ kN (←)

$\Sigma F_y = 0 \Rightarrow V_A + V_E = 90$ kN

Taking moment about A,

$\Sigma M_A = 0$

$\Rightarrow 50 \times 3 + 90 \times 2 - V_E \times 4 = 0$

$V_E = 82.5$ kN (↑)

$V_A = 7.5$ kN (↑)

Maximum bending moment,

$$(M_{max})_{at\ C} = V_E \times 2 = 82.5 \times 2$$
$$= 165 \text{ kN-m}$$

End of Solution

Q.40 For a hydraulic jump formed in a rectangular horizontal channel, the sequent depth ratio is 2. The Froude number of supercritical stream is

(a) $\sqrt{3}$ (b) $\sqrt{5}$

(c) $\sqrt{6}$ (d) $\sqrt{8}$

Ans. (a)

Given: $\frac{y_2}{y_1} = 2$

$$\therefore \quad \frac{y_2}{y_1} = \frac{-1+\sqrt{8F_r^2+1}}{2}$$
$$(2 \times 2 + 1)^2 = 1 + 8F_r^2$$
$$\Rightarrow \quad F_r = \sqrt{3}$$

End of Solution

Q.41 In a laminar flow of a Newtonian fluid through a circular pipe of radius 5 cm, the maximum velocity is found to be 2 m/s. The velocity (in m/s) at a radial distance of 2.50 cm from the axis of the pipe is

(a) 1.00 (b) 1.25

(c) 1.50 (d) 1.75

Ans. (c)

Given:

Maximum velocity, $u_{max} = 2$ m/sec

Radius of pipe, $R = 5$ cm

Radial distance, $r = 2.5$ cm

For laminar flow, velocity at any radial distance 'r' is given by

$$u(r) = u_{max}\left(1-\frac{r^2}{R^2}\right)$$

at $r = 2.5$ cm

$$u(r = 2.5 \text{ cm}) = 2\left[1-\left(\frac{2.5}{5}\right)^2\right] = 1.5 \text{ m/sec}$$

End of Solution

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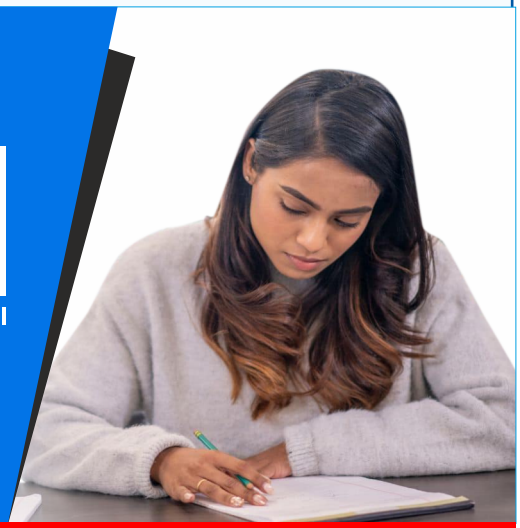

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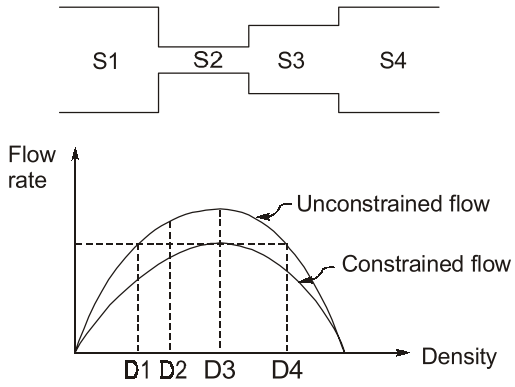
Q.42 A road is divided into four sections having varying widths as shown in the figure. Section-2 (S2) represents a capacity constrained condition with respect to the traffic flow passing through Section-1 (S1). Section-3 (S3) and Section-4 (S4) do not face any such capacity constraint with respect to the flow. A flow-density relationship for unconstrained and constrained flow conditions is shown in the figure.



If Section-1 observes density D2, the option representing the correct state of density in Sections 2, 3 and 4 is:

(a) S2 – D4; S3 – D3; S4 – D2
(b) S2 – D3; S3 – D2; S4 – D1
(c) S2 – D3; S3 – D4; S4 – D2
(d) S2 – D4; S3 – D3; S4 – D1

Ans. **(d)**

From the graph and figure, we can infer that as section-2 is the most constrained, it will have the highest density i.e. it will correspond to D4 on the graph.
Similarly, section-3 corresponds to D3 on the graph as it will have slightly lower density and seciton -4 will correspond to D1.

End of Solution

Q.43 Locations P and Q are separated by a wide valley. The difference in levels of locations P and Q measured by a levelling instrument stationed near P is 3.0 m. The same instrument stationed near Q measures the difference in levels of locations P and Q as –1.0 m. Assume that the atmospheric refraction is same during the measurements. The true difference in levels (in m) of locations P and Q is

(a) 1.0 (b) 1.5
(c) 2.0 (d) 4.0

Ans. **(a)**

Given:

$$h_P - h_Q = 3 \text{ m}$$

$$h_P' - h_Q' = -1 \text{ m}$$

$$\therefore \quad \Delta h = \frac{(h_P - h_Q) + (h_P' - H_Q')}{2}$$

$$\Rightarrow \quad \Delta h = \frac{3 + (-1)}{2} = 1\,\text{m}$$

End of Solution

Q.44 The average sewage from a city is 90 million litres per day and the average 5-day Biochemical Oxygen Demand (BOD_5) is 300 mg/l. Average standard BOD_5 of the domestic sewage is 0.08 kg/day/person. The population equivalent of the city is

(a) 337500 (b) 216000
(c) 270000 (d) 168750

Ans. **(a)**

Given: $Q = 90$ MLD

$BOD_5 = 300$ mg//

Average per capita BOD= 0.08 kg/day

$$\text{Population equivalent} = \frac{90 \times 10^6 \times 300 \times 10^{-6}}{0.08} = 337500$$

End of Solution

Q.45 Select ALL CORRECT option(s) which can be considered to check whether the flexural stresses in a prestressed concrete beam are within the allowable stresses at the transfer and the service stages.

(a) Limiting zone for prestressing (b) Magnel's graph
(c) Hoyer effect (d) Load balancing method

Ans. **(a, b)**

Hoyer effect enhance bond strength of tendon and concrete. Nothing to do with flexure stress.

End of Solution

Q.46 As per the Rankine's earth pressure theory, which of the following statements is/are FALSE?

(a) For the active earth pressure, the inclination of failure plane is $(45° + \phi/2)$ with respect to the major principal plane.
(b) For the active earth pressure, the inclination of failure plane is$(45° - \phi/2)$ with respect to the major principal plane.
(c) For the passive earth pressure, the inclination of failure plane is $(45° + \phi/2)$ with respect to the major principal plane.
(d) For the passive earth pressure, the inclination of failure plane is $(45° - \phi/2)$ with respect to the major principal plane.

Ans. (b, d)

For both active earth pressure as well as passive earth pressure, failure plane makes $\left(45° + \frac{\phi}{2}\right)$ with major principal plane.

End of Solution

Q.47 Which of the following statements is/are TRUE in the context of the geometric design of highways?

(a) The coefficient of friction used for the design of horizontal curves is lower than the coefficient of friction used in the computation of the sight distances.

(b) Centrifugal force at horizontal curve is counteracted by raising the middle of the pavement with respect to the edges.

(c) Grade compensation is achieved by increasing the gradient of the horizontal curve.

(d) Under identical conditions, the design length of the summit curve of a road having unidirectional flow will be greater than that of the same road having bidirectional flow.

Ans. (a)

The value of friction is taken lower for horizontal alignment calculation as compared to sight distance.

End of Solution

Q.48 Starting with the first approximation as $x = 0.5$, the second approximation for the root of the following function by the Newton-Raphson method is _____ (rounded off to two decimal places)

$$f(x) = e^{-x}, - x$$

Ans. (0.57)(0.55 to 0.58)

$$f_{(x)} = e^{-x} - x$$
$$x_0 = 0.5$$
$$x_1 = ?$$

by N.R. method,

$$f_x = e^{-x} - x$$
$$f'(x) = -e^{-x} - 1$$
$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$
$$\Rightarrow \quad x_1 = 0.5 - \frac{\left(e^{-0.5} - 0.5\right)}{-e^{-0.5} - 1}$$
$$\Rightarrow \quad x_1 = 0.5 - \frac{[0.6065 - 0.5]}{-[0.6065 + 1]} = 0.56631 \simeq 0.57$$

End of Solution

Q.49 Values of y for different values of x are tabulated below.

x	–2	1	2
Y	28	4	16

If a second-degree interpolating polynomial $P_2(x)$ is used to represent y, the value of $P_2(0)$ is _____ (rounded off to the nearest integer).

Ans. (2)(2 to 2)

–2	1	2
28	4	16

2nd degree polynominal

Since it is not equally spaced,
So we can apply lagrange's interpolation,

x_0	x_1	x_2
–2	1	2
28	4	16
y_0	y_1	y_2

$$f(x) = \frac{(x-x_1)(x-x_2)}{(x_0-x_1)(x_0-x_2)}y_0 + \frac{(x-x_0)(x-x_2)}{(x_1-x_0)(x_1-x_2)}y_1 + \frac{(x-x_0)(x-x_1)}{(x_2-x_0)(x_2-x_1)}y_2$$

$$f(x) = \frac{(0-1)(0-2)}{(-2-1)(-2-2)}28 + \frac{(0+2)(0-2)}{(1+2)(1-2)}4 + \frac{(0+2)(0-1)}{(2+2)(2-1)}\times 16$$

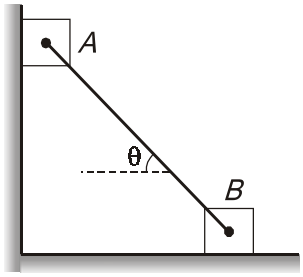
$$\Rightarrow \quad f(0) = \frac{2}{3\times 4}\times 28 + \frac{2x-2}{3x-1}\times 4 + \frac{2x-1}{4\times 1}\times 16$$

$$\Rightarrow \quad f(0) = \frac{14}{3} + \frac{16}{3} - 8$$

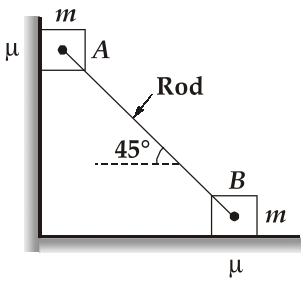
$$\Rightarrow \quad f(0) = \frac{30-24}{3} = \frac{6}{3} = 2$$

End of Solution

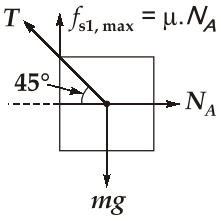
Q.50 Two identical blocks A and B are connected by a rigid rod. The blocks rest against vertical and horizontal planes, as shown in the figure. The coefficient of static friction at the vertical and horizontal planes is the same. If the sliding impends when $\theta = 45°$, the value of the coefficient of static friction is _____ (rounded off to two decimal places).



Ans. (0.41)(0.39 to 0.44)



Block A (F.B.D.)



For equilibrium: $T \cos 45° = N_A$

$$N_A = \frac{T}{\sqrt{2}}$$

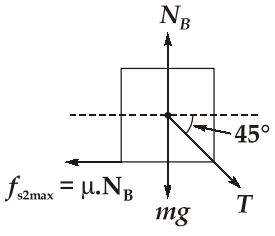
$$T \sin 45° + \mu N_A = mg$$

$$\frac{T}{\sqrt{2}} + \mu N_A = mg$$

$$\frac{T}{\sqrt{2}} + \mu \frac{T}{\sqrt{2}} = mg$$

$$\frac{T}{\sqrt{2}}(1 + \mu) = mg \quad \ldots(i)$$

Block B (F.B.D.)



For equilibrium: $T\cos 45° = F_{s2max} = \mu \cdot N_B$

$$N_B = mg + T\sin 45° = \left(mg + \frac{T}{\sqrt{2}}\right)$$

$$T\cos 45° = \frac{T}{\sqrt{2}} = m\left(mg + \frac{T}{\sqrt{2}}\right) \quad \text{...(ii)}$$

By equation (i) and (ii):

$$\frac{mg}{1+\mu} = \mu\left(mg + \frac{mg}{1+\mu}\right)$$

$$\frac{mg}{1+\mu} = \mu\left(\frac{mg(1+\mu)+mg}{1+\mu}\right)$$

$$1 = \mu\,[1 + \mu + 1]$$

$$1 = \mu\,(2 + \mu)$$

$$\mu^2 + 2\mu - 1 = 0$$

$$\mu = \frac{-2 \pm \sqrt{4+4}}{2} = \frac{-2 \pm \sqrt{8}}{2}$$

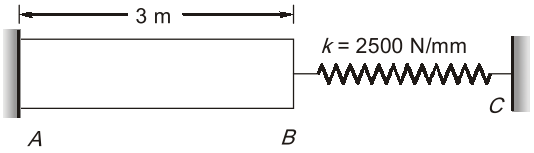
Since, μ can not be negative we shall take (+ve) sign.

$$\mu = \frac{-2+\sqrt{8}}{2} = 0.414$$

$$\mu = 0.414$$

End of Solution

Q.51 A homogenous, linearly elastic rod AB is connected to a linearly elastic spring BC in between the fixed supports at A and C, as shown in the figure. The cross-sectional area, modulus of elasticity, and the coefficient of thermal expansion of the rod AB are 500 mm^2, 60 × 10^3 MPa, and 12 × 10^{-6} per °C, respectively. The stiffness (k) of spring BC is 2500 N/mm.



(Figure not to scale)

The internal force (in kN) that will develop in the spring BC when the temperature of rod AB is increased by 100°C is _____ (rounded off to one decimal place).

Ans. (7.2)(7.0 to 7.4)

Given:

$\alpha = 12 \times 10^{-6}/°C$

$E = 60 \times 10^3$ MPa

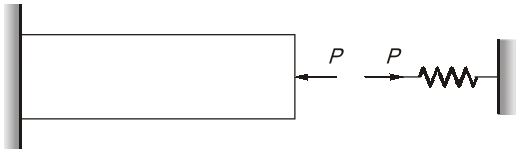
$\Delta T = 100°C$

$L = 3$ m

$A = 500\ mm^2$

$k = 2500$ N/mm

Since the system is fixed, net deflection will be zero.



$$\therefore \left[L\alpha\Delta T + \left(\frac{-PL}{AE}\right)\right] + \left[\frac{-P}{k}\right] = 0$$

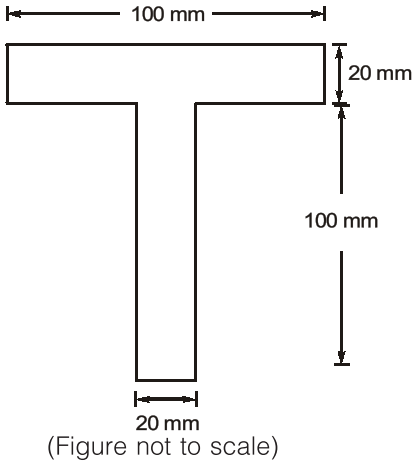
$$\Rightarrow 3000 \times 12 \times 10^{-6} \times 100 - \frac{P \times 3000}{500 \times 60 \times 10^{3}} - \frac{P}{2500} = 0$$

$$\Rightarrow \quad 3.6 = P(5 \times 10^{-4})$$

$$\Rightarrow \quad P = 7200 \text{ N} = 7.2 \text{ kN}$$

End of Solution

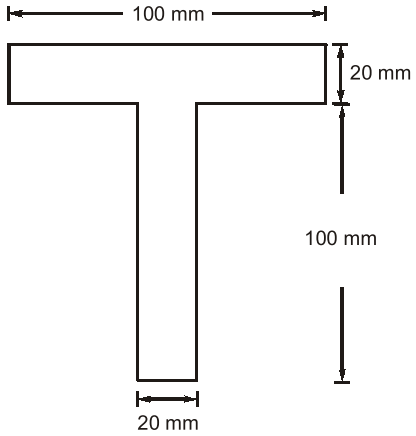
Q.52 The cross-section of a steel T-beam is shown in the figure where all dimensions are in mm.



(Figure not to scale)

The plastic section modulus of the given cross-section is _____ $\times 10^4$ mm^3 (in integer).

Ans. (12)(12 to 12)



Plastic section modulus,

$$Z_P = \frac{A}{2}(\bar{y}_c + \bar{y}_t)$$

Here, $A = 2(100 \times 20) = 4000 \text{ mm}^2$

$$\bar{y}_c = \frac{20}{2} = 10 \text{ mm}$$

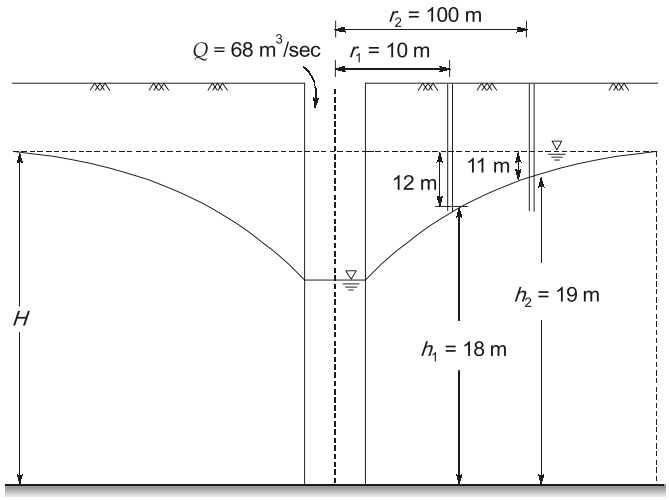
$$\bar{y}_t = \frac{100}{2} = 50 \text{ mm}$$

$\therefore$ $$Z_P = \frac{4000}{2}(10+50) = 12 \times 10^4 \text{ mm}^3$$

End of Solution

Q.53 A fully-penetrating well of 20 cm diameter is provided in an unconfined aquifer. The height of the ground water table is 30 m from the bottom of the aquifer. After a long period of pumping at a rate of 63 m^3/s, the drawdown in the observation wells at 10 m and 100 m from the pumped well is 12 m and 11 m, respectively. The transmissibility (in m^2/s) of the aquifer is _____ (rounded off to one decimal place).

Ans. (37.4)(35 to 40)



Given, $S_1 = 11 \text{ m}$

$h_1 = 30 - 11 = 19 \text{ m}$

$S_2 = 12 \text{ m}$

$h_2 = 30 - 12 = 18 \text{ m}$

$\therefore$ $$Q = \frac{\pi k\left(h_1^2 - h_2^2\right)}{\ln\left(\frac{r_2}{r_1}\right)}$$

$r_2 = 100 \text{ m}$, $r_1 = 10 \text{ m}$

$$\therefore \quad k = \frac{68 \times \ln\left(\frac{100}{10}\right)}{\pi \times 63 \times (19^2 - 18^2)} = 1.248 \text{ m/s}$$

$$\therefore \quad T = kB = 1.248 \times 30 = 37.44 \text{ m}^2/\text{sec}$$

End of Solution

Q.54 A wide unlined channel carries sediment-free water. The depth of water is 1 m. The specific weight of water is 10 kN/m^3. To prevent scouring, the maximum permissible tractive stress on bed is 10 N/m^2. The maximum slope of the channel bed to prevent scouring is 1 in *n*. The value of n is _____ (in integer).

Ans. (1000)(1000 to 1000)

Critical shear stress, $\tau_0 = \gamma_w R S_0$

$$\Rightarrow \quad 10\text{N/m}^2 = 10 \times 10^3 \text{ N/m}^3 \times 1 \times \frac{1}{n}$$

$$\Rightarrow \quad \frac{1}{n} = \frac{1}{10^3}$$

$$n = 1000$$

End of Solution

Q.55 A bridge with an expected life of 50 years is designed for a flood of 10000 m^3/s corresponding to the return period of 100 years. The risk associated with this design is _____ (rounded off to two decimal places).

Ans. (0.39)(0.38 to 0.41)

$n = 50$ year

$T = 100$ year

$$\text{Risk} = 1 - q^n = 1 - \left(1 - \frac{1}{T}\right)^n = 1 - \left(1 - \frac{1}{100}\right)^{50} = 0.39$$

End of Solution

Q.56 An infinite slope with slope angle $\beta = 22°$ consists of soil with the following properties:

Unit weight $\gamma = 15.72$ kN/m^3

Cohesion $c' = 12$ kPa

Angle of internal friction $\phi' = 15°$

The critical height of the slope (in m) is _____ (rounded off to two decimal places).

Ans. (6.53)(6.4 to 6.8)

$$\text{FOS} = \frac{\text{Shear strength}}{\text{Mobilised shear stress}} = \frac{C + \gamma H \cos^2\beta \tan\phi}{\gamma H \cos\beta \sin\beta}$$

$$1 = \frac{12 + 15.72 \times H_c \cos^2 22° \tan 15°}{15.72 \times H_c \cos 22° \times \sin 22°}$$

$$H_c = 6.525 \text{ m} \simeq 6.53 \text{ m}$$

End of Solution

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Q.57 A circular pile of 600 mm diameter and 6 m length is embedded in a saturated clayey soil. Undrained cohesion of the soil is 80 kPa. Unit weight of the soil is 19.20 kN/m^3. The adhesion factor is 0.54. If the diameter of the pile is doubled to 1200 mm (keeping the length constant), the ratio of pile capacity of 1200 mm diameter pile to that of 600 mm diameter pile is _____ (rounded off to two decimal places).

Ans. (2.56)(2.50 to 2.65)

Given: $d_1 = 600$ mm
$l = 6$ m
$c = 80$ kN/m^2
$\gamma = 19.20$ kN/m^3
$\alpha = 0.54$
$d_2 = 1200$ mm

Pile capacity, $Q_u = 9CA_b + \alpha \bar{C} A_s$

Now,
$$\frac{Q_{u2}}{Q_{u1}} = \frac{9C \times \frac{\pi}{4} d_2^2 + 0.54C\pi d_2 l}{9C\frac{\pi}{4} d_1^2 + 0.54C\pi d_1 l}$$

$$= \frac{1200\pi C\left(9 \times \frac{1}{4} \times 1200 + 0.54 \times 6000\right)}{600\pi C\left(9 \times \frac{1}{4} \times 600 + 0.54 \times 6000\right)}$$

$$= \frac{2(5940)}{(4590)} = 2.588 \simeq 2.56$$

End of Solution

Q.58 A group of 25 circular piles is arranged in 5 × 5 uniform pattern in a soft clay soil with equal spacing in both the directions. These are friction piles with negligible end bearing. Consider the following details:

Diameter of each pile = 1 m

Length of each pile = 15 m

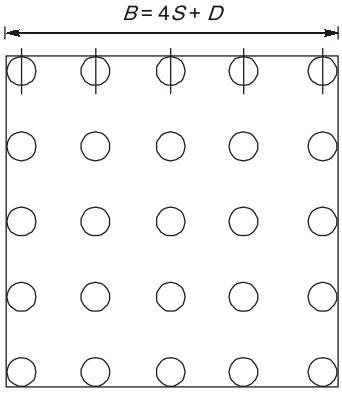
Cohesion of the soil = 20 kN/m^2

Unit weight of the soil = 16 kN/m^3

Adhesion factor = 0.75

Considering the efficiency of the pile group as unity, the optimum value of the ratio of the pile spacing to pile diameter is _____ (rounded off to one decimal place).

Ans. (3.4)(3.2 to 3.6)



$$\eta = \frac{\text{Pile group capacity}}{\text{No. of pile} \times \text{Single pile capacity}}$$

Individual pile capacity, $Q_u = \alpha C A_s$ [∵ Friction piles]

$= 0.75 \times 20\pi \times 1 \times 15 = 706.85$

Pile group $= 1 \times 20 \times 4B \times 15$

As efficiency of pile group = 1,

$\Rightarrow \quad 1200B = 25 \times 706.85$

$1200 \times (4S + 1) = 25 \times 706.85$

$S = 3.43$ m

Ratio of pile spacing to pile diameter = 3.43 m

End of Solution

Q.59 A shallow strip footing of width 2 m is embedded at a depth of 1.5 m below the ground surface in a homogeneous pure clay with an angle of internal friction zero. Consider unit weight of soil as 20 kN/m^3 and undrained cohesion of soil as 20 kN/m^2.

Due to rise of ground water table from far below the founding depth to the ground surface in monsoon season, the magnitude of percentage change in the net ultimate bearing capacity as per Terzaghi's theory is _____ (rounded off to two decimal places).

Ans. (0)(0 to 0)

For clayey soil, $q_{nu} = CN_C$

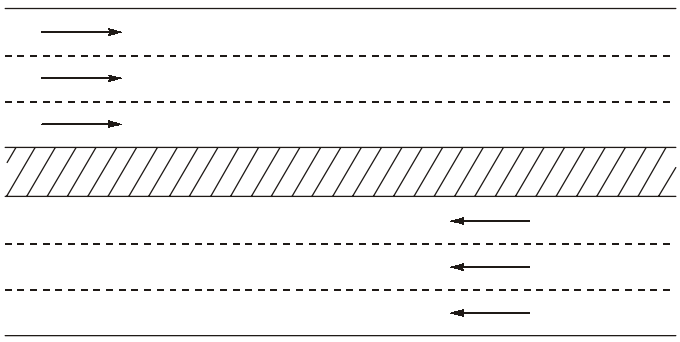
As independent of water table so change in net bearing capacity = 0

End of Solution

Q.60 Traffic is moving on a 6-lane dual carriageway road. Traffic volume per direction during peak hour (08:00 am to 09:00 am) is 6000 veh/h. It is assumed that the traffic is distributed uniformly across the lanes in each direction. Just at 08:00 am, a truck goes out of order on the middle lane of one side, thus disrupting the traffic on that lane in one direction. The lane capacity under normal conditions is 2000 veh/h/ln and under queue formation it is 1600 veh/h/ln. The traffic resumes at 08:30 am on removing the truck from the middle lane. Hourly traffic volume after 09:00 am reduces to 5000 veh/h/dir.

The number of vehicles in the queue at 10:00 am is _____ (in integer).

Ans. (2200)(2200 to 2200)



6-lane dual carriageway road

Now, Traffic under normal conditions = 2000 veh/hr/lane

and Queue discharge capacity = 1600 veh/hr/lane

From 8 am – 9 am,

Traffic volume per direction = 6000 veh/hr

Traffic volume per lane = 2000 veh/hr/lane

I. From 8 am – 8:30 am:

1 lane is blocked, so only 2 lanes will be available.

Arrival rate = 6000 veh/hr

Queu discharge capacity per lane = 1600 veh/hr

Total service rate in this duration = 2 × 1600 = 3200 veh/hr

Queue growth rate = 6000 – 3200 = 2800 veh/hr

Duration of this growth rate = 30 min = 0.5 hr

Queue formed in this duration = 0.5 × 2800 = 1400 vehicles

II. From 8:30 am to 9 am:

Truck is removed from lane, so the lane is open but the queue still exists.

Discharge rate = 1600 veh/hr/lane

Total service rate in this duration = 3 × 1600 = 4800 veh/hr

Queue growth rate = 6000 – 4800 = 1200 veh/hr

Duration of this growth rate = 30 min = 0.5 hr

Queue formed during this duration = 0.5 × 1200 = 600 veh

III. From 9 am to 10 am:

Arrival rate is reduced to 5000 veh/hr

Total service rate in this duration = 3 × 1600 = 4800 veh/hr

Queue growth rate = 5000 – 4800 = 200 veh/hr

Duration = 1 hr

Queue formed = 1 × 200 = 200 vehicles

Total numbers of vehicles in queue will be,

Queue in I + Queue in II + Queue in III

1400 + 1600 + 200 = 2200 vehicles

End of Solution

Q.61 In a bituminous mix, the percentage by weight of coarse aggregate, fine aggregate, filler, and bituminous binder is 58, 25, 12, and 5, respectively. The corresponding specific gravity of these materials is 2.68, 2.45, 2.42, and 1.15. The bulk specific gravity of the mix is 2.2.

The Voids Filled with Bitumen (VFB, in percentage) is _____ (rounded off to the nearest integer).

Ans. (50)(48 to 52)

Given, $W_{CA} = 58\%,\ W_{FA} = 25\%,\ W_b = 5\%$

$W_{MA} = 12\%$

$$\therefore \quad G_t = \frac{100}{\frac{W_{CA}}{G_{CA}} + \frac{W_{FA}}{G_{FA}} + \frac{W_b}{G_b} + \frac{W_{MA}}{G_{MA}}}$$

$$G_t = \frac{100}{\frac{58}{2.68} + \frac{25}{2.45} + \frac{5}{1.15} + \frac{12}{2.42}} = 2.43$$

$G_m = 2.2$

$$V_v(\%) = \left(\frac{G_t - G_m}{G_t}\right) \times 100 = \left(\frac{2.43 - 2.2}{2.2}\right) \times 100 = 9.465\%$$

$V_v(\%) = 9.465\%$

$$V_b(\%) = \frac{W_b}{G_b} \times G_m = \frac{5}{1.15} \times 2.2 \times 100 = 9.565\%$$

$$\therefore \quad VFB = \frac{V_b}{V_v + V_b} \times 100 = 50.26\%$$

End of Solution

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CE — 9 in Top 10

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2	PRAKHAR SHRI	Classroom Foundation Course
3	ARJUN SHARMA	Mains Online Course
4	BOLLA U NANDAN	Classroom Foundation Course
5	KESHAV	Test Series & IGP
7	TUSHAR AGGARWAL	Classroom Foundation Course
8	AYUSH JAIN	Classroom Foundation Course
9	ADITYA P SINGH	Test Series & IGP
10	PUSHPENDRA RATHORE	Test Series & IGP

ME — 10 in Top 10

AIR	Name	Course
1	NIMESH CHANDRA	Classroom Foundation Course
2	ASHOK KUMAR	Classroom Foundation Course
3	HARI SINGH	Mains Online Course
4	SIDDESH RAO	GS Online Course
5	GOLLANGI SATEESH	Mains Online Course
6	AVINASH VERMA	Mains Online Course
7	PRASHANT SINGH	Mains Offline Course
8	MONU KUMAR	Classroom Foundation Course
9	NIKHIL KUMAR SAHA	Test Series & IGP
10	AMIT KUMAR SINGH	Classroom Foundation Course

EE — 10 in Top 10

AIR	Name	Course
1	RAJAN KUMAR	Classroom Foundation Course
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3	OMPRAKASH RAJPUT	Classroom Foundation Course
4	TUSHAR CHAUDHARY	Classroom Foundation Course
5	RAM KUMAR	Test Series & IGP
6	PUNIT MEENA	Classroom Foundation Course
7	JYOTI K. PANDA	Classroom Foundation Course
8	D A SAI RAM REDDY	Test Series & IGP
9	DHRUV KAWAT	Classroom Foundation Course
10	AKSHIT PARASHARI	Live Online Foundation Course

E&T — 10 in Top 10

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2	RAJESH TIWARI	Live Online Foundation Course
3	PRASHANT LAVANIA	Classroom Foundation Course
4	PRADEEP SHUKLA	Mains Online Course
5	ASHISH SINGH PATEL	Classroom Foundation Course
6	TANYA TYAGI	Mains Online Course
7	PALAK MISHRA	Mains Online Course
8	HAYAT ALI	Classroom Foundation Course
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10	RAM PAL SINGH	Classroom Foundation Course

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1	ME	Rajneesh Bijarniya	Classroom Course
1	EE	Pradip Chauhan	Test Series
1	IN	Kailash Goyal	Classroom Course
1	ES	Yash Jain	Classroom Course
2	CE	Harshvardhan Singh	Classroom Course
2	ME	Gollangi Sateesh	Online Course
2	EE	Kailash Goyal	Classroom Course
2	EC	Ankush Philip John	Postal Package & Test Series
2	IN	S. Bhattacharya	Test Series
2	ES	Jitesh Choudhary	Classroom Course
2	ES	Tarun Yadav	Classroom Course
3	CE	Pankaj Meena	Classroom Course
3	ME	Nimesh Chandra	Classroom Course
3	PI	Aditya Kr. Prasad	Classroom Course
3	XE	Rohan Kr. Biswal	Test Series
5	CE	Kartik Pokhriyal	Classroom Course
5	PI	Kuldeep Singh Naruka	Classroom Course
5	IN	Sachin Yadav	Test Series
5	EC	M. M. Nafeez	Test Series
5	ES	Sachin Kumar	Classroom Course
6	PI	Kaushal Kr. Kaushik	Online Course
6	CE	Shivanand Chaurasia	Online Course
6	CE	Nimish Upadhyay	Online Course
6	EE	Puneet Soni	Test Series
6	EE	Shivam Kr. Gupta	Test Series
6	EC	Pentela J. Bhavani	Test Series
6	IN	Utkarsh P. Patil	Classroom Course
7	PI	Waleed Shaikh	Test Series
7	ME	Abhinn	Online Course
7	IN	Dev J. Patel	Test Series
7	ES	Ankit Kumar	Classroom Course
8	ME	Goutam Kumar	Test Series
9	CE	Tarun Yadav	Classroom Course
9	CS	Omhari	Test Series
9	EC	Chilukuri S. Charan	Test Series
9	XE	Apar Harsh Chandra	Classroom Course
10	CE	Adnan Quasain	Classroom Course
10	CE	Rahul Singh	Online Course
10	ME	Ashutosh Kumar	Classroom Course
10	ME	Jetti Ganateja	Test Series
10	ME	Muhammed Sinan K	Test Series
10	ME	Pitchika Kr. Vasu	Online Course
10	PI	M Gopu Ganesh	Test Series
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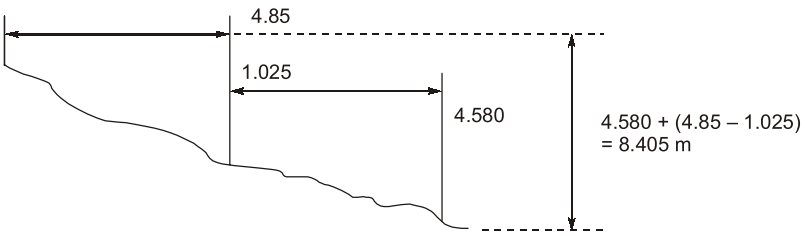
Q.62 The following consecutive readings (in m) were taken with a dumpy level and a levelling staff at a common interval of 20 m:

0.385; 1.030; 1.925; 2.825; 3.730; 4.850; 1.045; 2.005; 3.330; 4.580

The dumpy level was shifted after taking the sixth reading.

The gradient (in %) of the ground between the first and the last location of the reading is _____ (in integer).

Ans. (5)(5 to 5)



True vertical difference = 8.405 – 0.385 = 8.02 m

$$\therefore \quad \text{radiant} = \frac{8.02}{20\times 8} = \frac{8.02}{160} = 0.05 = 5\%$$

End of Solution

Q.63 An Activated Sludge Process (ASP) has an inlet wastewater flowrate of 20000 m^3/day with a Biochemical Oxygen Demand (BOD) concentration of 250 mg/l. It produces treated wastewater containing 20 mg/l BOD. The aeration tank has a working volume of 6000 m^3 and a biomass concentration of 3000 mg/l. Biological Sludge Residence Time (BSRT) of the system is 6 days. The influent wastewater and the treated effluent from the system have negligible concentrations of biomass. The sludge recycle line from the bottom of the Secondary Sedimentation Tank (SST) to the inlet of the aeration tank has a flowrate of 6000 m^3/day.

To maintain equilibrium, the flowrate (in m^3/day) of sludge that is to be wasted from the system is _____ (in integer).

Ans. (231)(230 to 250)

Given:

$Q = 20000\ m^3/d$
$S_o = 250$ mg/l
$S_e = 20$ mg/l
$V = 6000\ m^3$
$X = 3000$ mg/l
$\theta = 6$ days
$X_e \simeq 0$
$Q_R = 6000\ m^3/d$

We know, $\dfrac{Q_R}{Q} = \dfrac{X}{X_u - X}$

$$\Rightarrow \quad \frac{6000}{20000} = \frac{3000}{X_u - 3000}$$

$$\Rightarrow \quad X_u = 13000 \text{ mg/l}$$

Also, $$\theta = \frac{VX}{Q_w X_u}$$

$$\Rightarrow \quad 6 = \frac{6000 \times 3000}{Q_w \times 13000}$$

$$\Rightarrow \quad Q_w = 230.77 \text{ m}^3\text{/d} \simeq 231 \text{ m}^3\text{/d}$$

End of Solution

Q.64 The intensity-duration relationship for a rainfall on a rectangular plot ABCD of area 7 ha (1 ha = 10^4 m^2) can be modelled by the following equation:

$$I = \frac{25}{(t+10)}$$

where I is rainfall intensity (in cm/h), and t is the duration (in minutes) of rainfall. The average runoff coefficient over the area is 0.60. The time of entry (in minutes) to the outfall from the corners A, B, C, and D is 10, 20, 15 and 25, respectively.

The design flowrate (in m^3/h) of the storm-sewer at the outfall is _____ (in integer).

Ans. (300)(300 to 300)

Time of concentration is minimum time for which rational formula is applicable.

Rotational formula, $Q_P = kiA$

Here, $$i = \frac{25}{t+10} = \frac{25}{25+10} = \frac{25}{35} \text{cm/hr}$$

$\therefore$ $$Q_P = 0.6 \times \frac{25}{35} \times 10^{-2} \times 7 \times 10^4 = 300 \text{ m}^3\text{/hr}$$

End of Solution

Q.65 The maximum demand at a water purification plant has been estimated as 12 million litres per day. For the raw supplies, a rectangular sedimentation tank is to be designed with mechanical sludge removal arrangement. Consider depth of the tank as 4 m, detention period as 6 hours, and velocity of flow as 0.003 m/s.

The width (in m) of the detention tank is _____ (rounded off to two decimal places).

Ans. (11.57)(11 to 12)

Given: $Q = 12 \times 10^6$ l/day $= 12 \times 10^3$ m^3/day

$H = 4$ m

$D_t = 6$ hours

$v = 0.003$ m/s

We know, $D_t = \frac{V}{Q} = \frac{L}{v}$

Now, $D_t = \frac{V}{Q}$

$\Rightarrow \quad \frac{6}{24}\text{days} = \frac{V}{12\times10^3\ \text{m}^3/\text{day}}$

$\Rightarrow \quad V = 3000\ \text{m}^3$

Now, $D_t = \frac{L}{v}$

$\Rightarrow \quad 6 \times 3600 = \frac{L}{0.003\ \text{m/s}}$

$\Rightarrow \quad L = 64.8\ \text{m}$

Now, $V = L \times B \times H$

$\Rightarrow \quad 300 = 64.8 \times B \times 4$

$\Rightarrow \quad B = 11.57\ \text{m}$

End of Solution

■■■■