MADE EASY

GATE 2025

Civil Engineering
Shift-1

Questions & Solutions

Exam held on
16/02/2025 (Forenoon Session)

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SECTION - A GENERAL APTITUDE

Q.1 Is there any good show _____ television tonight?
Select the most appropriate option to complete the above sentence.
(a) in (b) at
(c) within (d) on

Ans. (d)
Is there any good show on television tonight.

End of Solution

Q.2 As the police officer was found guilty of embezzlement, he was _____ dismissed from the service in accordance with the Service Rules.
Select the most appropriate option to complete the above sentence.
(a) sumptuously (b) brazenly
(c) unintentionally (d) summarily

Ans. (d)

End of Solution

Q.3 The sum of the following infinite series is:

$$\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\frac{1}{5!}+\ldots$$

(a) π (b) $1 + e$
(c) $e - 1$ (d) e

Ans. (c)
Extension of e^x about $a = 0$

$$e^x = 1+\frac{x}{\lfloor 1}+\frac{x^2}{\lfloor 2}+\frac{x^3}{\lfloor 3}+\ldots.$$

Put $x = 1$

$$e^1 = 1+\frac{1}{\lfloor 1}+\frac{1}{\lfloor 2}+\frac{1}{\lfloor 3}+\ldots.$$

So, $1+\frac{1}{\lfloor 1}+\frac{1}{\lfloor 2}+\frac{1}{\lfloor 3}+\ldots. = e - 1$

$\Rightarrow e - 1$

End of Solution

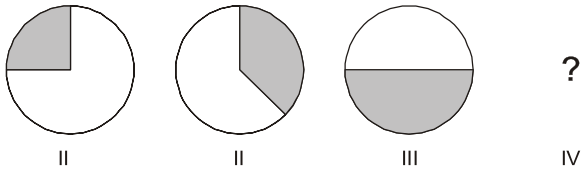
Q.4 A thin wire is used to construct all the edges of a cube of 1 m side by bending, cutting and soldering the wire. If the wire is 12 m long, what is the minimum number of cuts required to construct the wire frame to form the cube?

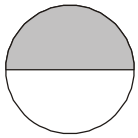
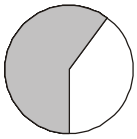
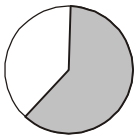
(a) 3 (b) 4
(c) 6 (d) 12

Ans. (a)

End of Solution

Q.5 The figures, I, II and III are parts of a sequence. Which one of the following options comes next in the sequence is IV?



(a) 
(b) 
(c) 
(d) 

Ans. (b)

End of Solution

Q.6 – Q.10 Carry TWO marks Each

Q.6 "Why do they pull down and do away with crooked streets, I wonder, which are my delight, and hurt no man living? Every day the wealthier nations are pulling down one or another in their capitals and their great towns: they do not know why they do it; neither do I. It ought to be enough, surely, to drive the great broad ways which commerce needs and which are the life-channels of a modern city, without destroying all history and all the humanity in between: the islands of the past."

(From Hilaire Belloc's "The Crooked Streets")

Based only on the information provided in the above passage, which one of the following statements is true?

(a) The author of the passage takes delight in wondering.
(b) The wealthier nations are pulling down the crooked streets in their capitals.

(c) In the past, crooked streets were only built on islands.
(d) Great broad ways are needed to protect commerce and history.

Ans. (b)

End of Solution

Q.7 Rohit goes to a restaurant for lunch at about 1 PM. When he enters the restaurant, he notices that the hour and minute hands on the wall clock are exactly coinciding. After about an hour, when he leaves the restaurant, he notices that the clock hands are again exactly coinciding. How much time (in minutes) did Rohit spend at the restaurant?

(a) $64\frac{6}{11}$ (b) $66\frac{5}{13}$

(c) $65\frac{5}{11}$ (d) $66\frac{6}{13}$

Ans. (c)

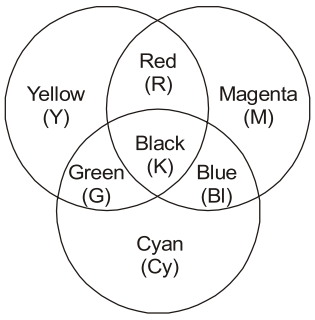
For R.G of 1 minute hand goes $\frac{12}{11}$

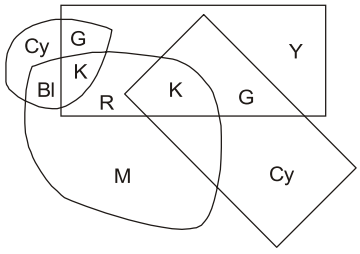
For R.G of 60 = $60\times\frac{12}{11}=\frac{720}{11}=65\frac{5}{11}$

End of Solution

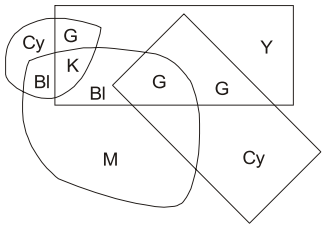
Q.8 A color model is shown in the figure with color codes: Yellow (Y), Magenta (M), Cyan (Cy), Red (R), Blue (Bl), Green (G), and Black (K).

Which one of the following options displays the color codes that are consistent with the color model?

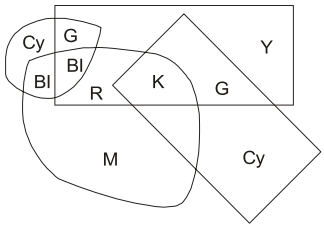


(a)


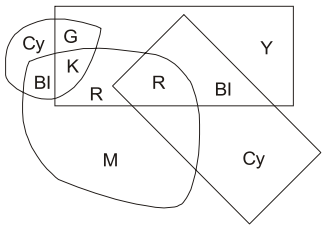
(b)



(c)



(d)



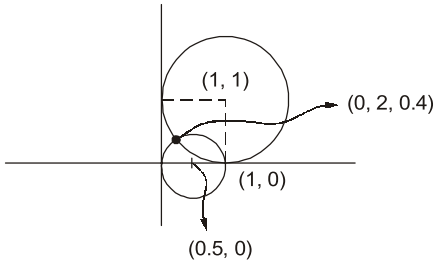
Ans. (a)

End of Solution

Q.9 A circle with center at $(x, y) = (0.5, 0)$ and radius = 0.5 intersects with another circle with center at $(x, y) = (1, 1)$ and radius = 1 at two points. One of the points of intersection (x, y) is:

(a) (0, 0)
(b) (0.2, 0.4)
(c) (0.5, 0.5)
(d) (1, 2)

Ans. (b)



Equation of the circles,

$$(x - 0.5)^2 + y^2 = 0.5 \quad \text{...(i)}$$

$$(x - 1)^2 + (y - 1)^2 = 1 \quad \text{...(ii)}$$

From equation (i) and (ii),

Points of intersection are (0.2, 0.4) and (1, 0).

End of Solution

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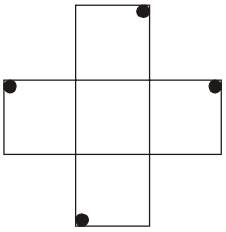
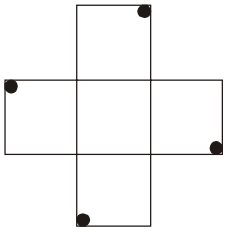
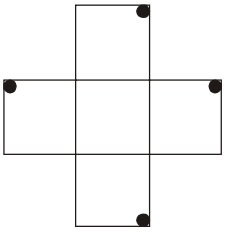
Q.10 An object is said to have an n-fold rotational symmetry if the object, rotated by an angle of $\frac{2\pi}{n}$, is identical to the original.

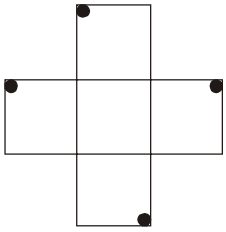
Which one of the following objects exhibits 4-fold rotational symmetry about an axis perpendicular to the plane of the screen?

Note: The figures shown are representative.

(a) 

(b) 

(c) 

(d) 

Ans. (b)

End of Solution

SECTION - B TECHNICAL

Q.11 – Q.35 Carry ONE mark Each

Q.11 Suppose λ is an eigenvalue of matrix A and x is the corresponding eigenvector. Let x also be an eigenvector of the matrix B = A – 2I, where I is the identity matrix. Then, the eigenvalue of B corresponding to the eigenvector x is equal to

(a) λ (b) λ + 2
(c) 2λ (d) λ – 2

Ans. (d)

Eigen value of $A = \lambda$
then eigen value of $(A - 2I) = \lambda - 2$
i.e. eigen value of $(B = A - 2I)$ is $(\lambda - 2)$

End of Solution

Q.12 Let $A = \begin{bmatrix} 1 & 1 \\ 1 & 3 \\ -2 & -3 \end{bmatrix}$ and $b = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$. For Ax = b to be solvable, which one of the following options is the correct condition on b_1, b_2 and b_3:

(a) $b_1 + b_2 + b_3 = 1$ (b) $3b_1 + b_2 + 2b_3 = 0$
(c) $b_1 + 3b_2 + b_3 = 2$ (d) $b_1 + b_2 + b_3 = 2$

Ans. (b)

$$[A : B] = \begin{bmatrix} 1 & 1 & b_1 \\ 1 & 3 & b_2 \\ -2 & -3 & b_3 \end{bmatrix}$$

↓

Convert into echelon form

For solution exist
⇓
System should be consistent
⇓
$\rho(AB) = \rho(A)$

$$[AB] = \begin{bmatrix} 1 & 1 & b_1 \\ 1 & 3 & b_2 \\ -2 & -3 & b_3 \end{bmatrix} \xrightarrow[R_3 = R_3 + 2R_1]{R_2 = R_2 - R_1}$$

$$\begin{bmatrix} 1 & 1 & b_1 \\ 0 & 2 & b_2 - b_1 \\ 0 & -1 & b_3 + 2b_1 \end{bmatrix} \downarrow R_3 = R_3 + \frac{R_2}{2}$$

$$\begin{bmatrix} 1 & 1 & b_1 \\ 0 & 2 & b_2 - b_1 \\ \underbrace{0 \quad 0}_{A} & & 3b_1 + b_2 + 2b_3 \end{bmatrix}$$

$$\rho(A) = 2$$

For, $\rho(AB) = 2$

$\Rightarrow \quad 3b_1 + b_2 + 2b_3 = 0$

End of Solution

Q.13 Which one of the following options is the correct Fourier series of the periodic function f(x) described below:

$$f(x) = \begin{cases} 0 & \text{if } -2 < x < -1 \\ 2k & \text{if } -1 < x < 1; \text{ period} = 4 \\ 0 & \text{if } -1 < x < 2 \end{cases}$$

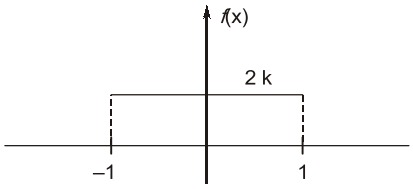
(a) $f(x) = \frac{k}{2} + \frac{2k}{\pi}\left(\cos\frac{\pi}{2}x - \frac{1}{3}\cos\frac{3\pi}{2}x + \frac{1}{5}\cos\frac{5\pi}{2}x - + \ldots\right)$

(b) $f(x) = \frac{k}{2} + \frac{2k}{\pi}\left(\sin\frac{\pi}{2}x - \frac{1}{3}\sin\frac{3\pi}{2}x + \frac{1}{5}\sin\frac{5\pi}{2}x - + \ldots\right)$

(c) $f(x) = k + \frac{4k}{\pi}\left(\cos\frac{\pi}{2}x - \frac{1}{3}\cos\frac{3\pi}{2}x + \frac{1}{5}\cos\frac{5\pi}{2}x - + \ldots\right)$

(d) $f(x) = k + \frac{4k}{\pi}\left(\sin\frac{\pi}{2}x - \frac{1}{3}\sin\frac{3\pi}{2}x + \frac{1}{5}\sin\frac{5\pi}{2}x - + \ldots\right)$

Ans. (c)



$$a_0 = \frac{1}{L}\int_{-L}^{L} f(x)dx$$

$$= \frac{1}{2}\int_{-2}^{2} f(x)dx$$

$$= \frac{1}{2} \times 2\int_{0}^{2} f(x)dx$$

$$= \int_{0}^{1} 2kdx = 2k$$

$f(x)$ = even function

So $b_n = 0$

Period = 4 i.e. i.n (– 2, 2)

$L = 2$

$$a_n = \frac{1}{L}\int_{-L}^{L}\cos\left(\frac{n\pi x}{2}\right)f(x)\,dx$$

$$= \frac{1}{2}\int_{-2}^{2}\cos\left(\frac{n\pi x}{2}\right)f(x)\,dx$$

$$= 2\times\frac{1}{2}\int_{0}^{1}\cos\left(\frac{n\pi x}{2}\right)2k\cdot dx$$

$$= 2k\int_{0}^{1}\cos\left(\frac{n\pi x}{2}\right)dx$$

$$= 2k\left[\frac{\sin\left(\frac{n\pi x}{2}\right)}{\left(\frac{n\pi}{2}\right)}\right]_0^1 = \frac{4k}{n\pi}\left[\sin\left(\frac{n\pi x}{2}\right)\right]_0^1$$

$$a_n = \frac{4k}{n\pi}\sin\frac{n\pi}{2}$$

Now, $$f(x) = \frac{a_0}{2}+\sum_{n=1}^{\infty}a_n\cos\left(\frac{n\pi x}{L}\right)$$

$$= \frac{2k}{2}+\sum_{n=1}^{\infty}a_n\cos\left(\frac{n\pi x}{L}\right)$$

$$= k+\frac{4k}{\pi}\cos\frac{\pi x}{2}+\frac{4k}{2\pi}\times 0+\frac{4k}{3\pi}(-1)\cos\left(\frac{3\pi x}{2}\right)+0+\frac{4k}{5\pi}\times\cos\frac{5\pi x}{2}+\ldots$$

$$= k+\frac{4k}{\pi}\left[\cos\left(\frac{\pi x}{2}\right)-\frac{1}{3}\cos\frac{3\pi x}{2}+\frac{1}{5}\cos\frac{5\pi x}{2}-..\right]$$

End of Solution

Q.14 X is the random variable that can take any one of the values, 0, 1, 7, 11 and 12. The probability mass function for X is

$P(X = 0) = 0.4$; $P(X = 1) = 0.3$; $P(X = 7) = 0.1$;

$P(X = 11) = 0.1$; $P(X = 12) = 0.1$

Then, the variance of X is

(a) 20.81 (b) 28.40

(c) 31.70 (d) 10.89

Ans. (a)

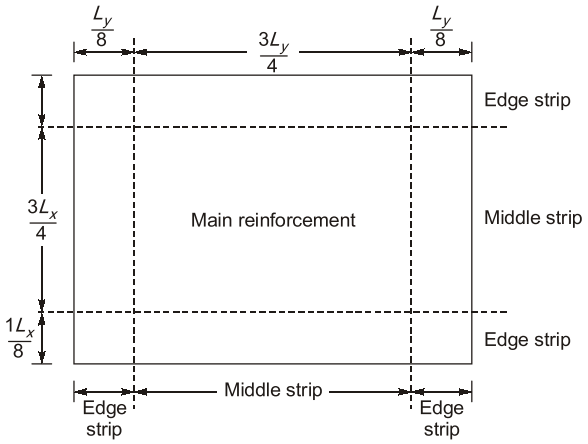
x	0	1	7	11	12
$P(x)$	0.4	0.3	0.1	0.1	0.1

$E(x) = 0 \times 0.4 + 1 \times 0.3 + 7 \times 0.1 + 11 \times 0.1 + 12 \times 0.1$
$= 3.3$
$E(x^2) = 0^2 \times 0.4 + 1^2 \times 0.3 + 7^2 \times 0.1 + 11^2 \times 0.1 + 12^2 \times 0.1$
$= 0 + 0.3 + 4.9 + 12.1 + 14.4$
$\text{Var}(x) = E(x)^2 - (E(x))^2$
$= 14.4 - (3.3)^2 = 20.81$

End of Solution

Q.15 As per IS 456:2000 provisions for two-way slabs with continuous edges, the longitudinal steel reinforcement to be provided in the edge strip is based on
(a) the calculated minimum bending moment
(b) the area of longitudinal steel provided in the middle strip in the shorter span
(c) the area of longitudinal steel provided in the middle strip in the longer span
(d) the prescribed minimum cross-sectional area of longitudinal steel for slabs

Ans. (d)



As per IS 456 : 2000
In edge strip minimum reinforcement are provided.
0.15% of BD for Fe250
0.12% of BD for HYSD

End of Solution

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Q.16 Identify the FALSE statement from the following options:

(a) The compressive strength of a concrete test specimen can vary depending on its shape and size

(b) Air-dried and saturated test specimens show the same compressive strength for concrete

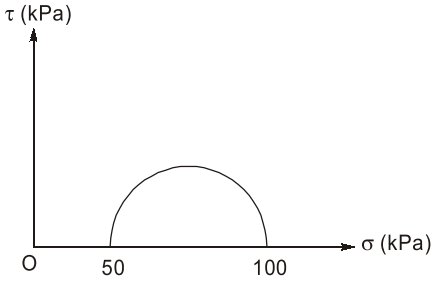
(c) Curing conditions, such as temperature and relative humidity, can influence the compressive strength of concrete

(d) Compressive strength depends on the water-to-binder ratio used in the concrete mixture

Ans. (b)

End of Solution

Q.17 The results of a consolidated drained triaxial test on a normally consolidated clay are shown in the figure. The angle of internal friction is



(a) $\sin^{-1}\left(\frac{1}{2}\right)$

(b) $\sin^{-1}\left(\frac{1}{3}\right)$

(c) $\sin^{-1}\left(\frac{2}{3}\right)$

(d) $\sin^{-1}\left(\frac{3}{4}\right)$

Ans. (b)

For CD test, $C = 0$

$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right)$$

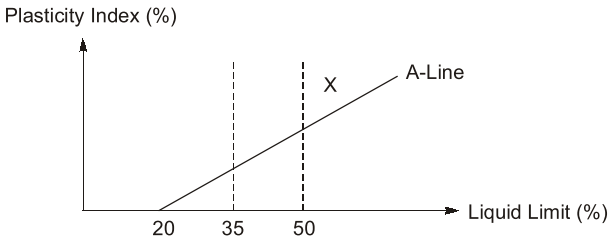
$$100 = 50 \times \left[\frac{1+\sin\phi}{1-\sin\phi}\right]$$

$$\sin\phi = \frac{1}{3}$$

$$\Rightarrow \quad \phi = \sin^{-1}\left(\frac{1}{3}\right)$$

End of Solution

Q.18 The standard plasticity chart for the classification of a fine-grained soil is shown in the figure. As per the Indian standard soil classification system, X represents



(a) inorganic clay with medium plasticity
(b) inorganic silt with medium plasticity
(c) inorganic clay with high plasticity
(d) inorganic silt with high compressibility

Ans. **(c)**
Soil X can be classified as inorganic clay with high plasticity.

End of Solution

Q.19 For a flowing fluid, a dimensionless combination of velocity (V), length scale (l), and acceleration due to gravity (g) would be

(a) $\frac{V^2}{gl}$ (b) $\frac{Vg}{l}$

(c) $\frac{gl^2}{V}$ (d) $\frac{l}{V^2 g}$

Ans. **(a)**

$$\frac{v^2}{gl} = \frac{\frac{m^2}{\sec^2}}{\frac{m}{\sec^2} \times m} \quad \text{(Dimensionless)}$$

End of Solution

Q.20 To derive the total flood hydrograph at a catchment outlet from an isolated storm, the order in which the following methods are applied, from the first method to the last method, is

P. Obtaining the hyetograph
Q. Addition of baseflow
R. Estimation of initial and infiltration losses
S. Application of unit hydrograph

(a) PRSQ (b) PQRS
(c) RPSQ (d) PSQR

Ans. **(a)**

To obtain the flood hydrograph, the methods would be arranged as **PRSQ**.

P. Obtaining the hyetograph
R. Estimation of initial and infiltration losses
S. Application of unit hydrograph
Q. Addition of base flow

End of Solution

Q.21 Fecal Coliform (FC) concentration in river water was measured as 10780 cfu/100 ml. The FC concentration after the conventional water treatment, but before chlorination, was measured as 23 cfu/100 ml. The 'Log Kill' (inactivation) of FC due to the conventional water treatment is closest to

(a) 4.00 (b) 2.50
(c) 2.67 (d) 3.00

Ans. **(c)**

Given, $N_0 = 10708$ cfu/100 ml
$N_t = 23$ cfu/100 ml
Log kill = Log N_0 – log N_t
= Log10708 – Log(23)
= 2.667

End of Solution

Q.22 A hydrocarbon (C_nH_m) is burnt in air ($O_2 + 3.78N_2$). The stoichiometric fuel to air mass ratio for this process is

Note: Atomic Weight: C(12), H(1)
Effective Molecular Weight: Air(28.8)
Ignore any conversion of N2 in air to the oxides of nitrogen (NO_x)

(a) $0.0291\frac{(4n+m)}{(12n+m)}$ (b) $34.42\frac{(12n+m)}{(4n+m)}$
(c) $34.42\frac{(4n+m)}{(12n+m)}$ (d) $0.0291\frac{(12n+m)}{(4n+m)}$

Ans. **(d)**

$$C_nH_m + aO_2 \rightarrow xCO_2 + yH_2O$$

For carbon c : n = x $\Rightarrow$ $x = n$ ...(1)

For hydrogen H : m = 2y $\Rightarrow$ $y = \frac{m}{2}$ ...(2)

For Oxygen O : 2a = 2x + y $\Rightarrow$ $a = \frac{2n+\frac{m}{2}}{2} = \left(n+\frac{m}{4}\right)$ ...(3)

Mass of fuel : $C_nH_m = 12n + m$ (C = 12, H = 1)

Mass of O_2: $32\times\left(n+\frac{m}{4}\right)$ (O = 16)

Mass of air $= 137.84\left(\frac{4n+m}{4}\right)$

Now, $\frac{\text{Fuel}}{\text{Air}} = \frac{12n+m}{\frac{137.84}{4}(4n+m)} = 0.0291\left(\frac{12n+m}{4n+m}\right)$

End of Solution

Q.23 All the vehicles that come during a particular peak hour come during a 10-minute period within this hour. The 15-minute peak hour factor for this peak hour is

(a) 0.25 (b) 0.167
(c) 0.75 (d) 1.0

Ans. **(a)**

Peak hour factor for 15 minutes $= \frac{q}{4\times q_{15}}$

Here, all the vehicle are passing in 10 minute interval,

$\therefore \quad q = q_{15}$

$\Rightarrow \quad \text{PHF} = \frac{1}{4} = 0.25$

End of Solution

Q.24 In the context of testing bitumen, which one of the following statements is FALSE:

(a) The depth of penetration of needle in the standard penetration test is measured in the units of one-tenth of millimeter
(b) Softening point is measured using a ring and ball apparatus
(c) Softening point is measured in the units of time
(d) Ductility is measured in the units of length

Ans. **(c)**

Softening point is measured in the units of temperature.

End of Solution

Q.25 The maximum degree of the curve that can be used for railways in a mountainous region is

(a) 10 (b) 20
(c) 50 (d) 40

Ans. **(d)**

The maximum degree of the curve that can be used for railways in a mountainous region is 40°.

End of Solution

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Q.26 If the horizontal distance between a staff point and the point of observation is d, the error due to the curvature of earth is proportional to

(a) d (b) $\frac{1}{d}$

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

Ans. **(c)**

We know, error due to curvature

$$E = +0.0785d^2$$

$$\Rightarrow \quad E \propto d^2$$

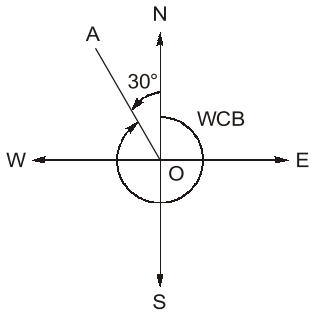
End of Solution

Q.27 If the quadrantal bearing of a line is N30„aW, then the whole circle bearing of the line is

(a) 120° (b) 210°

(c) 300° (d) 330°

Ans. **(d)**



WCB of line OA = 360° – 30°

= 330°

End of Solution

Q.28 Which of the following equations belong/belongs to the class of second-order, linear, homogeneous partial differential equations:

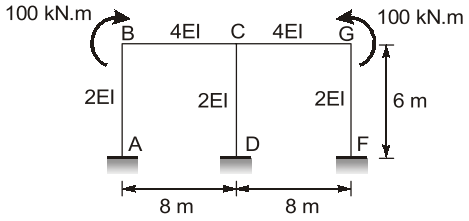
(a) $\frac{\partial^2 u}{\partial t^2} = c^2\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + xy$ (b) $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = 0$

(c) $\frac{\partial u}{\partial t} = c\frac{\partial u}{\partial x}$ (d) $\left(\frac{\partial^2 u}{\partial t^2}\right)^2 = c^2\frac{\partial^2 u}{\partial x^2}$

Ans. **(b)**

End of Solution

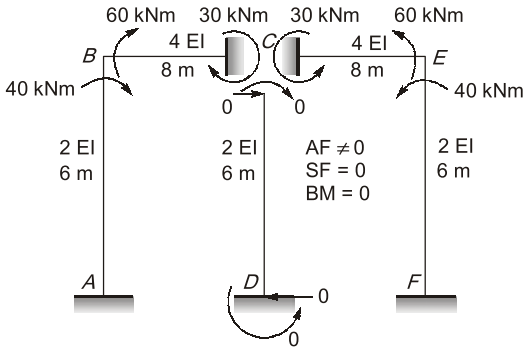
Q.29 Consider the frame shown in the figure under the loading of 100 kN.m couples at the joints B and G. Considering only the effects of flexural deformations, which of the following statements is/are true:



(a) Axial force is zero in the member CD
(b) Shear force is zero in the member CD
(c) There is no rotation in the joint C
(d) The magnitude of bending moment developed in the member BC at the end C is more than 50 kN.m

Ans. (b, c)

Joint	member	stiffness	T.S.	DF
B	BA	$\frac{4E(2I)}{6} = \frac{4}{3}EI$	$\frac{10}{3}EI$	2/5
	BC	$\frac{4E(4I)}{8} = 2EI$		3/5



Bending moment transfer in member BA.

$$M_{BA} = DF_{BA} \times M$$

$$= \frac{2}{5} \times 100 = 40 \text{ kN.}m$$

Bending moment Transfer in member BC

$$M_{BC} = DF_{BC} \times M$$

$$= \frac{3}{5} \times 100 = 60 \text{ kN.}m$$

It is clear that
- No rotation at joint 'C'
- Shear force in CD member = 0
- Axial force in CD member ≠ 0
- Bending moment developed in BC at joint C = 30 kN-m

Which is less than 50 kN-m

End of Solution

Q.30 For the Bernoulli's equation to be applicable in a fluid flow situation, which of the following conditions is/are to be satisfied:
(a) Fluid should be frictionless
(b) Fluid should be incompressible
(c) Flow should be steady
(d) Flow should be rotational

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

End of Solution

Q.31 The Surface Overflow Rate (SOR) in a rectangular sedimentation tank is 45 $m^3/m^2/d$. Minimum diameters of spherical inorganic and organic particles expected to be completely removed in this tank are calculated. Assume that Stoke's law is applicable. Which of the following options is/are *correct*:
Specific gravity of inorganic particles = 2.65
Specific gravity of organic particles = 1.20
Acceleration due to gravity (g) = 9.81 m/s^2
Kinematic viscosity (ν) = 1×10^{-6} m^2/s
(a) Minimum diameter of inorganic particles is 24 μm
(b) Minimum diameter of organic particles is 69 μm
(c) Minimum diameter of inorganic particles is 15 μm
(d) Minimum diameter of organic particles is 55 μm

Ans. **(a, b)**
Given:

SOR $V_0 = 45\ m^3/m^2/day = \frac{45}{86400} m/sec$

Kinematic viscosity, $\nu = 1 \times 10^{-6}\ m^2/sec$, $g = 9.81\ m/sec^2$
For inorganic solid $G = 2.65$
By stoke's Law settling velocity is given by

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

where, G_S = specific gravity of particle
d = diameter of particle

$$\frac{45}{86400} = \frac{9.81\times(2.65-1)d^2}{18\times1\times10^{-6}}$$

$$d_{\text{inorganic particle}} = 2.40 \times 10^{-5}\ \text{m} = 24\ \mu\text{m}$$

For organic solid ($G = 1.20$)

$$V_s = \frac{g}{180}(G-1)d^2$$

$$\frac{45}{86400} = \frac{9.81}{18\times1\times10^{-6}}(1.2-1)d^2$$

$$d_{\text{organic particle}} = 6.9 \times 10^{-5}\ \text{m} = 69\ \mu\text{m}$$

End of Solution

Q.32 Aeration is employed as a treatment option for the removal of several pollutants from contaminated water.
Identify the pollutant(s), where aeration is employed as a part of their removal:
(a) Iron (b) Cadmium
(c) Manganese (d) Zinc

Ans. **(a, c)**
Iron and Manganese are converted to precipitation through aeration and further removed through sedimentation and filtration.

End of Solution

Q.33 If the weights retained on the 2.36 mm, 1.18 mm, 600 μm, and 300 μm sieves are 30%, 35%, 15%, and 20%, respectively, of the total weight of an aggregate sample, then the fineness modulus of the sample is _____ (rounded off to 2 decimal places).

Ans. **(3.75)(3.74 to 3.76)**

Sieve size	Weight retained	Cumulative weight retained
80mm	0	0
40mm	0	0
20mm	0	0
10mm	0	0
4.75mm	0	0
2.36mm	30	30
1.18mm	35	65
600 μ	15	80
300 μ	20	100
150 μ	0	100
		375

$$\text{Fineness modulus} = \frac{\Sigma\%\text{age cumulativeretain}}{100} = \frac{375}{100} = 3.75$$

End of Solution

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Q.34 A water resources project with an expected life of 25 years has to be designed for an acceptable risk of 5% against a design flood. The return period for the design flood (in years) is _____ (rounded off to the nearest integer).

Ans. **(488)(485 to 490)**

Given, $n = 25$ years

Risk = 5%

$T = ?$

We know,

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

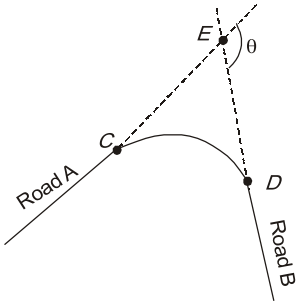
$$0.05 = 1-\left(1-\frac{1}{T}\right)^{25}$$

$\Rightarrow$ $T = 488$ day

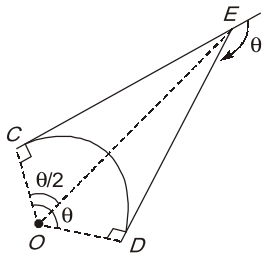
End of Solution

Q.35 Road A and Road B are joined by a circular horizontal curve of radius 200 m as shown in the figure. Road A and Road B are tangential to the curve at the points C and D, respectively. Had the curve not been there, straight roads A and B would have met at the point E. The distance from C to E is 92 m. The value of angle θ (in degrees) is _____ (rounded off to 1 decimal place).

Note: The value of angle .. is to be calculated only from the consideration of Euclidean geometry and the data given in the problem.



Ans. (49.40)(48 to 51)



Tangent length, $CE = R\frac{\tan\theta}{2}$

$$92 = 200 + \tan\frac{\theta}{2}$$

$$\theta = 2\tan^{-1}\left[\frac{92}{200}\right] = 49.40^\circ$$

End of Solution

Q.36 The value of $\lim_{x\to\infty}\left(x-\sqrt{x^2+x}\right)$ is equal to

(a) –1 (b) –0.5
(c) –2 (d) 0

Ans. (b)

$$= \lim_{x\to\infty}\left(x-\sqrt{x^2+x}\right) \qquad (\infty-\infty) \text{ form}$$

$$= \lim_{x\to\infty}\left(x-\sqrt{x^2+x}\right)\times\frac{\left(x+\sqrt{x^2+x}\right)}{\left(x+\sqrt{x^2+x}\right)}$$

$$= \lim_{x\to\infty}\frac{x^2-(x^2+x)}{x+\left(\sqrt{x^2+x}\right)}$$

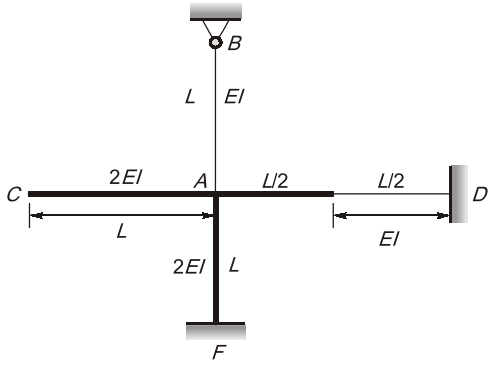
$$= \lim_{x\to\infty}\frac{-x}{x+\sqrt{x^2+x}}$$

$$= \lim_{x\to\infty}\frac{-x}{x\left(1+\sqrt{1+\frac{1}{x}}\right)}$$

$$\lim_{x\to\infty}\frac{-1}{1+\sqrt{1+\frac{1}{x}}} = \frac{-1}{1+1} = \frac{-1}{2} = -0.5$$

End of Solution

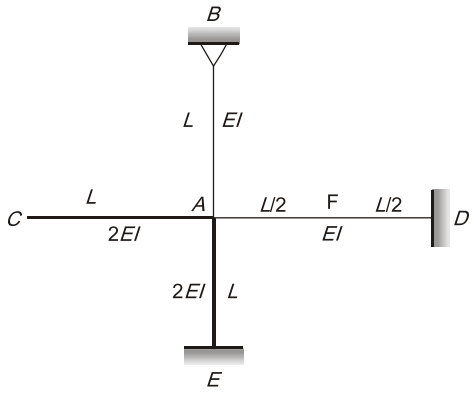
Q.37 In the rigid-jointed frame shown in the figure, the distribution factor of the member AD is closest to



(a) 0.254
(b) 0.267
(c) 0.398
(d) 0.421

Ans. (c)

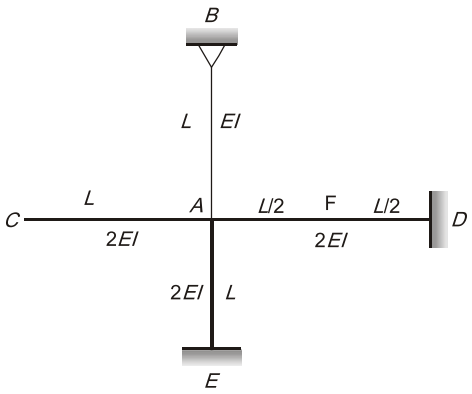
Assume flexure rigidity of member AD is 'EI'



Joint	member	stiffness	Total stiffness	DF
A	AC	0	$\frac{15EI}{L}$	0
	AB	$\frac{3(EI)}{L}$		3/15
	AD	$\frac{4(EI)}{L}$		4/15
	AE	$\frac{4(2EI)}{L}$		8/15

$$(DF)_{AD\ (\text{when } I_{AD} = I)} = \frac{4}{15} = 0.267$$

Assume flexural rigidity of number AD is '2EI'



Joint	member	stiffness	Total stiffness	DF
A	AC	0	$\frac{19EI}{L}$	0
	AB	$\frac{3(EI)}{L}$		3/19
	AD	$\frac{2(EI)}{L}$		8/19
	AE	$\frac{4(2EI)}{L}$		8/19

$$(DF)_{AD\ (\text{when } I_{AD} = 2I)} = \frac{8}{19} = 0.421$$

If, $I_{AF} = 2I$ and $I_{FD} = I$.

then $(DF)_{AD}$ should lies between (0.267) and (0.421)

only option (b) lies in this range

So,

$$(DF)_{AD \text{ for given frame}} = 0.398$$

End of Solution

Q.38 In an oedometer apparatus a specimen of fully saturated clay has been consolidated under a vertical pressure of 100 kPa and is at equilibrium state. Immediately on increasing the vertical pressure to 150 kPa, the effective stress σ' and excess pore water pressure Δu will be

(a) $\sigma' = 50$ kPa, $\Delta u = 100$ kPa (b) $\sigma' = 100$ kPa, $\Delta u = 50$ kPa

(c) $\sigma' = 150$ kPa, $\Delta u = 50$ kPa (d) $\sigma' = 100$ kPa, $\Delta u = 150$ kPa

Ans. **(b)**

Initial effective stress, $\sigma' = 100$ kPa

After immediate increment in vertical pressure,

Excess PWP, $\Delta u = 50$ kPa

$\therefore$ $\sigma' = 100$ kPa and $\Delta u = 50$ kPa

End of Solution

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Q.39 The mean rainfall over a catchment has to be estimated. The data for four rain gauges located in and around the catchment is listed in the table. Which one of the following statements is correct:

Rain gauge station	P	Q	R	S
Whether located inside the catchment	Yes	Yes	Yes	No
Thiessen weightage factor	0.25	0.50	0.10	0.15
Rainfall (mm)	100	110	100	125

(a) The estimate obtained from the Thiessen-mean method is greater than that obtained using the arithmetic-mean method
(b) The estimate obtained from the Thiessen-mean method is equal to that obtained using the arithmetic-mean method
(c) The estimate obtained from the Thiessen-mean method is less than that obtained using the arithmetic-mean method
(d) The Thiessen-mean method cannot be applied in this case

Ans. **(a)**

By Arithmetic mean method.

(Since, raingauge S located outside the catchment)

$$(\bar{P})_A = \frac{P_A + P_Q + P_R}{3} = \frac{100 + 110 + 100}{3} = 103.33 \text{ mm}$$

By Thiessen polygon method,

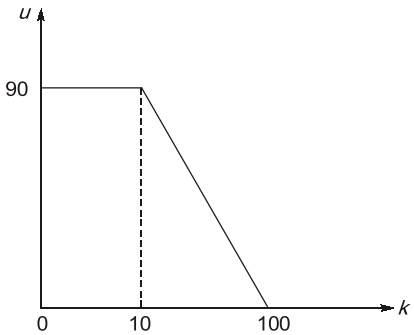
$$(\bar{P})_T = \frac{\sum P_i x_i}{\sum x_i}$$

$$= \frac{100 \times 0.25 + 110 \times 0.5 + 100 \times 0.1 + 125 \times 0.15}{1} = 108.75 \text{ mm}$$

$$\Rightarrow \quad (\bar{P})_T > (\bar{P})_A$$

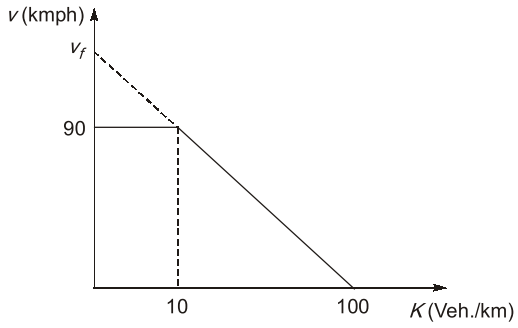
End of Solution

Q.40 The speed-density relation on a one-way, single lane road is shown in the figure, where speed u is in km/hour and density k is in vehicles/km. The maximum flow (in vehicles/hour) on this road is



(a) 2500
(b) 900
(c) 2250
(d) 2000

Ans. (a)



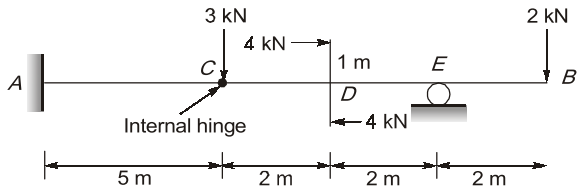
$$\frac{90}{100-10} = \frac{v_f}{100}$$

$$v_f = 100$$

$$q_{max} = \left(\frac{k_j}{2}\right)\left(\frac{v_f}{2}\right) = \left(\frac{100}{2}\right)\left(\frac{100}{2}\right) = 2500 \text{ veh/hr}$$

End of Solution

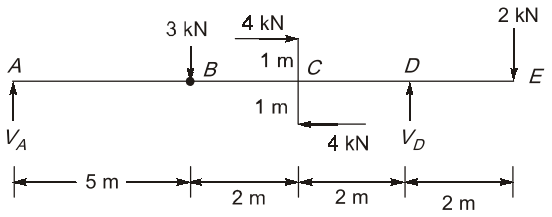
Q.41 Consider the beam *ACDEB* given in the figure. Which of the following statements is/are correct:



(a) Bending moment is zero between the points A and C
(b) There is a sudden jump in shear force at the point D
(c) There is a sudden jump in bending moment at the point E
(d) Bending moment is zero somewhere between the points D and E

Ans. (a, d)

Let V_A and V_D be the vertical reactions at *A* and *D* respectively.



From right side,

$$\Sigma M_B = 0$$

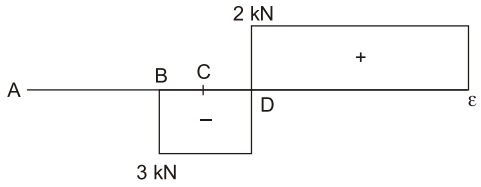
$$-V_D(4) + 4(2) + 2(6) = 0$$

$\Rightarrow$ $V_D = 5$ kN

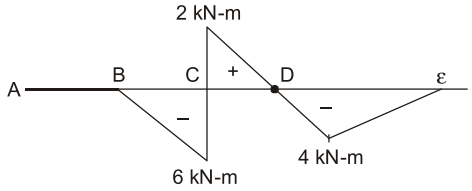
Also, $V_A + V_D = 5$

$V_A = 0,\ M_A = 0$

SFD:



BMD:



BM is zero in span AB and in between C and D.

Correct answer will be (a) and (d).

End of Solution

Q.42 In the context of construction project management, which of the following statements is/are true:

(a) A dummy activity will consume time and resources

(b) The programme evaluation and review technique (PERT) is best suited for projects with large uncertainties in the duration of activities

(c) A Gantt chart is commonly used for identifying the 'critical path' of activities in a project

(d) Free float is the amount of time by which the start of an activity can be delayed without causing a delay in the start of a following activity

Ans. (b, d)

End of Solution

Q.43 Lacey's regime equations, followed in India for making scour calculations while designing hydraulic structures across alluvial channels, are given below. Regarding these equations, which of the following statements is/are true:

$$D = 0.470 \times \left[\frac{Q}{f_s}\right]^{1/3}$$

$$P = 4.75 \times \sqrt{Q}$$

$$f_s = 1.76 \times \sqrt{d}$$

where, Q is discharge and f_s is silt factor

(a) D is the depth of scour below the existing riverbed

(b) P is the Lacey's waterway width

(c) d is the average grain size diameter of the bed material in centimetres

(d) D is the depth of scour below the design flood level

Ans. (b, d)

As per Lacey's

$$D = 0.470 \times \left[\frac{Q}{f_s}\right]^{1/3}$$

$$P = 4.75 \times \sqrt{Q}$$

$$f_s = 1.76 \times \sqrt{d}$$

where,
D = Depth of scour below the design flood level
Q = Discharge
f_s = Silt factor
d = Diameter of particle
P = Lacey's waterway width

End of Solution

Q.44 $MgCl_2$ and $CaSO_4$ salts are added to 1 litre of distilled deionized water and mixed until completely dissolved. Total Dissolved Solids (TDS) concentration is 500 mg/l, and Total Hardness (TH) is 400 mg/l (as $CaCO_3$). The amounts of $MgCl_2$ and $CaSO_4$ added are calculated (rounded off to the nearest integer). Which of the following options is/are true:
Atomic weights: Ca(40), Mg(24), S(32), O(16), Cl(35.5), C(12)
(a) Amount of $MgCl_2$ added is 143 mg
(b) Amount of $CaSO_4$ added is 357 mg
(c) Amount of $MgCl_2$ added is 103 mg
(d) Amount of $CaSO_4$ added is 397 mg

Ans. (c, d)

Total dissolved solid (TDS) = 500 mg/lt
Total hardness = 400 mg/lt (as $CaCO_3$)
$MgCl_2$ and $CaSO_4$ added in to the water.

$MgCl_2 \rightarrow Mg^{+2} + 2Cl^-$
95 24 71

$CaSO_4 \rightarrow Ca^{+2} + SO_4^- 2$
136 40 96

Now, Total hardness (as $CaCO_3$) $= \left(\frac{Ca^{+2}}{20} + \frac{Mg^{+2}}{12}\right) \times 50$

$$400 \text{ mg/lt} = \left(\frac{40B}{20} + \frac{24A}{12}\right) \times 50$$

$$2A + 2B = 8$$

$$A + B = 4 \quad \ldots (i)$$

Now, Total dissolved solid (TDS) = 500 mg/lt
($MgCl_2$ and $CaSO_4$ completely dissolved in water)
95 part of $MgCl_2$ + 136 part of $CaSO_4$ = 500 mg/lt

$$95A + 136B = 500 \quad \ldots (ii)$$

On solving equation (i) and (ii) weight

$A = 1.073$

$B = 2.926$

Now,

$MgCl_2$ added in water = $95A = 95 \times 1.073 = 103$ mg/lt

$CaSO_4$ added in water = $136B = 136 \times 2.926 = 397$ mg/lt.

End of Solution

Q.45 A facultative pond system is employed for wastewater treatment. Which of the following statements is/are true:

(a) The dissolved oxygen concentration will be high during daytime compared to night-time

(b) The pH will be high during daytime compared to night-time

(c) The dissolved oxygen concentration will be low during daytime compared to night-time

(d) The pH will be low during daytime compared to night-time

Ans. **(a, b)**

During day time photosynthesis takes place, algae produces oxygen and consumes CO_2, therefore pH will increase and dissolved oxygen will also increase.

Hence, the dissolved oxygen concentration will be high during daytime compared to night-time and the pH will be high during daytime compared to night-time.

End of Solution

Q.46 Organic fraction of municipal solid waste (OFMSW) with bulk density of 315 kg/m^3 and water content of 30% is mixed with municipal sludge of bulk density 700 kg/m^3 and water content of 70%, such that the water content of the mixture is 40%. The amount (in kg) of sludge to be mixed per kg of OFMSW (rounded off to 2 decimal places) and the density of the mixture (in kg/m^3) (rounded off to the nearest integer) are calculated. Which of the following options is/are true:

(a) 0.33 kg of sludge added per kg of OFMSW

(b) Density of the mixture is 365 kg/m^3

(c) 0.66 kg of sludge added per kg of OFMSW

(d) Density of the mixture is 450 kg/m^3

Ans. **(a, b)**

Given:

	MSW (X_1)	Sludge (X_2)
Weight	W_1	W_2
Moisture control	MC = 30%	MC = 70%
Density	ρ = 315 kg/m^3	ρ = 700 kg/m^3

Now,

$0.3W_1 + 0.7W_2 = 0.4\,(W_1 + W_2)$ (given in question)

$3W_1 + 7W_2 = 4W_1 + 4W_2$

$3W_2 = W_1$

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$$\frac{W_2}{W_1} = \frac{1}{3} = 0.33$$

Bulk density of mix.

$$\rho_{max} = \frac{M_1 + M_2}{\frac{M_1}{\rho_1} + \frac{M_2}{\rho_2}}$$

$$\therefore \frac{W_2}{W_1} = \frac{(\text{Mass})_2}{(\text{Mass})_1} = \frac{M_2}{M_1} = \frac{1}{3}$$

$M_1 = 1,\ M_2 = 0.33$

$$\rho_{bulk} = \frac{1 + 0.33}{\frac{1}{315} + \frac{0.33}{700}} \simeq 365\ \text{kg/m}^3$$

End of Solution

Q.47 Let y be the solution of the initial value problem $y'' + 0.8y' + 0.16y = 0$ where $y(0) = 3$ and $y'(0) = 4.5$. Then, $y(1)$ is equal to _____ (rounded off to 1 decimal place).

Ans. **(5.83)(5.7 to 5.9)**

$$y'' + 0.8y' + 0.16y = 0,$$

$$(D^2 + 0.8D + 0.16)Y = 0$$

A.E. $\quad m^2 + 0.8m + 0.16 = 0$

$$(m + 0.4)^2 = 0$$

$$m = -0.4, -0.4 \qquad \text{(repeated root)}$$

$$y = (c_1 + c_2 x)e^{-0.4x}$$

$$x = 0, \quad y = 3$$

$$3 = c_1$$

$$y' = (c_1 + c_2 x)e^{-0.4x} \times (-0.4) + e^{0.4x} \times c_2$$

$$x = 0, \quad y' = 4.5$$

$$4.5 = -3 \times 0.4 + c_2$$

$$4.5 = -1.2 + c_2$$

$$c_2 = 5.7$$

$$y = (c_1 + c_2 x)e^{-0.4x}$$

$$x = 1$$

$$y = (3 + 5.7 \times 1)e^{-0.4 \times 1}$$

$\Rightarrow$ $\quad y = 5.831$

End of Solution

Q.48 The maximum value of the function $h(x) = -x^3 + 2x^2$ in the interval $[-1, 1.5]$ is equal to _____. (rounded off to 1 decimal place)

Ans. **(3)(2.9 to 3.1)**

$$f(x) = -x^3 + 2x^2$$

$$f'(x) = -3x^2 + 4x = 0$$

$$x(-3x + 4) = 6$$

$$x = 0, \quad x = \frac{4}{3}$$

$$f''(x) = -6x + 4$$

$$f''(x)\big|_{x=0} = -6 \times 0 + 4 = 4 > 0 \quad \Rightarrow x = 0 \text{ point of minima}$$

$$f''(x)\big|_{x=\frac{4}{3}} = -6\times\frac{4}{3}+4 = -4 < 0 \quad \Rightarrow x = \frac{4}{3} \text{ is point of maxima}$$

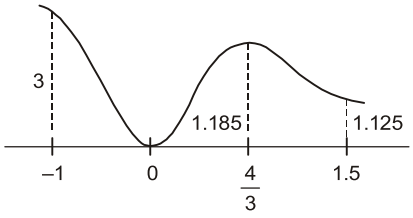
$$f(x) = -x^3 + 2x^2$$

$$f(x)\big|_{x=-1} = -(-1)^3 + 2(-1)^2 = 1 + 2 = 3$$

$$f(x)\big|_{x=0} = 0 + 0 = 0$$

$$f(x)\big|_{x=\frac{4}{3}} = -\left(\frac{4}{3}\right)^3 + 2\left(\frac{4}{3}\right)^2 = -\frac{64}{27}+\frac{32}{9}\times\frac{3}{3} = 1.185$$

$$f(x)\big|_{x=1.5} = -(1.5)^3 + 2(1.5)^2 = 1.125$$



So, maximum value of the function = 3 at $x = -1$

End of Solution

Q.49 Consider the differential equation given below. Using the Euler method with the step size (h) of 0.5, the value of y at $x = 1.0$ is equal to _____ (rounded off to 1 decimal place).

$$\frac{dy}{dx} = y + 2x - x^2;\ y(0) = 1 \qquad (0 \le x < \infty)$$

Ans. (2.6)(2.4 to 2.8)

$$\frac{dy}{dx} = y + 2x - x^2 \qquad h = 0.5$$

$$\frac{dy}{dx} = f(x, y) = y + 2x - x^2$$

$$f(x, y) = y + 2x - x^2$$

$$y(0) = 1$$

$$x_0 = 0,\ y_0 = 1$$

$$x_1 = 0.5$$

$$y_1 = y_0 + hf(x_0, y_0)$$
$$= y_0 + h(y_0 + 2x_0 - x_0^2)$$
$$= 1 + 0.5(1 + 0) = 1.5$$

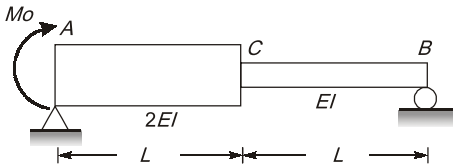
$x_2 = 1$

$$y_2 = y_1 + h(f(x_1\ y_1))$$
$$= y_1 + h(y_1 + 2x_1 - x_1^2)$$
$$= 1.5 + 0.5(1.5 + 2 \times 0.5 - 0.5^2)$$

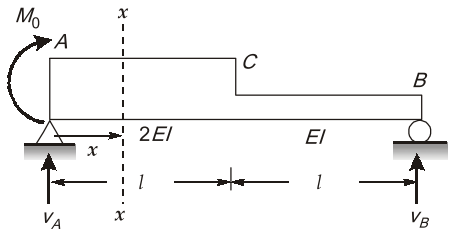
$$y_2 = 2.625$$

End of Solution

Q.50 For the beam and loading shown in the figure, the second derivative of the deflection curve of the beam at the mid-point of AC is given by $\frac{\alpha M_0}{8EI}$. The value of α is _____ (rounded off to the nearest integer).



Ans. (3)(3 to 3)



Let V_A and V_B be the vertical reactions at A and B respectively.

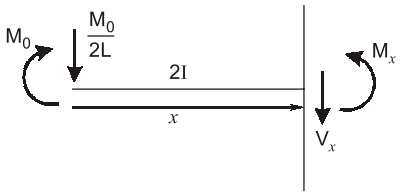
$$\Sigma M_A = 0$$

$$(-V_B \times 2L) + M = 0$$

$$V_B = \frac{M_0}{2L} \text{ and } V_A = \frac{-M_0}{2L}$$

By double integration method,

At section x-x,



$$M_0 - \frac{M_0}{2L}x + [-M_x] = 0$$

At $x = \frac{L}{2}$ $\quad M_0 - \frac{M_0}{2L}\cdot\frac{L}{2} = (2EI)\frac{d^2y}{dx^2}$

$$\frac{d^2y}{dx^2} = \frac{3M_0}{8EI}$$

$\Rightarrow \quad \alpha = 3$

End of Solution

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2	27th Feb 2025	75 Qs	1 Hour	Part Syllabus Test	Basics of project Management, Information and communication technologies, Ethics and values in engineering profession, intellectual property rights, Role of science and technology in daily life, recent developments in applied sciences, basics of artificial intelligence and robotics
3	6th Mar 2025	75 Qs	1 Hour	Part Syllabus Test	Green Energy, Energy conversion principles, Climate change, Disaster Management, Basics of thermodynamics, Water resources and conservation processes, Basics of measurement and instrumentation, Human health and sanitation
4	13th Mar 2025	75 Qs	1 Hour	Part Syllabus Test	General Hindi
5	20th Mar 2025	75 Qs	1 Hour	Part Syllabus Test	Indian History, Indian Polity, Geography, GK & Miscellaneous and Current Affairs
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7	3rd Apr 2025	150 Qs	2 Hours	Full Syllabus Test	Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies)
8	5th Apr 2025	150 Qs	2 Hours	Full Syllabus Test	Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies)
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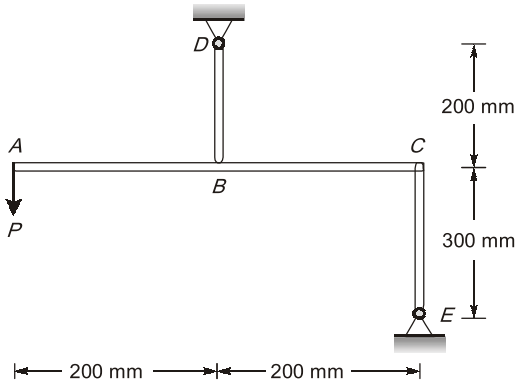
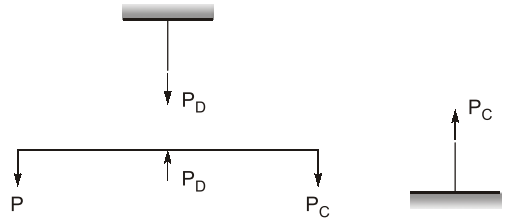
Q.51 Consider the rigid bar ABC supported by the pin-jointed links BD and CE and subjected to a load P at the end A, as shown in the figure. The axial rigidities of BD and CE are 22500 kN and 15000 kN, respectively. If CE elongates by 5 mm due to the load P, the magnitude of the downward deflection (in mm) of the end A would be ____ (rounded off to the nearest integer).



Ans. (14)(14 to 14)

FBD :



From equilibrium,

$$P_D = 2P \text{ and } P_C = P$$

Given, $\Delta_C = 5 \text{ mm} = \dfrac{P_C \cdot L_{CE}}{(AE)_{CE}}$

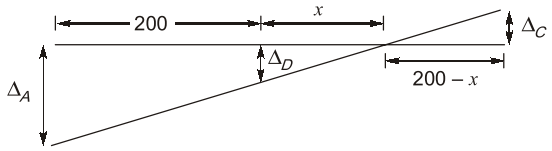
$$= \frac{P \times 300}{15000}$$

$$P = 250 \text{ kN}$$

$$P_D = 2P = 2 \times 250 = 500 \text{ kN}$$

$$\Delta_D = \frac{P_D \cdot L_{DB}}{(AE)_{DB}} = \frac{500 \times 200}{22500} = 4.44 \text{ mm}$$

Deformed profile :



From similar Δ's, property

$$\frac{\Delta_D}{\Delta_C} = \frac{x}{200 - x}$$

$$\frac{4.44}{5} = \frac{x}{200 - x}$$

$$x = 94.117 \text{ mm}$$

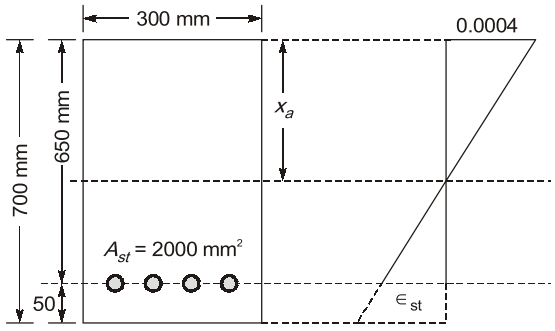
Now, $$\frac{\Delta_A}{4.44} = \frac{200 + x}{x} = \frac{200 + 94.117}{94.117}$$

$$\Delta_A = 13.87 \text{ mm} \simeq 14 \text{ mm} \quad \text{(Nearest integer)}$$

End of Solution

Q.52 Consider a reinforced concrete beam section of 300 mm width and 700 mm depth. The beam is reinforced with the tension steel of 2000 mm^2 area at an effective cover of 50 mm. Concrete in the tension zone is assumed to be cracked. Assume the modular ratio of 12 and Young's modulus of 200 GPa for steel. When the extreme fibre in the compression zone undergoes the strain of 0.0004 due to the applied bending moment, the stress in the steel (in MPa) is _____ (rounded off to the nearest integer).

Ans. **(126)(125 to 127)**



Strain diagram

Modular ration, $m = 12$ and $E_s = 200$ GPa

Actual depth of NA

$$\frac{Bx_a^2}{2} = mA_{st}(d - x_a)$$

$$\frac{300x_a^2}{2} = 12 \times 200 (650 - x_a)$$

$$150x_a^2 + 12 \times 2000x_a - 12 \times 2000 \times 650 = 0$$

$$x_a = 252.26 \text{ mm}$$

Now from strain diagram. (Let ϵ_{st} strain in steel)

$$\frac{0.0004}{x_a} = \frac{\epsilon_{st}}{d - x_a}$$

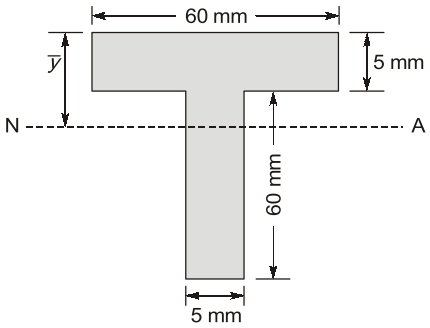
$$\epsilon_{st} = \frac{0.0004(650 - 252.26)}{252.26} = 6.306 \times 10^{-4}$$

Stress in steel, $\sigma_{st} = \epsilon_{st} \times E_s = 6.306 \times 10^{-4} \times 2 \times 10^5$

$\sigma_{st} = 126.136\ \text{N/mm}^2 \simeq 126\ \text{MPa}$ (Nearest integers)

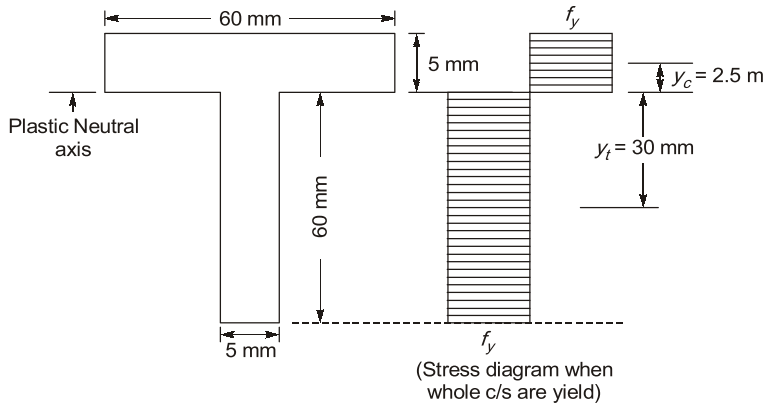
End of Solution

Q.53 Consider the beam section shown in the figure, with y indicating the depth of neutral axis (NA). The section is only subjected to an increasing bending moment. It is given that $y = 18.75$ mm, when the section has not yielded at the top and bottom fibres. Further, y decreases to 5 mm, when the entire section has yielded. The shape factor of the section is _____ (rounded off to 2 decimal places).



Ans. (1.81)(1.8 to 1.82)

For plastic section modulus $(Z_p) = \frac{A}{2}(y_c + y_t)$

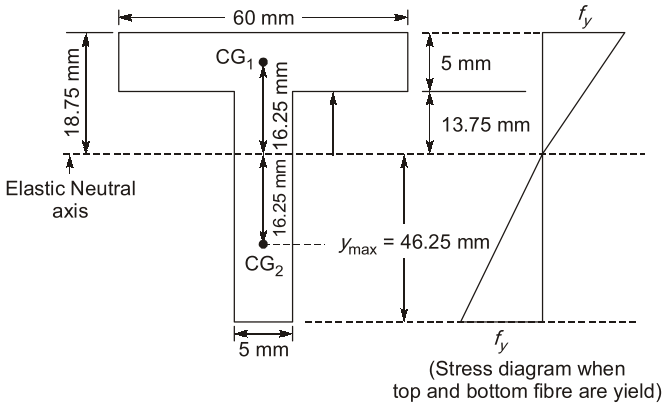


$$Z_p = \frac{A}{2}(y_c + y_t)$$

$$= \frac{2 \times 60 \times 5}{2}(2.5 + 30)$$

$$Z_p = 9750\ \text{mm}^3$$

For elastic section modulus $(Z_e) = \frac{I_{NA}}{y_{max}}$



(Stress diagram when top and bottom fibre are yield)

Area moment of inertia about NA

$$I_{NA} = \left[\frac{60\times5^3}{12} + 60\times5(16.25)^2\right] + \left[\frac{5\times60^3}{12} + 5\times60\times(16.25)^2\right]$$

$$I_{NA} = 249062.5 \text{ mm}^4$$

$$y_{max} = 46.25 \text{ mm}$$

$$Z_e = \frac{I_{NA}}{y_{max}} = \frac{249062.5\text{mm}^4}{46.25\text{mm}}$$

$$Z_e = 5385.135 \text{ mm}^3$$

Now, shape factor $S = \frac{M_P}{M_y} = \frac{f_y Z_p}{f_y Z_e}$

$$= \frac{9750\text{mm}^3}{5385.135\text{mm}^3}$$

$$S = 1.81$$

End of Solution

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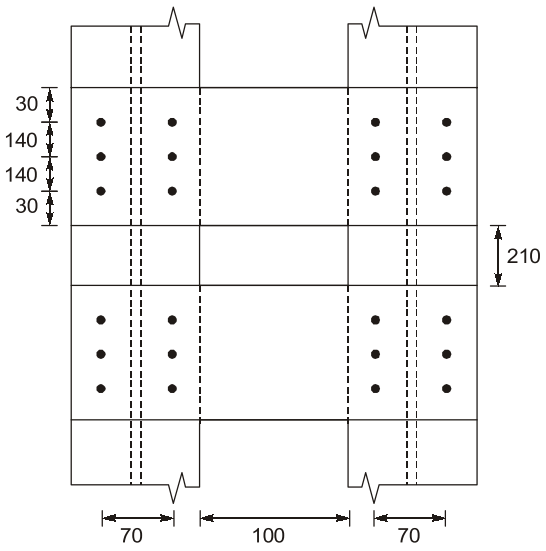
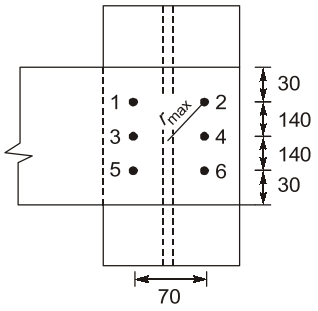
Q.54 Consider the built-up column made of two I-sections as shown in the figure, with each batten plate bolted to a component I-section of the column through 6 black bolts. Each connection of the batten plate with the component section is to be designed for a longitudinal shear of 70 kN and moment of 10 kN.m. The minimum bolt value required (in kN) is _____ (rounded off to the nearest integer).



(All dimensions are in mm)

Ans. (23)(21 to 24)



$$r_{max} = \sqrt{140^2 + 35^2} = 144.31\,\text{mm}$$

V_b = 70 kN (Longitudinal shear)

M_b = 10 kN-m (Moment)

Minimum bolt value required = ?

Concept : The bolt value $\not<$ Maximum resultant shear force on bolt.

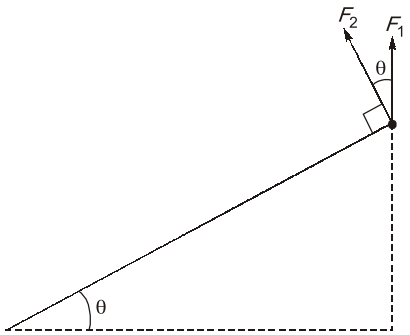
(1) Direct shear force on bolt,

$$F_1 = \frac{V_L}{n} = \frac{70}{6} = 11.67\ \text{kN}$$

(2) Maximum torsional shear on bolt,

$$F_2 = \frac{(T.M.)r_{max}}{\Sigma r_i^2} = \frac{10\times10^3\times144.31}{4\times144.31^2 + 2\times35^2} = 16.82\ \text{kN}$$

(3) Minimum angle of inclination between F_1 and F_2 will be



$$\theta = \tan^{-1}\left(\frac{140}{35}\right) = 75.96°$$

(4) Maximum resultant shear force on bolt,

$$F_{R\,max} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{11.67^2 + 16.82^2 + 2\times 11.67\times 16.82\times\cos 75.96°}$$

$$= 22.67 \text{ kN} \simeq 23 \text{ kN} \quad \text{(Nearest integer).}$$

End of Solution

Q.55 A cut slope is made in a silty clay soil for a new road project, as shown in the figure. The locations of ground water table (GWT) and potential failure surface are shown in the figure. After the cut is made, the excess pore water pressure is fully dissipated, and the shear stress at the point A is 60 kN/m^2. The factor of safety at the point A for long-term stability is _____ (rounded off to 2 decimal places).

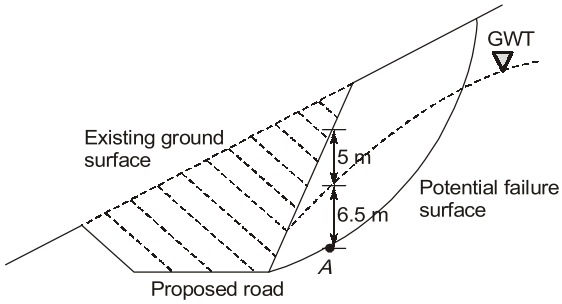
Note :

Shear strength properties of silty clay : c' = 15 kN/m^2, ϕ' = 15°, and c_u = 75 kN/m^2

Unit weight of soil above the GWT(γ) = 19 kN/m^3

Unit weight of soil below the GWT(γ_{sat}) = 20 kN/m^3

Unit weight of water (γ_w) = 9.81 kN/m^3



Ans. (0.97)(0.96 to 0.98)

For long term, effective shear parameters will be used,

$$\text{FOS} = \frac{C' + \bar{\sigma}_n \tan\phi'}{\tau}$$

$$\bar{\sigma}_n = (5\gamma_B + 6.5\gamma_{sat}) - 6.5\gamma_w$$

$$= 5 \times 19 + 6.5 \times 20 - 6.5 \times 9.81$$

$$= 161.235 \text{ kN/m}^2$$

$$\text{FOS} = \frac{15 + 161.235\tan 15°}{60}$$

$$= 0.97$$

End of Solution

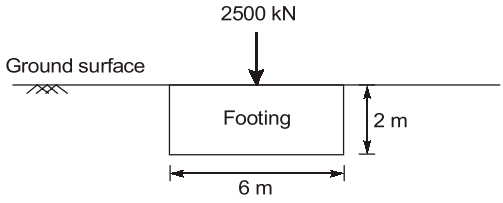
Q.56 A 6 m × 6 m square footing constructed in clay is subjected to a vertical load of 2500 kN at its centre. The base of the footing is 2 m below the ground surface, as shown in the figure. The footing is made of 2 m thick concrete. The ground water table is at a great depth. Considering Terzaghi's bearing capacity theory, the factor of safety of footing against the bearing capacity failure is _____ (rounded off to 2 decimal places).

Note:

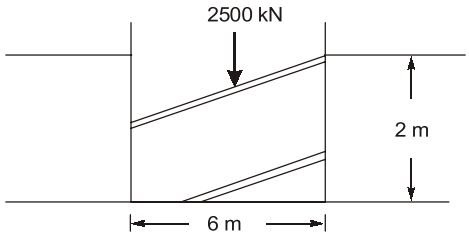
Unit of concrete = 24 kN/m^3

Properties of clay: c = 50 kN/m^3, ϕ = 0°, and γ = 19 kN/m^3

For ϕ = 0° : N_c = 5.7, N_q = 1, N_γ = 0



Ans. (4.66)(4.62 to 4.70)



$$Q_{safe} = \frac{Q_u - \bar{\sigma}}{FOS} + \bar{\sigma}$$

$$= \frac{Q_u - \gamma D_f}{FOS} + \gamma D_f$$

Here, Applied load $= \frac{2500}{6\times6} + \gamma_c \times 2$

$= 66.67 + 24 \times 2 = 117.44\ \text{kN/m}^2$

For square footing, $Q_u = 1.3\ CN_c + \gamma D_f N_q + 0.4B\gamma N_r$

$= 1.3 \times 50 \times 5.7 + 19 \times 2 \times 1 + 0$

$= 370.5 + 38 = 408.5$

$\Rightarrow \quad Q_{safe} = \frac{408.5 - 38}{FOS} + 38$

$117.44 = \frac{370.5}{FOS} + 38$

$FOS = 4.66$

End of Solution

Q.57 A clayey soil has a moisture content of 18%, a specific gravity of soil solids of 2.74, and a degree of saturation of 65%. The soil soaks up water during a rain event, and the degree of saturation increases to 85.2%. The change of the volume during the soaking is negligible. The new moisture content (in %) of the soil will be _____ (rounded off to 2 decimal places).

Ans. **(23.59)(23.3 to 23.63)**

For initial condition,

$w_1 = 18\%$

$S_1 = 65\%$

$G = 2.74$

$e = \frac{w_1 G}{S_1} = \frac{18\times2.74}{65} = 0.7587$

For e same and saturation 85.2%,

$w = \frac{eS}{G} = \frac{0.7587\times85.2}{2.74}\% = 23.59\%$

End of Solution

Q.58 A single pile with 450 mm diameter has been driven into a homogeneous clay layer, which has an undrained cohesion (c_u) of 20 kPa and unit weight of 18 kN/m^3. The ground water table is found to be at the surface of the clay layer. The adhesion factor (α) of the soil is 0.95 and bearing capacity factor (N_c) is 9. The pile is supporting a column load of 144 kN with a factor of safety of 3.0 against ultimate axial pile capacity in compression.

The required embedment depth of the pile (in m) is _____ (rounded off to the nearest integer).

Ans. (15)(15 to 15)

Here,

Ultimate load capacity of pile,

$$Q_{up} = 9CA_b + \alpha \bar{C} A_s$$

$$= 9 \times 20 \times \frac{\pi}{4} \times 0.45^2 + 0.95 \times 20 \times (\pi \times 0.45 \times L)$$

$$Q_{safe} = \frac{Q_{up}}{FOS}$$

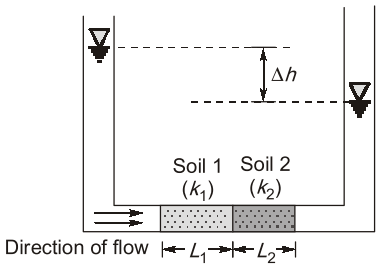
$$Q_{up} = 144 \times 3$$

$$432 = 28.627 + 26.861\ L$$

$$L = 15.01\ \text{m} \simeq 15\ \text{m} \quad \text{(Nearest integer).}$$

End of Solution

Q.59 Two soils of permeabilities k_1 and k_2 are placed in a horizontal flow apparatus, as shown in the figure. For Soil 1, L_1 = 50 cm, and k_1 = 0.055 cm/s; for Soil 2, L_2 = 30 cm, and k_2 = 0.035 cm/s. The cross sectional area of the horizontal pipe is 100 cm^2, and the head difference (Δh) is 150 cm. The discharge (in cm^3/s) through the soils is _____ (rounded off to 2 decimal places).



Ans. (8.49)(8.48 to 8.56)

For series arrangement of soil 1 and soil 2,

Discharge, $q = k_{eq}.i.A.$

$$= \frac{\Sigma z_i}{\Sigma \frac{z_i}{k_i}} \times \left(\frac{H_L}{\text{Length}} \right) \times A$$

$$= \frac{50 + 30}{\frac{50}{0.055} + \frac{30}{0.035}} \times \frac{150}{80} \times 100 = 8.49\ \text{cm}^3/\text{s}$$

End of Solution

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4	21st Feb 2025	150 Marks	150 Qs	2 Hours
5	25th Feb 2025	150 Marks	150 Qs	2 Hours
6	28th Feb 2025	150 Marks	150 Qs	2 Hours
7	4th Mar 2025	150 Marks	150 Qs	2 Hours
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Q.60 A hydraulic jump is formed in a 5 m wide rectangular channel, which has a horizontal bed and is carrying a discharge of 15 m^3/s. The depth of water upstream of the jump is 0.5 m. The power dissipated by the jump (in kW) is _____ (rounded off to the nearest integer).

Note:

Acceleration due to gravity = 9.81 m/s^2

Density of water = 1000 kg/m^3

Kinetic energy correction factor = 1.0

Ans. **(72)(69 to 75)**

Given: rectangular channel.

width B = 5 m

Discharge Q = 15 m^3/sec

Prejump depth y_1 = 0.5 m

Power dissipated = ?

$$\Delta P = \rho g Q \Delta E \quad \ldots(1)$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2} \quad \ldots(2)$$

For Froude number at upstream

$$Fr_1^2 = \frac{V_1^2}{g y_1} = \frac{q^2}{g y_1^3}$$

$$= \frac{3^2}{9.81 \times 0.5^3}$$

$$Fr_1^2 = 7.34$$

Now, $$\frac{y_2}{y_1} = \frac{-1 + \sqrt{1 + 8 Fr_1^2}}{2}$$

$$\frac{y_2}{0.5} = \frac{-1 + \sqrt{1 + 8 \times 7.34}}{2}$$

$$y_2 = 1.68 \text{ m}$$

Now, $$\Delta E = \frac{(1.68 - 0.5)^3}{4 \times 1.68 \times 0.5} = 0.49 \text{m}$$

From equation (1)

$$\Delta P = 10^3 \times 9.81 \times 15 \times 0.49$$

$$= 72.10 \text{ k Watt} \simeq 72 \text{ kW} \quad \text{(Nearest integer).}$$

End of Solution

Q.61 A symmetrical trapezoidal canal is 100 km long. The bottom width is 10 m and the side slope is 1 Horizontal : 1 Vertical. The average flow depth in the canal is 2.5 m throughout the month of April. The measurement from a Class-A evaporimeter in the vicinity of the canal indicated an average evaporation rate of 0.5 cm/day in April.

The volume of water evaporated from the canal (in m^3) in the month of April is close to _____ $\times 10^3$ (rounded off to 1 decimal place).

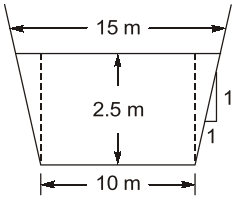
Ans. **(157.5)(155 to 160)**

In the month of April, number of days = 30

Pan evaporation (in terms of depth) = 0.5 cm/day × 30 day
= 15 cm

For trapezoidal canal of length 10 km,

Area of free surface of canal = 15 m × 100 × 10^3 m
= 15 × 10^5 m^2



Pan evaporation = 0.15 m

Evaporation loss in canal = C_P × Pan evaporation (For class A pan, C_P = 0.7)
= 0.7 × 0.15 m = 0.105 m

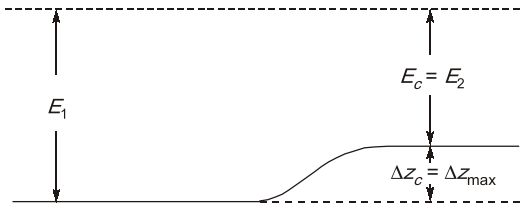
Evaporation loss from canal in terms of volume of water = 0.105 m × 15 × 10^5 m^2
= 157.5 × 10^3 m^3

End of Solution

Q.62 A 5.0 m wide rectangular channel carries a discharge of 10 m^3/s at a depth of 1.5 m under uniform flow. To produce critical flow conditions without affecting the upstream conditions, the channel bottom elevation should be raised (in m) by _____ (rounded off to 2 decimal places).

Assume that there is no loss of head at the raise, kinetic energy correction factor is 1.0, and acceleration due to gravity is 9.81 m/s^2.

Ans. **(0.48)(0.45 to 0.51)**



Given, B = 5 m

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$$Q = 10\ m^3/sec$$
$$y_1 = 1.5\ m$$
$$v_1 = \frac{Q}{By_1} = \frac{10}{5\times 1.5} = 1.33\ m/sec$$
$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$
$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{2^2}{9.81}\right)^{1/3} = 0.74m$$

For maximum height of hump $\Delta z = \Delta z_c$ and $E_2 = E_C = \frac{3}{2}y_c$

$$E_1 = E_2 + \Delta z_c$$
$$y_1 + \frac{v_1^2}{2g} = \frac{3}{2}y_c + \Delta z$$
$$1.5 + \frac{1.33^2}{2\times 9.81} = \frac{3}{2}\times 0.74 + \Delta z$$
$$\Delta z = 0.48\ m$$

End of Solution

Q.63 A one-way, single lane road has traffic that consists of 30% trucks and 70% cars. The speed of trucks (in km/h) is a uniform random variable on the interval (30, 60), and the speed of cars (in km/h) is a uniform random variable on the interval (40, 80). The speed limit on the road is 50 km/h. The percentage of vehicles that exceed the speed limit is _____ (rounded off to 1 decimal place).

Note: X is a uniform random variable on the interval (α, β), if its probability density function is given by

$$f(x) = \begin{cases} \frac{1}{\beta - \alpha} & \alpha < x < \beta \\ 0 & \text{otherwise} \end{cases}$$

Ans. **(62.5)(61 to 63)**

x = Truck = 30%
y = Car = 70%

$x \in (30, 60)$
$y \in (40, 80)$

$$x = \text{Uniform R.V } f(x) = \frac{1}{60-30} = \frac{1}{30}$$
$$y = \text{Uniform R.M} = \frac{1}{80-40} = \frac{1}{40}$$

Probability of Truck exceeding the limit

$$P(50 < x < 60) = \int_{50}^{60} f(x)\,dx = \int_{50}^{60} \frac{1}{30}\,dx$$

$$= \frac{60-50}{30} = \frac{1}{3}$$

Probability of Car exceeding the limit

$$P(60 < x < 80) = \int_{50}^{80} f(y)\,dy = \int_{50}^{80} \frac{1}{40}\,dy$$

$$= \frac{3}{4}$$

$$\% \text{ of vehicle time} = \frac{1}{3}\times 30\% + \frac{3}{4}\times 70\%$$

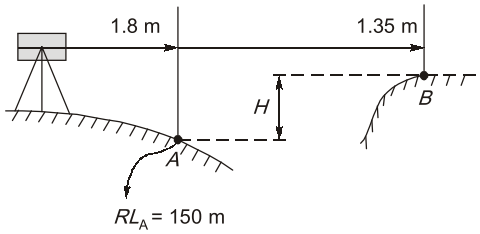
$$= 10 + 52.5\% = 62.5\%$$

End of Solution

Q.64 In levelling between two points A and B on the opposite banks of a river, the readings are taken by setting the instrument both at A and B, as shown in the table. If the RL of A is 150.000 m, the RL of B (in m) is _____ (rounded off to 3 decimal places).

Level position	Staff readings	
	A	B
A	1.800	1.350
B	1.450	0.950

Ans. (150.475)(150.470 to 150.480)



Here, $H_{avg} = \dfrac{(1.8-1.35)+(1.45-0.95)}{2} = 0.475$ m

$\therefore$ $R.L$ of B = $R.L$ of A + H_{avg}

= 150 + 0.475 = 150.475 m

End of Solution

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Q.65 During determination of the bulk specific gravity of compacted bituminous specimen, the mass in air of the specimen is 1260 g and volume is 525 cm^3. The density of water is 1.0 g/cm^3. The theoretical maximum specific gravity of mix is 2.510.

The percentage air voids in the compacted specimen is _____ (rounded off to 2 decimal places).

Ans. **(4.38)(4.22 to 4.56)**

Given,

Mass of specimen, $W = 1260$ gm,

Volume = 525 cm^3

Density of water, $\rho_w = 1$ gm/cm^3

Theoretical maximum specific gravity, $G_t = 2.51$

Percentage of air voids in bituminous mix $V_a\% = ?$

Mass specific gravity $G_m = \dfrac{\gamma_m}{\gamma_w} = \dfrac{w}{V \times 1} = \dfrac{1260}{525} = 2.4$

Percentage of air voids, $V\% = \left(\dfrac{G_t - G_m}{G_t}\right) \times 100 = \left(\dfrac{2.51 - 2.4}{2.51}\right) \times 100 = 4.38\%$

End of Solution

■■■■