MADE EASY

GATE 2025

Civil Engineering
Shift-2

Questions & Solutions

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

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SECTION - A GENERAL APTITUDE

Q.1 Even though I had planned to go skiing with my friends, I had to _____ at the last moment because of an injury.

Select the most appropriate option to complete the above sentence.

(a) back up
(b) back of
(c) back on
(d) back out

Ans. (d)

End of Solution

Q.2 The President, along with the Council of Ministers, _____ to visit India next week.

Select the most appropriate option to complete the above sentence.

(a) wish
(b) wishes
(c) will wish
(d) is wishing

Ans. (b)

The president along with the council of ministers wishes to visit India next week.

End of Solution

Q.3 An electricity utility company charges ₹7 per kWh (kilo watt-hour). If a 40-watt desk light is left on for 10 hours each night for 180 days, what would be the cost of energy consumption? If the desk light is on for 2 more hours each night for the 180 days, what would be the percentage-increase in the cost of energy consumption?

(a) ₹604.8; 10%
(b) ₹504; 20%
(c) ₹604.8; 12%
(d) ₹720; 15%

Ans. (b)

$$\text{Energy} = \text{Power} \times \text{Time} = 0.04 \times 100 = 0.4$$

Total energy of 180 days $= 0.4 \times 180 = 72$ kWh

$$\text{Total cost} = 72 \times 7 = 504$$

End of Solution

Q.4 In the context of the given figure, which one of the following options correctly represents the entries in the blocks labelled (i), (ii), (iii), and (iv), respectively?

N	U	F	(i)
21	14	9	6
H	L	(ii)	O
12	(iv)	15	(iii)

(a) Q, M, 12 and 8
(b) K, L, 10 and 14
(c) I, J, 10 and 8
(d) L, K, 12 and 8

Ans. (c)

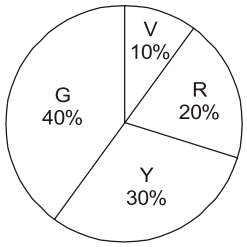
N	*U*	*F*	*I*
21	14	9	6
H	*L*	*J*	*O*
12	8	15	10

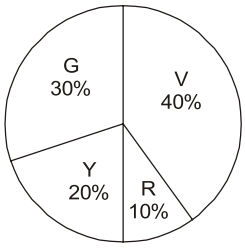
End of Solution

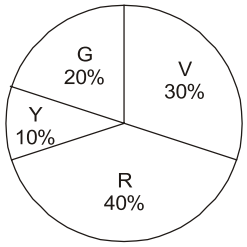
Q.5 A bag contains Violet (V), Yellow (Y), Red (R), and Green (G) balls. On counting them, the following results are obtained:

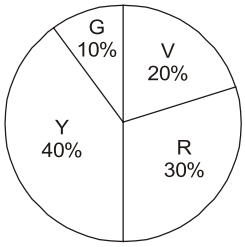
(i) The sum of Yellow balls and twice the number of Violet balls is 50.
(ii) The sum of Violet and Green balls is 50.
(iii) The sum of Yellow and Red balls is 50.
(iv) The sum of Violet and twice the number of Red balls is 50.

Which one of the following Pie charts correctly represents the balls in the bag?

(a)


(b)


(c)


(d)


Ans. (a)

$$V + R + Y + G = 100\%$$
$$Y + 2V = 50$$
$$V + G = 50$$
$$V + R = 50$$
$$V + 2R = 50$$

Only option (a) verify the above condition.

End of Solution

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Q.6 "His life was divided between the books, his friends, and long walks. A solitary man, he worked at all hours without much method, and probably courted his fatal illness in this way. To his own name there is not much to show; but such was his liberality that he was continually helping others, and fruits of his erudition are widely scattered, and have gone to increase many a comparative stranger's reputation."

(From E.V. Lucas's "A Funeral")

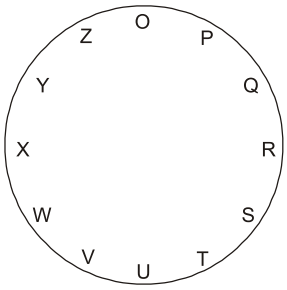
Based only on the information provided in the above passage, which one of the following statements is true?

(a) The solitary man described in the passage is dead.
(b) Strangers helped create a grand reputation for the solitary man described in the passage.
(c) The solitary man described in the passage found joy in scattering fruits.
(d) The solitary man worked in a court where he fell ill.

Ans. (a)

End of Solution

Q.7 For the clock shown in the figure, if
O* = O Q S Z P R T, and
X* = X Z P W Y O Q ,
then which one among the given options is most appropriate for P* ?



(a) P U W R T V X
(b) P R T O Q S U
(c) P T V Q S U W
(d) P S U P R T V

Ans. (b)

End of Solution

Q.8 Consider a five-digit number PQRST that has distinct digits P, Q, R, S and T, and satisfies the following conditions:

$P < Q$

$S > P > T$

$R < T$

If integers 1 through 5 are used to construct such a number, the value of *P* is:

(a) 1
(b) 2
(c) 3
(d) 4

Ans. (c)

According to given condition in question

1. $S > P > T > R$
2. $Q > P$

So, it is clear

$R = 1,\ T = 2$ and $P = 3$

New energy $= 0.04 \times 12 = 0.48$

$0.48 \times 180 = 86.4$ kwh

Total cost $= 86.4 \times 7 =$ Rs. 604.80

Percentage increase in cost $= \dfrac{604.80 - 504}{504} \times 100 = 20\%$

End of Solution

Q.9 A business person buys potatoes of two different varieties P and Q, mixes them in a certain ratio and sells them at ₹192 per kg.

The cost of the variety P is ₹800 for 5 kg.

The cost of the variety Q is ₹800 for 4 kg.

If the person gets 8% profit, what is the P : Q ratio (by weight)?

(a) 5 : 4 (b) 3 : 4

(c) 3 : 2 (d) 1 : 1

Ans. (a)

Cost price of variety, P = Rs. 800

Cost price of variety, Q = Rs. 800

Total cost price = Rs. 1600

Total potatoes = 5 kg + 4 kg = 9 kg

Selling price of 9 kg potatoes $= 9 \times 192 = 1728$

Profit = 128

$$\% \text{ Profit} = \frac{128}{1600} \times 100 = 8\%$$

Hence,required ratio is 5 : 4

End of Solution

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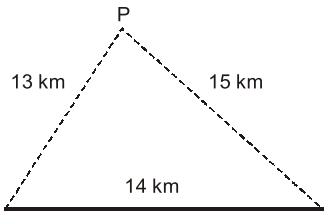
Q.10 Three villages P, Q, and R are located in such a way that the distance PQ = 13 km, QR = 14 km, and RP = 15 km, as shown in the figure. A straight road joins Q and R. It is proposed to connect P to this road QR by constructing another road. What is the minimum possible length (in km) of this connecting road?

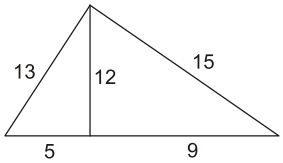
Note: The figure shown is representative.



(a) 10.5 (b) 11.0
(c) 12.0 (d) 12.5

Ans. **(c)**

$$h^2 + x^2 = 13^2 \quad \text{...(i)}$$
$$h^2 + (14 - x)^2 = 15^2 \quad \text{...(ii)}$$



After solving (i) and (ii)

We get $x = 5$ and $h = 12$

End of Solution

SECTION - B TECHNICAL

Q.11 For the matrix [A] given below, the transpose is _____.

$$[A]=\begin{bmatrix}2 & 3 & 4\\ 1 & 4 & 5\\ 4 & 3 & 2\end{bmatrix}$$

(a) $\begin{bmatrix}2 & 1 & 4\\ 3 & 4 & 3\\ 4 & 5 & 2\end{bmatrix}$ (b) $\begin{bmatrix}4 & 3 & 2\\ 5 & 4 & 1\\ 2 & 3 & 4\end{bmatrix}$

(c) $\begin{bmatrix}4 & 2 & 3\\ 5 & 1 & 4\\ 2 & 4 & 3\end{bmatrix}$ (d) $\begin{bmatrix}2 & 3 & 4\\ 1 & 4 & 5\\ 4 & 3 & 2\end{bmatrix}$

Ans. (a)

$$A=\begin{bmatrix}2 & 3 & 4\\ 1 & 4 & 5\\ 4 & 3 & 2\end{bmatrix}$$

$$A^T=\begin{bmatrix}2 & 1 & 4\\ 3 & 4 & 3\\ 4 & 5 & 2\end{bmatrix}$$

End of Solution

Q.12 Integration of $\ln(x)$ with x i.e.

$\int \ln(x)dx =$ _____.

(a) $x\cdot\ln(x) - x$ + Constant (b) $x - \ln(x)$ + Constant

(c) $x\cdot\ln(x) + x$ + Constant (d) $\ln(x) - x$ + Constant

Ans. (a)

$\int \ln x\,dx$

$\int \ln x\cdot 1\,dx$

Integration by part

$$= \ln x\int 1dx - \int\left[\frac{d}{dx}(\ln x)\cdot\int 1dx\right]dx$$

$$= \ln x - \int\frac{1}{x}xdx$$

$$= \ln x\cdot x - \int 1dx$$

$$= x\ln x - x + c$$

End of Solution

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Q.13 Consider the following statements (P) and (Q):

(P): Fly ash and ground granulated blast furnace slag can be used as mineral admixtures in concrete.

(Q): As per IS 456:2000, the minimum moist curing period becomes higher when a mineral admixture is added to concrete.

Identify the CORRECT option from choices given below.

(a) Both (P) and (Q) are TRUE.
(b) (P) is TRUE and (Q) is FALSE.
(c) (P) is FALSE and (Q) is TRUE.
(d) Both (P) and (Q) are FALSE.

Ans. **(a)**

Statement I and statement II both are correct.

S-I : Both Flyash and silica fumes are artificial admixture as Pozzolanic materials are supposed to be artificial mineral admixture.

S-II : As soon as an admixture is added rate of hydration decreases slightly which in turn increases curing time of concrete.

OPC $\rightarrow$ 7 to 10 days of curing

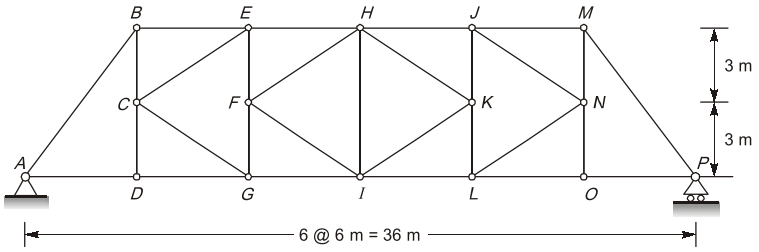
With mineral admixture $\rightarrow$ Minimum 10 days of curing.

Hence, the correct option is (a).

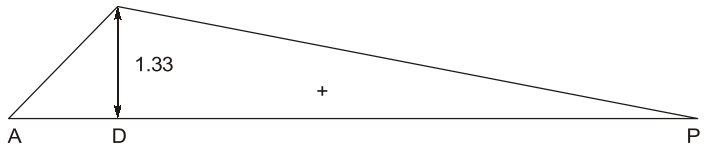
End of Solution

Q.14 Consider the pin-jointed truss shown in the figure. Influence line is drawn for the axial force in the member G-I, when a unit load travels on the bottom chord of the truss. Identify the **CORRECT** influence line from the following options:

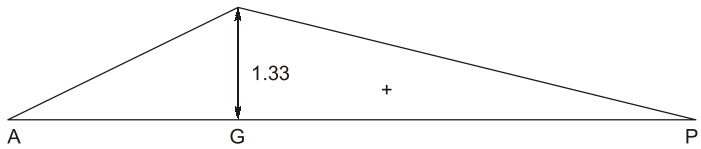
Note: Positive value corresponds to tension and negative value corresponds to compression in the member.

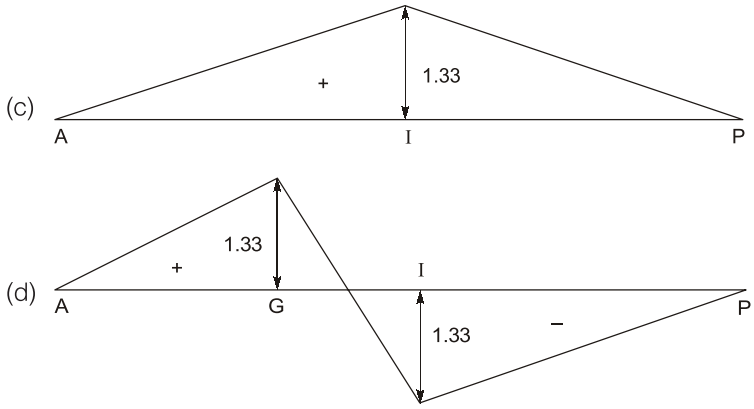


(a)

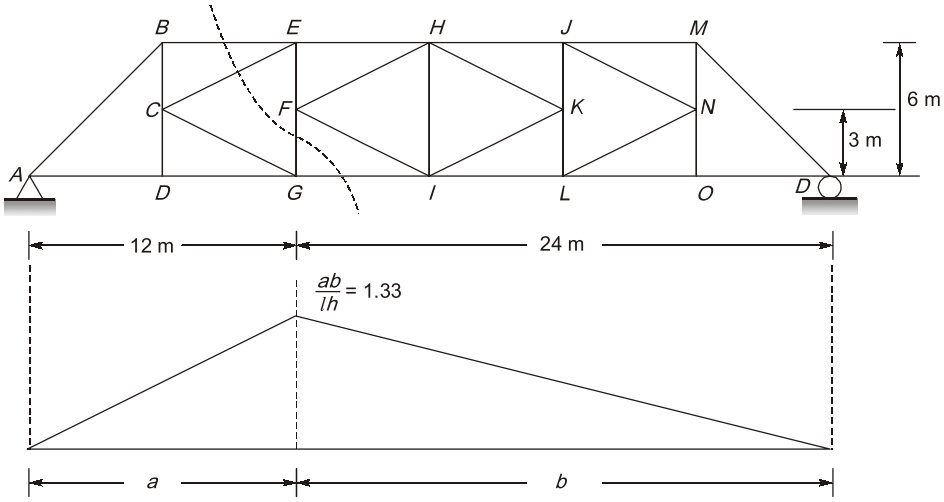


(b)





Ans. (b)



here, $a = 12$ m, $b = 24$ m,
$l = 6 \times 6 = 36$ m
$h = 6$ m (Bottom member are in tension)

$$\frac{ab}{lh} = \frac{12 \times 24}{36 \times 6} = 1.33$$

End of Solution

Q.15 The most suitable test for measuring the permeability of clayey soils in the laboratory is _____.

(a) Constant head test
(b) Pumping out test
(c) Hydrometer test
(d) Falling head test

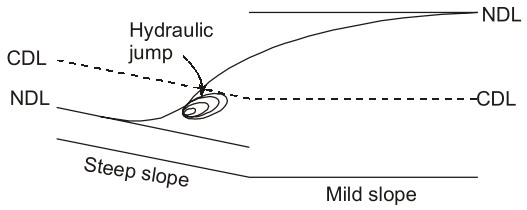
Ans. (d)

End of Solution

Q.16 A hydraulic jump occurs in an open channel when the slope of the channel changes from _____.

(a) MILD slope to STEEP slope
(b) STEEP slope to MILD slope
(c) MILD slope to ZERO slope
(d) STEEP slope to a STEEPER slope

Ans. (b)



Hydraulic jump is formed in an open channel when flow change from super critical ($F_r > 1$) to sub critical ($F_r < 1$).

End of Solution

Q.17 The bacteria mainly responsible for crown corrosion in a sewer is _____.

(a) Methanogenic bacteria
(b) Denitrifying bacteria
(c) Sulphur reducing bacteria
(d) Pseudomonas bacteria

Ans. (c)

Sulphur reducing bacteria is responsible for formation of hydrogen sulphide. This hydrogen sulphide on combining with oxygen makes sulphuric acid which is responsible for crown corrosion of sewer lines.

End of Solution

Q.18 The recommended minimum traffic growth rate and design period considered for structural design of flexible pavements for national highways in India as per IRC 37:2018 is _____ percentage and _____ years, respectively.

(a) 5, 20
(b) 5, 30
(c) 7, 20
(d) 7, 30

Ans. (a)

As per IRC 37 : 2018.
For structural design of flexible pavement for national highway in India.
Minimum traffic growth = 5%
Design period = 20 years

End of Solution

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Q.19 After applying the correction for elevation and temperature, the runway length is 700 m. The corrected runway length (in m) for an effective gradient of 1% is _____ (round off to the nearest integer).

(a) 840 (b) 700
(c) 720 (d) 740

Ans. **(a)**

Given:

Corrected length after applying elevation and temperature correction,

$$l = 700 \text{ m}$$

Gradient = 1%

For every 1% gradient, runway length increase by 20%.

Therefore corrected runway length = $700 + 700 \times \frac{20}{100}$

$$= 700 \times 1.2 = 840 \text{ m}$$

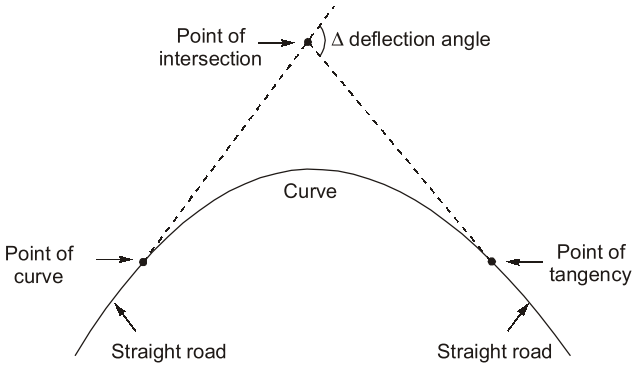
End of Solution

Q.20 The point where the road alignment changes from a tangent to a curve is known as _____.

(a) Point of deflection (b) Point of intersection
(c) Point of curve (d) Point of tangency

Ans. **(c)**

The point where road alignment changes from a tangent to a curve is called as point of curve.



End of Solution

Q.21 Consider a velocity vector, $\vec{V}$ in (x, y, z) coordinates given below. Pick one or more CORRECT statement(s) from the choices given below:

$\vec{V} = u\vec{x} + v\vec{y}$

(a) z-component of Curl of velocity; $\nabla \times \vec{V} = \left(\frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)\vec{z}$

(b) z-component of Curl of velocity; $\nabla \times \vec{V} = \left(\frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}\right)\vec{z}$

(c) Divergence of velocity; $\nabla \cdot \vec{V} = \left(\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y}\right)$

(d) Divergence of velocity; $\nabla \cdot \vec{V} = \left(\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y}\right)$

Ans. (a, c)

$$\vec{v} = u\hat{x} + v\hat{y} = u\hat{i} + v\hat{j}$$

$$\text{Div } \vec{v} = \frac{\partial v_1}{\partial x} + \frac{\partial v_2}{\partial y}$$

$$= \frac{\partial}{\partial x}(u) + \frac{\partial v}{\partial y}$$

$$= \frac{du}{dx} + \frac{\partial v}{\partial y}$$

$$\text{curl } \vec{v} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial n} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u & v & 0 \end{vmatrix}$$

$$\text{curl } \vec{v} = \hat{i}\left(0 - \frac{\partial v}{\partial z}\right) - \hat{j}\left(0 - \frac{\partial u}{\partial z}\right) + \hat{k}\left(\frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)$$

$$z - \text{component of curl } \vec{v} = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\hat{k}$$

End of Solution

Q.22 Given that A and B are not null sets, which of the following statements regarding probability is/are **CORRECT**?

(a) $P(A \cap B) = P(A)\,P(B)$, if A and B are mutually exclusive.

(b) Conditional probability, $P(A \mid B) = 1$ if $B \subset A$.

(c) $P(A \cup B) = P(A) + P(B)$, if A and B are mutually exclusive.

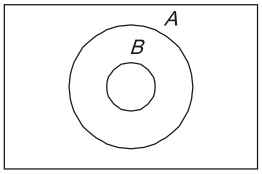
(d) $P(A \cap B) = 0$, if A and B are independent.

Ans. (b, c)

A and B are null set

$P(A \cap B) = P(A) \cdot P(B)$ of A and B are independent. so option (a) is wrong.

$$P\left(\frac{A}{B}\right) = \frac{P(A \cap B)}{P(B)}$$



If B is subset of A.

$B \subset A$

then $P(A \cap B) = P(B)$

So, $$P\left(\frac{A}{B}\right) = \frac{P(B)}{P(B)} = 1$$

So, option (b) is correct.

If A and B are mostally exclusive.

then $P(A \cap B) = 0$

i.e. $P(A \cup B) = P(A) + P(B)$

So, option (c) is correct.

End of Solution

Q.23 In the context of construction materials, which of the following statements is/are **CORRECT**?

(a) If the characteristic strength is defined as that value below which not more than 50% results are expected to fall, the target mean strength in mix design will be taken same as the characteristic strength irrespective of the degree of quality control expected at the site.

(b) Ten percent fines value is a non-dimensional quantity.

(c) The stress-strain curve of concrete for 1-day duration of loading is associated with a smaller secant modulus of elasticity compared to the stress-strain curve of the same concrete for 10-minutes duration of loading.

(d) The increase of carbon in steel usually leads to an increase in its 0.2% proof stress.

Ans. (a, c, d)

End of Solution

Q.24 Which of the following statements is/are **INCORRECT**?

(a) As the depth of the ground water table from the ground surface increases, the effective stress in the soil decreases.

(b) Bulking of the moist sand is due to the capillary action in the sand.

(c) The effective stress in a liquified soil is almost zero.

(d) The earth pressure at any point in the soil, under all conditions, is always smaller than the vertical effective stress at that point.

Ans. (a, d)

End of Solution

Q.25 Pick one or more CORRECT statement(s) from the choices given below, in the context of upstream and downstream cut-offs provided below the concrete apron of weirs/barrages constructed across alluvial rivers.

(a) Cut-offs are provided to increase the rate of flow over the weir / barrage.
(b) Cut-offs are provided to increase the seepage length and prevent failure due to piping.
(c) The bottom level of cut-offs mainly depends on the scour depth.
(d) Cut-offs are provided to ensure occurrence of hydraulic jump within the stilling basin.

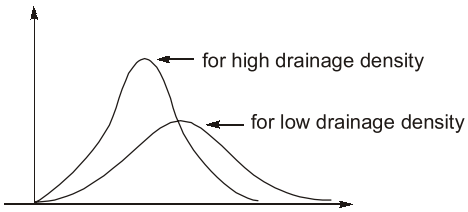
Ans. (b, c)

End of Solution

Q.26 In the context of the effect of drainage density on the run-off generation and the hydrograph at the catchment outlet, all other factors remaining the same, pick one or more **CORRECT** statement(s) from the choices given below.

(a) Lower drainage density results in higher peak in flood hydrograph compared to that when the drainage density is higher.
(b) Lower drainage density results in lower peak in flood hydrograph compared to that when the drainage density is higher.
(c) Lower drainage density results in a flood hydrograph with a longer time base compared to that when the drainage density is higher.
(d) Lower drainage density results in a flood hydrograph with a shorter time base compared to that when the drainage density is higher.

Ans. (b, c)



End of Solution

Q.27 Identify the treatment technology/technologies NOT recommended for highly biodegradable organic solid wastes.

(a) Biohydrogenation
(b) Anaerobic digestion
(c) Composting
(d) Open dumping

Ans. (d)

Open dumping is not used for treating highly organic waste.

End of Solution

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Q.28 Which of the following statements is/are **INCORRECT**?

(a) Bitumen having lower softening point is preferred in warm climate regions.

(b) The viscosity of bitumen influences the mixing and compaction of bituminous mix.

(c) The air voids in the range of 3% to 5% are required to arrive at the optimum bitumen content.

(d) The purity of bitumen can be determined using Solubility Test.

Ans. (a)

End of Solution

Q.29 The "order" of the following ordinary differential equation is _____.

$$\frac{d^3y}{dx^3}+\left(\frac{d^2y}{dx^2}\right)^6+\left(\frac{dy}{dx}\right)^4+y=0$$

Ans. (3)(3 to 3)

Order = 3

Degree = 1

End of Solution

Q.30 The design shear strength of a reinforced concrete rectangular beam with a width of 250 mm and an effective depth of 500 mm, is 0.3 MPa. The torsional moment capacity of the section (in kN.m) under pure torsion, as per IS 456:2000, is _____ (round off to one decimal place).

Ans. (5.86)(5.7 to 6.0)

Given: $B = 250$ mm

$d = 500$ mm

$\tau_c = 0.3$ N/mm^2

$$V_e = \tau_c B d = 0.3\times 250\times\frac{500}{1000} = 37.50 \text{ kN}$$

$$V_{ue} = V_u + \frac{1.6T_u}{B} = 37.5$$

$$T_u = \frac{37.5\times 0.25}{1.60} = 5.86 \text{ kN}$$

End of Solution

Q.31 From a flow-net diagram drawn under a concrete dam, following information are obtained:

(i) The head difference between upstream and downstream side of the dam is 9 m.

(ii) The total number of equipotential drops between upstream and downstream side of the dam is 10.

(iii) The length of the field nearest to the toe of the dam in the downstream side is 1 m.

If the soil below the dam is having a saturated unit weight of 21 kN/m^3 and unit weight of water is 9.81 kN/m^3, then the factor of safety against the quick condition will be _____ (round off to two decimal places).

Ans. (1.27)(1.24 to 1.30)

$$\text{FOS} = \frac{i_c}{i_{exit}}$$

where,

$$i_{exit} = \frac{\Delta h}{L} = \frac{H/N_D}{L} = \frac{9/10}{1} = 0.9$$

$$i_c = \frac{\gamma'}{\gamma_w} = \frac{21 - 9.81}{9.81} = 1.14$$

$$\Rightarrow \quad \text{FOS} = \frac{1.14}{0.9} = 1.27$$

End of Solution

Q.32 A 6 m thick clay stratum has drainage at both its top and bottom surface due to the presence of sand strata. The time to complete 50% consolidation is 2 years. The coefficient of volume change (m_v) is 1.51×10.3 m^2/kN and unit weight of water is 9.81 kN/m^3.

The coefficient of permeability (in m/year) is _____ (round off to three decimal places).

Ans. (0.013)(0.010 to 0.015)

$$\text{Time factor, } (T_V)_{50} = C_V \cdot \frac{t}{d^2} = \frac{k}{m_v \gamma_w} \cdot \frac{t}{d^2}$$

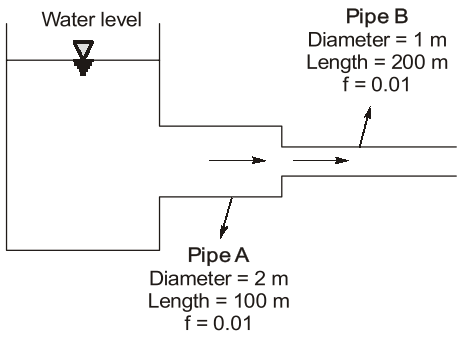
$$\frac{\pi}{4} \times 0.5^2 = \frac{k}{1.51 \times 10^{-3} \times 9.81} \times \frac{2}{\left(\frac{6}{2}\right)^2}$$

$$k = 0.013 \text{ m/year}$$

End of Solution

Q.33 Consider steady flow of water in the series pipe system shown below, with specified discharge. The diameters of Pipes A and B are 2 m and 1 m, respectively. The lengths of pipes A and B are 100 m and 200 m, respectively. Assume the Darcy-Weisbach friction coefficient, f as 0.01 for both the pipes.

The ratio of head loss in Pipe-B to the head loss in Pipe-A is _____ (round off to the nearest integer).



Ans. (64)(64 to 64)

Head loss in pipe, $h_f = \frac{8Q^2}{\pi^2 g}\cdot\frac{fL}{D^5}$

Ratio of head loss in pipe B to pipe A,

$$\frac{h_{f_B}}{h_{f_A}} = \frac{\frac{8Q^2}{\pi^2 g}\cdot f\frac{L_B}{D_B^5}}{\frac{8Q^2}{\pi^2 g}\cdot f\frac{L_A}{D_A^5}} = \left(\frac{D_A}{D_B}\right)^5 \times \frac{L_B}{L_A}$$

$$= \left(\frac{2}{1}\right)^5 \times \frac{200}{100} = 64$$

End of Solution

Q.34 Free residual chlorine concentration in water was measured to be 2 mg/l (as Cl_2). The pH of water is 8.5. By using the chemical equation given below, the HOCl concentration (in μmoles/l) in water is _____ (round off to one decimal place).

$HOCl \rightleftharpoons H^+ + OCl^-$, $pK = 7.50$

Atomic weight: Cl(35.5)

Ans. (2.6)(2.5 to 2.6)

$$k = \frac{[HOCl]}{[OCl^-][H^+]} \qquad \text{(All conc. in moles/}l\text{)}$$

$$10^{7.5} = \frac{[HOCl]}{[OCl^-]10^{-8.5}} \qquad \text{(PH = 8.5)}$$

$$10^{-1} = \frac{[HOCl]}{[OCl^-]}$$

$$\therefore \quad [OCl^-] = 10[HOCl]$$

$$[HOCl] + [OCl^-] = \frac{2mg\times 10^{-3} gm}{71} \qquad [Cl_2 = 71 \text{ gm}]$$

$$11[HOCl] = \frac{2\times 10^{-3}}{71}\frac{\text{moles}}{\text{lt.}}\times 10^6 \mu \text{ moles}$$

$$[HOCl] = 2.56 \ \mu \text{ moles/litre} \simeq 2.6 \ \mu \text{ moles/litre}$$

End of Solution

Q.35 A surveyor measured the distance between two points on the plan drawn to a scale of 1 cm = 40 m and the result was 468 m. Later, it was discovered that the scale used was 1 cm = 20 m.

The true distance between the points (in m) is _____ (round off to the nearest integer).

Ans. (936)(936 to 936)

$$\text{RF of wrong scale} = \frac{1}{20}$$

$$\text{RF of corrected scale} = \frac{1}{40}$$

$$\text{Measured length} = 468 \text{ m}$$

$$\text{Corrected length} = \frac{(RF)_{\text{wrong scale}}}{(RF)_{\text{corrected scale}}} \times \text{Measured length}$$

$$= \frac{\left(\frac{1}{20}\right)}{\left(\frac{1}{40}\right)} \times 468 = 936 \text{ m}$$

End of Solution

Q.36 Pick the **CORRECT** solution for the following differential equation

$$\frac{dy}{dx} = e^{x-y}$$

(a) $y = \ln(e^x + \text{Constant})$
(b) $\ln(y) = x + \text{Constant}$
(c) $\ln(y) = \ln(e^x) + \text{Constant}$
(d) $y = x + \text{Constant}$

Ans. (a)

$$\frac{dy}{dx} = e^{x-y}$$

$$\frac{dy}{dx} = e^x \cdot e^{-y}$$

$$\frac{dy}{dx} = e^x dx$$

$$e^y = e^x + c$$

$$\ln(e^y) = \ln(e^x + c)$$

$$y = \ln(e^x + c)$$

End of Solution

Q.37 A circular tube of thickness 10 mm and diameter 250 mm is welded to a flat plate using 5 mm fillet weld along the circumference. Assume Fe410 steel and shop welding.

As per IS 800:2007, the torque that can be resisted by the weld (in kN.m) is _____ (round off to one decimal place).

(a) 65.1
(b) 78.1
(c) 156.2
(d) 130.2

Ans. (a)

Given,

diameter of circular plate (d) = 250 mm

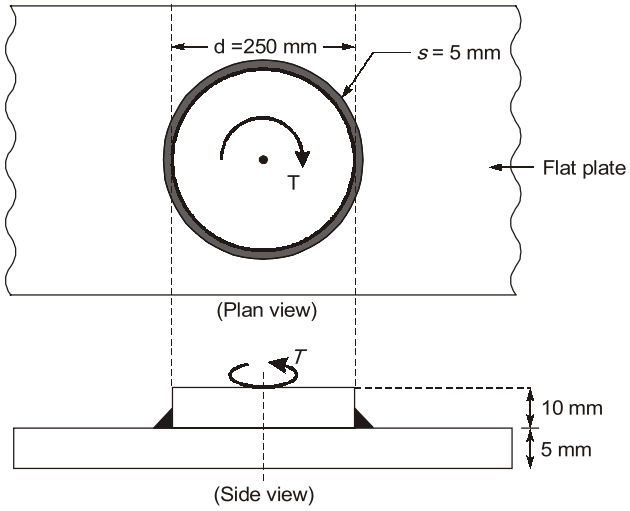
size of fillet weld (S) = 5 mm

thickness of circular plate = 10 mm

thickness of flat plate = 5 mm

f_u = 410 N/mm^2

For shop welding, γ_{mw} = 1.25



Throat thickness, $t_t = 0.75 = 0.7 \times 5 = 3.5$ mm

$$Z_P = \frac{J}{r} = \frac{Ar^2}{r} = Ar$$

$$Z_P = (\pi d t_t) \times \frac{d}{2} = \frac{\pi d^2 t_t}{2}$$

The maximum torque that can be applied on plate is

$$T = (f_s \times Z_p)$$

$$T = \left(\frac{f_u}{\sqrt{3}\gamma_{mw}}\right) \times \left(\frac{\pi d^2 t_t}{2}\right)$$

$$= \frac{410}{\sqrt{3} \times 1.25} \times \frac{\pi \times 250^2 \times 3.5}{2}$$

$$T = 65.07 \text{ kNm} \simeq 65.1 \text{ kNm}$$

End of Solution

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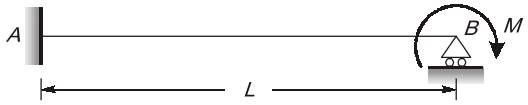
Q.38 The figure shows a propped cantilever with uniform flexural rigidity EI (in N.m^2) and subjected to a moment M (in N.m). Consider forces and displacements in the upward direction as positive.

Find the upward reaction at the propped support B (in N) when this support settles by $(-\Delta)$, given in metres.



(a) $\frac{3M}{2L} - \frac{6EI\Delta}{L^3}$

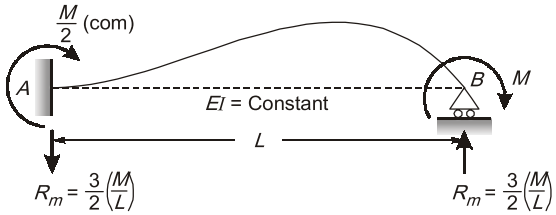
(b) $\frac{8M}{3L} - \frac{2EI\Delta}{L^3}$

(c) $\frac{3M}{2L} - \frac{3EI\Delta}{L^3}$

(d) $\frac{M}{L} - \frac{8EI\Delta}{L^3}$

Ans. **(c)**

Reaction due to moment,

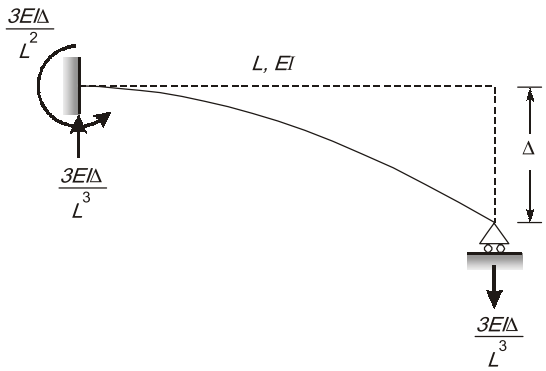


Deflection at $B = 0$

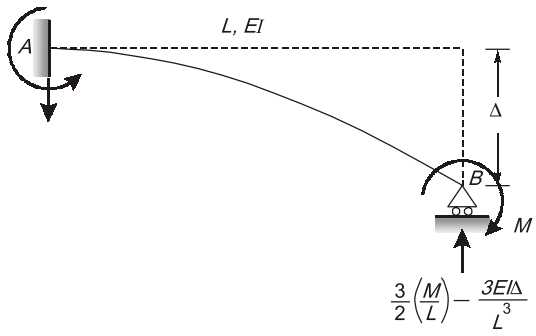
$$\frac{ML^2}{2EI} - \frac{R_m L^3}{3EI} = 0$$

$$R_m = \frac{3}{2}\left(\frac{M}{L}\right)$$

Reaction at propped end due to sinking of support.



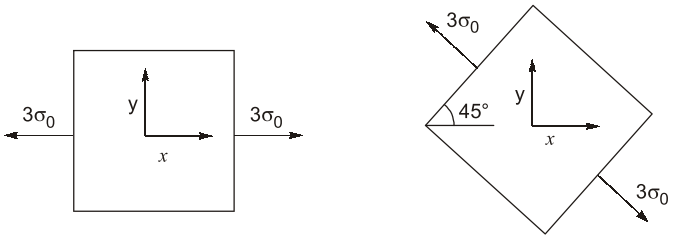
Net reaction at propped end is



$$(R_B)_{net} = \frac{3}{2}\left(\frac{M}{L}\right) - \frac{3EI\Delta}{L^3}$$

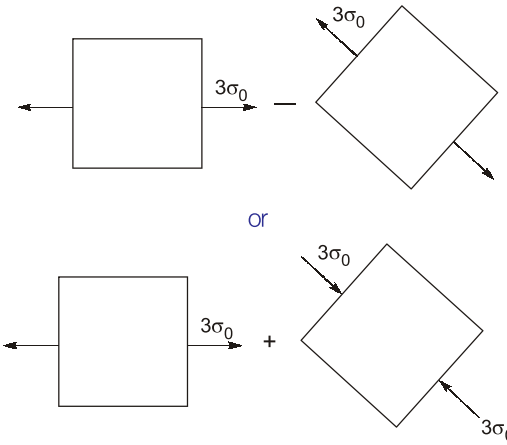
End of Solution

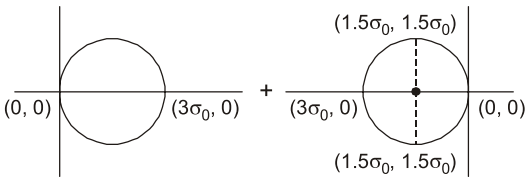
Q.39 Let the state of stress at a point in a body be the difference of two plane states of stress shown in the figure. Consider all the possible planes perpendicular to the x-y plane and passing through that point. The magnitude of the maximum compressive stress on any such plane is $k\sigma_0$, where k is equal to _____ (round off to one decimal place).



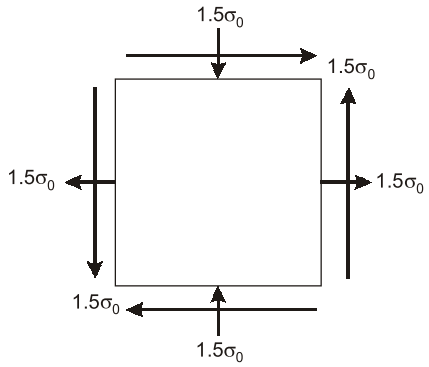
(a) 3.0
(b) 2.1
(c) 1.7
(d) 1.5

Ans. (b)





Resultant



$\sigma_x = 1.5\sigma_0$

$\sigma_y = -1.5\sigma_0,\ \tau_{xy} = 1.5\sigma_0$

$$\sigma_{P_1}/\sigma_{P_2} = \frac{\sigma_x+\sigma_y}{2} \pm \frac{1}{2}\sqrt{(\sigma_y-\sigma_x)^2+4\tau_{xy}^2}$$

$$= \frac{1.5\sigma_0+(-1.5\sigma_0)}{2} \pm \frac{1}{2}\sqrt{(1.5\sigma_0+1.5\sigma_0)^2+4(1.5\sigma_0)^2}$$

$$= 0 \pm \frac{1}{2}\sqrt{(3)^2+4(1.5)^2}\times\sigma_0$$

$\sigma_{P_1} = +2.1\sigma_0$

$\sigma_{P_2} = -2.1\sigma_0$

Given, the magnitude of the maximum compressive stress = $k\sigma_0$

$2.1\sigma_0 = k\sigma_0$

$k = 2.1$

End of Solution

Q.40 Consider a reinforced concrete beam section of 350 mm width and 600 mm depth. The beam is reinforced with the tension steel of 800 mm^2 area at an effective cover of 40 mm. Consider M20 concrete and Fe415 steel. Let the stress block considered for concrete in IS 456:2000 be replaced by an equivalent rectangular stress block, with no change in (a) the area of the stress block, (b) the design strength of concrete (at the strain of 0.0035), and (c) the location of neutral axis at flexural collapse. The ultimate moment of resistance of the beam (in kN.m) is _____ (round off to the nearest integer).

(a) 170 (b) 148

(c) 125 (d) 102

Ans. (b)

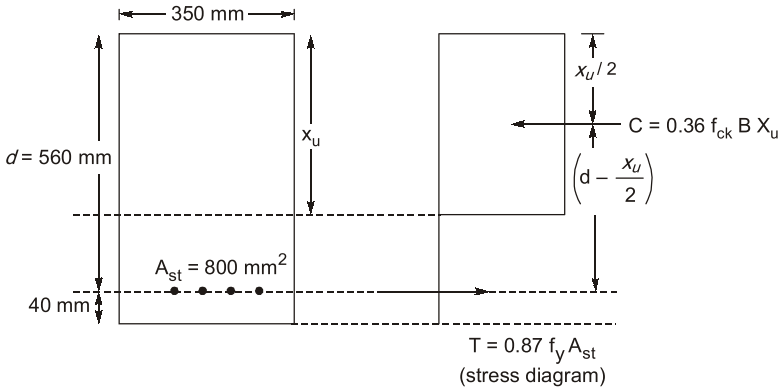
Given, width of beam B = 350 mm

effective depth d = 600 – 40 = 560 mm

f_{ck} = 20 N/mm^2

f_y = 415 N/mm^2

A_{st} = 800 mm^2



Limiting depth of NA

$$x_{ulim} = k.d = 0.48 \times 560 = 268.8 \text{ mm}^2.$$

Actual depth of NA

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} B} = \frac{0.87 \times 415 \times 800}{0.36 \times 20 \times 350}$$

$$x_u = 114.619 \text{ mm}$$

$\because$ $x_u < x_{ulim}$

$\therefore$ section is under reinforced

$$M_u = C \times LA$$

$$= 0.36 f_{ck} B x_u \left(d - \frac{x_u}{2}\right)$$

$$= 0.36 \times 20 \times 350 \times 114.619 \left(560 - \frac{114.619}{2}\right)$$

$$= 145.197 \times 10^6 \text{ N-mm}$$

$$M_u \simeq 145.2 \text{ kNm}$$ (Nearest value in option (b))

End of Solution

Q.41 For a partially saturated soil deposit at a construction site, water content (w) is 15%, degree of saturation (S) is 67%, void ratio (e) is 0.6 and specific gravity of solids in the soil (G_s) is 2.67. Consider unit weight of water as 9.81 kN/m^3.

To fully saturate 5 m^3 of this soil, the required weight of water (in kN) will be _____ (round off to the nearest integer).

(a) 5 (b) 6

(c) 7 (d) 8

Ans. (b)

Initial water content, $w_1 = 0.15$

Let water content be w_2

After full saturation, $Se = w_2 G_s$

$$w_2 = \frac{e}{G_s} = \frac{0.6}{2.67} = 0.2247$$

Now, $$w_2 - w_1 = \frac{\Delta \text{Weight of water}}{\text{Weight of solid}} = \frac{w}{w_s}$$

Also, $$w_s = V_s G \cdot \gamma_w = \left(\frac{V_T}{1+e}\right) G \cdot \gamma_w$$

$$\Rightarrow \quad 0.2247 - 0.15 = \frac{w}{\frac{5}{1.6} \times 2.67 \times 9.81}$$

$$w = 0.0747 \times 3.125 \times 2.67 \times 9.81$$

$$\simeq 6 \text{ kN}$$

End of Solution

Q.42 Consider flow in a long and very wide rectangular open channel. Width of the channel can be considered as infinity compared to the depth of flow. Uniform flow depth is 1.0 m. The bed slope of the channel is 0.0001. The Manning roughness coefficient value is 0.02. Acceleration due to gravity, g can be taken as 9.81 m/s^2.

The critical depth (in m) corresponding to the flow rate resulting from the above conditions is _____ (round off to one decimal place).

(a) 0.4 (b) 0.3

(c) 0.6 (d) 0.1

Ans. (b)

Given : Bed slope, $s = 0.0001$; Manning's coefficient, $n = 0.02$; Depth of flow (y) = 1 m, $g = 9.81$ m/s^2; Critical depth (y_c) = ?

For very wide rectangular channel ($B >> y$)

Hydraulic radius, $$R = \frac{A}{P} = \frac{By}{B+2y} \simeq y = 1 \text{ m} \qquad (\because \ B + 2y = B)$$

Critical depth of flow, $$y_c = \left(\frac{q^2}{g}\right)^{1/3} \qquad \ldots(i)$$

Now, Discharge, $Q = A \times v$

$$Q = By \times \frac{1}{n} R^{2/3} S^{1/2}$$

$$q = \frac{y}{n} R^{2/3} S^{1/2} \qquad \because \ q = \frac{Q}{B}$$

$$q = \frac{1}{n} y \times y^{2/3} \cdot S^{1/2}$$

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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
6	27th Mar 2025	150 Qs	2 Hours	Full Syllabus Test	Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies)
7	3rd 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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9	8th 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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$$q = \frac{1}{n} \times y^{5/3} \times S^{1/2}$$

$$q = \frac{1}{0.02} \times (1)^{5/3} \times (0.0001)^{1/2}$$

$$q = 0.5 \text{ m}^3/\text{sec/m}$$

From equation (i), critical depth of flow

$$y_c = \left(\frac{0.5^2}{9.81}\right)^{1/3}$$

$$y_c = 0.294 \text{ m} \simeq 0.3 \text{ m}$$

End of Solution

Q.43 Match the following in Column I with Column II.

Column I	Column II
1. Vehicle Damage Factor	A. Stability of subgrade soil
2. Passenger Car Unit	B. Capacity of a roadway
3. Perception Reaction Time	C. Design rigid pavement
4. California Bearing Ratio	D. Design flexible pavement
	E. Stopping sight distance

(a) 1-D; 2-B; 3-E; 4-A
(b) 1-C; 2-B; 3-D; 4-A
(c) 1-D; 2-E; 3-B; 4-A
(d) 1-D; 2-B; 3-A; 4-E

Ans. (a)

End of Solution

Q.44 Consider the function given below and pick one or more **CORRECT** statement(s) from the following choices.

$$f(x) = x^3 - \frac{15}{2}x^2 + 18x + 20$$

(a) $f(x)$ has a local minimum at $x = 3$
(b) $f(x)$ has a local maximum at $x = 3$
(c) $f(x)$ has a local minimum at $x = 2$
(d) $f(x)$ has a local maximum at $x = 2$

Ans. (a, d)

$$x^3 - \frac{15}{2}x^2 + 18x + 20 = 0$$

$$f(x) = x^3 - \frac{15}{2}x^2 + 18x + 20$$

$$f'(x) = 3x^2 - 15x + 18$$

$$x^2 - 5x + 6 = 0$$

$$x = 2, 3$$

$$f''(x) = 6x - 15$$

$$f''(x)\big|_{x=2} = 6 \times 2 - 15 = -3 < 0$$

$x = 2$ Local maxima

$$f''(x)\big|_{x=3} = 6 \times 3 - 15 = 3 > 0$$

$x = 3$ Local minima

$$f(x) = x^3 - \frac{15}{2}x^2 + 18x + 20$$

$$f(2) = (2)^3 - \frac{15}{2}(2)^2 + 18\times 2 + 20$$

$$= 8 - 30 + 36 + 20 = 34$$

$$f(3) = (3)^3 - \frac{15}{2}(3)^2 + 18\times 3 + 20$$

$$= 27 - 67.5 + 54 + 20 = 33.5$$

End of Solution

Q.45 Pick the CORRECT eigen value(s) of the matrix [A] from the following choices.

$$[A] = \begin{bmatrix} 6 & 8 \\ 4 & 2 \end{bmatrix}$$

(a) 10 (b) 4

(c) –2 (d) –10

Ans. **(a, c)**

Given matrix, $A = \begin{bmatrix} 6 & 8 \\ 4 & 2 \end{bmatrix}$

$$\lambda^2 - 8\lambda - 20 = 0$$

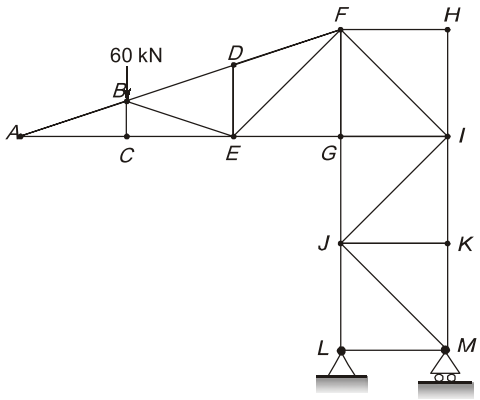
$$\lambda^2 - 10\lambda + 2\lambda - 20 = 0$$

$$\lambda(\lambda - 10) + 2(\lambda - 10) = 0$$

$$\lambda = -2, 10$$

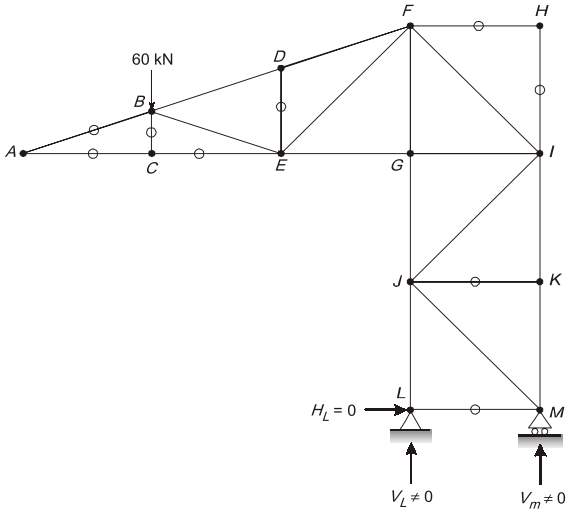
End of Solution

Q.46 In the pin-jointed truss shown in the figure, the members that carry zero force are identified. Which of the following options is/are zero-force members?



(a) BC
(b) EG
(c) FI
(d) JK

Ans. (a, d)



Force in members AB, AC, BC, CE, DE, FH, HI, JK and LM are zero.
Hence, $F_{JK} = 0$; $F_{BC} = 0$; $F_{FI} \neq 0$; $F_{EG} \neq 0$
Hence, the correct options are (a) and (d).

End of Solution

Q.47 In the context of shear strength of soil, which of the following statements is/are CORRECT?
(a) The unconfined compression test is a special case of the unconsolidated-undrained (UU) triaxial tests.
(b) The shear strength parameters obtained from the consolidated-drained (CD) triaxial tests should be used to analyse rapid construction in clay.
(c) Vane shear test is commonly used for determining in situ undrained strength of saturated clay soils.
(d) In an unconsolidated-undrained (UU) triaxial tests, the angle of internal friction (ϕ) is equal to zero.

Ans. (a, c, d)

End of Solution

Q.48 The drag force, F_D on a sphere due to a fluid flowing past the sphere is a function of viscosity, μ, the mass density, ρ, the velocity of flow, V and the diameter of the sphere, D.
Pick the relevant (one or more) non-dimensional parameter(s) pertaining to the above process from the following list.

(a) $\dfrac{F_D}{\rho V^2 D^2}$
(b) $\dfrac{\rho F_D}{V^2 D^2}$
(c) $\dfrac{\rho VD}{\mu}$
(d) $\dfrac{\mu\rho}{VD}$

Ans. (a, c)

$$F_D = F(D, V, \rho, \mu)$$

Derive that,

$$F_D = k \cdot D^2 v^2 \rho f\left(\frac{M}{\rho v D}\right)$$

$$m = 1 + 4,\ h = 3 = 5$$

Number of π-term $= m - n$

$$= 5 - 3 = 2$$

$$\pi_1 = D^a v^b \rho^c F_D$$

Dimension:

$$[M^\circ L^\circ T^\circ] = [L]^a [LT^{-1}]^b [ML^{-3}]^c [MLT^{-2}]$$

$$= [M^{c+1} L^{a+b-3c+1} T^{-b-2}]$$

Compare

$$c + 1 = 0,\ c = -1$$

$$b + 2 = 0 \quad b = -2$$

$$a + b - 3 + 1 = 0$$

$$a - 2 + 3 + 1 = 0$$

$$a = -2$$

$$\pi_1 = D^{-2} v^{-2} \rho^{-1} \cdot F_D$$

or $$\pi_1 = \frac{F_D}{D^2 v^2 \rho}$$

$$\pi_2 = D^a v^b \rho^c \mu$$

Dimensions

$$[M^\circ L^\circ T^\circ] = [L]^a [LT^{-1}]^b [ML^{-3}]^c [ML^{-1}T^{-1}]$$

$$= [M^{c+1} L^{a+b-3c-1} T^{-b-1}]$$

Compare

$$c + 1 = 0,\ c = -1$$

$$-b - 1 = 0 \quad b = -1$$

$$a + b - 3c + 1 = 0$$

$$a - 1 + 3 - 1 = 0$$

$$a = -1$$

$$\pi_2 = D^{-1} v^{-1} \rho^{-1} \mu$$

or $$\pi_2 = \frac{\mu}{\rho V D}$$

$$\pi_2 = D^a v^b \rho^c \mu$$

According to Buckingham's π-theorem

$$f(\pi_1, \pi_2) = 0$$

$$\pi_1 = k f(\pi_2)$$

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$$\frac{F_D}{D^2v^2\rho} = kf\left(\frac{\mu}{\rho vD}\right)$$

$$F_D = k{\cdot}D^2v^2\rho f\left(\frac{\mu}{\rho vD}\right)$$

Hence, the correct answer are (a) and (c).

End of Solution

Q.49 A compound has a general formula $C_aH_bO_cN_d$ and molecular weight 187. A 935 mg/l solution of the compound is prepared in distilled deionized water. The Total Organic Carbon (TOC) is measured as 360 mg/l (as C). The Chemical Oxygen Demand (COD) and the Total Kjeldahl Nitrogen (TKN) are determined as 600 mg/l (as O_2) and 140 mg/l (as N), respectively (as per the chemical equation given below). Which of the following ptions is/are CORRECT?

$$C_aH_bO_cN_d + \frac{(4a+b-2c-3d)}{4}O_2 \rightarrow aCO_2 + \frac{b-3d}{2}H_2O + dNH_3$$

Atomic weight : C(12), H(1), O(16), N(14)

(a) a = 6 (b) b = 7

(c) c = 5 (d) d = 3

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

Given: molecular weight of $C_aH_bO_cN_d$ = 187 gm

Solution of compound in distilled water = 935 mg/lt

TOC = 360 mg/lt (as C)

COD = 600 mg/lt (as O_2)

TKN = 140 mg/lt (As N)

$$C_aH_bO_cN_d + \frac{(4a+b-2c-3d)}{4}O_2 \rightarrow aCO_2 + \frac{b-3d}{2}H_2O + dNH_3$$

Now, $$d = \frac{\left(\frac{140}{935}\times 187\right)}{\text{Atomic weight of N}} = \frac{\frac{140}{935}\times 187}{14} = 2$$

$$a = \frac{\frac{360}{935}\times 187}{12} = 6$$

Now, $$\frac{4a+b-2c-3d}{4} = \frac{\left(\frac{660\times 187}{935}\right)}{\text{Atomic weight of } O_2} = \frac{\left(\frac{600\times 187}{935}\right)}{32}$$

$$\frac{4\times 6+b-2c-3\times 2}{4} = 3.75$$

$$b - 2c = -3 \qquad \ldots(i)$$

Now,

Molecular water of compound ($C_aH_bO_cN_d$) = 187

$12a + b \times 1 + 16c + 14d = 187$

$12 \times 6 + b + 16c + 14 \times 2 = 187$

$$b + 16c = 87 \quad \text{...(ii)}$$

On solving equation (i) and (ii), we get

$$b = 7$$
$$c = 5$$

Hence, a = 6, b = 7, c = 5, d = 2

Correct options are (a), (b) and (c).

End of Solution

Q.50 The free flow speed of a highway is 100 km/h and its capacity is 4000 vehicle/h. Assume speed density relation is linear.

For a traffic volume of 2000 vehicle/h, choose all the possible speeds (in km/h) from the options given below (round off to two decimal places).

(a) 85.36 (b) 65.20

(c) 14.64 (d) 7.22

Ans. **(a, c)**

Given:

Free mean speed, V_f = 100 kmph

Capacity, q_{max} = 4000 veh/hr

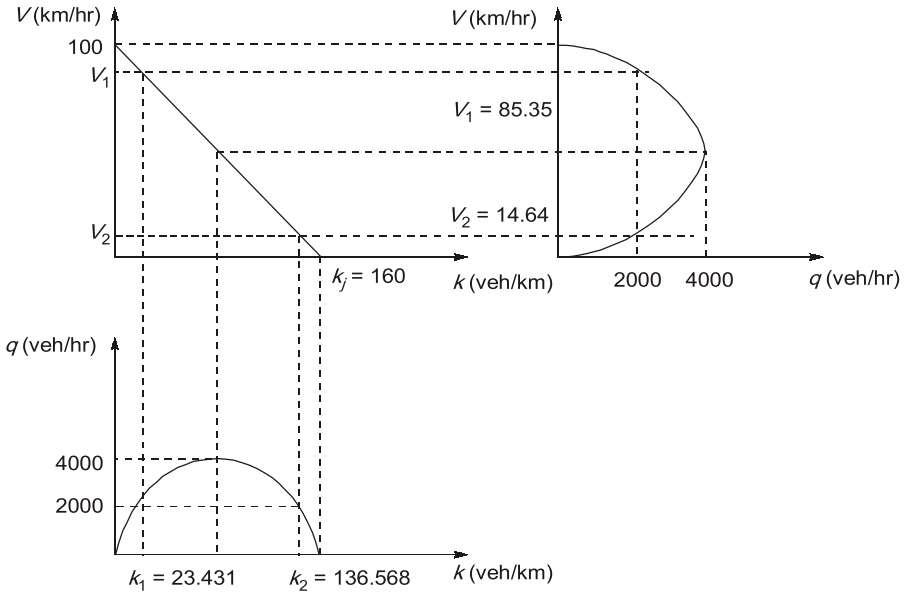
Possible speed, V_1, V_2 = ?

Speed density relation is linear

$$q_{max} = \frac{1}{4} k_j V_f$$

$$4000 = \frac{1}{4} \times 100 k_j$$

$$k_j = 160 \text{ veh/km}$$



Now, $q = vk$ $\quad\because\quad v = v_f\left(1-\frac{k}{k_j}\right)$

$$q = v_f\left(k-\frac{k^2}{k_j}\right)$$

$$2000 = 100\left(k-\frac{k^2}{160}\right)$$

On solving $k_1 = 23.431$ veh/km

$k_2 = 136.568$ veh/km

Velocity of traffic flow at $k_1 = 23.431$ veh/km

$$V_{1(k_1\,=\,23.431)} = 100\left(1-\frac{23.431}{160}\right) = 85.355 \text{ km/hr}$$

Velocity of traffic flow at $k_2 = 136.568$ veh/km

$$V_{2(k_2\,=\,136.568)} = 100\left(1-\frac{136.568}{160}\right) = 14.645 \text{ km/hr}$$

Hence, the correct options are (a) and (c).

End of Solution

Q.51 Consider a discrete random variable X whose probabilities are given below. The standard deviation of the random variable is _____ (round off to one decimal place).

x_1	1	2	3	4
$P(X = x_i)$	0.3	0.1	0.3	0.3

Ans. (2.8)(2.7 to 2.9)

x	1	2	4	8
$P(x)$	0.3	0.1	0.3	0.3

$$E(r) = \Sigma x P(x)$$

$$= 1 \times 0.3 + 2 \times 0.1 + 4 \times 0.3 + 8 \times 0.3 = 4.1$$

$$E(x^2) = \Sigma x^2 P(x)$$

$$= 1^2 \times 0.3 + 2^2 \times 0.1 + 4^2 \times 0.3 + 8^2 \times 0.3 = 24.7$$

$$V(x) = E(x^2) - (E(x)^2)$$

$$= (24.7) - (4.1)^2 = 7.89$$

Standard deviation, $\sigma = \sqrt{7.89} = 2.808$

End of Solution

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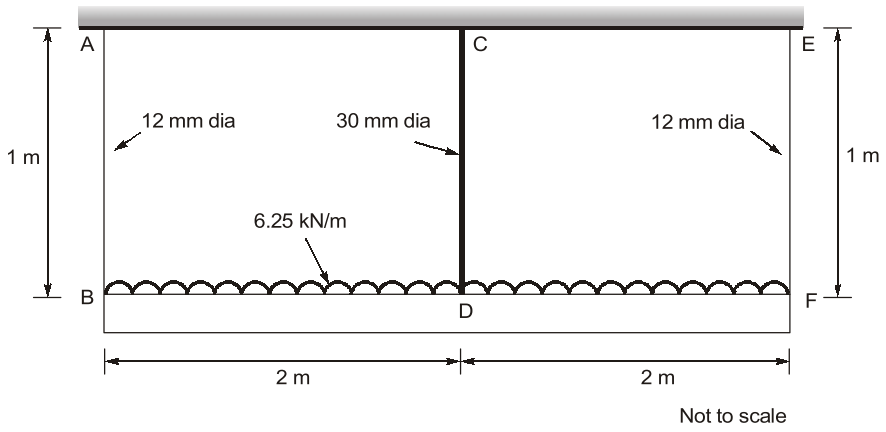
Q.52 A steel beam supported by three parallel pin-jointed steel rods is shown in the figure. The moment of inertia of the beam is 8×10^7 mm^4. Take modulus of elasticity of steel as 210 GPa. The beam is subjected to uniformly distributed load of 6.25 kN/m, including its self-weight.

The axial force (in kN) in the centre rod CD is _____ (round off to one decimal place).



Ans. **(16.48)(16.3 to 16.6)**

Given:

moment of inertia of beam, $I = 8 \times 10^7$ mm^4

modulus of elasticity of steel, $E = 210 \times 10^3$ N/mm^2

UDL, $w = 6.25$ kN/m $= 6.25$ N/mm (including self weight)

Axial force in CD, $P_1 = ?$

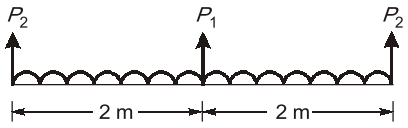
Flexural rigidity, $EI = 210 \times 10^3 \times 8 \times 10^7$

$= 1.68 \times 10^{13}$ N-mm^2

$= 16800$ kNm^2

Due to symmetry

$$\Delta_{EF} = \Delta_{AB} \text{ and } \Delta_{CD} \neq \Delta_{EF}$$



$$2P_2 + P_1 = 6.25 \times 40$$

$$2P_2 + P_1 = 25 \text{ kN}$$

$$P_2 = \left(\frac{25 - P_1}{2}\right) = (12.5 - 0.5P_1)$$

Net elongation of rod CD

$$(\Delta_{CD})_{net} = \frac{P_1 l_{CD}}{(AE)_{CD}} - \frac{P_2 l_{AB}}{(AE)_{AB}}$$

$$(\Delta_{CD})_{net} = \frac{P_1 \times 1}{\frac{\pi}{4}(0.03)^2 \times 210 \times 10^6} - \frac{(12.5 - 0.5P_1)}{\frac{\pi}{4}(0.012)^2 \times 210 \times 10^6}$$

$$= P_1\left(\frac{4}{\pi \times 0.03^2 \times 210 \times 10^6} + \frac{0.5 \times 4}{\pi \times 0.012^2 \times 210 \times 10^6}\right) - \frac{4 \times 12.5}{\pi(0.012) \times 210 \times 10^6}$$

$$(\Delta_{CD})_{net} = 2.77 \times 10^{-5}\, P_1 - 52.6 \times 10^{-4}$$

Deflection of beam at point D,

$$(\Delta_D)_{Beam} = \frac{5}{384}\left(\frac{wl^4}{EI}\right) - \frac{P_1 l^3}{48EI}$$

$$(\Delta_D)_{Beam} = \frac{4^3}{48 \times 16800}\left(\frac{5 \times 6.25 \times 4}{8} - P_1\right)$$

Now, $(\Delta_D)_{net} = (\Delta_D)_{Beam}$

$$2.77 \times 10^{-5} P_1 - 5.26 \times 10^{-4} = \frac{4^3}{48 \times 16800}\left(\frac{5 \times 6.25 \times 4}{8} - P_1\right)$$

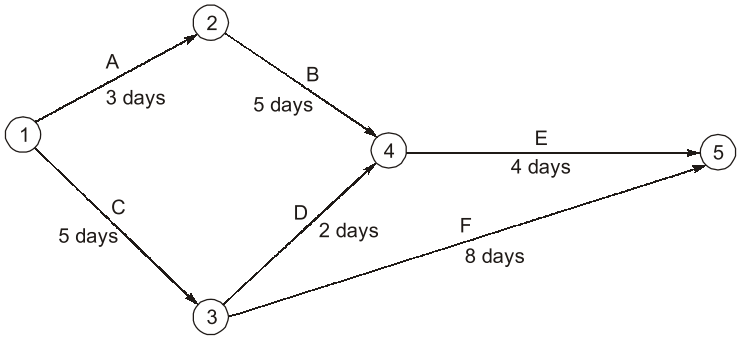
$$2.77 \times 10^{-5} P_1 - 5.26 \times 10^{-4} = 1.24 \times 10^{-3} - 7.936 \times 10^{-5}\, P_1$$

Axial force in Rod(CD) $P_1 = 16.48$ kN

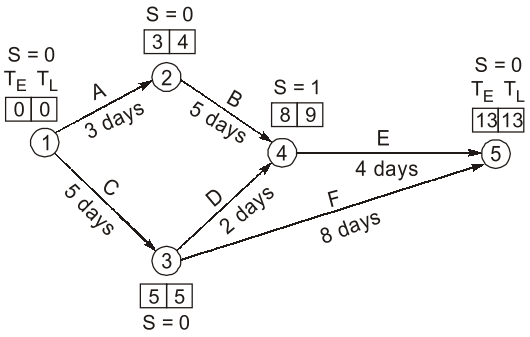
End of Solution

Q.53 The figure shows a network diagram for a construction project. The activities A, B, C, D, E, and F are represented by arrows and their durations are in the figure.

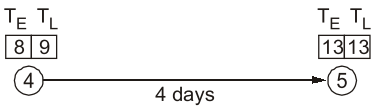
The total float available for the activity E in day(s) is equal to _____ (round off to the nearest integer).



Ans. (1)(1 to 1)



Activity E,



EST = 8 EFT = 12

LST = 9 LFT = 13

$\therefore$ F_T = LST − EST = 9 − 8 = 1

or F_T = LFT − EFT = 13 − 12 = 1

End of Solution

Q.54 A reinforced concrete beam has a support section with width of 300 mm and effective depth of 500 mm. The support section is reinforced with 3 bars of 20 mm diameter at the tension side. Two-legged vertical stirrups of 10 mm diameter and Fe415 steel at a spacing of 100 mm are provided as shear reinforcement. Assume that there is no possibility of diagonal compression failure at the section.

As per IS 456:2000, the maximum shear resisted by the vertical stirrups (in kN), as per limit state design, is _____ (round off to one decimal place).

Ans. (283.6)(283.0 to 284.0)

Given 2 legged vertical stirrups of diameter (ϕ = 10 mm)

c/c spacing S_v = 100 mm

f_y = 415 N/mm^2

effective depth d = 500 mm

Spacing for vertical shear stirrups

$$S_v = \frac{0.87 f_y A_{sv} \times d}{V_s}$$

where;

$V_s = (\tau_V - \tau_C)\, bd$

$\tau_v = \frac{V_u}{bd}$ (Nominal shear stress)

V_s = shear force resisted by shear stirrups

$$V_s = \frac{0.87 f_y A_{sv} d}{S_v} = \frac{0.87 \times f_y \times 2 \times \frac{\pi}{4}\phi^2 \times d}{S_v}$$

$$= \frac{0.87 \times 415 \times 2 \times \frac{\pi}{4} 10^2 \times 500}{100}$$

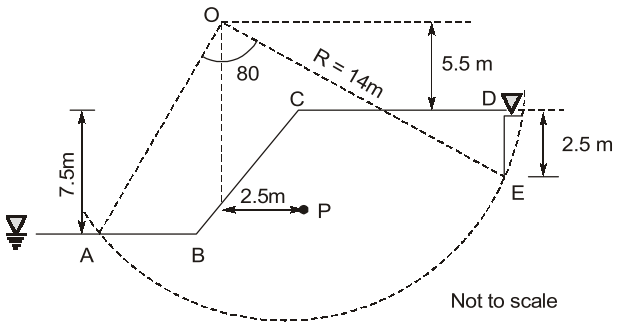
$$V_s = 283568 \text{ N}$$

$$V_s \simeq 283.6 \text{ kN}$$

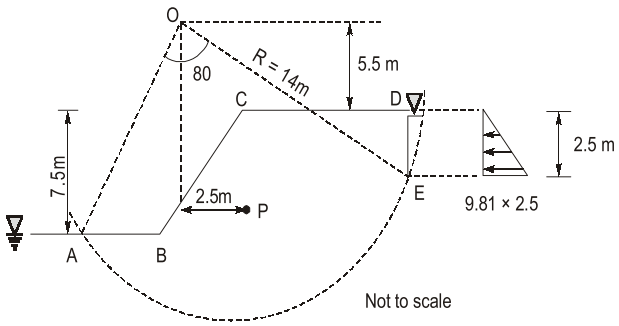
End of Solution

Q.55 The bank of a canal has the profile shown in the figure. The material is a homogeneous clay with a bulk unit weight of 20 kN/m^3, undrained cohesion of 30 kPa and it is fully saturated ($\phi_u = 0$). For the trial slip circle shown, the area ABCDEA is 150 m^2 and the centroid is at P. A tension crack (DE) of 2.5 m deep was also observed. Assume unit weight of water is 9.81 kN/m^3 and consider 1 m run of the bank for the analysis.

Considering the canal is empty and tension crack is completely filled with water, the factor of safety against slope failure of the bank is _____ (round off to two decimal places).



Ans. (1.06)(1.0 to 1.1)



$$\text{FOS} = \frac{\text{Resisting moment}}{\text{Overturning moment}}$$

$$= \frac{c(L \times 1) \times R}{w \times \bar{x} + P_w \cdot \bar{y}}$$

$$= \frac{30\times 14\left(\frac{80}{180}\times\pi\right)\times 14}{(150\times 1)\times 20\times 2.5+\frac{1}{2}\times 9.81\times 2.5^2\times\left(5.5+\frac{2.5\times 2}{3}\right)}$$

$$= \frac{8210.028}{7500+219.703} = 1.06$$

End of Solution

Q.56 A designer used plate load test to obtain the value of the bearing capacity factor N_γ. A circular plate of 1 m diameter was placed on the surface of a dry sand layer extending very deep beneath the ground. The unit weight of the sand is 16.66 kN/m^3. The plate is loaded to failure at a pressure of 1500 kPa.

Considering Terzaghi's bearing capacity theory, the bearing capacity factor N_γ is _____ (round off to the nearest integer).

Ans. **(300) (300 to 300)**

We know, for circular plate

$$q_u = 1.3CN_C + \gamma D_f N_q + 0.3B\gamma N_\gamma$$

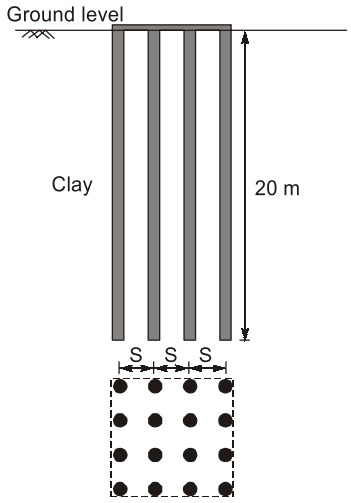
For sand, $c = 0$

$\Rightarrow$ $q_u = 0.3 \times 1 \times 16.66 \times N_\gamma = 1500$ $[\because D_f = 0]$

$\Rightarrow$ $N_\gamma = 300.12 \simeq 300$ (Nearest integer)

End of Solution

Q.57 A 4 × 4 group pile, with each pile 20 m long and 500 mm in diameter, is installed in a square pattern in a clayey soil, as shown in the figure. The average unconfined compressive strength of the soil is 100 kN/m^2, and the adhesion factor is 0.8. Neglect the bearing at the tip of the piles. For a group efficiency factor of 1.0, the centre to centre spacing(s) of the piles (in m) would be _____ (round off to two decimal places).



Ans. (1.51)(1.50 to 1.52)

$$\text{Group efficiency, } \eta_g = \frac{Q_{avg}}{nQ_u}$$

Here, $\eta_g = 1$ and $\bar{c} = \frac{UCS}{2} = \frac{100}{2} = 50 \text{ kN/m}^2$

$$Q_{ug} = n \cdot Q_{up}$$

$$\bar{c}(4 \times BL) = n\left[\alpha \bar{c}(\pi DL)\right]$$

$$50 \times 4 \times B \times 20 = 16 \times [0.8 \times 50 \times \pi \times 0.5 \times 20]$$

On solving, $B = 5.026$ m

$$B = 3s + D$$

$$= 3s + 0.5 = 5.026$$

$\Rightarrow$ $s = 1.51$ m

End of Solution

Q.58 A 60 cm diameter well completely penetrates a confined aquifer of permeability 5×10^{-4} m/s. The length of the strainer (spanning the entire thickness of the aquifer) is 10 m. The drawdown at the well under steady state pumping is 1.0 m. Assume that the radius of influence for this pumping is 300 m.

The discharge from the well (in litres per minute) is _____ (round off to the nearest integer).

Ans. (273)(271 to 273)

$k = 5 \times 10^{-4}$ m/s

$b = 10$ m, $R = 300$ m, $r_w = 0.3$ m, $s_w = 1$ m

$$Q = \frac{2\pi k b s_w}{\log_e\left(\frac{R}{r_w}\right)}$$

$$= \frac{2\pi \times 5 \times 10^{-4} \times 10 \times 1}{\log_e\left(\frac{300}{0.3}\right)} = 4.54 \times 10^{-3} \text{ m}^3/\text{s}$$

$$= 4.54 \times 10^{-3} \times 60 \text{ lt/min}$$

$\Rightarrow$ $Q = 272.87$ lt/min $\simeq$ 273 lt/min (nearest integer)

End of Solution

Q.59 The peak of flood hydrograph due to a 3-hour duration storm in a catchment is 180 m^3/s. The total rainfall depth is 6.6 cm. It can be assumed that the average infiltration loss is 0.2 cm/h. There are no other losses. The base flow is constant at a value of 30 m^3/s.

The peak value of the 3-hour unit hydrograph for this catchment (in m^3/s) is _____ (round off to the nearest integer).

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Ans. (25)(25 to 25)

Peak discharge = 180 m^3/s

Base flow = 30 m^3/s

ϕ-index = 0.2 cm/hr

R = 6.6 cm

Peak of 3 hr unit hydrograph,

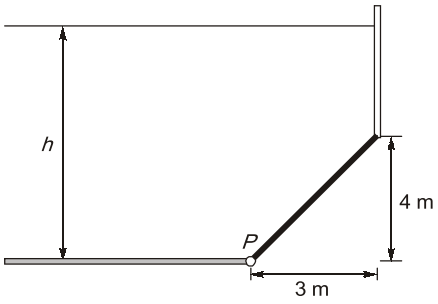
$$Q_P = \frac{\text{Peak discharge} - \text{Base flow}}{R - \phi t}$$

$$= \frac{180 - 30}{6.6 - 0.2 \times 3} = \frac{150}{6} = 25 \text{ m}^3/\text{s}$$

End of Solution

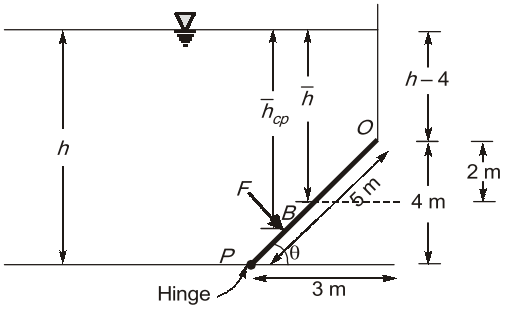
Q.60 The shaft of a 6 m wide gate in the figure will fail at a moment of 3924 kN.m about the hinge P. The maximum value of water depth h (in m) that the gate can hold is _____ (round off to the nearest integer).

Note:
Density of water = 1000 kg/m^3
Acceleration due to gravity = 9.81 m/s^2



Ans. (8)(7 to 9)

Let force F acts on a gate at B.



$$F = \rho g \bar{h} A$$

$$= \rho g (h - 4 + 2)(5 \times 6)$$

$$= 1000 \times 9.81 \times (h - 2) \times 30$$
$$= 294.3 \times (h - 2) \text{ kN}$$

From figure, $\sin\theta = \dfrac{h - \bar{h}_{cp}}{PB}$

$$\frac{4}{5} = \frac{h - \left[\bar{h} + \dfrac{I_{CG}\sin^2\theta}{A\bar{h}}\right]}{PB}$$

$$= \frac{h - \left[h - 2 + \dfrac{\dfrac{6 \times 5^3}{12} \times \left(\dfrac{4}{5}\right)^2}{(h-2) \times 5 \times 6}\right]}{PB}$$

$$\Rightarrow \quad PB = \frac{5}{4}\left[2 - \frac{4}{3(h-2)}\right]$$

Now, taking moment about P,

$$F \times PB = 3924$$

$$294.3 \times (h-2) \times \frac{5}{4}\left[2 - \frac{4}{3(h-2)}\right] = 3924$$

$$(h-2) \times \left(2 - \frac{4}{3(h-2)}\right) = \frac{32}{3}$$

$$2h - 4 - \frac{4}{3} = \frac{32}{3}$$

$$h = 8 \text{ m}$$

End of Solution

Q.61 The analyses results of a water sample are given below. The non-carbonate hardness of the water (in mg/L) as $CaCO_3$ is _____ (in integer).

Ca^{2+} = 150 mg/L as $CaCO_3$
Mg^{2+} = 40 mg/L as $CaCO_3$
Fe^{2+} = 10 mg/L as $CaCO_3$
Na^{+} = 50 mg/L as $CaCO_3$
K^{+} = 10 mg/L as $CaCO_3$
CO_3^{2-} = 120 mg/L as $CaCO_3$
HCO_3^{-} = 30 mg/L as $CaCO_3$
Cl^{-} = 50 mg/L as $CaCO_3$; Other anions were not analysed.

Ans. **(50)(50 to 50)**

Total hardness as $CaCO_3$ = 150 + 40 + 10 = 200 mg/L as $CaCO_3$
(For Ca^{2+}, Mg^{2+} and Fe^{2+})

Alkalinity as $CaCO_3$ = 100 + 50 = 150 mg/L as $CaCO_3$

CH (Carbonate hardness) = Min.{Alkalinity and Total hardness}

$\therefore$ CH = 150 mg/L

CH + NCH = TH

NCH = TH – CH (NCH = Non-carbonate hardness)

NCH = 200 – 150 = 50 mg/L as $CaCO_3$

End of Solution

Q.62 A community generates 1 million litres/day (MLD) of wastewater. This wastewater is treated using activated sludge process (ASP). The working volume of the aeration tank of the ASP is 250 m^3, and the biomass concentration in the tank is 3000 mg/L. Analyses results showed that a biomass concentration of 10 mg/L is present in the treated effluent from the secondary sedimentation tank of the ASP. Sludge wastage from the system is at a rate of 5000 L/day with a biomass concentration of 10000 mg/L. The system is in steady state condition.

The biological sludge residence time (BSRT) of the system (in days) is_____ (round off to one decimal place).

Ans. **(12.5)(12.3 to 12.7)**

Q_0 = 1 MLD = 1 × 10^6 lt/day

V = 250 m^3

X = 3000 mg/lt

Xe = 10 mg/lt

Q_w = 5000 lt/day

X_u = 10000 mg/lt

$$\text{Sludge age } (\theta_c) = \frac{V \cdot X}{Q_w \cdot X_u + (Q - Q_w) X_e}$$

$$= \frac{250 \times 3000 \times 10^3}{5000 \times 10000 + \left(10^6 - 5000\right) \times 10} \text{ day}$$

= 12.5 days

End of Solution

Q.63 A settling chamber is used for the removal of discrete particulate matter from air with following conditions. Horizontal velocity of air = 0.2 m/s; Temperature of air stream = 77°C; Specific gravity of particle to be removed = 2.65; Chamber length = 12 m; Chamber height = 2 m;

Viscosity of air at 77°C = 2.1 x 10^{-5} kg/m.s;

Acceleration due to gravity (g) = 9.81 m/s^2; Density of air at 77°C =1.0 kg/m^3;

Assume the density of water as 1000 kg/m^3 and Laminar condition exists in the chamber.

The minimum size of particle that will be removed with 100% efficiency in the settling chamber (in μm) is _____ (round off to one decimal place).

Ans. **(22)(21 to 23)**

Given :

$\mu = 2.1 \times 10^{-5}$ kg/msec $= 2.1 \times 10^{-5}$ m.sec/m^2

$\rho_{air} = 1$ kg/m^3

$\rho_{water} = 1000$ kg/m^3

$V = 0.2$ m/sec

$G = 2.65$ (of particle removed)

$L = 12$ m

$H = 2$ m, $C = 1$, $g = 9.81$ m/sec^2

$$d = C\sqrt{\frac{18\mu VH}{gL\rho}}$$

$$= 1\sqrt{\frac{18\times 2.1\times 10^{-5}\times 0.2\times 2}{9.81\times 12\times\left(2.65\times 10^{3}\right)}}$$

$= 2.201 \times 10^{-5}$ m

$= 22 \times 10^{-6}$ m

$d = 22$ μm

End of Solution

Q.64 On a two-lane highway, a horizontal curve of radius 300 m is provided. The design speed is 80 km/h.

If the longest wheelbase of vehicle expected on this highway is 7 m, then the extra widening required (in m) is _____ (round off to two decimal places).

Ans. **(0.65)(0.63 to 0.66)**

Given:

Two lane highway

Number of lanes, $n = 2$

Radius of curve, $R = 300$ m

Design speed, $v = 80$ km/hr

Longest wheel base of vehicle, $l = 6$ m

Extra widening, $W_e = ?$

As per IRC

Extra widening, $W_e = W_m + W_{ph}$

$$= \frac{nl^2}{2R} + \frac{v}{9.5\sqrt{R}}$$

$$= \frac{2\times 7^2}{2\times 300} + \frac{80}{9.5\sqrt{300}}$$

$W_e = 0.65$ m

End of Solution

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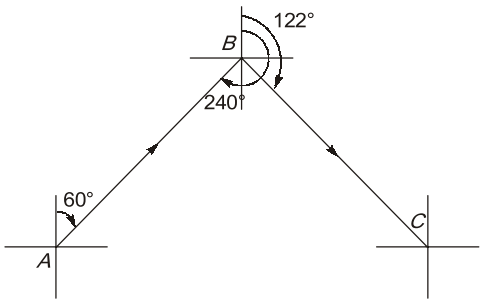
Q.65 If the Fore Bearing of the lines AB and BC are 60° and 122°, respectively, then the interior angle ∠ABC (in degrees) is _____ (round off to the nearest integer).

Ans. **(118)(118 to 118)**

Given : For bearing of line AB, $(FB)_{AB} = 60°$

For bearing of line BC, $(FB)_{BC} = 122°$



$(BB)_{AB} = (FB)_{AB} + 180°$ [$\because$ $(FB)_{AB} < 180°$]

$= 60° + 180° = 240°$

Interior angle $ABC = (BB)_{AB} - (FB)_{BC}$

$= 240° - 122° = 118°$

End of Solution

■■■■