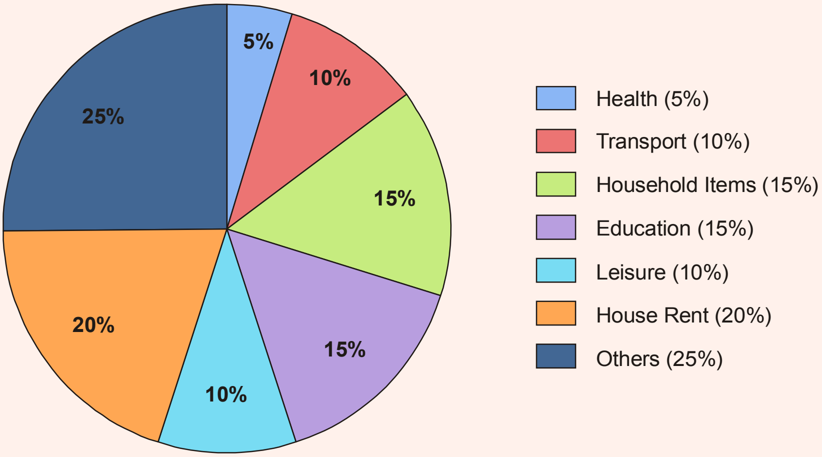
GENERAL APTITUDE

Q.1 The total expenditure of a family, on different activities in a month, is shown in the pie-chart. the extra money spent on education as compared to transport (in percent) is ____.



(a) 33.3 (b) 50
(c) 100 (d) 5

Ans. (b)

Let total monhly earining = Rs. 100

Monthly spent on education = $\frac{15}{100} \times 100 = \text{Rs.}15$

Monthly spent on transport = $\frac{10}{100} \times 10 = \text{Rs. } 10$

% money extra spent on education as compard to transportation

$$= \frac{15-10}{10} \times 100 = 50\%$$

End of Solution

Q.2 The unit's place in 26591749^{110016} is ________.

(a) 6 (b) 1
(c) 3 (d) 9

Ans. (b)

$\simeq 26591749^{(110016)}$

$\simeq$ Unit place of $9^{\text{even}} = 1$

$\therefore$ Cyclicity of 9 is (9, 1) (9, 1), (9, 1)

So answer will be 1.

End of Solution

Q.3 The sum of two positive numebrs is 100. After subtracting 5 from each number, the product of the resulting numbers is 0. One of the original numbers is ______.

(a) 95 (b) 90
(c) 85 (d) 80

Ans. **(a)**

If the product of two positive numbers should be zero, one of the number must be zero. After subtracting 5 if a positive number should become zero, that number should be 5. If one number is 5 and the sum is 100 then the other number must be 95.

Let the two positive numbers be x and y.

$\therefore \quad x + y = 100 \quad \text{...(i)}$

$(x - 5)(y - 5) = 0 \quad \text{...(ii)}$

$\Rightarrow x = 5$ or $y = 5$

If $x = 5$ then $y = 95$

If $y = 5$ then $x = 95$

$\therefore$ One of the number is 95 since 5 is not in any of the options.

End of Solution

Q.4 Five friends P, Q, R, S and T went camping. At night, they had to sleep in a row inside the tent. P, Q and T refused to sleep next to R since he snored loudly. P and S wanted to avoid Q as he usually hugged people in sleep.

Assuming everyone was satisfied with the sleeping arrangements, what is the order in which they slept?

(a) RSPTQ
(b) QRSPT
(c) QTSPR
(d) SPRTQ

Ans. **(a)**

Option (a) satisfies the given conditions in the paragraph.

End of Solution

Q.5 The american psychologist Howard Gardner expounds that human intelligence can be sub-categorised into multiple kinds, in such a vway that individuals differ with respect to their relative competence in each kind. Based on this theory, modern educationists insist on prescribing multi-dimensional curriculum and evluation parameters that enable development and assessment of multiple intelligences.

Which of the following statements can be inferred from the given text?

(a) Modern educationists want to develop and asses the theory of multiple intelligences.
(b) Modern educationists insist that the teaching curriculum and evaluation needs to be multi-dimensional.
(c) Howard Gardner wants to develop and assess the theory of multiple intelligences.
(d) Howard Gardner insits that the teaching curriculum and evaluation needs to be multi-dimensional.

Ans. **(b)**

End of Solution

Q.6 Insert seven numbers between 2 and 34, such that the resulting sequence including 2 abnd 34 is an arithmetic progression. The sum of these inserted seven numbers is ________.

(a) 124 (b) 120

(c) 126 (d) 130

Ans. **(c)**

$2, a, (a + d), (a + 2d), \ldots\ldots (a + 6d), 34$

$\therefore$ Total number of terms of $AP(n) = 9$

Let sum of seven inserted numbers $= S$

$$\therefore \quad S = \frac{7}{2}[a + (a + 6d)] = 7[a + 3d]$$

$$T_n = 34$$

Also, $a - 2 = (a + d - a)$

$\Rightarrow a - d = 2$

Similarly $a - 2 = 34 - (a + 6d)$

$\Rightarrow a - 2 = 34 - a - 6d$

$\Rightarrow 2a = 36 - 6d = 36 - 6(a - 2)$

$\Rightarrow 2a = 36 - 6a + 12$

$\Rightarrow 8a = 48$

$\Rightarrow a = 6$

$\therefore d = a - 2 = 6 - 2 = 4$

$\therefore S = 7(a + 3d) = 7(6 + 3 \times 4) = 126$

End of Solution

Q.7 It is a common criticism that most of the academicians live in their _____, so, they are not aware of the real life challenges.

(a) glas palaces (b) big flats

(c) ivory towers (d) homes

Ans. **(c)**

End of Solution

Q.8 Select the work that fits the analogy:

Fuse : Fusion :: Use : ______

(a) Usage (b) Uses

(c) Usion (d) User

Ans. **(a)**

End of Solution

Q.9 His number for reading is insatiable. He reads indiscriminately. He is most certainly a/an ________ reader.

(a) all-round (b) voracious

(c) precocious (d) wise

Ans. (b)

End of Solution

Q.10 If 0, 1, 2, ..., 7, 8, 9 are coded as O, P, Q, ..., V, W, X, then 45 will be coded as ________.

(a) ST (b) SS

(c) SU (d) TS

Ans. (a)

0,	1,	2,	3,	4,	5,	6,	7,	8,	9
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
O	P	Q	R	S	T	U	V	W	X

∴ 45 is coded as 'ST'.

End of Solution

■■■■

Q.1 The data for an agricultural field for a specific month are given below:

Pan Evaporation = 100 mm

Effective Rainfall = 20 mm (after deducting losses due to runoff and deep percolation)

Crop Coefficient = 0.4

Irrigation Efficiency = 0.5

The amount of irrigation water (in mm) to be applied to the field in that month, is

(a) 80
(b) 40
(c) 20
(d) 0

Ans. **(b)**

Water required by crop = 100 × 0.4 mm = 40 mm

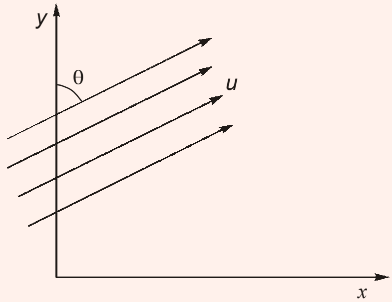
Effective rainfall = 20 mm

Additional water requried = 20 mm

Amount of water required after accounting irrigation efficiency = $\frac{20}{0.5} = 40$ mm

End of Solution

Q.2 Uniform flow with velocity U makes an angle θ with the y-axis, as shown in the figure



The velocity potential (ϕ), is

(a) ±U (x sinθ – y cosθ)
(b) ±U (y sinθ + x cosθ)
(c) ±U (y sinθ – x cosθ)
(d) ±U (x sinθ + y cosθ)

Ans. **(d)**

Velocity in x-depth, $u_x = u\sin\theta$

Velocity in y-depth, $u_y = u\cos\theta$

$$-\frac{\partial\phi}{\partial x} = u_x$$

Integrating it $\phi = -u_x x + f(y) + c$

$$= -(u\sin\theta)x + f(y) + c \quad \text{...(i)}$$

$$-\frac{\partial\phi}{\partial y} = u_y$$

Integrating it
$$\phi = -u_y\, y + f(x) + c$$
$$= -(u\cos\theta)y + f(x) + c \quad \text{...(ii)}$$

By equation (i) and (ii),
$$\phi = -u(x\sin\theta + y\cos\theta)$$

If we take
$$\frac{\partial\phi}{\partial x} = u_x \text{ and } \frac{\partial\phi}{\partial y} = u_y$$

Then
$$\phi = u(x\sin\theta + y\cos\theta)$$

So,
$$\phi = \pm u(x\sin\theta + y\cos\theta)$$

End of Solution

Q.3 An amount of 35.67 mg HCl is added to distilled water and the total solution volume is made to one litre. The atomic weights of H and Cl are 1 and 35.5, respectively. Neglecting the dissociation of water, the pH of the solution, is

(a) 2.50
(b) 2.01
(c) 3.01
(d) 3.50

Ans. (c)

$$HCl \rightarrow H^+ + Cl^-$$

1 mole of HCL gives 1 mole H^+ ions

36.5 gm of HCl gives 1 gm of H^+ ions

$$35.67 \text{ mg} = \frac{1}{36.5} \times 35.67 = 0.977 \text{ mg of } H^+$$

$$= \frac{0.977 \times 10^{-3}}{1} = 9.77 \times 10^{-4} \text{ moles of } H^+$$

$$pH = -\log_{10}[H^+] = -\log_{10}[9.77 \times 10^{-4}]$$
$$= -\log_{10}9.77 + 4\log_{10}10$$
$$= 4 - 0.989 = 3.01$$

End of Solution

Q.4 In a soil investigation work at a site, Standard Penetration Test (SPT) was conducted at every 1.5 m interval up to 30 m depth. At 3 m depth, the observed number of hammer blows for three successive 150 mm penetrations were 8, 6 and 9, respectively. The SPT-N-value at 3 m depth, is

(a) 14
(b) 17
(c) 23
(d) 15

Ans. **(d)**

No. of blows for each 150 mm penetration 8, 6 and 9.

We will not consider first 150 mm number of blows.

Hence, for last 300 mm, number of blows are 15.

Hence, observed SPT number = 15.

End of Solution

Q.5 In the following partial differential equation, θ is a function of t and z, and D and K are functions of θ

$$D(\theta)\frac{\partial^2\theta}{\partial z^2}+\frac{\partial K(\theta)}{\partial z}-\frac{\partial\theta}{\partial t}=0$$

The above equation is

(a) a second order linear equation

(b) a second order non-linear equation

(c) a second degree non-linear equation

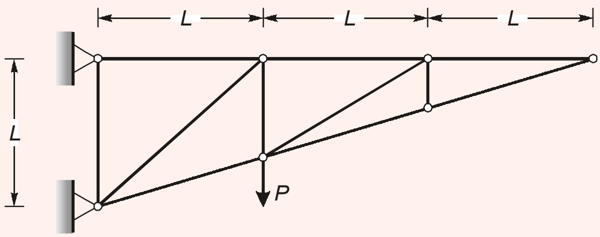
(d) a second degree linear equation

Ans. **(b)**

$\because$ 1^{st} term of given *D*. Equation contains product of dependent variable with it's derivative, so it is non-linear and also we have 2nd order derivative so it's order is two i.e., 2^{nd} order non linear equation.

End of Solution

Q.6 Consider the planar truss shown in the figure (not drawn to the scale)



Neglecting self-weight of the members, the number of zero-force members in the truss under the action of the load P, is

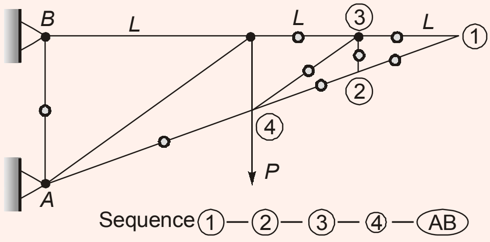
(a) 6

(b) 9

(c) 7

(d) 8

Ans. (d)

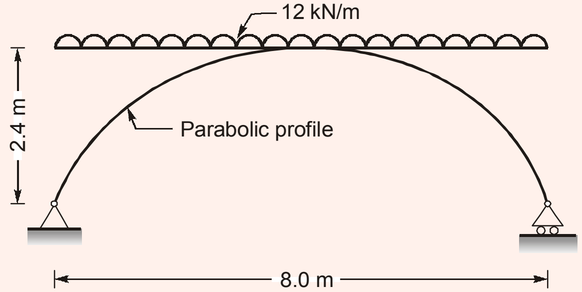


As $\Delta_{AB} = 0$, hence $F_{AB} = 0$

Total number of zero force member = 8

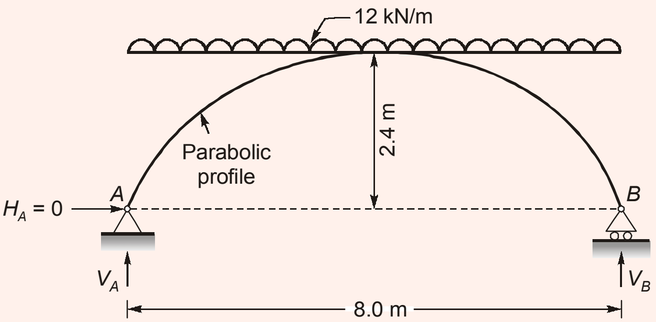
End of Solution

Q.7 A planar elastic structure is subjected to uniformly distributed load, as shown in the figure (not drawn to the scale)



Neglecting self-weight, the maximum bending moment generated in the structure (in kNm, round off to the nearest integer), is __________ .

Ans. (96)



$$V_A = V_B = \frac{wL}{2} = \frac{12 \times 8}{2} = 48 \text{ kN}$$

As horizontal thrust is zero so it behaves like a beam (curved beam)

$$M_{max} = \frac{wL^2}{8}(\text{At crown}) = \frac{12 \times 8^2}{8} = 96 \text{ kNm}$$

End of Solution

Q.8 A fully submerged infinite sandy slope has an inclination of 30° with the horizontal. The saturated unit weight and effective angle of internal friction of sand are 18 kN/m^3 and 38°, respectively. The unit weight of water is 10 kN/m^3. Assume that the seepage is parallel to the slope. Against shear failure of the slope, the factor of safety (round off to two decimal places) is ______.

Ans. **(0.60)**

$$\text{F.O.S.} = \frac{\gamma'}{\gamma_{sat}} \cdot \frac{\tan\phi}{\tan\beta} = \left(\frac{18-10}{18}\right)\frac{\tan 38°}{\tan 30°}$$

$$= 0.601$$

End of Solution

Q.9 The value of $\lim\limits_{x\to\infty} \frac{x^2 - 5x + 4}{4x^2 + 2x}$ is

(a) 0
(b) 1
(c) $\frac{1}{4}$
(d) $\frac{1}{2}$

Ans. **(c)**

It is in $\left(\frac{\infty}{\infty}\right)$ from so by L-Hospital Rule

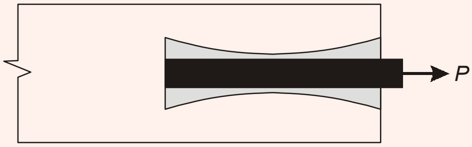
$$= \lim_{x\to\infty}\left(\frac{2x-5}{8x+2}\right) = \frac{\infty}{\infty}$$

$$= \lim_{x\to\infty}\left(\frac{2}{8}\right) = \left(\frac{1}{4}\right)$$

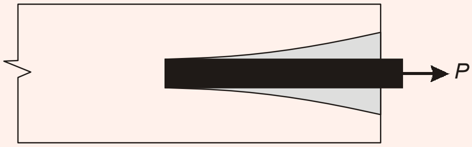
End of Solution

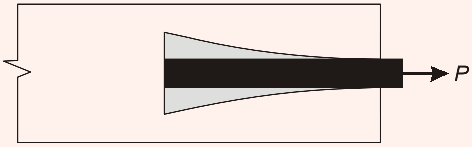
Q.10 A reinforcing steel bar, partially embedded in concrete, is subjected to a tensile force P. The figure that appropriately represents the distribution of the magnitude of bond stress (represented as hatched region), along the embedded length of the bar, is

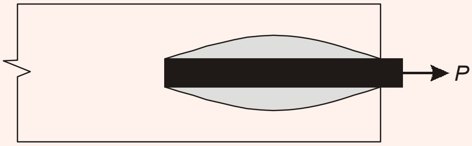
(a)



(b)



(c) 

(d) 

Ans. (b)

End of Solution

Q.11 Velocity of flow is proportional to the first power of hydraulic gradient in Darcy's law. The law is applicable to

(a) transitional flow in porous media
(b) turbulent flow in porous media
(c) laminar as well as turbulent flow in porous media
(d) laminar flow in porous media

Ans. (d)

Darcy's law is valid for laminar flow condition in porous media.

End of Solution

Q.12 The probability that a 50 year flood may NOT occur at all during 25 years life of a project (round off to two decimal places), is _______.

Ans. (0.60)

$$P = \frac{1}{T} = \frac{1}{50} = 0.02$$

$$q = 1 - P = 0.98$$

∴ Probability of non-occurance of an event is given by,

$$\text{Assurance} = q^n$$
$$= (0.98)^{25}$$
$$= 0.603$$

End of Solution

Q.13 In a two-dimensional stress analysis, the state of stress at a point P is

$$[\sigma] = \begin{bmatrix} \sigma_{xx} & \tau_{xy} \\ \tau_{xy} & \sigma_{yy} \end{bmatrix}$$

The necessary and sufficient condition for existence of the state of pure shear at the point P, is

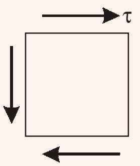
(a) $\tau_{xy} = 0$

(b) $(\sigma_{xx} - \sigma_{yy})^2 + 4\tau_{xy}^2 = 0$

(c) $\sigma_{xx} + \sigma_{yy} = 0$

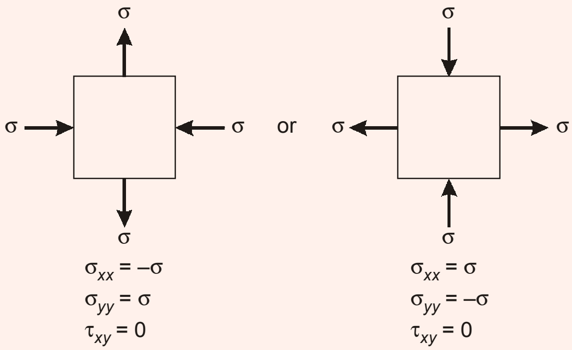
(d) $\sigma_{xx}\sigma_{yy} - \tau_{xy}^2 = 0$

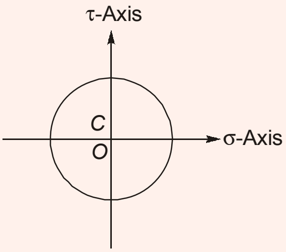
Ans. (c)



In pure shear condition

$$\sigma_x = 0,\ \sigma_y = 0,\ \tau_{xy} = \tau$$





For this condition

(c) is correct

$$\sigma_{xx} + \sigma_{yy} = 0$$

End of Solution

Q.14 The true value of ln(2) is 0.69. If the value of ln(2) is obtained by linear interpolation between ln(1) and ln(6), the percentage of absolute error (round off to the nearest integer), is

(a) 35

(b) 69

(c) 84

(d) 48

Ans. **(d)**

True value ln2 = 0.69 = T

x	$y = \ln x$
$x_0 = 1$	0
$x_1 = 6$	1.79

Divided differentiation

$$\frac{1.79-0}{6-1} = 0.358 = f[x_0, x_1]$$

Approx:
$$\ln 2 = f[x_0] + (x - x_0)\, f[x_0, x_1]$$
$$= 0 + (2-1)\, 0.358$$
$$= 0.358 = A$$

$$\%\text{ error} = \frac{T-A}{T} \times 100 = 48.11\%$$

End of Solution

Q.15 In an urban area, a median is provided to separate the opposing streams of traffic. As per IRC : 86-1983, the desirable minimum width (in m, expressed as integer) of the median, is ________.

Ans. **(5)**

As per IRC : 86-1983

Desirable minimum width of median in urban roads = 5 m

And minimum width = 1.2 m

End of Solution

Q.16 In a drained tri-axial compression test, a sample of sand fails at deviator stress of 150 kPa under confining pressure of 50 kPa. The angle of internal friction (in degree, round off to the nearest integer) of the sample, is ________.

Ans. **(37)**

Sand ($C = 0$); $\sigma_d = 150$; $\sigma_3 = 50$; $\sigma_1 = 200$

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

$$200 = 50 \tan^2\left(45 + \frac{\phi}{2}\right)$$

$$\phi = 36.87^\circ$$

So, the angle of internal friction to the nearest integer is 37°.

End of Solution

Q.17 During chlorination process, aqueous (aq) chlorine reacts rapidly with water to from Cl^-, HOCl, and H^+ as shown below

$$Cl_2\,(aq) + H_2O \rightleftharpoons HOCL + Cl^- + H^+$$

The most active disinfectant in the chlorination process from amongst the following, is

(a) H_2O
(b) H^+
(c) Cl^-
(d) HOCl

Ans. **(d)**

End of Solution

Q.18 A 4 m wide rectangular channel carries 6 m^3/s of water. The Manning's '*n*' of the open channel is 0.02. Considering $g = 9.81\ m/s^2$, the critical velocity of flow (in m/s, round off to two decimal places) in the channel, is ________.

Ans. **(2.45)**

$$\text{Critical depth } (Y_C) = \left(\frac{q^2}{g}\right)^{1/3}$$

$$= \left(\frac{1.5^2}{9.81}\right)^{1/3} = 0.612\ \text{m}$$

$$\text{Critical velocity } (V_C) = \sqrt{gY_C} = \sqrt{9.81 \times 0.612} = 2.45\ \text{m/s}$$

End of Solution

Q.19 The Los Angeles test for stone aggregates is used to examine

(a) specific gravity
(b) abrasion resistance
(c) soundness
(d) crushing strength

Ans. **(b)**

End of Solution

Q.20 A river has a flow of 1000 million litres per day (MLD), BOD_5 of 5 mg/litre and Dissolved Oxygen (DO) level of 8 mg/litre before receiving the wastewater discharge at a location. For the existing environmental conditions, the saturation DO level is 10 mg/litre in the river. Wastewater discharge of 100 MLD with the BOD_5 of 200 mg/litre and DO level of 2 mg/litre falls at that location. Assuming complete mixing of wastewater and river water, the immediate DO deficit (in mg/litre, round off to two decimal places), is ________.

Ans. **(2.54)**

$$DO_{mix} = \frac{DO_s \cdot Q_S + DO_R \cdot Q_R}{Q_s + Q_R} = \frac{2 \times 100 + 8 \times 1000}{100 + 1000}$$

$$= 7.45\ \text{mg}/l$$

$$DO = DO_{sat} - DO_{mix} = 10 - 7.45 = 2.545\ \text{mg}/l$$

End of Solution

Q.21 During the process of hydration of cement, due to increase in Dicalcium Silicate (C_2S) content in cement clinker, the heat of hydration

(a) does not change

(b) decreases

(c) initially decreases and then increases

(d) increases

Ans. **(b)**

End of Solution

Q.22 Which one of the following statements is **NOT** correct?

(a) the cohesion of normally consolidated clay is zero when tri-axial test is conducted under consolidated undrained condition.

(b) In case of a point load, Boussinesq's equation predicts higher value of vertical stress at a point directly beneath the load as compared to Westergaard's equation.

(c) The ultimate bearing capacity of a strip foundation supported on the surface of sandy soil increase in direct proportion to the width of footing.

(d) A clay deposit with a liquidity index greater than unity is in a state of plastic consistency.

Ans. **(d)**

A clay deposit with liquidty index greater then 1, will be in liquid stage of consistency.

$$\because \quad I_L = \frac{w_n - w_p}{w_L - w_p} > 1$$

$$\therefore \quad w_n > w_L$$

End of Solution

Q.23 The area of an ellipse represented by an equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is

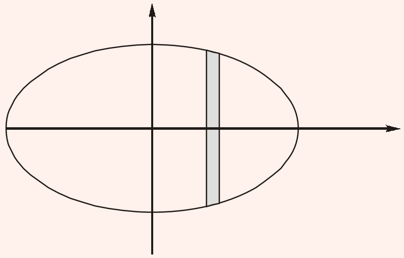
(a) $\frac{4\pi ab}{3}$

(b) πab

(c) $\frac{\pi ab}{2}$

(d) $\frac{\pi ab}{4}$

Ans. **(b)**



$$\text{Area} = \iint (1)dydx = \int_{x=-a}^{a} \int_{y=-\frac{b}{a}\sqrt{-x^2+a^2}}^{+\frac{b}{a}\sqrt{-x^2+a^2}} (1)\,dydx$$

$$= 4\int_{x=0}^{a}\int_{y=0}^{\frac{b}{a}\sqrt{a^2-x^2}} (1)\, dy\, dx$$

$$= 4\int_{x=0}^{a}\int_{y=0}^{\frac{b}{a}\sqrt{a^2-x^2}} dx$$

$$= \pi ab$$

End of Solution

Q.24 A road in a hilly terrain is to be laid at a gradient of 4.5%. A horizontal curve of radius 100 m is laid at a location on this road. Gradient needs to be eased due to combination of curved horizontal and vertical profiles of the road. As per IRC, the compensated gradient (in %, round off to one decimal place), is ______.

Ans. (4)

Gradient = 4.5%, R = 100 m

Grade compensation $= \left(\frac{30+R}{R}\right) \ngtr \left(\frac{75}{R}\right)\% = \frac{30+100}{100} \ngtr \frac{75}{100} = 1.3\% \ngtr 0.75 \Big\} G.C = 0.75$

Compansated Gradient = Gradient G.C = 4.5% – 0.75 = 3.75 $\nless$ 4%

Hence C.G = 4%

End of Solution

Q.25 A body floating in a liquid is in a stable state of equilibrium if its

(a) metacentre lies below its centre of gravity

(b) metacentre lies above its centre of gravity

(c) metacentre coincides with its centre of gravity

(d) centre of gravity is below its centre of buoyancy

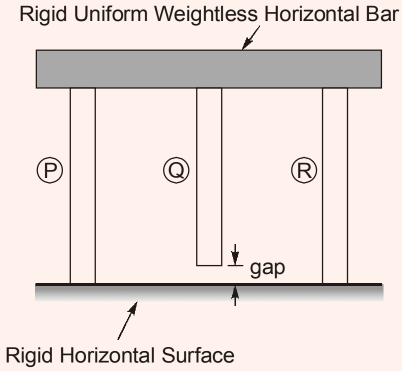
Ans. (b)

For stability of floating body M lies above G

$$GM > 0$$

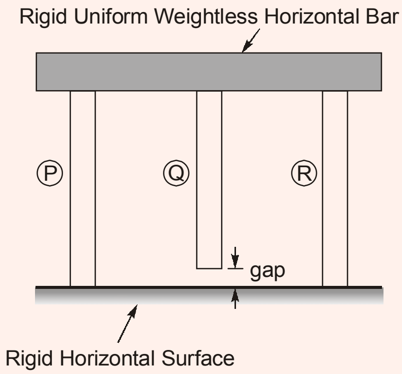
End of Solution

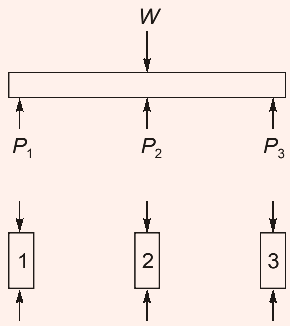
Q.26 A rigid, uniform, weightless, horizontal bar is connected to three vertical members P, Q and R as shown in the figure (not drawn to the scale). All three members have identical axial stiffness of 10 kN/mm. The lower ends of bars P and R rest on a rigid horizontal surface. When NO load is applied, a gap of 2 mm exists between the lower end of the bar Q and the rigid horizontal surface. When a vertical load W is placed on the horizontal bar in the downward direction, the bar still remains horizontal and gets displaced by 5 mm in the vertically downward direction.



The magnitude of the load W (in kN, round off to the nearest integer), is ______.

Ans. (130)





$$P_1 + P_1 + P_2 = W \quad \text{...(i)}$$

$$P_1 = P_3$$

$$\delta_1 = 5\text{ mm} = \frac{P_1 L}{AE} \qquad \frac{AE}{L} = 10\text{ kN/mm}$$

$$\delta_2 = 3\text{ mm} = \frac{P_2 L}{AE}$$

So,

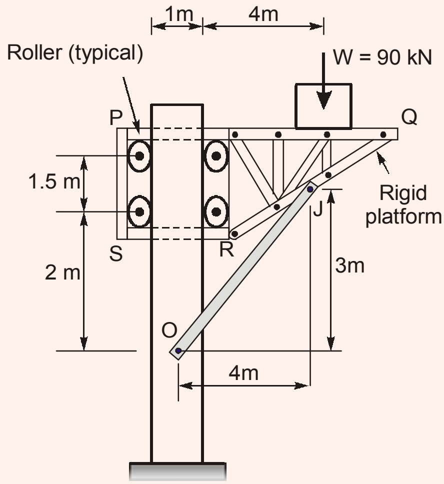
$$P_1 = 10 \times 5 = 50\text{ kN}$$

$$P_2 = 10 \times 3 = 30\text{ kN}$$

$$W = 2(50) + 30 = 130\text{ kN}$$

End of Solution

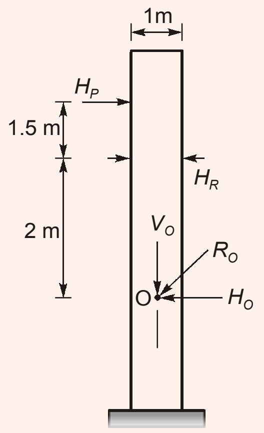
Q.27 A rigid weightless platform PQRS shown in the figure (not drawn to the scale) can slide freely in the vertical direction. The platform is held in position by the weightless member OJ and four weightless, frictionless rollers. Point O and J are pin connections. A block of 90 kN rests on the platform as shown in the figure.

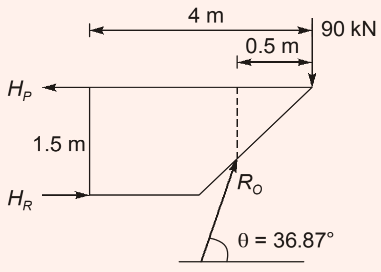


The magnitude of horizontal component of the reaction (in kN) at pin O, is

(a) 180
(b) 150
(c) 90
(d) 120

Ans. (d)





$$\Sigma y = 0$$

$\Rightarrow$ $R_o \sin 36.87 - 90 = 0$

$$R_o = \frac{90}{\sin 3687°} = 150 \text{ kN}$$

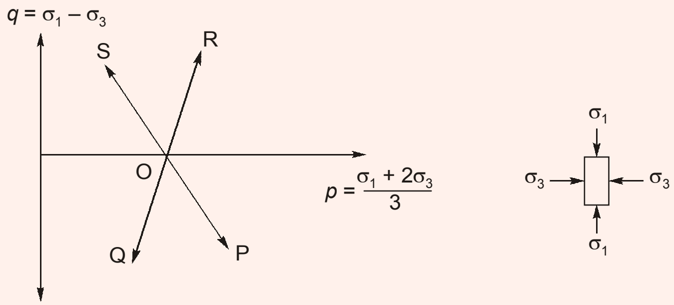
Horizontal reaction at $O = H_o$

$$= R_o \cos 36.87 = 150 \times \cos 36.87$$

$$= 120 \text{ kN}$$

End of Solution

Q.28 The total stress paths corresponding to different loading conditions, for a soil specimen under the isotropically consolidated stress state (O), are shown below:



Stress Path	Loading Condition
OP	I. Compression loading (σ_1 – increasing; σ_3 – constant)
OQ	II. Compression unloading (σ_1 – constant; σ_3 – decreasing)
OR	III. Extension unloading (σ_1 – decreasing; σ_3 – constant)
OS	IV. Extension loading (σ_1 – constant; σ_3 – increasing)

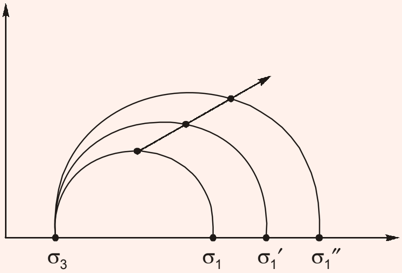
The correct match between the stress paths and the listed loading conditions, is

(a) OP–I, OQ–II, OR–IV, OS–III
(b) OP–III, OQ–II, OR–I, OS–IV
(c) OP–IV, OQ–III, OR–I, OS–II
(d) OP–I, OQ–III, OR–II, OS–IV

Ans. **(c)**

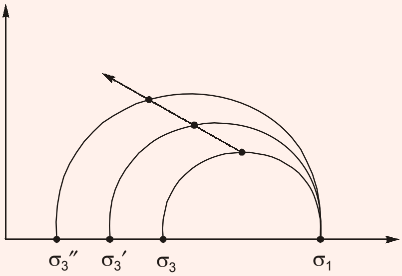
I. Compression loading

OR



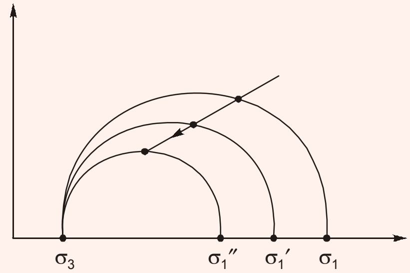
II. Compression unloading

OS



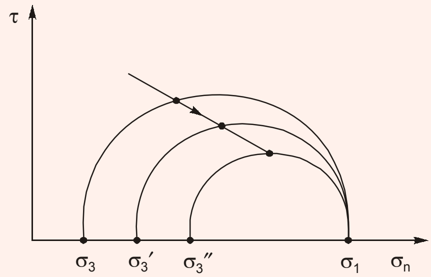
III. Exctension unloading

OQ



IV. Extension loading

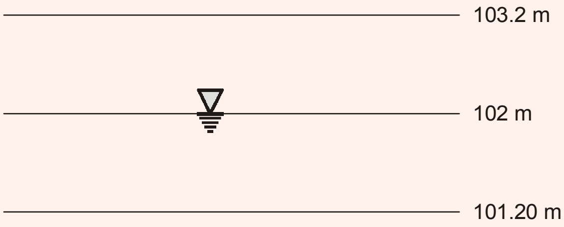
OP



End of Solution

Q.29 In a homogeneous unconfined aquifer of area 3.00 km^2, the water table was at an elevation of 102.00 m. After a natural recharge of volume 0.90 million cubic meter (Mm^3), the water table rose to 103.20 m. After this recharge, ground water pumping took place and the water table dropped down to 101.020 m. The volume of ground water pumped after the natural recharge, expressed (in Mm^3 and round off to two decimal places), is ______.

Ans. (1.5)



$$V_R = 0.9 \text{ Mm}^3$$

$$V = 3 \times (103.2 - 102)$$

$$= 3 \times 1.2 = 3.6 \text{ Mm}^3$$

$$y_s \text{ or } y_R = \frac{VR}{V} = \frac{0.9}{3.6}$$

Now,

$$y_s = \frac{V_D}{V}$$

$$V_D = \frac{0.9}{3.6}\left[3 \times (103.2 - 101.2)\right]$$

$$V_D = 1.5 \text{ Mm}^3$$

End of Solution

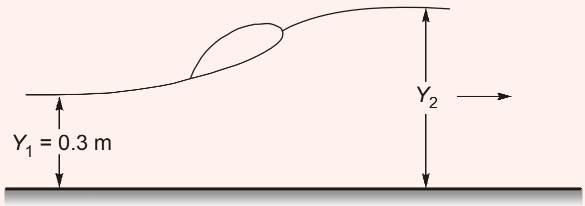
Q.30 Water flows at the rate of 12 m^3/s in a 6 m wide rectangular channel. A hydraulic jump is formed in the channel at a point where the upstream depth is 30 cm (just before the jump). Considering acceleration due to gravity as 9.81 m/s^2 and density of water as 1000 kg/m^3, the energy loss in the jump is

(a) 114.2 kW
(b) 141.2 J/s
(c) 141.2 h.p.
(d) 114.2 MW

Ans. (b)

Assuming channle bed to be horizontal and frictionless.

$$q = \frac{12}{6} = 2 \text{ m}^3\text{/s/m}$$



$$\text{Initial Froude No. } (F_r) = \left(\frac{q^2}{gY_1^3}\right)^{1/2}$$

$$= \left(\frac{2^2}{9.81 \times 0.3^3}\right)^{1/2} = 3.88$$

From Belenger's Momentum equation for a rectangular channel

$$\frac{Y_2}{Y_1} = \frac{1}{2}\left(-1 + \sqrt{1 + 8F_1^2}\right)$$

$$= \frac{1}{2}\left(-1 + \sqrt{1 + 8 \times 3.88^2}\right)$$

$$= 5.018$$

$$\therefore \quad Y_2 = 5.018 \times 0.3 = 1.505 \text{ m}$$

$$\text{Head loss in the jump } (h_L) = \frac{(Y_2 - Y_1)^3}{4Y_1Y_2}$$

$$= \frac{(1.505 - 0.3)^3}{4 \times 1.505 \times 0.3}$$

$$= 0.968 \text{ m}$$

$$\text{Power lost in the jump} = \gamma_w Q h_L$$

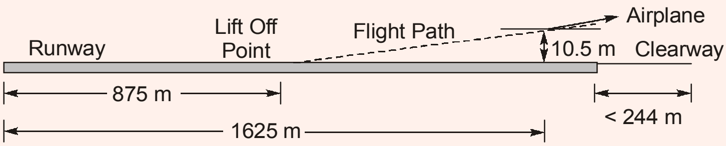
$$= (9.81 \times 12 \times 0.968) \text{ kW}$$

$$= 114.04 \text{ kW}$$

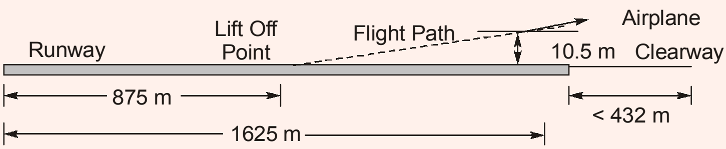
End of Solution

Q.31 The appropriate design length of a clearway is calculated on the basis of 'Normal Take-off' condition. Which one of the following options correctly depicts the length of the clearway? (Note: None of the option are drawn to scale)

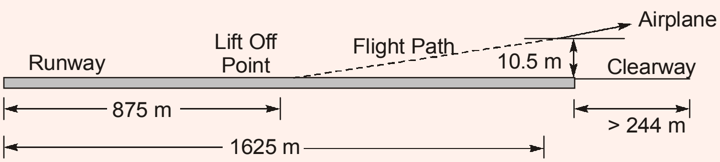
(a)



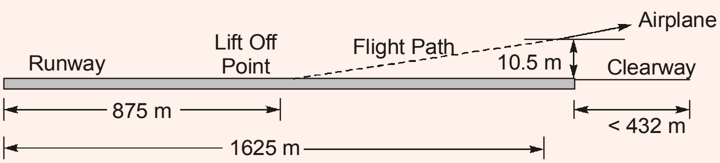
(b)



(c)



(d)



Ans. (d)

For normal take off condition:

$$\text{Clearway} \ngtr \frac{1}{2}(1.5 \text{ take off distance} - 1.15 \text{ of lift off distance})$$

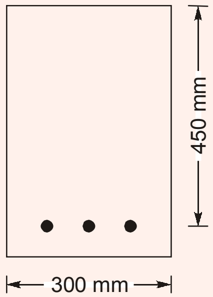
$$\ngtr \frac{1}{2}(1.15 \times 1625 - 1.15 \times 875)$$

$$\ngtr 431.25 \text{ m}$$

So clearway is less then for 432 m.

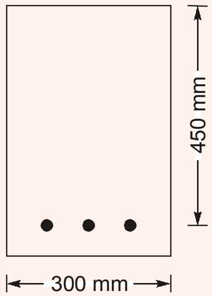
End of Solution

Q.32 The singly reinforced concrete beam section shown in the figure (not drawn to the scale) is made of M25 grade concrete and Fe500 grade reinforcing steel. The total cross-sectional area of the tension steel is 942 mm^2.



As per Limit State Design of IS 456 : 2000, the design moment capacity (in kNm round off to two decimal places) of the beam section, is ________.

Ans. (158.25)



M25 concrete
Fe500 steel

$$B = 300 \text{ mm}$$

$$d = 450 \text{ mm}$$

$$A_{st} = 942 \text{ mm}^2$$

$$M_u = ?$$

(i) $x_{u\lim} = 0.46 \times d = 0.46 \times 450 = 207 \text{ mm}$

(ii) $x_u = \dfrac{0.87 \cdot f_y \cdot A_{st}}{0.36 \cdot f_{ck} \cdot B} = \dfrac{0.87 \times 500 \times 942}{0.36 \times 25 \times 300} = 151.77 \text{ mm}$

(iii) $x_u < x_{u\lim}$ It is an under reinforcement section.

(iv) $M_u = 0.36 \cdot f_{ck} \cdot B \cdot x_u \cdot (d - 0.42x_u)$

$= 0.36 \times 25 \times 300 \times 151.77 \times (450 - 0.42 \times 151.77)/10^6$

$= 158.28 \text{ kN-m}$

End of Solution

Q.33 For the Ordinary Differential Equation $\frac{d^2x}{dt^2} - 5\frac{dx}{dt} + 6x = 0$, with initial condition $x(0) = 0$ and $\frac{dx}{dt}(0) = 10$, the solution is

(a) $-10e^{2t} + 10e^{3t}$ (b) $5e^{2t} + 6e^{3t}$

(c) $10e^{2t} + 10e^{3t}$ (d) $-5e^{2t} + 6e^{3t}$

Ans. (a)

A.E. is $m^2 - 5m + 6 = 0 \Rightarrow m = 2, 3$ so $C_f = C_1e^{2t} + C_2e^{3t}$.

PI = 0 and G. Solution is $x = CF + PI = C_1e^{2t} + C_2e^{3t}$ and $\frac{dx}{dt} = 2C_1e^{2t} + 3C_2e^{3t}$.

Now, using initial conditions we get $C_1 = -10$, $C_2 = 10$.

$$x = -10e^{2t} + 10e^{3t}$$

End of Solution

Q.34 The length and bearings of a traverse PQRS are:

Segment	Length (m)	Bearing
PQ	40	80°
QR	50	10°
RS	30	210°

The length of line segment SP (in m, round off to two decimal places), is ________.

Ans. (44.79)

$$\Delta L = 40\cos80° + 50\cos10° + 30\cos210°$$
$$= 30.20$$
$$\Delta D = 40\sin80° + 50\sin10° + 30\sin210°$$
$$= 33.07$$
$$\text{Length, SP} = \sqrt{\Delta L^2 + \Delta D^2} = 44.79 \text{ m}$$

End of Solution

Q.35 A continuous function $f(x)$ is defined. If the third derivative at x_i is to be computed by using the fourth order central finite-divided-difference scheme (the step length = h), the correct formula is

(a) $f'''(x_i) = \frac{-f(x_{i+3}) - 8f(x_{i+2}) + 13f(x_{i+1}) + 13f(x_{i-1}) + 8f(x_{i-2}) - f(x_{i-3})}{8h^3}$

(b) $f'''(x_i) = \frac{-f(x_{i+3}) + 8f(x_{i+2}) - 13f(x_{i+1}) + 13f(x_{i-1}) - 8f(x_{i-2}) + f(x_{i-3})}{8h^3}$

(c) $f'''(x_i) = \dfrac{f(x_{i+3}) - 8f(x_{i+2}) + 13f(x_{i+1}) + 13f(x_{i-1}) - 8f(x_{i-2}) - f(x_{i-3})}{8h^3}$

(d) $f'''(x_i) = \dfrac{f(x_{i+3}) - 8f(x_{i+2}) - 13f(x_{i+1}) + 13f(x_{i-1}) + 8f(x_{i-2}) + f(x_{i-3})}{8h^3}$

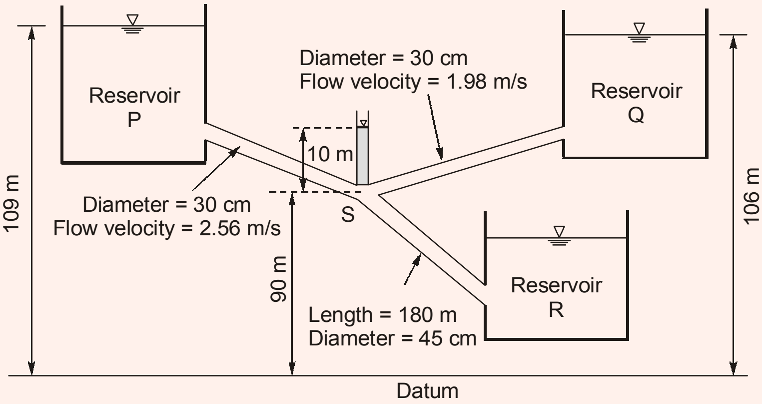
Ans. (b)

$$\left.\frac{\partial^3 u}{\partial x^3}\right|_{x_i} = \frac{-u_{i+3} + 8u_{i+2} - 13u_{i+1} + 13u_{i-1} - 8u_{i-2} + u_{i-3}}{8\Delta h^3}$$

$$f'''(x_i) = \frac{-f(x_{i+3}) + 8f(x_{i+2}) - 13f(x_{i+1}) + 13f(x_{i-1}) - 8f(x_{i-2}) + f(x_{i-3})}{8h^3}$$

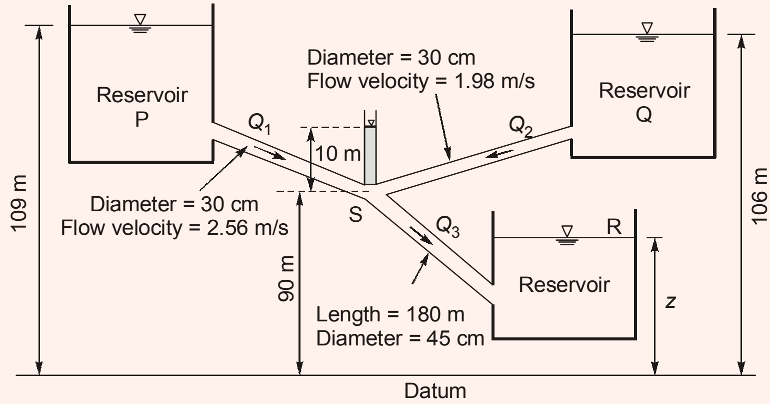
End of Solution

Q.36 Three reservoir P, Q and R are interconnected by pipes as shown in the figure (not drawn to the scale). Piezometric head at the junction S of the pipes is 100 m. Assume acceleration due to gravity as 9.81 m/s^2 and density of water as 1000 kg/m$^{`3}$. the length of the pipe from junction S to the inlet of reservoir R is 180 m.



Considering head loss only due to friction (with friction factor of 0.03 for all the pipes), the height of water level in the lowermost reservoir *R* (in m, round off to one decimal places) with respect to the datum, is ________.

Ans. (97.5)



Apply conutinuity $Q_3 = Q_1 + Q_2$

$$= A_1V_1 + A_2V_2$$

$$= \frac{\pi}{4}(0.3)^2(2.56) + \frac{\pi}{4}(0.3)^2(1.98)$$

$$= 0.3209 \text{ m}^3/\text{s}$$

Apply energy eq. between (S) and (R)

$$H_s = H_r + h_f$$

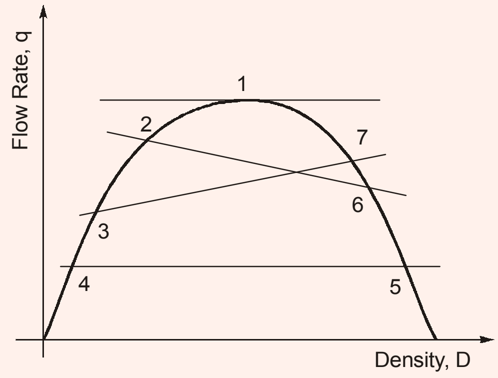
$$100 = z + \frac{8Q_3^2}{\pi^2 g} \times \frac{fL_3}{D_3^5}$$

$$100 = z + \frac{8(0.3209)^2}{\pi^2 g} \times \frac{(0.03)(180)}{(0.45)^5}$$

$$z = 97.51 \text{ m}$$

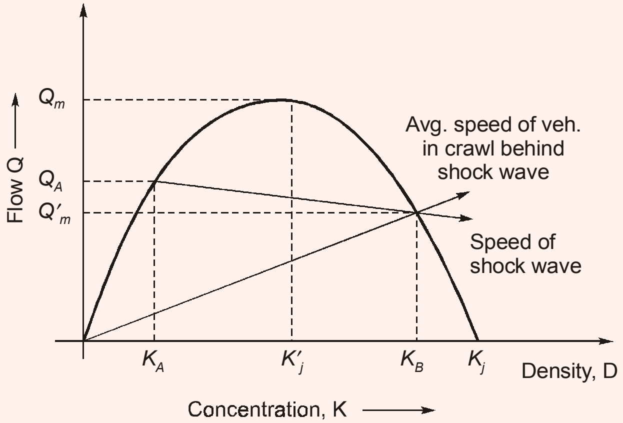
End of Solution

Q.37 The relationship between traffic flow rate (q) and density (D) is shown in the figure.



The shock wave condition is depicted by
(a) flow with respect to point 4 and point 5($q_4 = q_5$)
(b) flow changing from point 3 to point 7 ($q_3 < q_7$)
(c) flow changing from point 2 to point 6 ($q_2 > q_6$)
(d) flow with respect to point 1 ($q_1 = q_{max}$)

Ans. (c)



End of Solution

Q.38 A stream with a flow rate of 5 m^3/s is having an ultimate BOD of 30 mg/litre. A wastewater discharge of 0.20 m^3/s having BOD_5 of 500 mg/litre joins the stream at a location and instantaneously gets mixed up completely. The cross-sectional area of the stream is 40 m^2 which remains constant. BOD exertion rate constant is 0.3 per day (logarithm base to *e*). The BOD (in mg/litre round off to two decimal places) remaining at 3 km downstream from the mixing location, is ________.

Ans. (49.57)

$$t = \frac{d}{v} \qquad \text{where, } v = \frac{Q_S + Q_R}{A} = \frac{0.2 + 5}{40} = 0.13 \text{ m/sec}$$

$$t = \frac{3 \times 10^3}{0.13 \times 86400} = 0.26 \text{ days}$$

$$BOD_5 = BOD_u(1 - e^{-k \times 5})$$

$$BOD_u = \frac{500}{(1 - e^{-0.3 \times 5})} = 643.66 \text{ mg}/l$$

$$DO_{mix} = \frac{Q_R BOD_u + Q_S \cdot BOD_u}{Q_S + Q_R}$$

$$= \frac{5 \times 30 + 0.2 \times 643.66}{5 + 0.2} = 53.6 \text{ mg}/l$$

$$L_t = L_0\, e^{-k \times t}$$

$$= 53.6 e^{-0.3 \times 0.26}$$

$$= 49.57 \text{ mg}/l$$

End of Solution

Q.39 Consider the system of equations

$$\begin{bmatrix} 1 & 3 & 2 \\ 2 & 2 & -3 \\ 4 & 4 & -6 \\ 2 & 5 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 2 \\ 1 \end{bmatrix}$$

The value of x_3 (round off to the nearest integer), is ______.

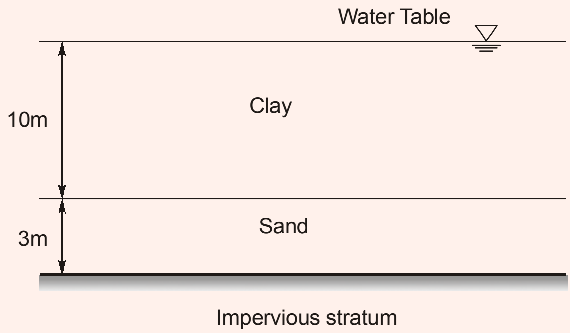
Ans. (3)

$$[A : B] = \begin{bmatrix} 1 & 3 & 2 & \vdots & 1 \\ 2 & 2 & -3 & \vdots & 1 \\ 4 & 4 & -6 & \vdots & 2 \\ 3 & 5 & 2 & \vdots & 1 \end{bmatrix} \xrightarrow[\text{an Echelon Form}]{\text{Converting into}} \begin{bmatrix} 1 & 3 & 2 & \vdots & 1 \\ 0 & -1 & -2 & \vdots & -1 \\ 0 & 0 & 1 & \vdots & 3 \\ 0 & 0 & 0 & \vdots & 0 \end{bmatrix}$$

$$\Rightarrow \quad \begin{bmatrix} 1 & 3 & 2 \\ 0 & -1 & -2 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \\ 3 \\ 0 \end{bmatrix} \Rightarrow x_3 = 3$$

End of Solution

Q.40 A 10 m thick clay layer is resting over a 3 m thick sand layer and is submerged. A fill of 2 m thick sand with unit weight of 20 kN/m^3 is placed above the clay layer to accelerate the rate of consolidation of the clay layer. Coefficient of consolidation of clay is 9×10^{-2} m^2/year and coefficient of volume compressibility of clay is 2.2×10^{-4} m^2/kN. Assume Taylor's relation between time factor and average degree of consolidation.



The settlement (in mm, *round off to two decimal places*) of the clay layer, 10 years after the construction of the fill, is ________.

Ans. **(18.83)**

$$\Delta\bar{\sigma} = 2 \times 20 = 40 \text{ kN/m}^2$$

$$\Delta H = m_V \Delta\bar{\sigma} H$$

$$= 2.2 \times 10^{-4} \times 40 \times 10 \times 10^3 \text{ mm}$$

$$= 88 \text{ mm}$$

$$T_v = \frac{C \times t}{H^2} = \frac{9 \times 10^{-2} \times 10}{5^2} = 0.036$$

$$T_v = \frac{\pi}{4} U^2$$

$$U = \sqrt{\frac{0.036 \times 4}{\pi}} = 0.214$$

Δh after 10 years = 0.214 × 88 = 18.832 mm

End of Solution

Q.41 If C represents a line segment between (0, 0, 0) and (1,1, 1) in Cartesian coordinate system, the value (expressed as integer) of the line integral

$$\int_C [(y + z)dx + (x + z)dy + (x + y)dz]$$

is ________.

Ans. **(3)**

$$I = \int_C [(ydx + xdy) + (zdx + xdz) + (zdy + ydz)]$$

$$= \int_C [d(xy) + d(xz) + d(yz)] = (xy + yz + zx)_{(0,0,0)}^{(1,1,1)}$$

$$= (1 + 1 + 1) - (0 + 0 + 0) = 3$$

End of Solution

Q.42 Surface Overflow Rate (SOR) of a primary settling tank (discrete settling) is 20000 litre/m^2 per day. Kinematic viscosity of water in the tank is 1.01 × 10^{-2} cm^2/s. Specific gravity of the settling particles is 2.64. Acceleration due to gravity is 9.81 m/s^2. The minimum diameter (in µm, round off to one decimal place) of the particles that will be removed with 80% efficiency in the tank, is ________.

Ans. **(14.46)**

$$\eta = 80 = \frac{u_s}{V_s} \times 100$$

$$u_s = \frac{0.8 \times 20000 \times 10^{-3}}{86400} = 1.85 \times 10^{-4} \text{ m/sec}$$

$$u_s = \frac{(G-1)gd^2}{18\nu}$$

$$1.85 \times 10^{-4} = \frac{(2.64-1)\times 9.81\times d^2}{18\times 1.01\times 10^{-2}\times 10^{-4}}$$

$$d = 1.446 \times 10^{-5} \text{ m}$$

$$= 14.46 \text{ µm}$$

End of Solution

Q.43 A gaseous chemical has a concentration of 41.6 µmol/m^3 in air at 1 atm pressure and temperature 293 K. The universal gas constant R is 82.05×10^{-6} (m^3 atm)/(mol K). Assuming that ideal gas law is valid, the concentration of the gaseous chemical (in ppm, round off to one decimal place), is ______.

Ans. (1)

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$= \frac{41.6\times 10^{-6}\times 32.05\times 10^{-6}}{1}\times 293 = 10^{-6}\text{m}^3$$

41.6 µ mole of gas volume of 10^{-6} m^3

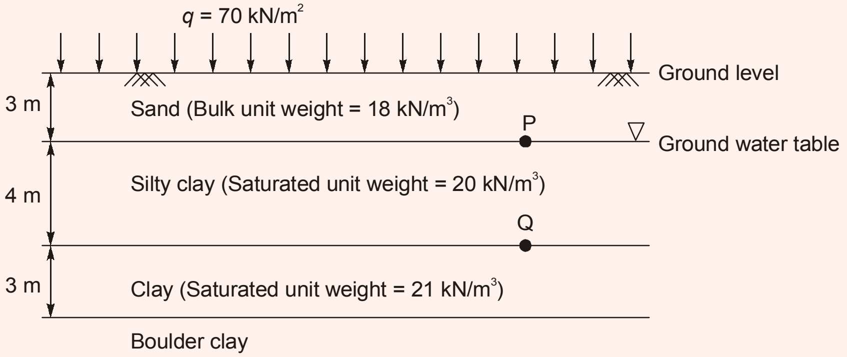
So, $$1 \text{ ppm} = \frac{1 \text{ part of gas}}{10^6 \text{ parts of air}} = \frac{1 \text{ m}^3 \text{ of gas}}{10^6 \text{ m}^3 \text{ of air}}$$

$$1 \text{ ppm} = \frac{41.6\times 10^6 \ \mu\text{moles}}{10^6 \text{m}^3}$$

So, 41.6 µ moles/m^3 = 1 ppm

End of Solution

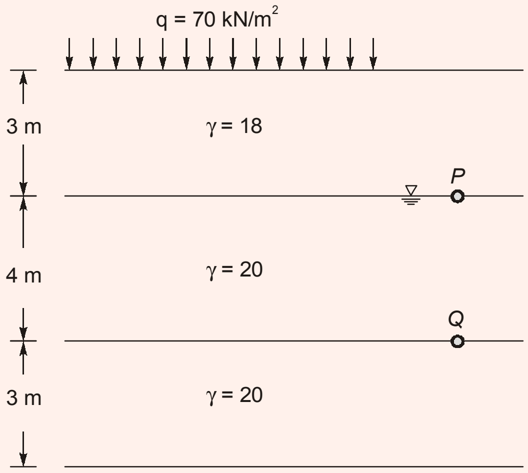
Q.44 The soil profile at a site up to a depth of 10 m is shown in the figure (not drawn to the scale). The soil is preloaded with a uniform surcharge (q) of 70 kN/m^2 at the ground level. The water table is at a depth of 3 m below ground level. The soil unit weight of the respective layers is shown in the figure. Consider unit weight of water as 9.81 kN/m^3 and assume that the surcharge (q) is applied instantaneously.



Immediately after preloading, the effective stresses (in kPa) at points P and Q respectively, are

(a) 36 and 126
(b) 36 and 90
(c) 54 and 95
(d) 124 and 204

Ans. (c)



Surcharge (q = 70 kN/m^2) is applied instantaneously hence excess pore pressure (u_i = 70 kPa) is developed at point P and Q [GWT level is at level P]

At point P: Total stress $\sigma = q + 3\gamma = 70 + 3 \times 18$

Pore water pressure = Hydrostatics pore pressure + Excess pore pressure

$= 0 + u_i = 0 + 70 = 70$ kN/m^2

Effective stress, $\bar{\sigma} = \sigma - u = 54$ kPa

At point Q: Total stress, $\sigma = q + 3\gamma + 4\gamma_{sat} = 70 + 3 \times 18 + 4 \times 20$

Pore pressure, u = Hydrostatics pore pressure + Excess pore pressure

$= 4\gamma_w + u_i = 4 \times 9.81 + 70$

Effective stress, $\bar{\sigma} = \sigma - u = 94.76$

End of Solution

Q.45 An open traverse PQRST is surveyed using theodolite and the consecutive coordinates obtained are given in the table

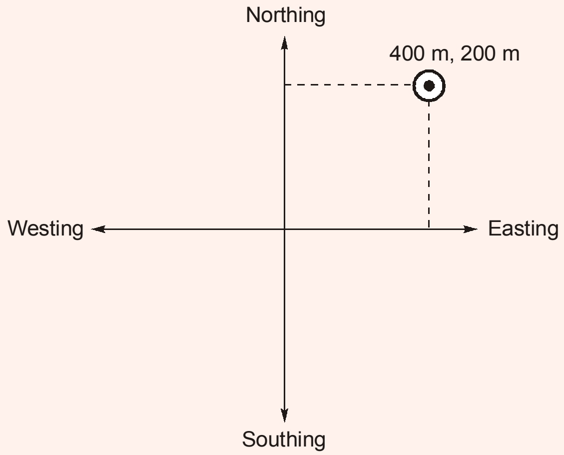
Line	Consecutive Coordinates			
	Northing (m)	Southing (m)	Easting (m)	Westing (m)
PQ	110.2	–	45.5	–
QR	80.6	–	–	60.1
RS	–	90.7	–	70.8
ST	–	105.4	55.5	–

If the independent coordinates (Northing, Easting) of station P are (400 m, 200 m) the independent coordinates (in m) of station T, are

(a) 405.3, 229.9 (b) 394.7, 170.1

(c) 194.7, 370.1 (d) 205.3, 429.9

Ans. (b)



$$\Delta L = -5.3$$

$$\Delta D = -29.9$$

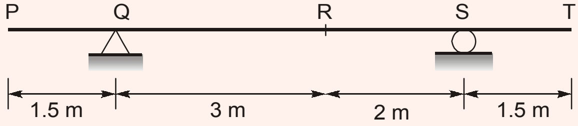
$$T, \text{Northing}\{400 + (-5.3) = 394.7$$

$$T, \text{Easting}\{200 + (-29.9) = 170.1$$

T [394.7 m, 170.1 m]

End of Solution

Q.46 Distributed load(s) of 50 kN/m may occupy any position(s) (either continuously or in patches) on the girder PQRST as shown in the figure (not drawn to the scale)

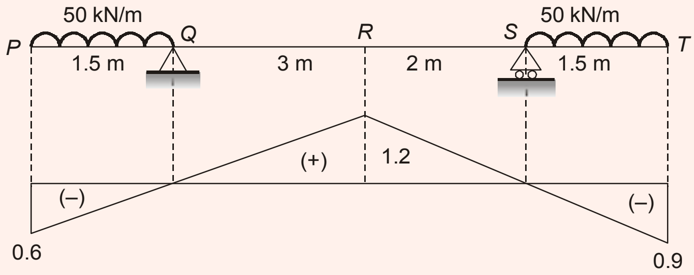


The maximum negative (hogging) bending moment (in kNm) that occurs at point R is

(a) 56.25 (b) 22.50

(c) 150.00 (d) 93.75

Ans. **(a)**



ILD for BM at R:

To get maximum hogging BM at R, keep UDL over PQ and ST.

$$\text{Max. –ve BM at R} = 50\left[-\frac{1}{2}\times 1.5\times 0.6\right] + 50\left[-\frac{1}{2}\times 1.5\times 0.9\right]$$

$$= 56.25 \text{ kNm}$$

End of Solution

Q.47 A water supply scheme transports 10 MLD (Million Litres per Day) water through a 450 mm diameter pipeline for a distance of 2.5 km. A chlorine dose of 3.50 mg/litre is applied at the starting point of the pipeline to attain a certain level of disinfection at the downward end. It is decided to increase the flow rate from 10 MLD to 13 MLD in the pipeline. Assume exponent for concentration, n = 0.86. With this increased flow, in order to attain the same level of disinfection, the chlorine does (in mg/litre) to be applied at the starting point should be

(a) 5.55 (b) 4.75

(c) 3.95 (d) 4.40

Ans. **(b)**

$$\text{Waterson law, } tc^h = \text{Constant}$$

$$t_1c_1^n = t_2c_2^n$$

$$\frac{d_1}{v_1}c_1^n = \frac{d_2}{v_2}c_2^n$$

$$\frac{d_1}{Q_1}A_1c_1^n = \frac{d_2A_2c_2^n}{Q_2}$$

$$d_1 = d_2,\ A_1 = A_2$$

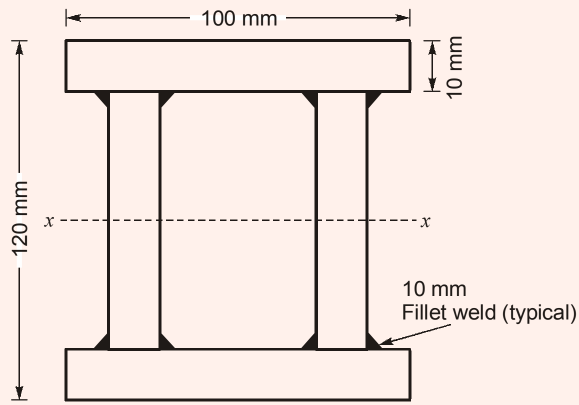
$$\frac{(3.5)^{0.86}}{10} = \frac{(c_2)^{0.86}}{13}$$

$$c_2 = \left(\frac{13}{10}\right)^{1/0.86} \times 3.5 = 4.747$$

$$= 4.75 \text{ mg}/l$$

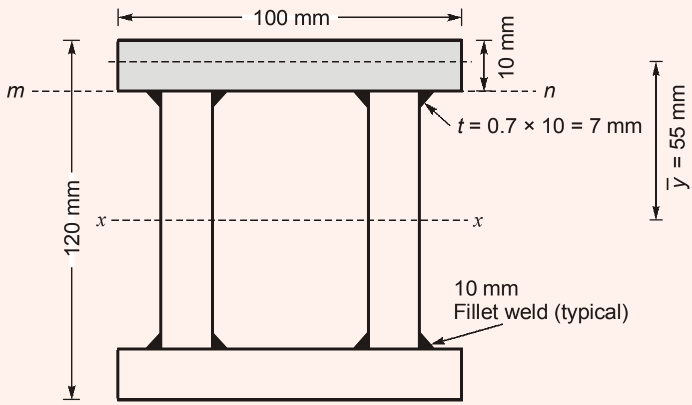
End of Solution

Q.48 The flange and web plates of the doubly symmetric built-up section are connected by continuous 10 mm thick fillet welds as shown in the figure (not drawn to the scale). The moment of inertia of the section about its principal axis X-X is 7.73×10^6 mm^4. The permissible shear stress in the fillet welds is 100 N/mm^2. The design shear strength of the section is governed by the capacity of the fillet welds.



The maximum shear force (in kN, round off to one decimal place) that can be carried by the section, is _______.

Ans. **(393.5)**



q = Shear stress at the level mn in the weld = 100 MPa = $\dfrac{FA\bar{y}}{Ib}$

F = Shear force at the given section

A = Area of the cross-section above the level mn = 100 × 10 mm^2

$\bar{y}$ = C.G. of shaded area above the level mn = 60 – 5 = 55 m

$I = 7.73 \times 10^6$ mm^4

b = Width of weld at mn (4 welds) = 4 × t = 4 × 7 = 28 mm

t = Throat thickness

= 0.7 × s = 0.7 × 10 × 4 = 28 mm

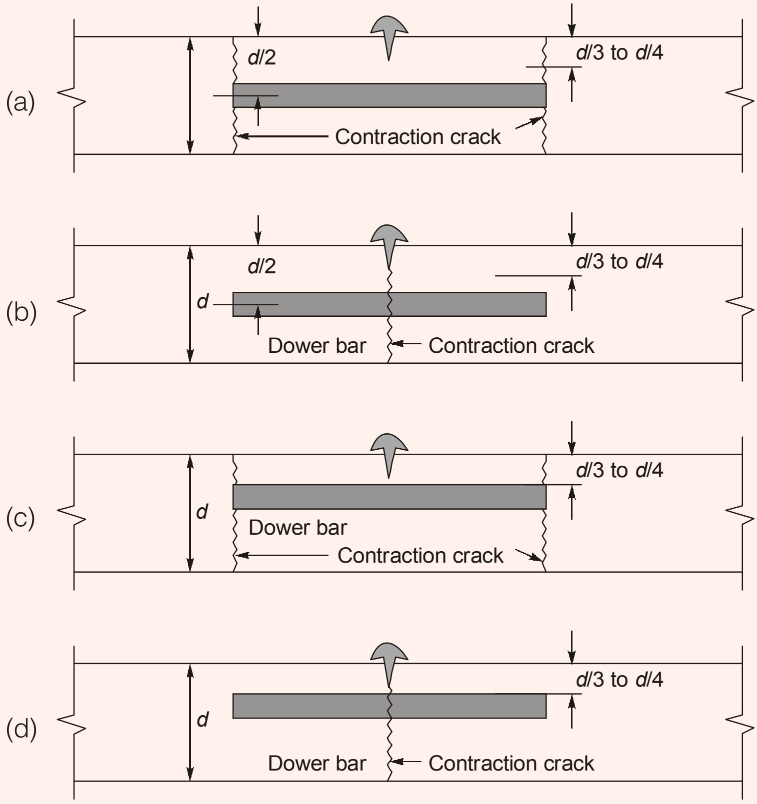
$$\therefore \quad 100 = \frac{F \times (100 \times 10) \times 55}{7.73 \times 10^6 \times 28}$$

$$F = \frac{100 \times 7.73 \times 10^6 \times 28}{1000 \times 55} = 393.527 \text{ kN}$$

= 393.5 kN

End of Solution

Q.49 A dowel bar is placed at a contraction joint. When contraction occurs, the concrete slab cracks at predetermined location(s). Identify the arrangement, which shows the correct placement of dowel bar and the place of occurrence of the contraction crack(s).

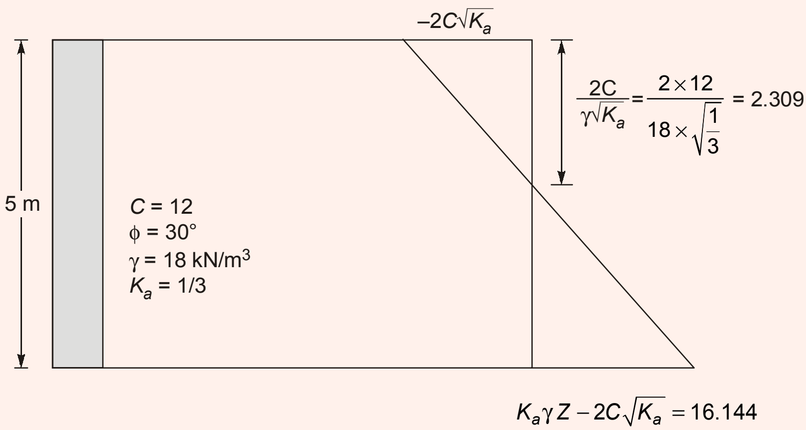


Ans. (b)

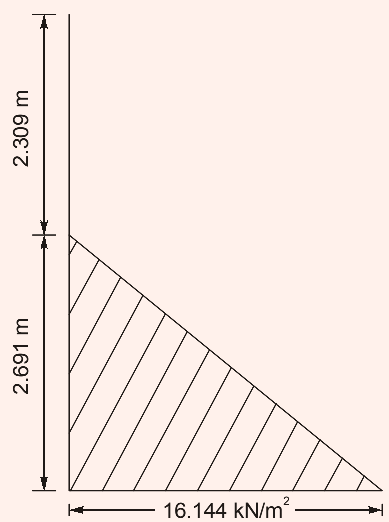
End of Solution

Q.50 A vertical retaining wall of 5 m height has to support soil having unit weight of 18 kN/m^3, effective cohesion of 12 kN/m^2, and effective friction angle of 30°. As per Rankine's earth pressure theory and assuming that a tension crack has occurred, the lateral active thrust on the wall per meter length (in kN/m, round off to two decimal places), is ______.

Ans. (21.71)



After tension crack



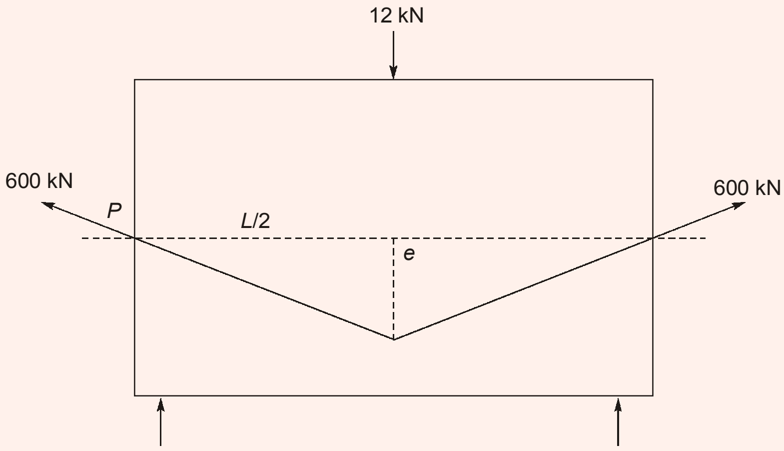
$$P_a = \frac{1}{2}\times 16.144(5-2.309)$$

$$= 21.714 \text{ kN/m}$$

End of Solution

Q.51 A simply supported prismatic concrete beam of rectangular cross-section, having a span of 8 m, is prestressed with an effective prestressing force of 600 kN. The eccentricity of the prestressing tendon is zero at supports and varies linearly to a value of e at the mid-span. In order to balance an external concentrated load of 12 kN applied at the mid-span, the required value of e (in mm, round off to the nearest integer) of the tendon, is ______.

Ans. (40)



$$P = 600 \text{ kN}$$

$$\text{Simply supported span} = L = 8 \text{ m}$$

To support a point load applied at mid span (W)

$$= 12 \text{ kN}$$

$$\text{Balancing load} = \text{Point load}$$

$$2P \sin\theta = W$$

$$2P\left(\frac{e}{L/2}\right) = 2$$

$$\frac{2Pe \times 2}{L} = W$$

$$\frac{4Pe}{L} = W$$

$$e = \frac{WL}{4P} = \frac{12000 \text{ N} \times 8000 \text{ mm}}{4 \times 600 \times 1000 \text{ N}}$$

$$= 40 \text{ mm}$$

End of Solution

Q.52 Traffic volume count has been collected on a 2 lane road section which needs upgradation due to severe traffic flow condition. Maximum service flow rate per lane is observed as 1280 veh/h at level of service 'C'. The Peak Hour Factor is reported as 0.78125. Historical traffic volume count provides Annual Average Daily Traffic as 122270 veh/day. Directional split of the traffic flow is observed to be 60 : 40. Assuming that traffic stream consists of 'All Cars' and all drivers are 'Regular Commuters', the number of extra lane(s) (round off to the next higher integer) to be provide, is ________.

Ans. **(6)**

Directional design hourly volume (DDHV)

$$DDHV = AADT \times K \times D$$

where, D = Volume proportion in major direction, K = The proportion of AADT occuring in peak hour.

$$DDHV = 12270 \times 0.6 \times K \qquad [\because \; K \text{ Assumed } 1]$$

$$= 7362$$

f_{HV} = Heavy veh. adjustment factor = 1 for car

f_P = Road user familarity adjustment factor

= 1 for regular commuters

As per HCM,

Number of lanes required,

$$N = \frac{DDHV}{PHF \times MSF \times F_{HV} \times f_p}$$

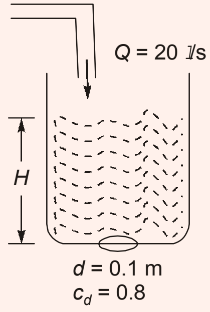
$$= \frac{7362}{0.78125 \times 1280 \times 1 \times 1} = 7.362 = 8 \text{ lanes}$$

Number of extra lanes = 8 – 2 = 6 lanes

End of Solution

Q.53 A circular water tank of 2 m diameter has a circular orifice of diameter 0.1 m at the bottom. Water enters the tank steadily at a flow rate of 20 litre/s and escapes through the orifice. The coefficient of discharge of the orifice is 0.8. Consider the acceleration due to gravity as 9.81 m/s^2 and neglect frictional loses. The height of the water level (in m, round off to two decimal places) in the tank at the steady state, is ______.

Ans. **(0.52)**



Assume H is the level of weter in the tank in steady condition.

For steady water level in the tank

$$\text{Discharge through orifice} = \text{Water enters in the tank}$$

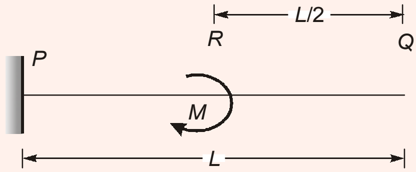
$$C_d \cdot a \cdot \sqrt{2gH} = 20 \times 10^{-3}$$

$$0.8 \times \frac{\pi}{4}(0.1)^2 \sqrt{2gH} = 0.02$$

$$H = 0.5164 \text{ m}$$

End of Solution

Q.54 A cantilever beam PQ of uniform flexural rigidity (EI) is subjected to a concentrated moment M at R as shown in the figure.



The deflection at the free end Q is

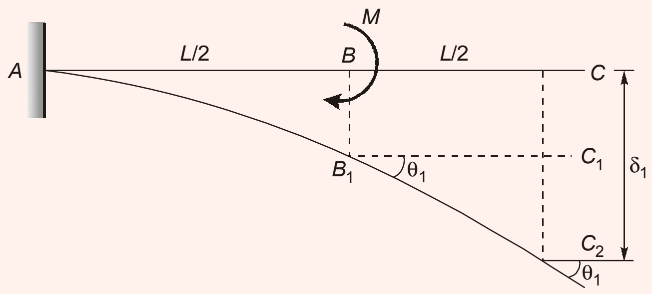
(a) $\frac{ML^2}{6EI}$

(b) $\frac{ML^2}{4EI}$

(c) $\frac{3ML^2}{4EI}$

(d) $\frac{3ML^2}{8EI}$

Ans. (d)



$$\delta_c = \delta_1 = CC_1 + C_1C_2$$

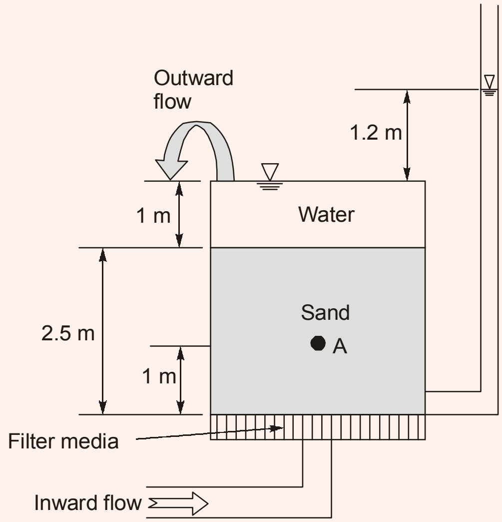
$$= BB_1 + C_1C_2$$

$$= \frac{M\left(\frac{L}{2}\right)^2}{2EI} + \frac{M\left(\frac{L}{2}\right)}{EI}\left(\frac{L}{2}\right)$$

$$\delta_c = \frac{3}{8}\frac{ML^2}{EI}$$

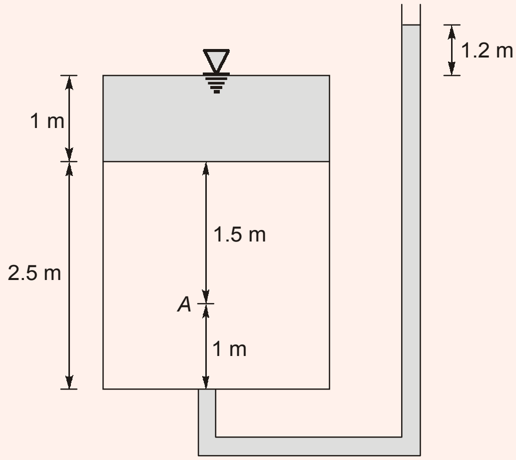
End of Solution

Q.55 Water flows in the upward direction in a tank through 2.5 m thick sand layer as shown in the figure. The void ratio and specific gravity of sand are 0.58 and 2.7, respectively. The sand is fully saturated. Unit weight of water is 10 kN/m^3.



The effective stress (in kPa, round off to two decimal places) at point A, located 1 m above the base of tank, is ________.

Ans. (8.94)



$$\gamma_{suv} = \left(\frac{G-1}{1+e}\right)\gamma_\omega = \left(\frac{2.7-1}{1+0.58}\right)\times 10 = 10.759$$

$$\bar{\sigma} = z\gamma_{suv} - iz\gamma_\omega$$

$$= 1.5(\gamma_{suv}) - \left(\frac{1.2}{2.5}\right)\times 1.5 \times \gamma_\omega$$

$$= 8.939 \text{ kN/m}^2$$

End of Solution

■■■■