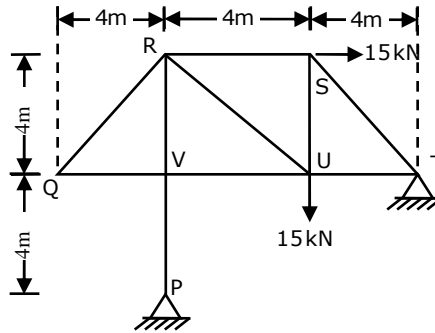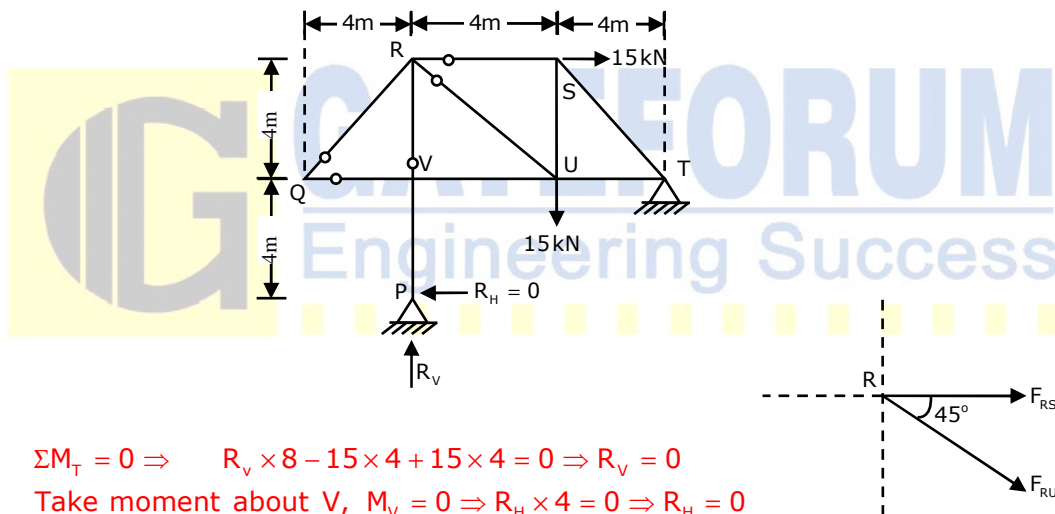## Q. No. 1 – 25 Carry One Mark Each

1. A pin-jointed 2-D truss is loaded with a horizontal force of 15 kN at joint S and another 15 kN vertical force at joint U as shown in figure. Find the force in member RS (in kN) and report your answer taking tension as +ve and compression as –ve

Explanations:-

$\Sigma M_T = 0 \Rightarrow \quad R_v \times 8 - 15 \times 4 + 15 \times 4 = 0 \Rightarrow R_V = 0$

Take moment about V, $M_V = 0 \Rightarrow R_H \times 4 = 0 \Rightarrow R_H = 0$

If two members meet at a joint which are not collinear and also there is no external forces acting on that joint then both members will carry zero forces.

$\therefore F_{QV} = F_{QR} = 0$

Now, consider joint R, $\Sigma F_y = 0 \Rightarrow F_{RU} \sin 45° = 0 \Rightarrow F_{RU} = 0$

Considering $\Sigma F_x = 0 \Rightarrow F_{RS} + F_{RU} \cos 45° = 0 \Rightarrow F_{RS} = 0$
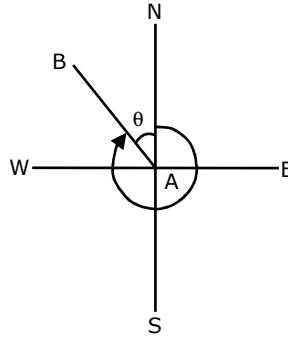
So, force is member is "RS" will be zero

2. The latitude and departure of a line AB are +78m and –45.1m respectively. The whole circle bearing of the line AB is

(A) 30°   (B) 150°   (C) 210°   (D) 330°

Explanations:-

(D)

Since the latitude of line is positive and departure is negative, the line lies in Fourth quadrant.

$\therefore l\cos\theta = 78; \ l\sin\theta = -45.1 \Rightarrow \tan\theta = -0.578 \Rightarrow \theta = -30^\circ$

$\therefore$ WCB of $AB = 360^\circ - 30^\circ = 330^\circ$

3. For two major-roads with divided carriage way crossing at right angle, a full clover leaf interchange with four indirect ramps is provided. Following statements are made on turning movement of vehicles to all direction from both roads. Identity the correct statement

(A) Merging from left is not possible, but diverging to left is possible

(B) Merging from left and diverging to left is possible

(C) Merging from left is possible but diverging is not possible

(D) Neither merging from left nor diverging to left is possible

Explanations:-

(B)

4. For subcritical flow in an open channel, the control section for gradually varied flow profile is

(A) at the downstream end   (B) at the upstream end

(C) at the both end s   (D) at any intermediate section

Explanations:-

(A)

5. Creep strain is

(A) caused due to dead load only   (B) caused due to live load only

(C) caused due to cyclic load only (D) independent of load

Explanations:-

(A)

6. A water treatment plant, having discharge $1 m^3 / sec,$ has 14 filters to treat the water. Each filter is having $50 m^2$ area, but due to backwashing activity, 2 filters are non operational. Calculate hydraulic loading rate in $\dfrac{m^3}{day \cdot m^2}$

Explanations:-

$$\begin{pmatrix} Hydraulic \\ loading\ rate \end{pmatrix} = \frac{Q}{A} = \frac{1}{12 \times 50} \frac{m^3}{sec \cdot m^2} = \frac{1 \times 24 \times 60 \times 60}{12 \times 50} \frac{m^3}{day \cdot m^2} = 144 \frac{m^3}{day \cdot m^2}$$

7. In its natural condition a soil sample has a mass of 1.980 kg and a volume of $0.001 m^3$. After being completely dried in an oven, the mass of the sample is 1.800 kg. Specific gravity is 2.7. Unit weight of water is $10 kN / m^3$. The degree of saturation of soil is

(A) 0.65   (B) 0.7   (C) 0.54   (D) 0.61

Explanations:-

(C)

$$\rho = \frac{M}{V} = \frac{1.980}{0.001} = 1980\ kg / m^3; \quad \rho_d = \frac{M_d}{V} = \frac{1.800}{0.001} = 1800\ kg / m^3$$

$$\rho_d = \frac{\rho}{1 + w} \Rightarrow 1800 = \frac{1980}{1 + w} \Rightarrow w = 0.1$$

$$\rho_d = \frac{G \rho_w}{1 + e} \Rightarrow 1800 = \frac{2.7 \times 1000}{1 + e} \Rightarrow e = 0.5$$

$$wG = e.S \Rightarrow 0.1 \times 2.7 = 0.5S \Rightarrow S = 0.54$$

8. Group-I contains dimensionless parameter and **Group-II** contains ratio

	Group-I		Group-II
P.	Mach number	1.	Ratio of inertial force and gravity force
Q.	Reynold number	2.	Ratio of fluid velocity and velocity of sound
R.	Weber number	3.	Ratio of inertial force and viscous force
S.	Froude number	4.	Ratio of inertial force and surface tension force

Correct match of the dimensionless parameter in Group-I with Group-II is

(A) $P - 3, Q - 2, R - 4, S - 1$ (B) $P - 3, Q - 4, R - 2, S - 1$

(C) $P - 2, Q - 3, R - 4, S - 1$ (D) $P - 1, Q - 3, R - 2, S - 4$

Explanations:-

(C)

9. For a 2-D flow field, the stream function ψ is given as $\psi = \frac{3}{2} \left(y^2 - x^2 \right)$.

The magnitude of discharge occurring between the stream line passing through points (0, 3) and (3, 4) is

(A) 6 units   (B) 3 units   (C) 1.5 units   (D) 2 units

Explanations:-

(B)

$$Q = \psi_1 - \psi_2 = \frac{3}{2}(9-0) - \frac{3}{2}(16-9) = 3 \text{ units}$$

10. Select the strength parameter of concrete used in design of plain jointed cement pavement from the following choices:

    (A) Tensile strength   (B) Compressive strength

    (C) Flexural strength   (D) Shear strength

Explanations:-

(C)

11. Four columns of building are to be located within a plot size of $10\,m \times 10\,m$. The expected load on each column is 400 kN. Allowable bearing capacity of soil deposit is $100\,kN/m^2$. The type of foundation to be used is

    (A) Isolated foundation   (B) Raft foundation

    (C) Pile foundation   (D) Combined foundation

Explanations:-

(A)

Load on each column $= 400\,kN$

Bearing capacity of soil $= 100\ kN/m^2$

$\therefore$ Area of each footing required $= \dfrac{400}{100}\,m^2 = 4\,m^2$

$\therefore$ Total area required $= 4 \times 4 = 16\,m^2$; $\therefore \dfrac{\text{Foundation area}}{\text{Plot area}} = \dfrac{16}{100} = 16\%$

If the foundation area is less than 40% of plot area, then isolated foundation is suitable.

12. Following statement are made on compacted soil, where DS stands for soil compaction on Dry Side of OMC and WS stands for soil compacted on Wet Side of OMC. Identify incorrect statement

    (A) Soil structure is flocculated on DS and dispersed on WS

    (B) Construction of pore water pressure is low on DS and High on WS

    (C) Soil on drying, shrinkage is high on DS and Low on WS

    (D) On addition to water, swelling is high on DS and low on WS

Explanations:-

(C)

13. It was observed that 150 vehicle crossed a particular location of highway in 30 minutes. Assume that vehicle arrival follow a negative exponential distribution. The number of time headways greater than 5 seconds in above observation is

Explanations:-

Probability of time head way greater than 't_{sec}' is given by $p(h \geq t) = e^{-m}$

If v = hourly flow rate, then $m = \dfrac{v}{3600} t$; $p(h \geq t) = e^{-vt/3600} = e^{-\frac{150 \times 2 \times 5}{3600}} = 0.659254$

$\begin{pmatrix} \text{No. of time headway} \\ \text{greater than 't' sec} \end{pmatrix} = \begin{pmatrix} \text{No of observed} \\ \text{time headway} \end{pmatrix} \times p(h \geq t) = 150 \times 0.65924 = 98.88$

14.   As per IS 800: 2007 the cross-section in which extreme fibre can reach the yield stress but cannot develop the plastic moment of resistance due to local buckling is classified as
       (A) Plastic section   (B) Compact section
       (C) Semi compact section   (D) Shear section

Explanations:-

(C)

As per clause 3.7.2 of IS 800:2007

15.   The "Plane section remain plane" assumption in bending theory implies
       (A) Strain profile is linear   (B) Stress profile is linear
       (C) Both profiles are linear   (D) Shear deformation is neglected

Explanations:-

(A)

16.   The ratio N_f / N_d is known as shape-factor where N_f is the number of flow channels and N_d is the equipotential drop. The flownet always drawn with a constant b/ a ratio where b and a are distance between two consecutive flow lines and equipotential lines respectively. Assuming that b/a ratio remains same, the shape factor of a flow net will change if the
       (A) Upstream and downstream heads are interchanged
       (B) Soil in the flow space is changed
       (C) Dimension of the flow space are changed
       (D) Head difference causing the flow is changed

Explanations:-

(B)

17.   Match the given water properties in **Group-I** to the given titrants shown in **Group-II**

	Group-I		Group-II
P.	Alkalinity	1.	N / 35.5 AgNO$_3$
Q.	Hardness	2.	N / 40 Na$_2$S$_2$O$_3$
R.	Chlorine	3.	N / 50 H$_2$SO$_4$
S.	Dissolved oxygen	4.	N / 50 EDTA

       (A) P – 1, Q – 2, R – 3, S – 4   (B) P – 2, Q – 1, R – 4, S – 3
       (C) P – 3, Q – 4, R – 1, S – 2   (D) P – 4, Q – 3, R – 2, S – 1

Explanations:-

(C)

18. Two steel column P (length L and yield strength $f_y = 250\,MPa$) and Q (length 2L and yield strength $f_y = 500\,MPa$) have the same cross-section and end condition. The ratio of buckling load of column P to that of column Q is

(A) 0.5   (B) 1.0   (C) 2.0   (D) 4.0

Explanations:-

(D)

Buckling load, $P = \dfrac{\pi^2 EI}{\left(l_{eff}\right)^2} \Rightarrow P_P = \dfrac{\pi^2 EI}{\left(L\right)^2};\ P_Q = \dfrac{\pi^2 EI}{\left(2L\right)^2};\ \dfrac{P_P}{P_Q} = 4$

19. As per IS 456 : 2000, bond strength of concrete $\tau_{bd} = 1.2$ for M20. It is increased by 60% for HYSD bar. The development length L_d in terms of ϕ is $\left(\sigma_{st} = 360\ MPa\right)$

Explanations:-

$L_d = \dfrac{\phi\sigma_{st}}{4\,\tau_{bd}} = \dfrac{\phi \times 360}{4 \times 1.2 \times 1.60} = 46.875\,\phi$

20. A 1 hour rainfall of 10 cm has return period of 50 year. The probability that 1 hour of rainfall 10 cm or more will occur in each of two successive years is

(A) 0.04   (B) 0.2   (C) 0.2   (D) 0.0004

Explanations:-

(D)

Return period of rainfall, $T = 50$ years

$\therefore$ Probability of occurrence once in 50 years, $p = \dfrac{1}{50} = 0.02$

Probability of occurrence in each of 2 successive years

$= p^2 = \left(0.02\right)^2 = 0.0004$

21. A symmetric I-section (with width of each flange = 50 mm, thickness of web = 10 mm) of steel is subjected to a shear force of 100 kN. Find the magnitude of the shear stress (in N/mm²) in the web at its junction with the top flange

Explanations:-

$I = \dfrac{50 \times 120^3}{12} - \dfrac{40 \times 100^3}{12} = 3.866 \times 10^6\ mm^4$

$q = \dfrac{SA\bar{y}}{Ib} = \dfrac{100 \times 10^3 \times 50 \times 10 \times 55}{3.866 \times 10^6 \times 10}$

$= 71.12\,N / mm^2$
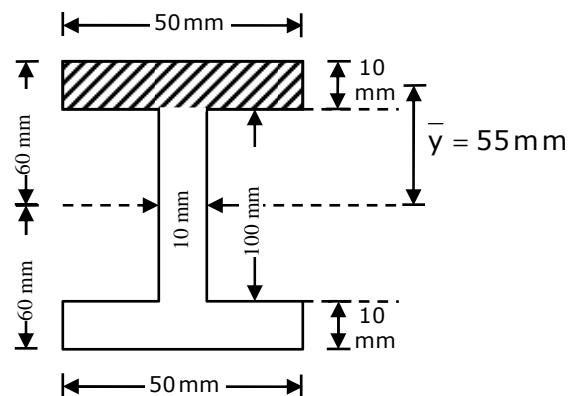
22. Maximum possible value of compaction factor for fresh (green) concrete is

    (A) 0.5   (B) 1.0   (C) 1.5   (D) 2.0

Explanations:-

    (B)

23. In a setting chamber, what is the minimum dimension of particle which can be completely removed, if rate of overflow is $30m^3/d/m^2$. Take G = 2.65; $\mu = 1 \times 10^{-5} Ns/m^2$

    (A) 0.001mm   (B) 0.002mm   (C) 0.003mm   (D) 0.004mm

Explanations:-

    (B)

    $$v = \frac{g\rho}{18\mu}(G-1)d^2 = \frac{30m^3}{d/m^2} = \frac{30}{24 \times 60 \times 60} m/s = 3.472 \times 10^{-4}$$
    $$3.472 \times 10^{-4} = \frac{9.81 \times 1000}{18 \times 10^{-5}} \times 1.65 \times d^2 \Rightarrow d^2 = 3.86 \times 10^{-12} \Rightarrow d = 0.002mm$$

24. An isohyet is a line joining points of

    (A) Equal temperature   (B) Equal humidity
    (C) Equal rainfall depth   (D) Equal evaporation

Explanations:-

    (C)

25. If $|4x - 7| = 5$ then the value of $2|x| - |-x|$ is

    (A) $2, \frac{1}{3}$ (B) $\frac{1}{2}, 3$ (C) $\frac{2}{3}, \frac{1}{3}$ (D) $\frac{2}{9}, 3$

Explanations:-

    (B)

    $|4x - 7| = 5;\ 4x - 7 = 5$ or $4x - 7 = -5 \Rightarrow x = 3$ or 0.5

    $\therefore 2|x| - |-x| = 2 \times 3 - 3 = 3$ or $2|x| - |-x| = 2 \times \frac{1}{2} - \frac{1}{2} = \frac{1}{2}$

Q. No. 26 – 55 Carry Two Marks Each

26. A rectangular concrete beam 250 mm wide and 600 mm deep is prestressed by means of 16 wire of high tensile steel wires, each of 7 mm diameter located at 200 mm from the bottom face of the beam at a given section. If the effective pre-stress in the wires is 700 MPa, what is the maximum sagging B.M (in kN-m) due to live load which this section of the beam can with stand without causing tensile stresses at the bottom face of the beam. Neglect the self weight of the beam.

Explanations:-
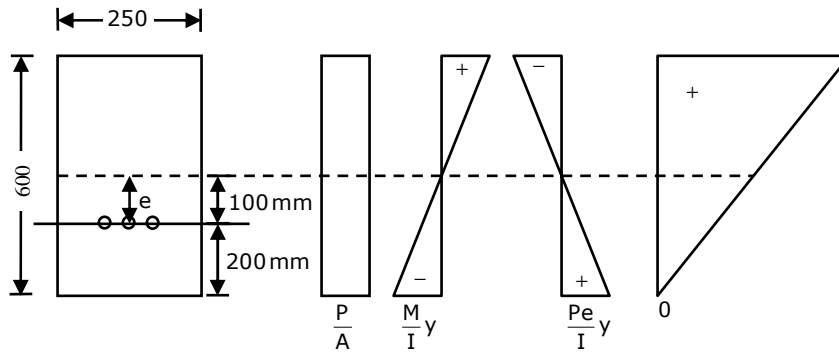
Since the tensile stress at bottom face of the beam is zero,

$$\frac{P}{A} - \frac{M}{I}y + \frac{Pe}{I}y = 0$$

$$P = 700 \times \frac{\pi}{4}(7)^2 \times 16 = 431.0265 \times 10^3 N \Rightarrow \frac{P}{A} - \frac{M}{Z} + \frac{Pe}{Z} = 0$$

Since the prestressing force is located at 200 mm from the bottom face of the beam. Ecentricity $= 300 - 200 = 100$ mm

$$\therefore \frac{431.0265 \times 10^3}{250 \times 600} - \frac{M \times 6}{250 \times 600^2} + \frac{431.0265 \times 10^3 \times 100}{250 \times 600^2} \times 6 = 0$$

$$\Rightarrow 2.8735 + 2.87351 = 6.66 \times 10^{-8}M \Rightarrow M = 86.205 \text{kNm}$$

27. In compacted cylindrical bituminous mix,

$$VMA = 15\% \begin{pmatrix} \text{void mineral} \\ \text{aggregate} \end{pmatrix}; \ V_v = 4.5\% \text{ (air void)}$$

The magnitude of VFB (void filled bituminous) is

(A) 24   (B) 30   (C) 54   (D) 70

Explanations:-

(D)

$$VFB = \frac{V_B}{V_v} = \left(\frac{15 - 4.5}{15}\right) \times 100\% = 70\%$$

28. The magnitude as the error (correct to two decimal places) in the estimation of integral $\int_0^4 (x^4 + 10) dx$ using Simpson 1/3 rule is ____. [Take the step length as 1]

Explanations:-

Using Simpson's Rule

X	0	1	2	3	4
Y	10	11	26	91	266

$$\int_0^4 (x^4 + 10) dx = \frac{1}{3}\left[(10 + 266) + 2(26) + 4(11 + 91)\right] = 245.33$$

The value of integral, $\int_0^4 \left(x^4 + 10\right) dx = \left[\dfrac{x^5}{5} + 10x\right]_0^4 = \dfrac{4^5}{5} + 10 \times 4 = 244.8$

$\therefore$ Magnitude of error $= 245.33 - 244.8 = 0.53$

29. The normal depth in a wide rectangular channel is increased by 10%. The percentage increase in discharge in the channel is

(A) 20.1   (B) 15.4   (C) 10.5   (D) 17.2

Explanations:-

(D)

The discharge in the channel is given by

$Q = \dfrac{1}{n} AR^{2/3}S^{1/2} = \dfrac{1}{n}(By)\left(\dfrac{By}{B + 2y}\right)^{2/3} S^{1/2}$; For a wide rectangular channel, B   y

$\therefore Q = \dfrac{1}{n}(By)(y)^{2/3} S^{1/2} \Rightarrow Q \propto y^{5/3}$; Let $Q_1 = k(y)^{5/3}$, then $Q_2 = k(1.1y)^{5/3}$

$\therefore \dfrac{Q_2 - Q_1}{Q_1} \times 100 = \dfrac{(1.1y)^{5/3} - (y)^{5/3}}{(y)^{5/3}} \times 100 = 17.21\%$

30. Elevation and temperature data for places are tabulated below

Elevation 'm'	Temperature °C
4	21.25
444	15.70

Based on this data, lapse rate can be referred as

(A) Super-adiabatic   (B) Sub-adiabatic

(C) Neutral   (D) Inversion

Explanations:-

(A)

Ambient lapse rate $= \dfrac{21.25 - 15.70}{(444 - 4)} \times 1000 = 12.6 \,^\circ C \,/\, km \left[> 9.8\,^\circ C \,/\, km\right]$

When the ambient lapse rate exceeds the adiabatic lapse rate, the ambient lapse rate is said to be super adiabatic.

31. 2D stress at a point is given by a matrix, $\begin{bmatrix} \sigma_{xx} & \tau_{xy} \\ \tau_{yx} & \sigma_{yy} \end{bmatrix} = \begin{bmatrix} 100 & 30 \\ 30 & 20 \end{bmatrix} MPa$.

The maximum shear stress in MPa is

(A) 50   (B) 75   (C) 100   (D) 110

Explanations:-

(A)

$$\Rightarrow \sigma_1 = 110 \text{ and } \sigma_2 = 10; \quad \therefore \ \tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{110 - 10}{2} = 50 \, MPa$$

$$\sigma_{1/2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x + \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \frac{100 + 20}{2} \pm \sqrt{\left(\frac{100 - 20}{2}\right)^2 + (30)^2} = 60 \pm 50$$

32. Find the value of λ such that function f(x) is valid probability density function

$$f(x) = \begin{cases} \lambda(x-1)(2-x) \text{ for } 1 \le x \le 2 \\ 0 \qquad\qquad\qquad \text{otherwise} \end{cases}$$

Explanations:-

$$\int_{-\infty}^{\infty} f(x)\,dx = 1; \quad f(x) = \begin{cases} \lambda(-x^2 + 3x - 2) \ 1 \le x \le 2 \\ 0 \quad \text{otherwise} \end{cases}$$

$$\int_1^2 \lambda(-x^2 + 3x - 2)\,dx = 1 \Rightarrow \lambda\left[-\frac{x^3}{3} + 3\frac{x^2}{2} - 2x\right]_1^2 = 1$$

$$\Rightarrow \lambda\left[-\left(\frac{8}{3} - \frac{1}{3}\right) + \frac{3}{2}(4-1) - 2(2-1)\right] = 1 \Rightarrow \lambda\left[-\frac{7}{3} + \frac{9}{2} - 2\right] = 1 \Rightarrow \lambda = 6$$

33. The value of $\int_0^{\pi/6} \cos^4 3\theta \sin^3 6\theta \, d\theta$ is

(A) 0　　　　　(B) $\frac{1}{15}$　　　　　(C) 1　　　　　(D) $\frac{8}{3}$

Explanations:-

(B)

$$\int_0^{\pi/6} \cos^4 3\theta \sin^3 6\theta\,d\theta = 8\int_0^{\pi/6} \cos^6 3\theta \sin^3 \cos 3\theta \, d\theta \ ; \text{Puting } \sin 3\theta = t,$$

we get $3\cos 3\theta \, d\theta = dt$

$$I = \frac{8}{3}\int_0^1 (1-t^2)^3 t^3 \cdot dt = \frac{8}{3}\int_0^1 (t^6 - 2t^2 + 3t^4)t^3 dt = \frac{8}{3}\int_0^1 (t^3 - t^9 - 3t^5 + 3t^7)\,dt$$

$$I = \frac{8}{3}\left[\frac{t^4}{4} - \frac{t^{10}}{10} - \frac{3t^6}{6} + \frac{3t^8}{8}\right]_0^1 = \frac{8}{3}\left[\frac{1}{4} - \frac{1}{10} - \frac{3}{6} + \frac{3}{8}\right] = \frac{8}{3}\left[\frac{30 - 20 - 60 + 45}{120}\right] = \frac{1}{15}$$

Alternative Method:

Let $3\theta = t; \ 3 \times d\theta = dt \Rightarrow d\theta = \frac{dt}{3}; \ \theta = \frac{\pi}{6}, \ t = \frac{\pi}{2} \text{ and } \ \theta = 0, t = 0$

$$I = \int_0^{\pi/2} \cos^h t \cdot \sin^3 2t \cdot \frac{dt}{3} = \frac{1}{3}\int_0^{\pi/2} \cos^h t \cdot (2\sin t \cos t)^3 \cdot dt = \frac{8}{3}\int_0^{\pi/2} \cos^h t.\sin^3 t.\cos^3 t\,dt$$

$$I = \frac{8}{3}\int_0^{\pi/2} \cos^7 t \sin^3 t\,dt = \frac{8}{3}\left[\frac{6 \cdot 4 \cdot 2 \cdot 2}{10 \cdot 8 \cdot 6 \cdot 4 \cdot 2}\right] = \frac{1}{15}$$

34. Laplace equation for water flow in soil is given by $\dfrac{\partial^2 H}{\partial x^2} + \dfrac{\partial^2 H}{\partial y^2} + \dfrac{\partial^2 H}{\partial z^2} = 0$

Head H does not vary in y and z-direction. Boundary condition

$x = 0$, $H = 5\,m$, $\dfrac{dH}{dx} = -1$. What is the value of H at $x = 1.2$?

Explanations:-

$\dfrac{\partial^2 H}{\partial x^2} = 0$; Integrating both sides, we get, $\dfrac{\partial H}{\partial x} = C_1$; Integrating again, $H = C_1 x + C_2$

At $x = 0$, $H = 5 \Rightarrow C_2 = 5$; At $x = 0$, $\dfrac{dH}{dx} = -1 \Rightarrow C_1 = -1; H = -x + 5$

At $x = 1.2\,m$, $H = 5 - 1.2 = 3.8\,m$

35. A student began an experiment of 5 day 20°C BOD on Monday. Since the 5th day fell on Saturday, the final DO reading was taken on Monday. On calculation BOD (i.e. 7 day 20°C) was found to be 150 mg/L. What would be the 5 day, 20°C BOD (in mg/L)? Assume value of BOD rate constant (K) at standard temperature of 20°C as 0.23/day (base e).

Explanations:-

$k_D = 0.434 \times 0.23 = 0.0998$

$BOD_7 = L\left[1 - 10^{-k_D t}\right] \Rightarrow 150 = L\left[1 - 10^{(-0.0998 \times 7)}\right] \Rightarrow L = 187.54\ mg/L$

$\therefore BOD_5 = L\left[1 - 10^{-k_D t}\right] = 187.539 \times \left[1 - 10^{-0.0998 \times 5}\right] = 128.0979\ mg/L$

36. A 2 km pipe of 0.2 m diameter connects two reservoirs. The difference between the water levels in the reservoir is 8 m. The Darcy Weisbach friction factor of the pipe is 0.04. Accounting for frictional entry and exit losses, the velocity in the pipe in (m/sec) is

(A) 0.63   (B) 0.35   (C) 2.52   (D) 1.25

Explanations:-

(A)

Frictional loss, $h_f = \dfrac{fLV^2}{d \times 2g}$; Loss of head at entrance, $h_L = \dfrac{0.5V^2}{2g}$

Loss at exit of pipe $h_c = \dfrac{V^2}{2g}$

$8 = \dfrac{fLV^2}{d \times 2g} + \dfrac{0.5V^2}{2g} + \dfrac{V^2}{2g} = \dfrac{0.04 \times 2000 \times V^2}{2 \times g \times 0.2} + \dfrac{V^2}{2g} + \dfrac{0.5V^2}{2g} = 20.3873V^2 + 0.07645V^2$

$\Rightarrow V = 0.625\,m/s$

37.   Bearing of the given system is shown below:

Line	Fore bearing	Back bearing
AB	126°45'	308°00'
BC	45°15'	227°30'
CD	340°30'	161°45'
DE	258°30'	78°30'
EA	216°30'	31°45'

Applying correction due to local attraction, the correct bearing of line BC will be

(A) 48°15'   (B) 50°15'   (C) 49°15'   (D) 48°45'

Explanations:-

(D)

The difference between back bearing and fore bearing of line DE

$= 258°30' - 78°30' = 180°$

$\therefore$ Station D and E are free from local attraction

Fore bearing of line EA = 212°30'

$\therefore$ Correct back bearing of line EA $= 216°30' - 180° = 36°30'$

$\therefore$ Error at A $= 31°45' - 36°30' = -4°45'$; Hence correction at A $= +4°45'$

Correct fore bearing of line AB $= 126°45' + 4°45' = 131°30'$

Correct back bearing of AB $= 131°30 + 180° = 311°30'$

$\therefore$ Error at B $= -3°30'$; Correction at B $= +3°30'$

Hence correct bearing of BC $= 45°15' + 3°30' = 48°45'$

38.   Two soil profile are used as backfill behind a retaining wall as shown in the figure, where γ_t is total unit weight and c' & ϕ'' are effective shear parameters. Find the resultant active earth pressure in kN/m

2 m $\gamma_1 = 15 kN/m^3$ c' = 0, $\phi' = 30°$

2 m $\gamma_2 = 20 kN/m^3$ c' = 0, $\phi' = 40°$
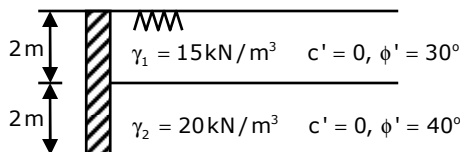
(A) 31.7   (B) 35.2   (C) 57.8   (D) 57

Explanations:-

(A)

$$k_{a_1} = \frac{1 - \sin 30^o}{1 + \sin 30^o} = \frac{1}{3} = 0.33; \quad k_{a_2} = \frac{1 - \sin 40^o}{1 + \sin 40^o} = 0.217$$

$$P_{a_1} = \frac{1}{2} k_{a_1} \gamma_1 H_1^2 = \frac{1}{2} \times \frac{1}{3} \times 15 \times 2^2 = 10 \, kN/m$$

$$P_{a_2} = k_{a_2} \gamma_1 H_1 . H_2 = 0.217 \times 15 \times 2 \times 2 = 13.02 \, kN/m$$

$$P_{a_3} = \frac{1}{2} k_{a_2} \gamma_2 H_2^2 = \frac{1}{2} \times 0.217 \times 20 \times 2^2 = 8.68 \, kN/m$$

$$P_a = P_{a_1} + P_{a_2} + P_{a_3} = 10 + 13.02 + 8.68 = 31.7 \, kN/m$$
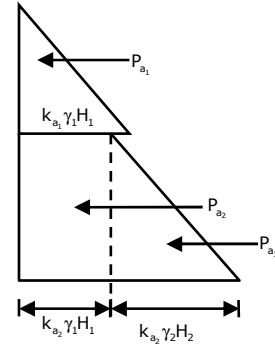
39. The soil profile above the rock surface at 25° infinite slope is shown in figure where S_u is undrain shear stress and γ_t is total unit weight. The slip will occur at a depth of
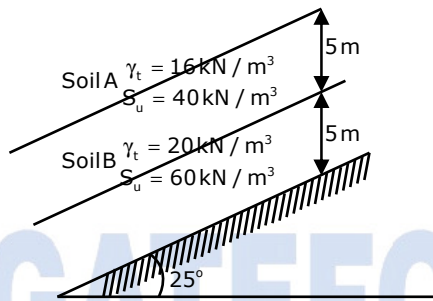
(A) 8.83 m   (B) 9.79 m   (C) 7.83 m   (D) 6.53 m

Explanations:-

(A)
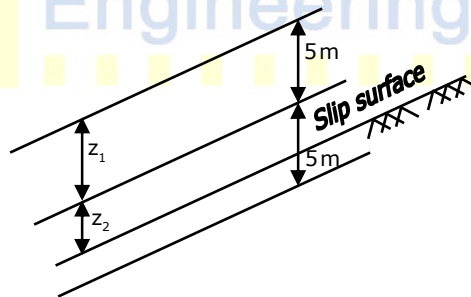
The slip will occur when shear stress is greater than or equal to shear strength

$$\tau \geq S_u \Rightarrow (\gamma_1 z_1 + \gamma_2 z_2) \sin\beta \cos\beta \geq S_u \Rightarrow \frac{(16 \times 5 + 20 + z_2)\sin 2\beta}{2} \geq S_u$$

$$\Rightarrow \frac{(80 + 20 z_2) \sin 50^o}{2} \geq 60 \Rightarrow z_2 = 3.83 \, m$$

$$\Rightarrow \text{Depth of slip} = 5 + 3.83 = 8.83 \, m$$

40. A Theodolite is placed at A and a 3 m long vertical staff is held at B. The depression angle made at reading of 2.5m marking on staff is $6^o10'$. The horizontal distance between A and B is 2200 m. The height of instrument at A is 1.2 m and reduced level of point A is 880.88 m. Using curvature correction and refraction correction determine the R.L. of point B (in m).

Explanations:-

R.L. of A $= 880.88\,m$

R.L. of Plane of Collimation $= 880.88 + 1.2 = 882.08\,m$
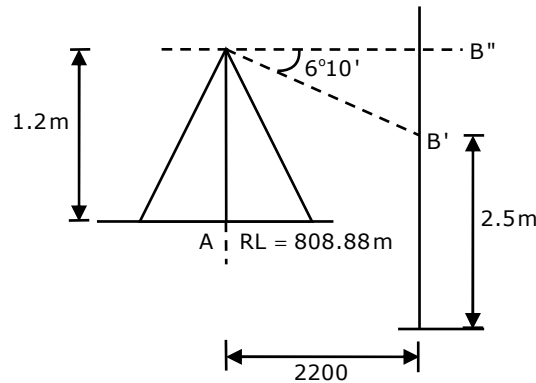
True staff reading at station B $= 2.5 - 0.0673 \times 2.2^2 = 2.174\,m$

Now, $B'B'' = (\tan 6^\circ\,10') \times 2200 = 237.701\,m$

R.L. of station B = R.L. of Plane of Collimation − True staff reading − B'B''

$= 882.08 - 2.174 - 237.701 = 642.205\,m$

41. A settling tank is designed for a surface overflow rate of $30\,\dfrac{m^3}{day\,m^2}$. Assuming specific gravity of sediment particles $= 2.65$, Density of water, $r_w = 1000\,kg/m^3$, dynamic viscosity of water $m_{water} = 0.001\,Ns/m^2$ and stokes law is valid.

The approximate minimum size of particles which can be completely removed is

(A) 0.01 mm   (B) 0.02 mm   (C) 0.03 mm   (D) 0.04

Explanations:-

(B)

To calculate minimum size of particles equating settling velocity to overflow rate, we get

$$V_0 = V_s = \frac{(G_s - 1)\gamma_w d^2}{18\mu} = \frac{30\,m^3}{day \cdot m^2} = \frac{30}{24 \times 60 \times 60}\frac{m}{s} = \frac{(2.65 - 1) \times 9.81 \times 10^3 \times d^2}{18 \times 0.001}$$

Solving we get $d = 1.965 \times 10^{-5}\,m \approx 0.02\,mm$

42. A uniform beam weighing 1800 N is supported at E & F by cable ABCD. Determine the tension force in segment AB at this cable (correct to 1 decimal place). Assume the cable ABCD, BE and CF are weightless
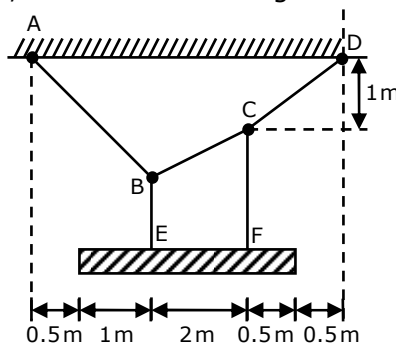
Explanations:-
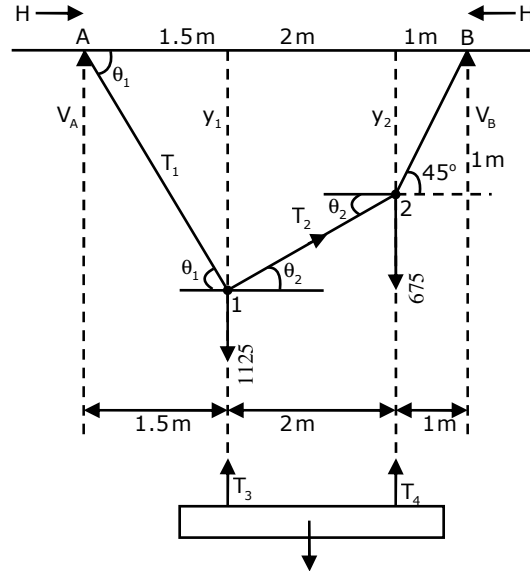
Taking Moment about A

$$T_3 = \frac{1800 \times 1.25}{2} = 1125\,N; \quad T_4 = \frac{1800 \times 0.75}{2} = 675\,N$$

We get, $V_B \times 4.5 = (1125 \times 1.5 + 675 \times 3.5) \Rightarrow V_B = 900\ kN$

$V_A = (1125 + 675 - 900) = 900\,kN$

$M_{1,beam} = (V_A \times 1.5) = 900 \times 1.5 = 1350\,Nm$

$M_{2,beam} = (V_A \times 3.5 - 1125 \times 2) = (900 \times 3.5 - 2250) = 900\ Nm$

Taking bending moment about point (1) [as we know that bending moment at every point in the cable is zero] $\Rightarrow Hy_1 = M_{1,beam} = 1350$

Taking bending moment about point (2) $\Rightarrow Hy_2 = 900 \Rightarrow H = \dfrac{900}{1} = 900\,N$

$\Rightarrow 900\,y_1 = 1350 \Rightarrow y_1 = \left(\dfrac{1350}{900}\right) = 1.5\,m$

$\therefore \theta_1 = \tan^{-1}\left(\dfrac{y_1}{1.5}\right) = \tan^{-1}\left(\dfrac{1.5}{1.5}\right) = 45; \quad \theta_2 = \tan^{-1}\left(\dfrac{y_1 - y_2}{2}\right) = \tan^{-1}\left(\dfrac{1.5 - 1}{2}\right) = 14.03$

From Lamis Theorem

$$\frac{T_1}{\sin(90 + \theta_2)} = \frac{1125}{\sin\{[180 - (\theta_1 + \theta_2)]\}} \Rightarrow T_1 = \frac{1125\sin(90 + 14.03)}{\sin[180 - (45 + 14.03)]} = 1272.91\,N$$

43. A uniform beam (EI = constant) PQ in the form of a quarter circle of radius R is fixed at end P and free at the end Q, where a load W is applied as shown. The vertical downward displacement δ_Q at the loaded point Q is given by

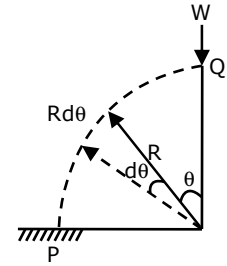$\delta_Q = \beta\left(\dfrac{wR^3}{EI}\right)$. Find the value of β correct to 4-decimal place
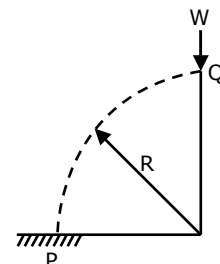
Explanations:-

$$U = \int \frac{M^2 dx}{2EI} = \int_0^{\pi/2} \frac{(WR \sin\theta)^2 R d\theta}{2EI} = \int_0^{\pi/2} \frac{P^2 R^3}{2EI} \sin^2\theta d\theta$$

$$= \frac{P^2 R^3}{2EI} \int_0^{\pi/2} \frac{(1 - \cos 2\theta) d\theta}{2} = \frac{P^2 R^3}{4EI} \left[\theta - \frac{\sin 2\theta}{2} \right]_0^{\pi/2} = \frac{P^2 R^3}{4EI} \left[\frac{\pi}{2} \right] = \frac{P^2 R^3 \pi}{8EI}$$

$$\therefore \delta_Q = \frac{\partial U}{\partial W} = \frac{2P^2 R^3 \pi}{8EI} = \frac{PR^3}{EI} \frac{\pi}{4} = \frac{\pi}{4} \left(\frac{WR^3}{EI} \right) \Rightarrow \beta = \frac{\pi}{4} = 0.7854$$

44. The transplantation of rice requires 10 days and total depth of water required during transplantation is 48 cm. During transplantation there is an effective rainfall (useful for irrigation) of 8 cm. The duty of irrigation water in hectare/cumecs is

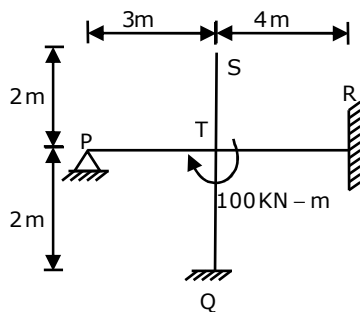(A) 612   (B) 216   (C) 300   (D) 108

Explanations:-

(B)

$$D = 864B / \Delta \text{ hectares / cumecs} = \frac{864 \times 10}{(48 - 8) \times 10} = 216 \text{ hectares / cumecs}$$

45. All members in the rigid-jointed frame shown are prismatic and have the same flexural stiffness EI. Find the magnitude of the B.M. at Q (in kN-m) due to given loading
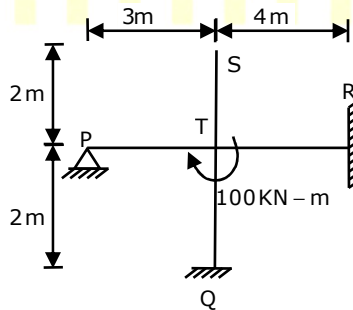
Explanations:-

Joint	Member	RS	TRS	DF
	TP	$\dfrac{3}{4}\dfrac{I}{3} = \dfrac{I}{4}$		$\dfrac{1}{4}$
T	TS	0	I	0
	TR	$\dfrac{I}{4}$		$\dfrac{1}{4}$
	TQ	$\dfrac{I}{2}$		$\dfrac{1}{2}$

$\therefore \qquad M_Q = 25$ kNm

46. There are three matrixes $P(4 \times 2), Q(2 \times 4)$ and $R(4 \times 1)$. The minimum of multiplication required to compute the matrix PQR is
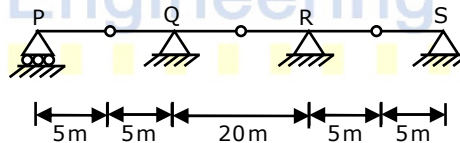
Explanations:-

If we multiply QR first then

$Q_{2 \times 4} \times R_{(4 \times 1)}$ having multiplication number 8

Therefore $P_{(4 \times 2)} QR_{(2 \times 1)}$ will have minimum number of multiplication $= (8 + 8) = 16$
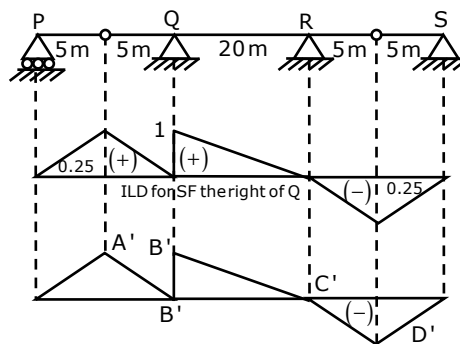
47. Beam subjected to moving distributed load of 4 kN/m maximum shear force that can occur just to right of Q is

(A) 30 kN 　　　 (B) 40 kN 　　　 (C) 45 kN 　　　 (D) 55 kN

Explanations:-

When a cut is made just to the right of Q and displacements are given such that A'B' is parallel to B'C', as B' is very close to Q, displacement of B' to the left will be zero and that to the right will be 1.

Hence slope of $B'C' = \dfrac{1}{20} \Rightarrow$ Slope of $B'A' = \dfrac{1}{20} \times 5 = 0.25$

ordinate at $A' = \dfrac{1}{20} \times 5 = 0.25$; ordinate at $D' = \dfrac{1}{20} \times 5 = 0.25$

If udl is loading span PR, we get maximum SF just to the right of Q

$\Rightarrow SF = \left(\dfrac{1}{2} \times 0.25 \times 10 + \dfrac{1}{2} \times 20 \times 1\right) \times 4 = 45 \text{ kN}$

Common Data Questions: 48 & 49

For a portion of highway descending gradient 1 in 25 meets an ascending gradient 1 in 20. A valley curve needs to be designed at a velocity of 90 kmph based on

(i) Head light sight distance equal to stopping sight distance of a level terrain. Consider length of curve > SSD

(ii) Comfort condition if rate of change of acceleration is $0.5 \text{ m}/\text{s}^3$

Reaction time = 2.5 sec, coefficient of longitudinal friction $\mu = 0.35$. Height of head light = 0.75 m, and beam angle $= 1°$

48. What is the length of valley curve as per headlight sight distance?

Explanations:-

$N = \left|-\dfrac{1}{25} - \dfrac{1}{20}\right| = 0.09;\ S = 0.278 \times 90 \times 2.5 + \dfrac{(90)^2}{254 \times 0.35}$
$= 62.55 + 91.11 = 153.66$

Assume L>SSD

$L = \dfrac{NS^2}{(1.50 + 0.035S)} = \dfrac{0.09(153.6636)^2}{(1.50 + 0.035 \times 153.6636)} = 308.9641\,m$

49. What is the length of valley curve (in meter) based on comfort condition?

Explanations:-

$L_v = 2\left[\dfrac{NV^3}{C}\right]^{1/2} = 2\left[\dfrac{0.09 \times (0.278 \times 90)^3}{0.5}\right]^{1/2} = 106.066\,m$

Common Data Questions: 50 & 51

Storm-I of duration 5 hours gives a direct run-off of 4 cm and has an average intensity of $2\,cm/hr$

Storm-II of 8 hour duration gives a run-off of 8.4 cm.

(Assume ϕ-index is same for both the storms.)

50.   The value of $\phi-\text{index}$ is
(A) 1.2   (B) 1.6   (C) 1   (D) 1.4

Explanations:-
(A)

$$\phi-\text{index} = \frac{2\times 5 - 4}{5} = \frac{10-4}{5} = \frac{6}{5} = 1.2 \text{ cm/hr}$$

51.   Intensity of storm-II in cm/hr is
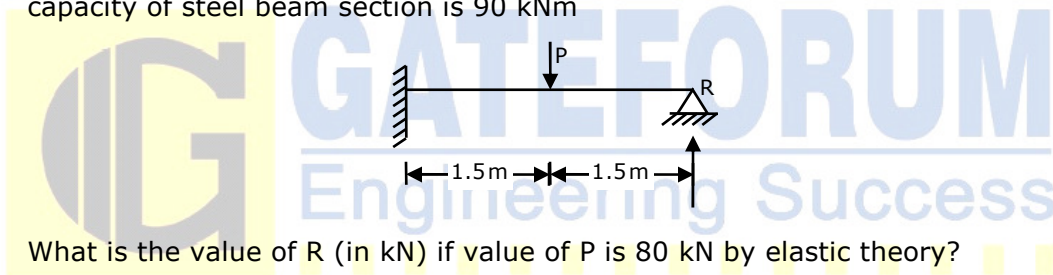(A) 2   (B) 1.5   (C) 1.75   (D) 2.25

Explanations:-
(D)
Let intensity of storm-II be P cm/hr

$$1.2 = \frac{P\times 8 - 8.4}{8} \Rightarrow 1.2\times 8 + 8.4 = P\times 8 \Rightarrow P = 2.25 \text{ cm/hr}$$

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

The magnitude of load P is increased till collapse and the plastic moment carrying capacity of steel beam section is 90 kNm
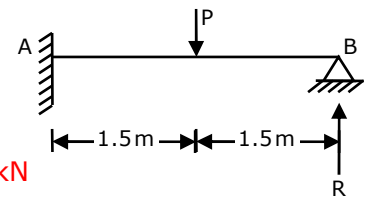

52.   What is the value of R (in kN) if value of P is 80 kN by elastic theory?
Explanations:-
Equating deflection at end R

Let $l = 3m$; $\dfrac{R(l)^3}{3EI} = \dfrac{P(1.5)^3}{3EI} + \dfrac{P(1.5)^2}{2EI}\times 1.5$

$\Rightarrow \dfrac{R(3)^3}{3EI} = \dfrac{1.125P}{EI} + \dfrac{1.6875P}{EI} \Rightarrow R = \dfrac{5}{16}P = \dfrac{5}{16}\times 80 = 25\,kN$
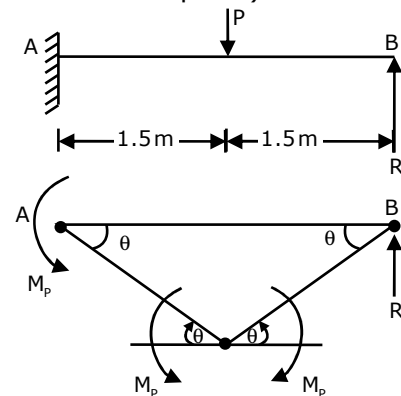

53.   The value of R (in kN), using plastic analysis is (upto 1 decimal place).
Explanations:-

$$-3M_p\theta + P\frac{l}{2}\theta = 0 \Rightarrow P_u = \frac{6M_p}{l} = \frac{6\times 90}{3} = 180\,kN$$

At collapse condition $\Sigma M_A = 0$
$R\times 3 + M_p - P\times 1.5 - M_p + M_p = 0 \Rightarrow R = 60\,kN$

Statement for Linked Answer Questions: 54 & 55

A multistorey building with a basement is to be constructed. The top 4 m contains loose silt below which dense sand layer is present upto a great depth. Ground water table is at the ground surface. The foundation consists of the basement slab of 6 m width which will rest on the top of dense sand as shown in figure. For dense sand saturated unit weight is $20\,kN/m^3$ and bearing capacity factor, $N_q = 40, N_\gamma = 45$, for loose silt saturated unit weight $= 18\,kN/m^3$, $N_q = 15, N_\gamma = 20$. Effective cohesion is 0. Neglect depth factor average elastic modulus E, and Poisson ratio μ of dense sand is $60 \times 10^3\ kN/m^2$ and 0.3 respectively, using factor of safety = 3. (Take influence factor = 2)

54.   The net safe bearing capacity $(in\ kN/m^3)$ of foundation is
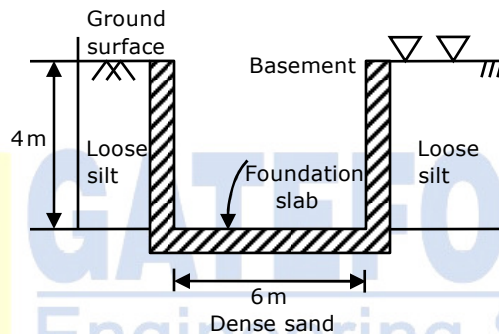
(A) 610   (B) 320   (C) 980   (D) 693

Explanations:-

$q_u = 1.3C\ N_c + \gamma'\ D_f N_q + 0.4\gamma'N_r$; For given soil, $C = 0$

Use $N_q = 15$ for loose silt and $N_r = 45$ for dense sand

use term $\gamma = \gamma'$ for loose silt in the term $\gamma'D_f$

$\therefore \gamma' = 18 - 9.81 = 8.19\ kN/m^3$

Use $\gamma = \gamma'$ for dense sand in the term $0.4\gamma B$

$\gamma' = 20 - 9.81 = 10.19\ kN/m^3$

$\therefore q_u = 8.19 \times 4 \times 15 + 0.4 \times 10.19 \times 6 \times 45 = 1591.92\ kN/m^3$

$q_{nu} = q_u - \gamma'D_f = 1591.92 - 8.19 \times 4 = 1559.16\ kN/m^2$

$\therefore q_{ns} = \dfrac{q_{nu}}{FOS} = \dfrac{1559.16}{3} = 519.72$

$\therefore q_{safe} = q_{ns} + \gamma'\ D_f = 519.72 + 8.19 \times 4 = 552.48\ kN/m^2$

None of the options is correct

55.   The immediate settlement of foundation is
(A) 58 mm   (B) 111 mm   (C) 178 mm   (D) 126 mm

Explanations:-

$$S_i = \frac{q_s B\left(1 - \mu^2\right) I_f}{E_s}$$

Where $E_s = 60 \times 10^3 \text{KPa}$

$\mu = 0.3$

$I_f = 2$

$Si = 552.48 \times 6 \times [1-(0.3)2] \times 2/ (60 \times 103) = 100.55 \text{ mm}$

Section- II (General Aptitude)

56. Friendship, No matter how _____ it is, has its limitation

(A) cordial   (B) intimate   (C) secret   (D) pleasant

Explanations:-

(B)

Friendship, No matter how intimate it is, has its limitation. Intimate refers to close personal relations, e.g. an intimate friend. It is also characterized by or involving warm friendship or a personally close or familiar association or feeling.

57. A number much greater than 75 and smaller than 117 is

(A) 91   (B) 93   (C) 89   (D) 96

Explanations:-

(D)

58. The pair that best express a relationship similar to that expression in the pair:

Medicine: Health

(A) Science: Experiment   (B) Wealth : Peace

(C) Education: Knowledge   (D) Money: Happiness

Explanations:-

(C)

Medicine leads to good health. Similarly, Education leads to Knowledge. Science does not lead to experiment. Wealth may not necessarily lead to peace. Also money may not also lead to happiness all the time

59. Which of the following options is closest in meaning to the word given below?

"Primeval"

(A) Modern   (B) Historic   (C) Primitive   (D) Antique

Explanations:-

(C)

Primeval pertains to the first age or ages, especially of the world. E.g.: primeval forms of life

60.   A reduction of 5% in price of sugar enables a housewife to buy 3 kg more for Rs.280. Find the reduced price

Explanations:-

Let the original price be Rs. x/kg

Number of kgs that can be bought $= \dfrac{280}{x}$

Number of kgs that can be bought after reduction in price $= \dfrac{280}{0.95\,x}$

$\Rightarrow \dfrac{280}{0.95x} - \dfrac{280}{x} = 3 \Rightarrow x = \left(\dfrac{280}{0.95} - 280\right) \times \dfrac{1}{3}$

$\Rightarrow \text{Re}\,duced\ price = 0.95x = Rs.\,4.667\,/\,kg$

61.   x and y are two positive real numbers, such that equation

$2x + y \le 6;\ x + 2y \le 8$

For which values of (x, y), the function $f(x, y) = 3x + 6y$ will give maximum value

(A) $4\,/\,3,\ 10\,/\,3$ (B) $8\,/\,3,\ 20\,/\,3$ (C) $8\,/\,3,\ 10\,/\,3$ (D) $4\,/\,3,\ 20\,/\,3$

Explanations:-

(A)

$2x + y \le 6;\ x + 2y \le 8$

$x \le 1.33;\ y \le 3.33;\ \therefore$ option(B) and (C) is rejected becuase $x \not> 1.33$

Option (D) is rejected $x \not> 10\,/\,3$

62.   A firm is selling it product at Rs. 60/unit. The total cost of production is Rs. 100 and firm is earning total profit of Rs. 500. Later, the total cost increased by 30%. By what percentage the price should be increased to maintain the same profit level

(A) 5   (B) 15   (C) 10   (D) 30

Explanations:-

(A)

63.   Abhishek is elder to Savan, Savan is younger to Anshul. The correct relations is

(A) Abhishek is elder to Anshul
(B) Anshul is elder to Abhishek
(C) Abhishek and Anshul are of same age
(D) No conclusion can be drawn

Explanations:-

(D)

64.

	2010	2011
Raw material	5200	6240
Power & fuel	7000	9450
Salary & wages	9000	12600
Plants & machinery	20000	25000
Advertising	15000	19500
Research & development	22000	26400

Which one of the following increased by same percentage in year 2010-2011?

(A) Raw material and salary and wages

(B) Salary and wages and advertising

(C) Power and fuel and advertising

(D) Raw material and research and development

Explanations:-

(D)

% increase in raw material $= \dfrac{6240 - 5200}{5200} \times 100 = 20\%$

$\begin{pmatrix} \% \text{ increase research} \\ \text{and development} \end{pmatrix} = \dfrac{26400 - 22000}{22000} \times 100 = 20\%$

65.

$$\underline{\text{The professor}}_{\text{(I)}} \; \underline{\text{ordered to}}_{\text{(II)}} \; \underline{\text{the student to go}}_{\text{(III)}} \; \underline{\text{out of the class}}_{\text{(IV)}}$$

The incorrect one is

(A) (I)   (B) (II)   (C) (III)   (D) (IV

Explanations:-

(B)