Solutions

1. Ans. D.
experiences short-term memory loss.

2. Ans. A.
Contentment is the key to their happiness,

3. Ans. C.
Women’s solidarity knows no national boundaries: Women Empowerment

4. Ans. C.

$$\left.\begin{array}{l} P=0.04=\frac{4}{100} \\ \text{For 1 earth quake} \\ \frac{100}{4}P=\text{1 earth quake} \\ \text{25 years} \end{array}\right\}\text{Reverse probability}$$

5. Ans. A.

$\frac{20}{140}\times 8$

After 1 year

P = 6

2 years = 7.2

After 3 = $\frac{20}{100}\times 1.2$

= 8.65

After 4 years = $\frac{20}{100}\times 8.25$

$= \approx 10$

Time will be in between 3-4 years.

6. Ans. A.
First statement itself clarify the eldest child

7. Ans. C.
“Exactitude is not critical in dealing with big data”

8. Ans. D.

$\left.\begin{array}{l}\text{revenue generated through export} \\ \text{of item 1 Kg}\end{array}\right\}$

$\Rightarrow \frac{\text{Item}}{\text{quantity}}=\frac{11}{100}\times 5=\frac{11}{20}\text{(lakhs tows)}$

$\left.\begin{array}{l}\text{revenue gen} \\ \text{Item 1}\end{array}\right\}\frac{12}{100}\times 6\times 250\times (C)$

$=\frac{30cr}{11}\times 20 \qquad ...(1)$

Revenue gen Item 4 $=\frac{6}{100}\times 250.(C)$

$=\frac{15\ cr}{22}\times 20\ \text{Lt.} \qquad ...(2)$

1:2

$\frac{30}{11}\times\frac{20\times 22}{15\times 20}=4:1$

9. Ans. C.

From the fig: $zx=\sqrt{2}.$ [Pythagoras theorem]

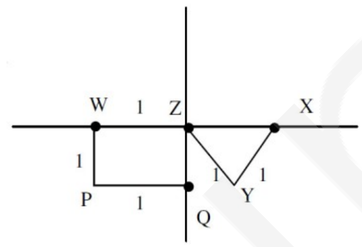
zQ=1 Given

$\Rightarrow$ Considerating ZQX, which is right angle, is

$\Rightarrow Qx^2=ZQ^2+Zx^2$

$=\sqrt{1+2}$

$=\sqrt{3}$



10. Ans. C.
The patient is actually HIV +ve. So probability of that = P(he belongs to HIV +ve population) * P(HIV +ve test gives correct result given he is HIV +ve).
So the probabilty P(A) = 0.1 and P(E/A) = 0.95
b) The next case is a patient is HIV -ve but the test is showing HIV +ve i.e. test shows wrong result. So,
P(B) = 0.9 and P(E/B) = 1 - 0.89 = 0.11
So By Bayes' Theorem,
P(A/E) i.e. P(actually is HIV +ve) = P(A) * P(E/A) / [(P(A) * P(E/A)) + (P(B) * P(E/B))]
= 0.1 * 0.95 / [(0.1 * 0.95) + (0.9 * 0.11)]
= 0.095 / 0.095 + 0.099
= 0.095 / 0.194
= 95 / 194
= 0.4897
= 48.97 %

11. Ans. B.

$P(T)=\frac{1}{2}$

12. Ans. A.

$$\begin{vmatrix}0&1&2&3\\1&0&3&0\\2&3&0&1\\3&0&1&2\end{vmatrix}=-1\begin{vmatrix}1&2&3\\3&0&1\\0&1&2\end{vmatrix}-3\begin{vmatrix}0&1&3\\2&3&1\\3&0&2\end{vmatrix}$$

$=[1(0-1)-2(6-0)+3(3-0)]$

$=-3[0\text{-}1(4\text{-}3)\text{+}3(0\text{-}9)]=88$

13. Ans. B.

$z=\frac{2\text{-}3i}{\text{-}5+i}$

$=\frac{2\text{-}3i}{\text{-}5+i}\times\frac{\text{-}5\text{-}i}{\text{-}5\text{-}i}$

$=\frac{\text{-}10\text{-}2i+15i+3i^2}{5^2\text{-}i^2}=\frac{\text{-}10+13i\text{-}3}{25+1}$

$=\frac{13i\text{-}13}{26}=13\frac{(i\text{-}1)}{26}=\frac{i\text{-}1}{2}=\frac{i}{2}\text{-}\frac{1}{2}=0.5i\text{-}0.5.$

14. Ans. D.

$$\frac{dP}{dt}+k_2P=K_1L_0e^{-k_1t}$$

The standard form of Linear differential equation is

$$\frac{dy}{dx}+py=Q;I.F=e^{\int p\,dx}$$

$$\Rightarrow \frac{dP}{dt}+K_2P=(k_1L_0e^{-k_1t})$$

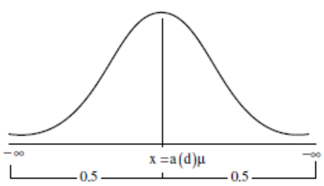
Integrating factor, $I.F=e^{\int K_2dt}=e^{K_2t}$.

15. Ans. B.

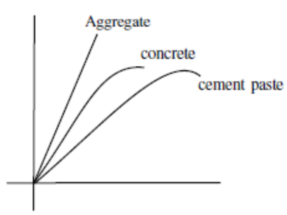
We have $\int_{-\infty}^{\infty} f(x)\,dx=1$

$$\Rightarrow \int_{-\infty}^{a} f(x)\,dx+\int_{a}^{\infty} f(x)\,dx=1$$

$$\Rightarrow \int_{-\infty}^{a} f(x)\,dx=0.5$$



16. Ans. B.



So, P=2,
Q=3,
R=1

17. Ans. B.

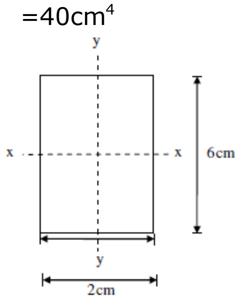
∵ Section modulus, $z=\frac{I}{r}=\frac{A.r^2}{r}=A.r$, i.e. Moment of Area.

18. Ans. D.

$I_p=I_{xx}+I_{yy}$

$$=\frac{2\times(6)^3}{12}+\frac{6(2)^3}{12}$$

$=40cm^4$



19. Ans. D.
$f_m= f_{ck} +1.65\sigma$ (As per IS:456.2000)

20. Ans. B.
As per IS Code modulus of elasticity is based on initial tangent modulus

21. Ans. A.
$D_s=3m+r-3j-r_r$

m=no. of members=4

r=no. of external reaction=4

j=no. of joints=5

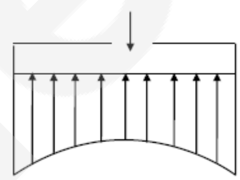
r_r=no. of reactions released=2-1=1

So, $D_g=3\times4+4-3\times5-1=0$

22. Ans. A.
$I_p=0.73(w_L - 20)$

23. Ans. D.
Montmorillonite is primarly responsible for swelling behavior of Black Cotton soil.

24. Ans. D.



Rigid footing: stress distribution for clay minimum at center maximum at edge

25. Ans. B.
$G_s=2.71$, n=4% =0.40,

W=20%, S=?

$$e=\frac{n}{1-n}=\frac{0.4}{0.6}=0.67$$

$$S=\frac{WG}{e}=\frac{0.20\times2.71}{0.67}=0.808=81\%$$

26. Ans. D.

$U=\frac{x}{T_1}$, $V=\frac{-y}{T_2}$, w=0

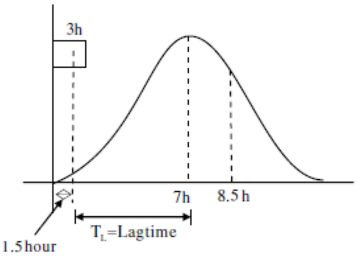
For incompressible flow

$$\frac{2v}{2x}+\frac{2v}{2y}+\frac{2w}{2z}=0$$

$$\Rightarrow \frac{1}{T_1}-\frac{1}{T_2}=0 \Rightarrow T_1=T_2$$

27. Ans. D.
Aneometer ⟶ Wind speed
Hygrometer ⟶ water vapour content of air
Pilot tube ⟶ flow velocity at a specific point in the flow stream
Tensionmeter ⟶ Capillary potential of soil water.

28. Ans. D.



For small catchment, time of concentration is equal to lag time of peak flow.
$T_c=7-1.5=5.5h$

29. Ans. D.
$K_0 + K_2 + K_2 = 1$

30. Ans. A.
As activated sludge process takes place in the presence of Oxygen
An organism is said to be aerobic if it can only exist in the presence of free oxygen
A heterotroph is an organism that cannot fix carbon from inorganic sources (such as carbon dioxide) but uses organic carbon for growth
So overall its aerobic heterotrophs that dominates in activated sludge process

31. Ans. C.
Electrostatic Precipitator and Fabric Filter are the two air pollution control devices that are usually used to remove very fine particles from the flue gas are

32. Ans. D.

$$\text{Density, } K=\frac{1000}{s}=\frac{1000}{50}=20 \text{ veh/km}$$

33. Ans. D.

$$\text{Ruling gradient}=\frac{V^2}{127(e+f)}$$

$$=\frac{110\times110}{127(0.08+0.10)}=529.30\text{m}$$

34. Ans. D.
Topographic survey is carried out to delineate natural features.
35. Ans. A.
By L' Hospital rule,

$$L=\frac{\frac{d}{d\alpha}\left(x^{\alpha-1}\right)}{\frac{d}{d\alpha}(\alpha)}$$

$$=\lim_{\alpha\to0}\frac{x^{\alpha}.\log x}{1}=\log x$$

36. Ans. A.
Average no. of vehicles per hour,

λ=240/hour

$$=\frac{240}{60}\text{/min}$$

=4/mm =2/30sec

$$P(x=1)=\frac{e^{-2}.2'}{1!}=0.27$$

37. Ans. C.

$$\begin{bmatrix}6 & 0 & 4 & 4\\ -2 & 14 & 8 & 18\\ 14 & -14 & 0 & -10\end{bmatrix} R_2\to3R_2+R_1;R_3\to6R_3-14R_1$$

$$\sim\begin{bmatrix}6 & 0 & 4 & 4\\ & 42 & 28 & 58\\ 0 & -84 & -56 & -116\end{bmatrix} R_3\to R_3-R_2$$

$$\sim\begin{bmatrix}6 & 0 & 4 & 4\\ & 2 & 28 & 58\\ 0 & 0 & 0 & 0\end{bmatrix}$$

→Rank=No. of non-zero rows=2

38. Ans. A.

$$\frac{d^2H}{dx^2}=0$$

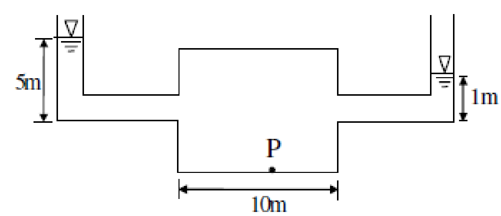
$$\Rightarrow\frac{dH}{dX}=K\Rightarrow H=Kx+C$$

at x=0, H=5 $\Rightarrow$ C=5

at x=10, H=1 $\Rightarrow$ K=-0.4

So, H=-0.4x+5

At x=5, H=-.4×5+5=3m

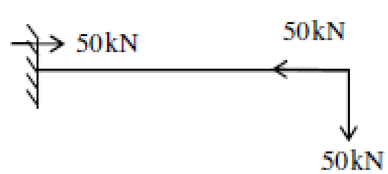


39. Ans. B.
Loading after removing of cable

$$\text{Axial stress}=\frac{50}{0.2\times0.2}=1250\text{kN/m}^2$$

B.M = 50×3 = 150kNm

S.F = 50kN



40. Ans. B.

From properties of circle,

$$(2R-\Delta).\Delta=\frac{L}{2}\times\frac{L}{2}$$

$\because$ ery small, neglect Δ^2

$$2R.\Delta=\frac{L^2}{4}$$

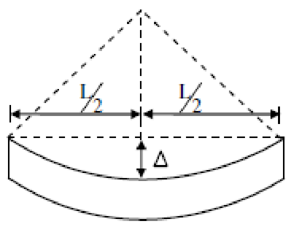
$$\Rightarrow \Delta=\frac{L^2}{8R} \qquad \text{But } R=\frac{h}{\alpha T}$$

$$=\frac{L^2}{8.h}.\alpha T$$

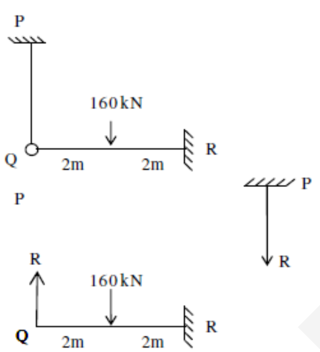
Here, L=3m, $\alpha=1.50\times10^{-5}$ / °C,

T=72°-36°=36°C

$$\Delta=\frac{(3)^2\times1.5\times10^{-5}\times36}{8\times0.250}=0.00243m=2.43mm$$



41. Ans. A.



Taking PQ to be rigid; so, $\Delta_Q=0$

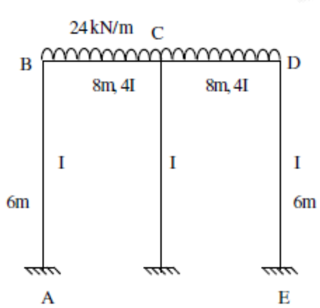
$$\Rightarrow \frac{R(4)^3}{2EI}=\frac{160(2)^3}{3EI}+\frac{160(2)^2}{2EI}\times2$$

$$\Rightarrow 64R=160\times8+160\times4\times3$$

$$\Rightarrow R=50kN$$

So, Tension in PQ=50 kN

42. Ans. C.

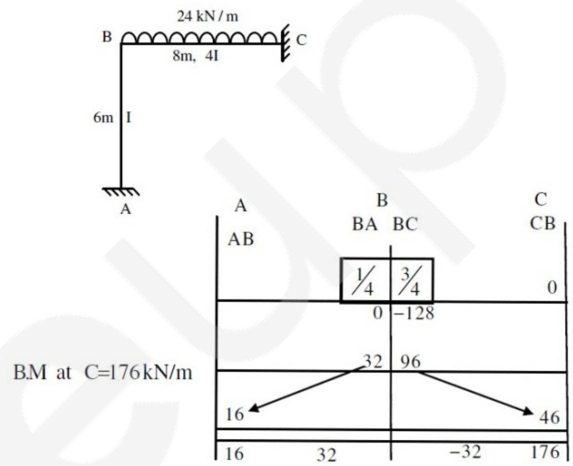


Axis of symmetry is passing through a column; hence it can be treated as

Member	Stiffness	D.F
BA	$\frac{4EI}{6}$	$\frac{1}{4}$
BC	$\frac{4E(4I)}{8}$	$\frac{3}{4}$

$$M_{BC}=\frac{-WL^2}{12}=\frac{-24\times8\times8}{12}=-128kNM$$

$$M_{CB}=+128\text{ kNM}$$



43. Ans. C.

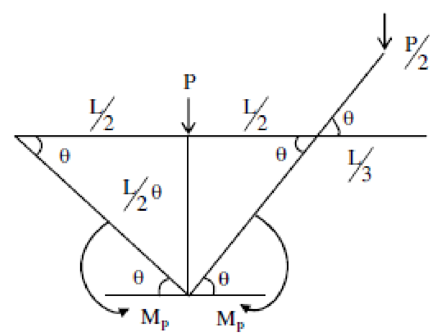
Degree of static indeterminacy D_s = 0

$\therefore$Number of plastic hinges=D_s+1=1

From principle of virtual work

$$-M_p\theta-M_p.\theta+P.\left(\frac{L}{2}.\theta\right)-\frac{P}{2}.\left(\frac{L}{3}.\theta\right)=0$$

$$\Rightarrow P=\frac{LM_p}{L}$$



44. Ans. B.

Taking moment about Q=0

$$R\times6-120\times3=0\Rightarrow R_A=60kN$$

Taking moment about R = 0

$$R\times3-H\times4=0\Rightarrow H=\frac{3}{4}\times60=45kN$$

$$T=\sqrt{R^2-H^2}=\sqrt{(60)^2+(45)^2}=75kN$$

45. Ans. D.

$\sigma_x = 2, \sigma_y = 4, \tau = 4$

Max shear stress, $\tau_{max} = \dfrac{\sigma_1 - \sigma_2}{2}$

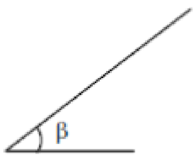
Where, $\sigma_1 = \dfrac{\sigma_x - \sigma_y}{2} + \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_2}$

$= \dfrac{-2+4}{2} + \sqrt{\left(\dfrac{-2-4}{2}\right)^2 + (4)^2} = 1 + 5 = 6\text{MPa}$

$\sigma_2 = \dfrac{\sigma_x - \sigma_y}{2} - \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_2} = 1 - 5 = -4\text{MPa}$

So, $\tau_{max} = \dfrac{6-(-4)}{2} = 5\text{MPa}$

46. Ans. A.



Given, C=20KPa, $\gamma_d = 16\text{kN/m}^3$

$\beta = 40°$, H=5m, ϕ=?

$H = \dfrac{C}{\gamma_d(\tan\beta - \tan\phi)\cos^2\beta}$

$\Rightarrow 5 = \dfrac{20}{16(\tan 40° - \tan\phi).\cos^2 40^2}$

$\Rightarrow \phi = 22.44°$

47. Ans. A.

Group I	Group II
(P) Pressure meter Test (PMT)	(1) Menard's modulus (E_m)
(Q) Static Cone Penetration Test (SCPT)	(3) Skin resistance (f_c)
(R) Standard Penetration Test (SPT)	(2) Number of blows (N)
(S) Vane Shear Test (VST)	(4) Undrained cohesion (c_x)

48. Ans. D.

For friction pile

$Q_u = f_s.A_s$

Where, $f_s = \dfrac{1}{2}\bar{\sigma}_v .K.\ \tan\delta$

$\sigma_V = \gamma_d \times L = 20 \times 20 = 400\text{kN/m}^2$

$\tan\delta = \tan\left(\dfrac{2}{3}\phi\right) = \tan\left(\dfrac{2}{3}\times 30\right) = 0.364$

So, $f_s = \dfrac{1}{2}\times 400 \times 2.7 \times 0.364 = 196.56\ \text{kN/m}^2$

So, $Q_u = (196.56)\times \pi D.L = 196.56 \times \pi \times 0.5 \times 20$

$= 6175\text{kN}$

49. Ans. B.

Elastic settlement of rigid footing

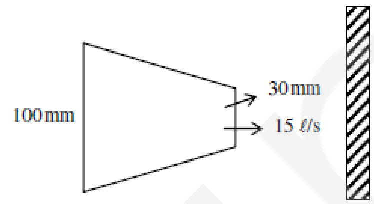
$S = 0.8\left[\dfrac{qB(1-\mu^{2)}}{E}\right]$

Given, q=110kN/m², B=20m, μ=0.30

$E_s = 30\text{GPa} = 30\times 10^3\text{kN/m}^2$

$S = 0.8\left[\dfrac{110\times 20\times(1-0.09)}{30\times 10^3}\right] = 53.38\ \text{mm}$

50. Ans. A.



Velocity of jet, $v = \dfrac{Q}{A} = \dfrac{15\times 10^{-3}\text{m}^{3/s}}{\frac{\pi}{4}\times(0.03)^2}$

$= 21.22\text{m/s}$

Force on plate, $F = \rho a.v^2$

$= 1000 \times \dfrac{\pi}{4}\times(0.03)^2 \times (21.22)^2$

$= 318.29\text{N}$

51. Ans. C.

$Q = C_d.\dfrac{a_1 \times a_2}{\sqrt{a_1^2 - b_2^2}}.\sqrt{2gh}$

$a_1 = \dfrac{\pi}{4}\times(0.2)^2 = 0.0314\text{m}^2$

$a_2 = \dfrac{\pi}{4}\times(0.1)^2 = 0.0078\text{m}^2$

so, $Q = \dfrac{1\times 0.0314\times 0.0078}{\sqrt{(0.0314)^2 - (0.0078)^2}} \times \sqrt{2\times 9.81\times 2}$

$= 0.050\text{m}^3/\text{s}$

52. Ans. C.

$B = 2.5\text{m},\ Q = 4\text{m}^3/\text{s},\ g = 9.81/\text{s}^2$

Critical depth, $y_c = \left(\dfrac{q}{g}\right)^{1/3}$

$q = \dfrac{Q}{B} = \dfrac{4}{2.5} = 1.6\ \text{m}^2/\text{s}$

So, $y_c = \left[\dfrac{(1.6)^2}{9.81}\right]^{1/3} = 0.64\ \text{m}$

Now, $Q = A.v_c$

$\Rightarrow v_c = \dfrac{Q}{B.y_c} = \dfrac{4}{2.5\times 0.64}$

$= 2.5\ \text{m/s}$

53. Ans. D.
Depth of irrigation water

$$d = \frac{\gamma_d}{\gamma_w} d(F.C - W.P)$$

$$= \frac{1.3}{1} \times 70 \times (0.28 - 0.18)$$

$$= 9.1\,cm \Rightarrow 91\,mm$$

54. Ans. A.

$$U = \frac{-h^2}{8\mu}\left(\frac{dp}{dx}\right)\left[1 - 4\left(\frac{y}{2h}\right)^2\right]$$

Maximum velocity is at y=0

$$U_{max} = \frac{-h^2}{8\mu}\left(\frac{dp}{dx}\right)$$

$$U_{avg} = \frac{Q}{A} = \frac{\int U.dA}{A} = \frac{\int U_{max}\left(1 - \frac{4y^2}{h^2}\right).dA}{A}$$

$$= \frac{2\int_0^{h/2} U_{max}\left(1 - \frac{4y^2}{h^2}\right).dy \times 1}{h \times 1} = \frac{2U_{max}}{h}\left[y - \frac{4y^3}{3h^2}\Big|_0^{h/2}\right]$$

$$= \frac{2U_{max}}{h}\left[\frac{h}{2} - \frac{4h^3}{24h^2}\right] = \frac{2}{3}U_{max}$$

55. Ans. B.
Particle size=0.06m < 0.1 mm
So, Stoke's law is valid

$\frac{Q}{A}$ = overflow rate $\le$ settling velocity of 0.06 mm particle

$$\Rightarrow \frac{Q}{A} \le V_s \Rightarrow A = \frac{Q}{V_s}$$

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

$$= \frac{1}{18} \times \frac{(0.06 \times 10^{-3})^2 \times 9.81}{1.0105 \times 10^{-6}} \times (2.65 - 1)$$

$$= 3.20 \times 10^{-3} m/s$$

$$\Rightarrow A \ge \frac{0.1}{3.20 \times 10^{-3}} = 31.21 m^2$$

56. Ans. C.
Given $Q = 35m^3/min = 35 \times 10^3 \times 60 \times 24\ell$

Alum dosage =25 mg/l

Alum quantity required for 30 days

$= 35 \times 10^3 \times 60 \times 24 \times 25 \times 10^{-6} \times 30 = 37800kg.$

57. Ans. B.

$Q = 2760\ m^3/day$, chlorine dose=15 mg/ℓ

$N_b = N_0.e^{-0.145t}$

If 98% micro organisms are killed, 2% are surviving

So, $N_t = 0.02$

N_0 = number of micro-organisms present at t=0

ie., 100%=1

So, $0.02 = e^{-0.145.t} \Rightarrow t = 26.98$ minutes

$$V = Q \times t_d = \left(2670\frac{m^3}{d}\right) \times \left(\frac{26.98}{60 \times 24}\right) = 50.02\ m^3$$

58. Ans. C.

$Q_s = 2m^s/s$, BOD ultimate, $L_s = 90mg/\ell$

$Q_R = 12m^3/s$, $L_R = 5mg/\ell$

$$(BOD)_{mix} = \frac{90 \times 2 + 12 \times 5}{2 + 12} = 17.14mg/\ell$$

Velocity of River flow, $V_R = \frac{Q}{A} = \frac{12 + 2}{50}$

$= 0.28m/s$

Time taken to travel 10km=$\frac{10000}{0.28}$

$= 35714.28s = 0.41d$

$L_t = L_0 \times e^{-kt} = 17.14 \times e^{-0.25 \times 0.41} = 15.46mg/l$

59. Ans. A.

$$VFB = \frac{V_b}{V_{MA}} \times 100$$

Where, V_b = voids filled with bitumen=$\frac{G_m}{G_4} \times W_4$

$$= \frac{2.324}{1.10} \times 5 = 10.564$$

$$V_{MA} = V_v + V_b$$

V_v = Volume of voids=$\frac{G_t - G_m}{G_t} \times 100$

$$= \frac{2.441 - 2.324}{2.441} \times 100 = 4.79\%$$

$$V_{MA} = 10.56 + 4.79 = 15.35$$

So, $V_{FB} = \frac{10.564}{15.35} \times 100 = 68.82\%$

60. Ans. B.

$V = 80 - \frac{2}{3}K$

Capacity $= \frac{V_f \times K_j}{4}$, where

V_f = free mean velocity

K_j = Jam density

K_j is when, V=0

$\Rightarrow K_j = 80 \times \frac{3}{2} = 120$ veh / km

V_f is at K=0, $V_f = 80$ km/h

So, Capacity=$\frac{80 \times 120}{4} = 2400$ veh/h

61. Ans. A.

Total time lost, t=$4 \times 4 = 16a$; $C = \frac{1.5L + 5}{1 - y}$

$Y = y_1 + y_2 + y_3 + y_4$

$= \frac{q_1}{s_1} + \frac{q_2}{s_2} + \frac{q_3}{s_3} + \frac{q_4}{s_4}$

$= \frac{200}{1800} + \frac{187}{1800} + \frac{210}{1800} + y_4 = 0.332 + y_4$

$60 = \frac{1.5 \times 16 + 5}{1 - (0.332 + y_4} \Rightarrow .668 - y_4 = \frac{29}{60} \Rightarrow y_4$

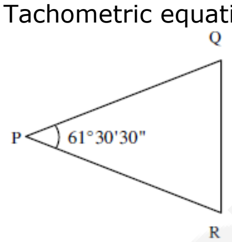
$= 0.185$

Effective green time for 4th phase

$= \frac{(Co - L) \times y_4}{y_1 + y_2 + y_3 + y_4} = \frac{(60 - 16) \times 0.185}{0.332 + 0.185} = 15.74s$

62. Ans. C.

Tachometric equation,



$D = kS + C$

$D_{PZ} = 100 \times 0.32 + 0.10 = 32.1$ m

$D_{PR} = 100 \times 0.210 + 0.10 = 21.1$ m

From cosine rule in triangle PQR

$QR^2 - (PQ)^2 + (PR)^2 - 2(PQ)(PR) \cos 61°30'30"$

$=(32.1)^2 + (21.1)^2 - 2 \times 32.1 \times 21.1 \times \cos 61°30'30"$

=28.8 m

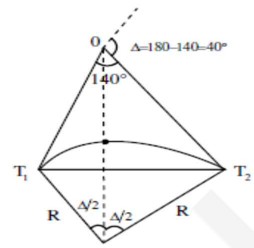
63. Ans. C.

Lenght of curve, $L = \frac{\pi}{180} \times \Delta \times R$

$= \frac{\pi}{180} \times 40 \times 600 = 418.88$ m

Tangent distance, T=R $\tan\left(\Delta/2\right)$

$=600 \tan\left(\frac{40}{2}\right) = 218.38$ m



64. Ans. D.

Flexular tensile strength, $f_{cr} = 0.7\sqrt{f_{ck}}$ N/mm^2

$= 0.7 \times \sqrt{25}$

$= 3.5$ N/mm^2

65. Ans. D.

This is based on moving observer method.
Flow density, q = 45 veh/min = 180 veh/hr
Stream speed vs is computed from equation, As

$$v_s = \frac{l}{t_w - \frac{m_w}{q}}$$

l = 5 Km

t_w = Observation time when the observer is moving with the stream = 25 min = 0.416 hr

M_w = Net vehicles overtake the observer when it is moving with the stream. = 60 vehicles

V_s = 5/(0.416 – 60/180) = 60 km/hr

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