ACE *Pre*-GATE 2017 **Branch: Civil Engg.**

Q.1 – Q.5 Carry One Mark Each

01. Choose the most appropriate phrase from the options given below to complete the following sentence.

The bus stopped to _____ more passengers.

(A) Take in (B) Take on (C) Take up (D) Take for

01. Ans: (B)

02. Choose the appropriate sentence from the following options.

(A) She has been discharged since (B) She has since been discharged.

(C) She has been since discharged (D) She since has been discharged.

02. Ans: (B)

03. Fill in the blank with an appropriate phrase.

The jet _____ into the air.

(A) Soared. (B) Soured (C) Sourced. (D) Sored.

03. Ans: (A)

04. Choose the most appropriate word from the options given below to complete the following sentence.

If I had known that you were coming, I _____ you at the airport.

(A) Would meet (B) Would have met (C) Will have met (D) Had met

04. Ans: (B)

05. Reaching a place of appointment on Friday. I found that I was two days earlier than the scheduled day. If I had reached on the following Wednesday then how many days late would I have been?
(A) One (B) Two (C) Three (D) Four

05. Ans: (c)

Sol: Friday $\rightarrow$ 2 days earlier

Therefore, scheduled day = Friday + 2

= Sunday

Sunday + 3 = Wednesday

Therefore, I would have been late by 3 days

Q.6 – Q.10 Carry two marks each

06. A contractor, who got the contract for building the flyover, failed to construct the flyover in the specified time and was supposed to pay ₹ 50,000 for the first day of extra time. This amount increased by ₹ 4,000 each day. If he completes the flyover after one month of stipulated time, he suffers a loss of 10% in the business. What is the amount he received for making the flyover in crores of rupee? (One month = 30 days)

(A) 3.1 (B) 3.24 (C) 3.46 (D) 3.68

06. Ans: (b)

Sol: The sum of money that the contractor was supposed to pay for the period of an month over the stipulated time is

$$= S_n = \frac{n}{2}[2a + (n-1)d]$$

$a = 50{,}000, \quad n = 30, \quad d = 4000$

$$S_{30} = \frac{30}{2}[2 \times 50{,}000 + (30-1) \times 4000]$$

$$= 15[100{,}000 + 29 \times 4000]$$

₹ 3240000 = ₹ 32.4 lakhs

Loss in the business = 10%

$\therefore$ Amount he received for making the flyover = $\frac{3240000}{0.1} = 32400{,}000$

= ₹ 3.24 crores

07. A person has to go from city A to city E. There is no direct way to reach city E from city A. However, there are intermediate cities B, C and D by which A can travel through. The information about the number of routes between any two cities is given in the table below.

A → B	7 routes
A → C	6 routes
A → D	8 routes
B → C	5 routes
B → E	4 routes
C → E	4 routes
D → E	6 routes

For instance, there are 5 ways in which the person can go from city B and city C. Also, the arrow between cities B and C indicates that the person can travel from city B to C but not from city C to B. In how many ways can that person travel from city A to city E?

(A) 140 (B) 240 (C) 100 (D) 72

07. Ans: (B)

Sol: The routes that can be used are ABE, ABCE, ACE and ADE.

For ABE, number of ways = $7 \times 4 = 28$

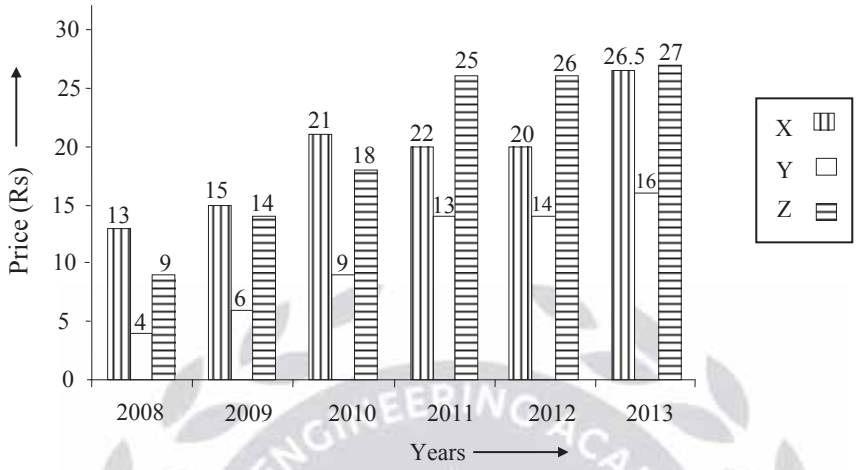
For ABCE, number of ways = $7 \times 5 \times 4 = 140$

For ACE, number of ways = $6 \times 4 = 24$

For ADE, number of ways = $8 \times 6 = 48$

$\therefore$ Total number of ways to travel from city A to city E = 28 +140 + 24 + 48 = 240.

08. The following bar graph shows the price per litre of different fuels X, Y and Z in the year 2008 to 2013. Study the graph carefully and answer the following question.



The percentage increase in the price of fuel X from 2008 to 2013 is ____% of the percentage increase in the price of fuel Z for the given period?

(A) 200% (B) 100% (C) 50% (D) 120%

08. Ans: (C)

Sol: Percentage increase in the price of fuel $X = \frac{26.5-13}{13} \times 100 = 100\%$

Percentage increase in the price of fuel $Z = \frac{27-9}{9} \times 100 = 200\%$

Percent of percentage increase of X to percentage increase of

$$Z = \frac{200-100}{200} \times 100 = \frac{100}{200} \times 100 = 50\%$$

09. Examine the information given below. Who is to the immediate right of P among five persons P, Q, R, S and T, facing north?

Two statements, labeled I and II, are given below. You have to decide whether the data given in the statements are sufficient for answering the question. Using the data given in the statements, you have to choose the correct alternative.

Statements:

I. R is third to the left of Q and P is second to the right of R

II. Q is the immediate left of T who is second to the right of P.

(A) I alone is sufficient while II alone is not sufficient to answer the question.

(B) II alone is sufficient while I alone is not sufficient to answer the question

(C) Either I (or) II is sufficient to answer the question

(D) Neither I (nor) II is sufficient to answer the question

09. Ans: (C)

Sol: From statement I, we have the order: R – P, Q ……. (i)

From statement II, we have the order: P, Q, T ……. (ii)

It is clear from both the equations that Q is to the immediate right of P. So, either of the statements is sufficient to answer the question.

10. Which of the following can be logically inferred from the given statement.

"No other studied medicine except Helen"

(A) Helen only studied medicine (B) Only Helen studied medicine

(C) Helen studied only medicine (D) Helen studied medicine only

10. Ans: (B)

Q.11 – Q.35 Carry one mark each.

11. A 40 m*l* of water sample of treated waste water requires 160 m*l* of odour free distilled water to reduce the odour to a level that is perceptible. What is the threshold odour number (TON) for the waste water sample?

11. **Ans: 5** **Range: No range**

Sol: $\text{TON} = \frac{A+B}{A} = \frac{40+160}{40} = 5$

12. Space occupied by 3000 mg/*l* of MLSS in 1 litre sewage sample after 30 min settling is 300 m*l*. Then SVI in m*l*/gm is_____

12. Ans: 100 **Range: No range**

$$\text{SVI} = \frac{300}{3} = 100 \text{ m}\ell/\text{gm}$$

13. Two sounds 50 dB and 50 dB together produce a sound harmony of _____ dB.

13. Ans: 53 **Range: No range**

$L_T = L_1 + x$ When $L_1 - L_2 = 0$

$L_T = 50 + 3 = 53$ dB $x = 3$ dB

14. A dry soil has a mass specific gravity of 1.84 and specific gravity of solids as 2.7. The void ratio of the soil is_____

Sol: Ans: 0.4674 **Range: 0.46 to 0.47**

Given: $G = 2.7$; $\frac{\gamma_d}{\gamma_w} = 1.84$

$$\frac{\gamma_d}{\gamma_w} = \frac{G}{1+e}$$

$$1.84 = \frac{2.7}{1+e}$$

$$e = 0.4674$$

15. Equilibrium discharge of a S-curve obtained from a storm of effective rainfall intensity 1 cm/hr is 277.8 m^3/sec. Then catchment area represented by the S-curve is____ km^2.

15. Ans: 100 **Range: No range**

$$Q_{equ} = 2.778\frac{A}{D}$$

$$277.8 = 2.778 \times \frac{A}{1}$$

$$A = \frac{277.8}{2.778} = 100\ km^2 \bullet$$

16. Consider the following data related to a project.

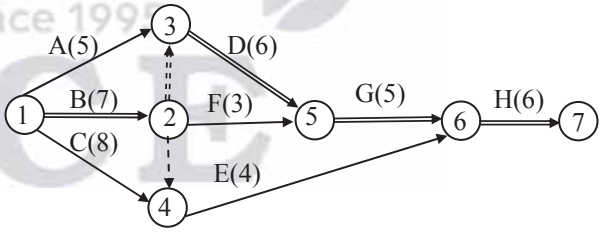
Activity	A	B	C	D	E	F	G	H
Predecessor	-	-	-	A, B	B, C	B	D, F	E, G
Duration (days)	5	7	8	6	4	3	5	6

The project duration is _____

(A) 24 days (B) 22 days (C) 25 days (D) 21 days

16. **Ans: (A)**

Sol:



Path	**Duration**
A-D-G-H	22
B-Dummy-D-G-H	24 → Critical Path
B-F-G-H	21
B-Dummy-E-H	17
C-E-H	18

Project duration = Critical path duration = 24 days

17. The three time estimates of a PERT activity are given as 2, 3 and 10. The expected duration and standard deviation of the activity respectively are

(A) 3 and 1.15 (B) 4 and 1.77 (C) 4 and 1.33 (D) 3 and 1.77

17. Ans: (C)

Sol: $t_o = 2$, $t_m = 3$, $t_p = 10$

Expected duration $(t_E) = \dfrac{t_o + 4t_m + t_p}{6} = \dfrac{2 + 4(3) + 10}{6} = 4$

Standard deviation $(\sigma) = \dfrac{t_p - t_o}{6} = \dfrac{10 - 2}{6} = 1.33$

18. Match **List-I** with **List-II** and select the ***correct*** answer using the codes given below.

List-I		**List-2**
P. Winkler's method	1.	Sulphates
Q. Mohr's method	2.	Hardness
R. Versanate method	3.	D.O
S. Turbidimetry	4.	Chlorides

Codes:

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

18. **Ans: (D)**

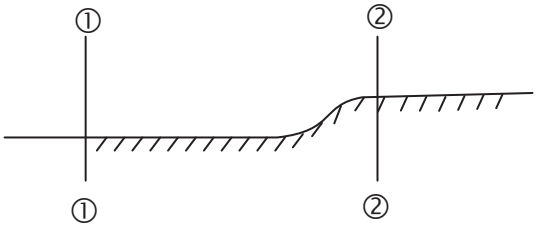
19. The specific energy at upstream and downstream of a open channel are 3 m and 2.6 m respectively. The headloss from upstream to downstream is 0.1 m. The channel transition is

(A) a rise of 0.3 m (B) a rise of 0.4 m

(C) a drop of 0.3 m (D) a drop of 0.4 m

19. Ans: (A)

Sol:



$E_1 > E_2$

$\Rightarrow$ Rise of channel bottom

$E_1 = E_2 + \Delta Z + h_L$

$3 = 2.6 + \Delta Z + 0.1$

$\Rightarrow \Delta Z = 0.3$ m

20. Error due to inclination of line of collimation in levelling across a river can be eliminated by

(A) Reciprocal Levelling (B) Differential Levelling

(C) Making the bubble in the centre (D) Reciprocal ranging

Ans: (A)

21. Match **List-I** with **List-II** and select the ***correct*** answer using the codes given below.

List –I	**List-II**
P. Most probable value	1. Optical instrument for multiple surveys
Q. Total station	2. Ratio between focal of camera and flying height
R. GPS Reciever	3. Arithmetic mean of observation
S. Datum scale	4. ESRI
	5. Microstrip antenna

Codes:

	P	**Q**	**R**	**S**		**P**	**Q**	**R**	**S**
(A)	1	2	3	5	(B)	2	1	3	4
(C)	3	1	5	2	(D)	3	2	5	1

21. Ans: (C)

Since they are all related

22. What is the steepest gradient permissible on a 2° curve for a BG railway line having ruling gradient of 1 in 200?

(A) 1 in 198 (B) 1 in 209 (C) 1 in 238 (D) 1 in 250

22. **Ans: (C)**

Sol: Ruling gradient = 1 in 200

$$= \frac{1}{200} \times 100 = 0.5\%$$

Permissible gradient = Ruling gradient – Total grade compensation for curve

$$= 0.5\% - 0.04\% \times D^\circ \quad \text{(for BG)}$$

$$= 0.5\% - 0.04\% \times 2 = 0.42\% = \frac{0.42}{100} = \frac{1}{238}$$

23. Read the following statements with regard to vertical stress determination below the ground surface.

P. Boussinesq's equation assumes that the soil is homogeneous, isotropic, semi-infinite and elastic medium

Q. Westergaard's equation is best suited to stratified soils like varved clay.

R. Boussinesq's equation gives best results for surcharge loads.

The correct statement/s is/are

(A) P only (B) Q only (C) P and Q only (D) P, Q and R

23. **Ans: (C)**

24. How many number of additional raingauges required to measure mean precipitation with an allowable error 0.3 cm if rain fall recorded by 3 raingauges is 2 cm, 3cm and 4 cm respectively.

(A) 5 (B) 7 (C) 9 (D) 12

24. Ans: (C)

Sol:

$$\sigma = \sqrt{\frac{\Sigma\left(P_i - \overline{P}\right)^2}{n-1}}$$

$$= \sqrt{\frac{1^2 + 1^2}{2}} = 1 \text{ cm}$$

$$\overline{P} = \frac{2+3+4}{3} = 3 \text{ cm}$$

$$E = \frac{0.3}{3} \times 100 = 10\%$$

$$C_V = \frac{100\sigma}{\bar{P}} = \frac{100\times 1}{3} = 33.33\%$$

$$n = \left(\frac{C_v}{E}\right)^2 = \left(\frac{33.33}{10}\right)^2 = 11.11$$

Provide 12 raingauges

Additional Raingauges = 12 – 3 = 9

25. If a, b, c are all different from zero and $\begin{vmatrix} 1+a & 1 & 1 \\ 1 & 1+b & 1 \\ 1 & 1 & 1+c \end{vmatrix} = 0$ then the value of $(a^{-1} + b^{-1} + c^{-1})$ =?

(A) abc (B) $a^{-1} b^{-1} c^{-1}$ (C) –a –b –c (D) –1

25. Ans: (D)

Sol: $\begin{vmatrix} 1+a & 1 & 1 \\ 1 & 1+b & 1 \\ 1 & 1 & 1+c \end{vmatrix} = 0$

$(R_3 - R_2)$ & $(R_2 - R_1)$

$$\Rightarrow \begin{vmatrix} 1+a & 1 & 1 \\ -a & b & 0 \\ 0 & -b & c \end{vmatrix} = 0$$

$\Rightarrow (1 + a)(bc) + a(c + b) = 0$

$bc + abc + ac + ab = 0$

$\therefore (ab + bc + ac) = -abc$

$(c^{-1} + a^{-1} + b^{-1}) = -1$

26. If $x = e^{y+e^{y+e^{y+\cdots\cdots}}}$ then $\frac{dy}{dx} =$ _____.

(A) (1 – x) (B) $\frac{(1-x)}{x}$ (C) $\frac{1}{x}$ (D) $\frac{x}{(1-x)}$

26. Ans: (B)

Sol: $x = e^{y+e^{y+e^{y+\cdots}}}$

$x = e^{y+x}$

$\log x = (y + x)$

$\therefore\ y = (\log x - x)$

$\Rightarrow \dfrac{dy}{dx} = \left(\dfrac{1}{x} - 1\right) = \left(\dfrac{1-x}{x}\right)$

27. The particular solution of $\left(\dfrac{d^2y}{dx^2} + y\right) = \cosh 3x$ is _____

(A) $\dfrac{1}{10}\sinh 3x$ (B) $\dfrac{1}{5}\sinh 3x$ (C) $\dfrac{1}{10}\cosh 3x$ (D) $\dfrac{1}{5}\cosh 3x$

27. Ans: (C)

Sol: $y_p = \dfrac{\cosh 3x}{(D^2+1)} = \dfrac{\left(e^{3x} + e^{-3x}\right)}{2(D^2+1)} = \dfrac{\left(e^{3x} + e^{-3x}\right)}{2(9+1)}$

$= \dfrac{1}{10}\cosh 3x$

28. $L^{-1}\left\{\dfrac{e^{-1/s}}{s^{1/2}}\right\} = \dfrac{\cos 2\sqrt{t}}{\sqrt{t}}$ then $L^{-1}\left\{\dfrac{e^{-a/s}}{s^{1/2}}\right\} = ?$

(A) $\dfrac{\cos 2\sqrt{at}}{\sqrt{at}}$ (B) $\dfrac{\cos 2\sqrt{t}}{\sqrt{at}}$ (C) $\dfrac{\cos 2\sqrt{at}}{\sqrt{t}}$ (D) $\dfrac{\cos \sqrt{at}}{\sqrt{t}}$

28. Ans: (C)

Sol: By using change of scale properly

$L^{-1}\left\{f\left(\dfrac{s}{a}\right)\right\} = a\,F(at)$

$$L^{-1}\left\{\frac{e^{\frac{-1}{(s/a)}}}{\left(\frac{s}{a}\right)^{\frac{1}{2}}}\right\}=\frac{a\cos 2\sqrt{at}}{\sqrt{at}}$$

$$\Rightarrow L^{-1}\left\{\frac{e^{-a/s}}{s^{1/2}}\right\}=\frac{\cos 2\sqrt{at}}{\sqrt{t}}$$

29. A biased die such that any even number is twice likely to occur for any odd number is rolled once. What is the probability of getting a number greater than '3' occurring in a single roll of the die?

(A) $\frac{4}{9}$ (B) $\frac{5}{9}$ (C) $\frac{3}{9}$ (D) $\frac{1}{9}$

29. Ans: (B)

Sol:

X	1	2	3	4	5	6
P(X)	P	2P	P	2P	P	2P

But P + 2P + P + 2P + P + 2P = 9P = 1

$$= P = \frac{1}{9}$$

$\therefore$ Required probability = 2P + P + 2P = 5P = $\frac{5}{9}$

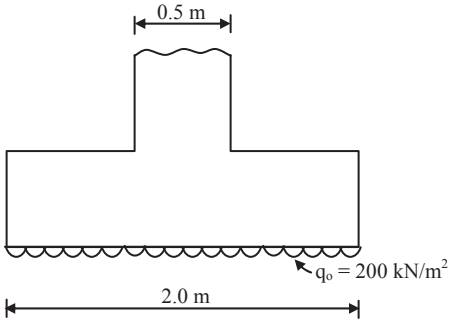
30. A plain concrete footing shown in figure is made of M20 concrete. The minimum thickness of the footing required based on IS: 456-2000 is _____

(A) 1278 mm

(B) 1909 mm

(C) 955 mm

(D) Insufficient data



30. Ans: (C)

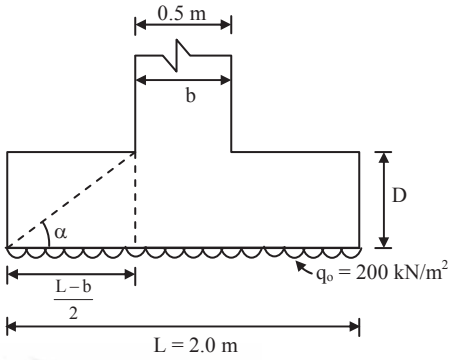
Sol: As per IS: 456-2000 for PCC footings

$$\tan\alpha = 0.9\sqrt{\frac{100\times 200\times 10^{-3}}{20}+1} = 1.2728$$

Thickness of footing $D = \left(\frac{L-b}{2}\right)\tan\alpha$

$$= \left(\frac{2-0.5}{2}\right)\times 1.2728$$

$$= 0.9546 \text{ m} = 955 \text{ mm}$$



31. Neglecting axial deformation, the kinematic indeterminacy of the beam shown in the figure below is

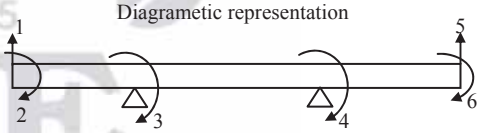
(A) Six (B) Five (C) Four (D) Three

31. Ans: (A)

$$\left.\begin{matrix} j = 4 \\ m = 3 \\ r = 4 \end{matrix}\right\} D_k' = 3j - r = 3\times 4 - 4 = 8$$

Member 2 cannot undergo change in length

$\Rightarrow$ Final $D_k = 8 - 1 - 1 = 6$



32. Consider the following statements.

P. Poisson's ratio for incompressible material is 0.5

Q. In pure bending the beam bends in the form of circular arc.

R. Middle third rule, for no tension is applicable for solid circular cross sections.

Which of the following statements are correct

(A) P and Q (B) P and R (C) Q and R (D) P, Q and R

32. **Ans: (A)**

(i) For incompressible material Poisson's ratio is 0.5.

(ii) Incase of pure bending the beam bends in the form of arc of a circle with Radius (R) as constant. This is one of the assumptions in bending theory

(iii) Middle third rule is applicable for a rectangular (or) square sections. For solid circular section middle fourth rule is applicable.

33. The design strength of workshop bolt is_____ that of deign strength of site bolt as per LSD of IS800:2007

(A) 20 % Higher than (B) 10 % Higher than

(C) 10% Lesser than (D) Same as

33. **Ans: (D)**

Sol: The installation of bolt by using spanner in case of ordinary bolt or torque wrench in case of HSFG bolt at workshop and site conditions are involving same quality, hence the partial safety factor against bolt yield and ultimate strength is same for work shop bolt and site bolt as per LSD of IS 800:2007. Hence design strength of workshop and site bolt is same

34. Which of the following statements are true

P. The frictional stress in a rigid pavement is zero if the pavement slab is weightless

Q. The stress due to self weight during day time is tensile on bottom fibre

R. The load stress is tensile on bottom fibre during day time.

(A) P and Q (B) Q and R (C) P and R (D) P, Q and R

34. Ans: (A)

Sol: Wheel load stress is tensile at corner at any time (day/night) at winter or summer. Therefore statement 'R' is wrong

Frictional stress is proportional to self weight only

Warping stress during day time is tensile at bottom face of edge and interior.

35. Which of the following statements are true?

P. Safe stopping sight distance in case of single lane two way traffic is intermediate sight distance

Q. Coefficient of lateral friction on horizontal curves is 0.35 to 0.4

R. The ideal transition curve for horizontal transition is spiral

(A) P and Q (B) Q and R (C) P and R (D) P, Q and R

35. Ans: (C)

Sol: Option C is correct

Statement Q is wrong

As lateral friction on horizontal curve is 0.15

Q.36 – Q.65 carry two marks each.

36. A Cl_2 dose of 0.6 mg/l is required of pH 8. The amount of Cl_2 dose required to have same degree at removal for same contact time at pH 7 in mg/lit is_____ (take $k = 2.7 \times 10^{-8}$ mol/lit)

36. Ans: 0.205 (Range: 0.20 to 0.21)

at pH = 8 $\quad \%\ HOCl = \dfrac{100}{1+\dfrac{2.7\times10^{-8}}{10^{-8}}} = 27.02$

at pH = 7 $\quad \%\ HOCl = \dfrac{100}{1+\dfrac{2.7\times10^{-8}}{10^{-7}}} = 78.74$

$(Cl_2 \text{ dose} \times \%\ HOCl)_{pH=8} = (Cl_2 \text{ dose} \times \%\ HOCl)_{pH=7}$

$0.6 \times 27.02 = Cl_2 \text{ dose} \times 78.74$

$\therefore\ Cl_2 \text{ dose} = 0.205$ mg/lit

37. The concentration of 120 μg/m^3 of NO_2 at temperature 20°C and pressure 101.39 kPa in terms of ppm (Take $R = 82.05 \times 10^{-6}$ atm. m^3/mol.k) is_____

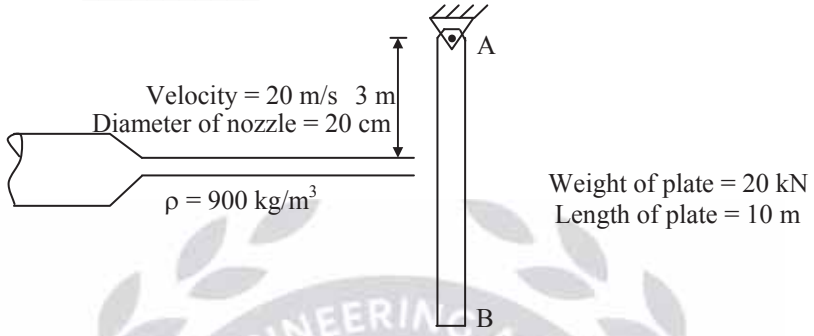
37. Ans: 0.06 Range: 0.05 to 0.07

Sol: M : Mol. Weight of $NO_2 = 14+2\times 16 = 46$

$$K = 82.05 \times 10^{-6} \times \frac{T}{P} \times 10^3 = 82.05 \times 10^{-6} \times \frac{293}{1} = 24.04$$

$$120\ \mu g/m^3 \text{ of } NO_2 = 120 \times \frac{K}{M\times10^3} = 120\times \frac{24.04}{46\times10^3} = 0.06 \text{ ppm}$$

38. A metal plate weighing 20 kN and 10 m long is hung as shown in figure. A jet of liquid of 20 cm diameter impinges with its axis perpendicular and 3 m below the edge of hinge and with a velicity of 20 m/sec. The angle of inclination of the flat plate with respect to the vertical axis, for the system given below is _____ degree

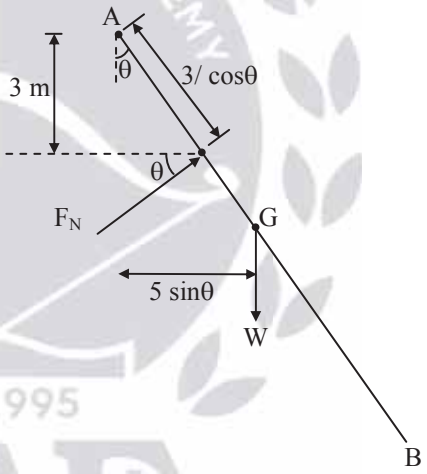


38. Ans: 19.83 **Range: (19.5 to 20.5)**

Sol: $F_N = \rho A V^2 \cos\theta$

For equation

$\sum M_A = 0$



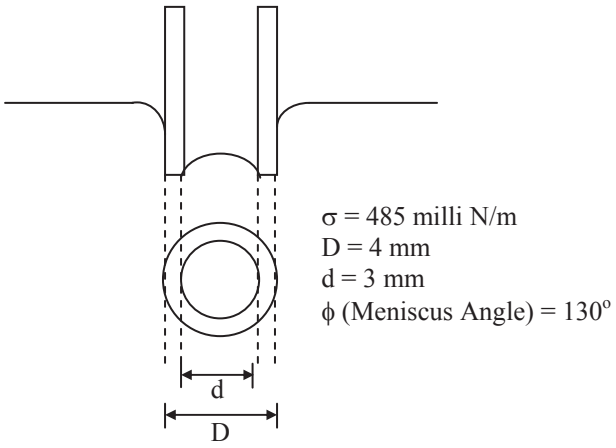
$$\Rightarrow F_N\left(\frac{3}{\cos\theta}\right) = W(5\sin\theta)$$

$$3(\rho A V^2) = 5W\sin\theta$$

$$\Rightarrow \sin\theta = \frac{3\times 900\times \pi\times (0.2)^2\times 20^2}{5\times 4\times 20{,}000}$$

$$\Rightarrow \theta = 19.83^o$$

39. The value of upward thrust (in milli N) imparted by the fluid on the glass tube is_____



39. Ans: 6.86 **Range: (6.7 to 6.9)**

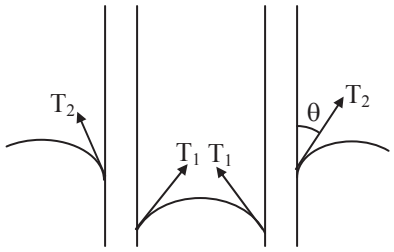
Sol: $\theta = 180 - \phi$

$= 50^o$

$F = \sigma.L$

$\Rightarrow T_1 = \sigma\pi d$

$= (0.485) \times \pi \times 3 \times 10^{-3}$



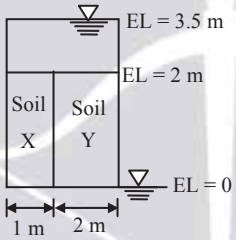
Similarly $T_2 = \sigma\pi D$

$= (0.485) \times \pi \times 4 \times 10^{-3}$

Upward thrust $= (T_1 + T_2) \cos 50^o$

$= 6.86 \times 10^{-3}$ N

40.



Two soils, soil X and soil Y are arranged as shown above. The permeability of the soils X and Y are 0.1 cm/sec and 0.01 cm/sec respectively. The total quantity of flow per metre length will be_____ cm^3/sec.

40. **Ans: 2100** **Range: No range**

Sol: $k_x = 0.1$ cm/sec $= 10^{-3}$ m/s; $k_y = 0.01$ cm/sec $= 10^{-4}$ m/s

Flow is occuring vertically downward through both soils simultaneously (Flow is parallel in both soils)

$\therefore$ Hydraulic gradient is same in both cases.

$$i = \frac{h}{Z} = \frac{3.5}{2} = 1.75$$

Total quantity of flow, $Q = Q_x + Q_y$

$Q = k_x \,.\, i_x.\, A_x + k_y.\, i_y.\, A_y$

$= 10^{-3} \times 1.75 \times 1 \times 1 + 10^{-4} \times 1.75 \times 2 \times 1$

$= 10^{-4} \times 17.5 + 10^{-4} \times 3.5$

$= 21 \times 10^{-4}$ m^3/sec/m

$= 21 \times 10^{-4} \times 10^6 = 2100$ cm^3/sec/m

41. A CU test was conducted on a saturated normally consolidated clay. The sample failed at a deviator stress of 60 kPa when the cell pressure was 120 kPa. If $\phi' = 20°$, the pore water pressure (kPa) at failure is_____

41. Ans: 62.28 **Range: 61 to 64**

For NC clay, in CU test C_u & $C' = 0$

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

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

$$(120 + 60 - u) = (120 - u)\tan^2\left(45 + \frac{20}{2}\right)$$

Solving, we get u = 62.28 kPa

42. A smooth vertical wall 5m high retains a soil which has $\phi = 20°$, C = 10 kPa and $\gamma = 18$ kN/m^3. The horizontal backfill carries a uniform surcharge load of 40 kN/m^2. If the retaining wall is caused to move towards the backfill soil, the intensity of lateral earth pressure developed at the base of the wall in kPa is_____

42. Ans: 293.7 **Range: 290 to 295**

As the wall is moved towards the backfill, passive pressure develops behind the wall.

$$k_P = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 20°}{1-\sin 20} = 2.04$$

At base, $p_p = k_p.\sigma_v + 2C\sqrt{k_p}$

$= k_p(q + \gamma H) + 2C\sqrt{k_p}$

$= 2.04(40 + 18 \times 5) + 2 \times 10\sqrt{2.04} = 293.7$ kN/m^2

43. In a gravity dam of elementary profile, the vertical stress at toe is found to be 900 kPa. Magnitude of principal stress there is _____kPa with specific gravity of concrete 2.5 and uplift coefficient 1.

43. Ans: 1500 **Range: No range**

Vertical stress at toe = wH (S – C)

Principal stress at toe = wH (S – C + 1)

wH (S – C) = 900

wH (S – C+1) = ?

$\Rightarrow$ 1500 kPa

44. A prestressed concrete beam is subjected to initial prestress 1000 MPa and area of tendons is 200 mm^2. Ignoring the curvature effect then the loss of prestressing force at 5 m due to friction is_____ kN (Take $\mu = 0.25$, $k = 0.002/m$, $L = 10$ m)

44. **Ans: 198.009** **Range: (196 - 200)**

$P_x = P_o e^{-kx}$

$= \sigma_o A_s e^{-kx}$

$= 1000 \times 200\, e^{-0.002 \times 5}$

$= 198.009$ kN

45. If the sides of a box are 2 ± 0.01 m, 3± 0.02 m, 4 ± 0.03 m, most probable value of the volume of box in (m^3) is_____

45. Ans: 24 ± 0.2691 **Range: (23.7 to 24.3)**

V = a . b . c

a = 2; $e_a = \pm 0.01$ m

b = 3; $e_b = \pm 0.02$ m

c = 4; $e_c = \pm 0.03$ m

$$e_v^2 = \left(\frac{\partial v}{\partial a}\right)^2 e_a^2 + \left(\frac{\partial v}{\partial b}\right)^2 e_b^2 + \left(\frac{\partial v}{\partial c}\right)^2 .e_c^2$$

$$\frac{\partial v}{\partial a} = b.c = 12;\ \frac{\partial v}{\partial b} = a.c = 8;\ \frac{\partial v}{\partial c} = a.b = 6$$

$$e_v^2 = 12^2 \times 0.01^2 + 8^2(0.02)^2 + 6^2(0.03)^2$$

$$= 0.0144 + 0.0256 + 0.0324$$

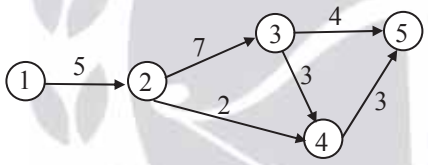
$$e_v^2 = 0.0724$$

$$\therefore \quad e_v = \pm 0.2691 m^3$$

$$V = 24$$

$$M.P.V = V \pm e_v = 24 \pm 0.2691\ m^3$$

46. Consider the following project network with six activities



The total float of activity 2-4 and 3-5 respectively are

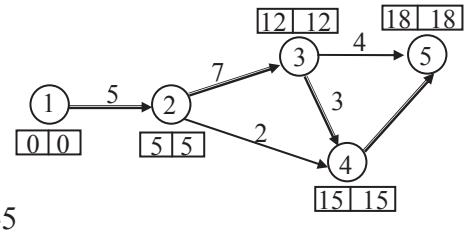
(A) '0' and '2' (B) '2' and '4'

(C) '0' and '0' (D) '8' and '2'

46. **Ans: (D)**

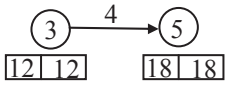
Path	**Duration**
1-2-3-516	$\Rightarrow$ Total float = 18 – 16 = 2
1-2-3-4-5	18 $\Rightarrow$ Total float = 18 – 18 = 0
1-2-4-5	10 $\Rightarrow$ Total float = 18 – 10 = 8

Critical Activity:



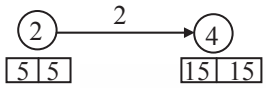
1-2, 2-3, 3-4 and 4-5

Sub-critical activity (3-5):



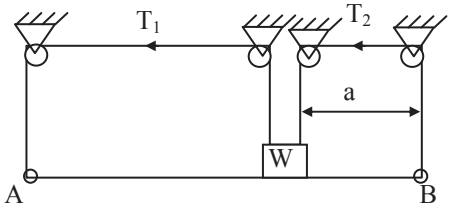
Total float = (18 – 12) – 4 = 2

Non ciritical activity (2-4):



Total float = (15 – 5) –2 = 8

47. AB is a massless rod of length L. Find T_1 and T_2 for equilibrium to be established.



(A) $T_1 = \frac{W}{2}\left(\frac{a}{L}\right)$ $T_2 = \frac{W}{2}\left(\frac{L+a}{L}\right)$

(B) $T_1 = \frac{W}{2}\left(\frac{a}{L}\right)$ $T_2 = \frac{W}{2}\left(\frac{L-a}{L}\right)$

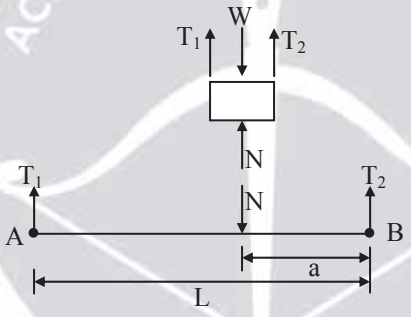
(C) $T_1 = \frac{W}{2}\left(\frac{L-a}{L}\right)$ $T_2 = \frac{W}{2}\left(\frac{a}{L}\right)$

(D) $T_1 = \frac{W}{2}\left(\frac{2a}{L}\right)$ $T_2 = \frac{W}{2}\left(\frac{L-2a}{L}\right)$

47. **Ans: (B)**

For Block:

$W = N + T_1 + T_2$



For Rod:

$N = T_1 + T_2$

$\sum M_B = 0$

$T_1 L = (T_1 + T_2)a$

$T_2 = \frac{T_1(L-a)}{a}$

$\Rightarrow W = 2(T_1 + T_2)$

$\Rightarrow \frac{W}{2} = T_1 + T_1\left(\frac{L-a}{a}\right)$

$\frac{W}{2} = \frac{T_1 a + T_1 L - T_1 a}{a}$

$\frac{Wa}{2} = T_1 L$

$T_1 = \frac{W}{2}\frac{a}{L}$

$\frac{W}{2} = T_1 + T_2$

$$\Rightarrow T_2 = \frac{W}{2} - \frac{W}{2}\frac{a}{L}$$

$$T_2 = \frac{W}{2} - \left(1 - \frac{a}{L}\right)$$

$$\Rightarrow T_2 = \frac{W}{2}\left(\frac{L-a}{L}\right)$$

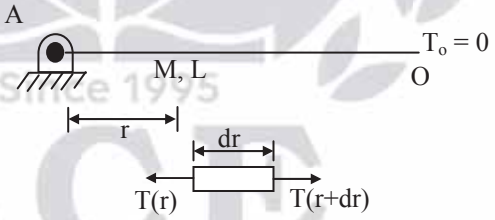
48. A rope of mass "M" and length "L" is tied at A and whirled at an angular veloicty of "ω". The tension in the rope at a radius 'r' from A is

(A) $\frac{M.\omega^2}{2L}.r^2$ (B) $\frac{M.\omega^2}{2L}(L^2 - r^2)$ (C) $\frac{M.\omega^2}{2L}(L^2 + r^2)$ (D) $\frac{M.\omega^2}{L}(L^2 + r^2)$

48. Ans: (B)

Sol: By force balancing

$$T(r) - T(r + dr) = dm.r.\omega^2$$



$$dm = \frac{M}{L}.dr$$

$$-dT = \frac{M}{L}.\omega^2.r.dr$$

$$\rightarrow \quad T = \frac{-M}{L}.\omega^2.\frac{r^2}{2} + C \quad \text{\_\_\_\_\_ (1)}$$

at r = L ; $T = T_o = 0$

$$0 = \frac{-M}{L}\omega^2.\frac{L^2}{2} + C$$

$$C = \frac{M}{L}.\frac{\omega^2}{2}.L^2$$

Substitute C in Equation (1)

$$T = -\frac{M}{L}\omega^2\frac{r^2}{2} + \frac{M}{L}\frac{\omega^2}{2}L^2$$

$$\Rightarrow \quad T = \frac{M\omega^2}{2L}(L^2 - r^2)$$

49. An inclined manometer uses mercury and has a least count of 3 mm. If the minimum pressure difference measured is 100 Pa, the approximate sensitivity of the manometer is _____

(A) 4 (B) 3 (C) 2 (D) 1.5

49. Ans: (A)

3 mm of Hg = 3 × 133 Pa

= 400 Pa (approx.)

(3 mm sinθ) of Hg = 100 Pa

$$\Rightarrow \sin\theta = \frac{1}{4} \Rightarrow S = \frac{1}{\sin\theta} = 4$$

$\therefore$ The sensitivity of the Manometer = 4

50. A certain clay layer has a thickness of 5 m. After 1 year, when the clay was 50% consolidated, 8 cm of consolidation settlement occured. For a similar clay and loading conditions, what would be the settlement at the end of 4 years, if the thickness of this new clay layer is 25 m?

(A) 8 cm (B) 16 cm (C) 32 cm (D) 48 cm

50. **Ans: (B)**

For clay of 5 m thick

$$T_v = \frac{C_v t}{d^2} \qquad U = \frac{S_1}{S_{f_1}} \times 100$$

$$T_v = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 \qquad 50 = \frac{8}{S_{f_1}} \times 100$$

$$= \frac{\pi}{4}\left(\frac{50}{100}\right)^2 = 0.196 \qquad \therefore\ S_{f_1} = 16 \text{ cm}$$

For the clay of 25 m:

Since $S_f \propto H_o$ for same loading conditions

$$\therefore \quad S_{f_2} = \frac{25}{5} \times 16 = 80\,\text{cm}$$

Since C_v will be same for the same clay

$$T_v \propto \frac{t}{d^2}$$

$$\frac{T_{V_2}}{T_{V_1}} = \frac{t_2}{t_1}\left(\frac{d_1}{d_2}\right)^2$$

$$\frac{T_{V_2}}{0.196} = \frac{4}{1}\left(\frac{5}{25}\right)^2$$

$$T_{V_2} = 0.0314\,;\; T_{V_2} = \frac{\pi}{4}\left(\frac{U_2}{100}\right)^2$$

$$0.0314 = \frac{\pi}{4}\left(\frac{U_2}{100}\right)^2$$

$$U_2 = 20\%$$

$$S_2 = U_2 \times S_{f_2} = 0.2 \times 80 = 16\ \text{cm}$$

51. A nine pile group arranged in a square pattern consists of 250 mm diameter piles of 8m length. The spacing between the piles is 750 mm. The soil consists of uniform deposit of medium clay with unconfined compressive strength of 120 kN/m^2. The shear mobilisation factor is 0.8. Considering a factor of safety of 2.5, the safe load carrying capacity of the group by block failure mode is

(A) 2005 kN (B) 4010 kN (C) 1736 kN (D) 3015 kN

51. Ans: (A)

Take $N_c = 9$

$B_o = 2s + d = 2 \times 0.750 + 0.250 = 1.75$ m

$$C_u = \frac{q_u}{2} = \frac{120}{2} = 60\ \text{kN/m}^2$$

Safe load for block failure mode

$$= \frac{1}{F}(A_B.CN_c + A_s.C)$$

$$= \frac{1}{F}(B_o^2.CN_c + 4B_o.L.C)$$

$$= \frac{1}{2.5}(1.75^2 \times 60 \times 9 + 4 \times 1.75 \times 8 \times 60) = 2005.5\,\text{kN}$$

52. Match the following

List-I	List-II
P. SPT	1. N-value
Q. CPT	2. Point resistance and skin resistance
R. Plate load test	3. In-situ shear strength of clays
S. Field vane shear test	4. Load settlement data

Codes:

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

52. Ans: (D)

53. If $\begin{vmatrix} a+1 & a+2 & a+p \\ a+2 & a+3 & a+q \\ a+3 & a+4 & a+r \end{vmatrix} = 0$ then p, q, r are in

(A) A. P (B) G. P (C) H. P (D) None of these

53. Ans: (A)

Sol: $\begin{vmatrix} a+1 & a+2 & a+p \\ a+2 & a+3 & a+q \\ a+3 & a+4 & a+r \end{vmatrix} = 0$

$(R_3 - R_2)\ (R_2 - R_1)$

$$\Rightarrow \begin{vmatrix} a+1 & a+2 & a+p \\ 1 & 1 & q-p \\ 1 & 1 & r-q \end{vmatrix} = 0$$

$(R_3 - R_2)$

$$\Rightarrow \begin{vmatrix} a+1 & a+2 & a+p \\ 1 & 1 & q-p \\ 0 & 0 & r-2q+p \end{vmatrix} = 0$$

$\therefore (r - 2q + p)(a + 1 - a - 2) = 0$

$\therefore (p + r) = 2q$

i.e., 'q' is the AM of p and q

54. The solution of $\frac{d^2y}{dx^2} = y$ which passes through the origin and $\left(\ell n2, \frac{3}{4}\right)$ is _____

(A) $y = \frac{e^x}{2} - e^{-x}$ (B) $\frac{3}{8}\left(e^x + e^{-x}\right)$

(C) $y = \frac{1}{2}\left(e^x - e^{-x}\right)$ (D) $\frac{e^x}{2} + e^{-x}$

54. Ans: (C)

Sol: The given equation is $(D^2 - 1)\ y = 0$

i.e., $D = \pm 1$ are the roots of A. E

$\therefore y = (C_1e^x + C_2e^{-x})$

If it passes through the origin i.e. $x = 0, y = 0$

then $C_1 + C_2 = 0$ ..... (1)

Similarly if passes through $\left(\ell n2, \frac{3}{4}\right)$

then $\frac{3}{4} = \left(2C_1 + 0.5C_2\right)$ ..... (2)

By solving (1) & (2) for C_1 ; C_2

We get $C_1 = 0.5 \& C_2 = -0.5$

$\therefore y = \frac{1\left(e^x - e^{-x}\right)}{2}$ is the required solution.

55. $\int_C \frac{z\cos z}{\left(z - \frac{\pi}{2}\right)^2} dz =$? where 'C' is $|Z - 1| = 1$

(A) $i\pi$ (B) $-i\pi$ (C) $i\pi^2$ (D) $-i\pi^2$

55. Ans: (D)

Sol: $z = \frac{\pi}{2} = \frac{3.14}{2} = 1.57$ is a pole of order '2' lies inside 'C'

$\therefore \int_C \frac{z\cos z}{\left(z - \frac{\pi}{z}\right)^2} dz = 2\pi i \, f^1\left(\frac{\pi}{2}\right)$ (where f(z) = zcosz)

$= 2\pi i\left(\frac{-\pi}{2}\right)$

$= -\pi^2 i$

56. $f(x, y) = (x^2 + y^2 + 6x\ 12)$ has

(A) maximum value at (–3, 0) (B) minimum value at (–3, 0)

(C) maximum value at (0, –3) (D) minimum value at (0, –3)

56. Ans: (B)

Sol: $\frac{\partial f}{\partial x} = (2x + 6) = 0$ ..... (1)

$\frac{\partial f}{dy} = 2y = 0$ ..... (2)

By solving (1) & (2) for (x, y) = (–3, 0) is the stationary point

$r = \frac{\partial^2 f}{\partial x^2} = 2,\ s = \frac{\partial^2 f}{\partial x \partial y} = 0,\ t = \frac{\partial^2 f}{\partial y^2} = 2$

$\therefore$ At (–3, 0); $(rt - s^2) = 4$ & $r = 2$

$\therefore$ we get minimum value of f(x ,y)

57. Consider simply supported prestressed concrete beam of size b × D. The span of beam is 'L'. It is subjected to uniformly distributed load w (kN/m) throughout the span. If the stress at bottom fibre at midspan is zero, what is the stress at top fibre at a distance $\frac{L}{4}$ from either end is_____ $\left(\text{Take } e = \frac{D}{6}\right)$

(A) $\frac{2P}{bD}$ (B) $\frac{3}{2}\frac{P}{bD}$ (C) $\frac{P}{2bD}$ (D) $\frac{2}{3}\frac{P}{bD}$

57. Ans: (B)

At centre

$$f_{bottom} = \frac{P}{A} + \frac{Pe}{Z} - \frac{M}{Z} = 0$$

$$= \frac{P}{bD} + \frac{P\left(\frac{D}{6}\right)}{\frac{bD^2}{6}} - \frac{\frac{wL^2}{8}}{\frac{bD^2}{6}} = 0$$

$$\Rightarrow \quad \frac{2P}{bD} = \frac{\frac{wL^2}{8}}{\frac{bD^2}{6}}$$

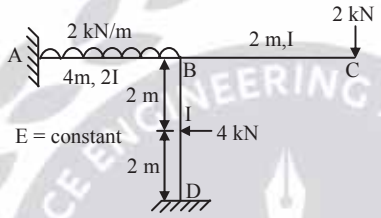
At L/4

B.M at $\frac{L}{4} = \frac{wL}{2} \times \frac{L}{4} - \frac{wL}{4}.\frac{L}{8} = \frac{3}{32}.wL^2$,

$$f_{top} = \frac{P}{A} - \frac{Pe}{Z} + \frac{M}{Z} = \frac{P}{bD} - \frac{P\left(\frac{D}{6}\right)}{\frac{bD^2}{6}} + \frac{3}{4}\frac{\left(\frac{wL^2}{8}\right)}{\frac{bD^2}{6}}$$

$$= \frac{3}{4}\left(\frac{2P}{bD}\right) = \frac{3}{2}\left(\frac{P}{bD}\right)$$

58. The rotation of joint B (θ_B) in the rigid frame shown in figure below is:



(A) $\frac{4.44}{EI}$ (B) $\frac{3.33}{EI}$ (C) $\frac{2.22}{EI}$ (D) $\frac{1.11}{EI}$

58. Ans: (D)

$$M_{FBA} = \frac{+2\times 4^2}{12} = +2.67 \text{ kN-m}$$

$$M_{FBD} = \frac{-4\times 4}{8} = -2 \text{ kN-m}$$

Slope-deflection equations are

$$M_{BA} = M_{FBA} + \frac{2E(2I)}{4}(2\theta_B + \theta_A)$$

$$M_{BD} = M_{FBD} + \frac{2EI}{4}(2\theta_B + \theta_D)$$

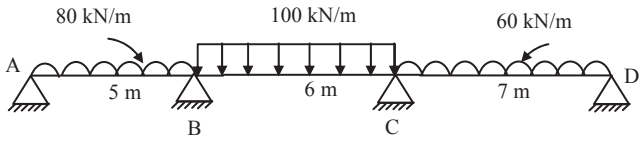
Since support A and D are fixed, $\theta_A = \theta_D = 0$

$M_{BC} = -2 \times 2 = -4$ kN-m

Now, $M_{BA} + M_{BD} + M_{BC} = 0$

Give $\theta_B = \frac{1.11}{EI}$

59. A three span continous beam ABCD is loaded with ultimate loads as shown in the figure below. The required plastic moment of resistance considering beam of uniform section is



(A) 171.6 kN-m (B) 225 kN-m (C) 252.23 kN-m (D) 260 kN-m

59. Ans: (C)

Span AB behaves like propped $\Rightarrow M_{P_1} = \frac{w_c \ell^2}{11.656} = 171.6$ kN-m

Proped cantilever $\Rightarrow w_c = \frac{11.656\, M_P}{\ell^2}$

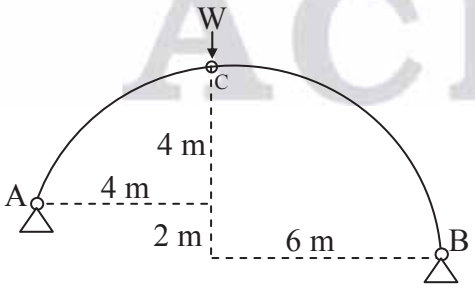
Span BC behaves like fixed beam $\Rightarrow M_{P_2} = \frac{w_c \ell^2}{16} = 225$ kN-m

$\Rightarrow w_c = \frac{16 M_p}{\ell^2}$

Span CD behaves like propped cantilever $\Rightarrow M_{P_3} = \frac{w_c \ell^2}{11.656} = 252.23$ kN-m

Maximum of the above three values gives required $M_p = 252.23$ kN-m

60. The resultant reaction at support A of the 3-hinged arch shown in figure is



(A) $\frac{W}{\sqrt{2}}$ (B) $\frac{W}{2}$ (C) $W\sqrt{2}$ (D) 2W

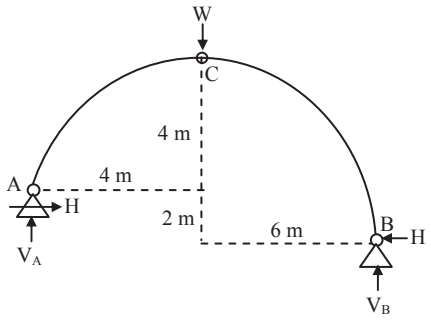
60. Ans: (A)

$$\sum M_c = 0(LHS) \Rightarrow V_A \times 4 - H \times 4 = 0$$

$$V_A = H$$

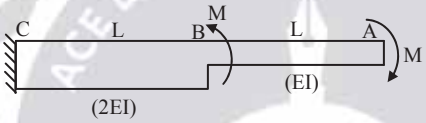
$$\sum M_c = 0(RHS) \Rightarrow V_B \times 6 - H \times 6 = 0$$

$$V_B = H \Rightarrow V_A = V_B = \frac{W}{2} = H$$



$$R_A = \sqrt{V_A^2 + H^2} = \sqrt{\left(\frac{W}{2}\right)^2 + \left(\frac{W}{2}\right)^2} = \frac{W}{2}\sqrt{2} = \frac{W}{\sqrt{2}}$$

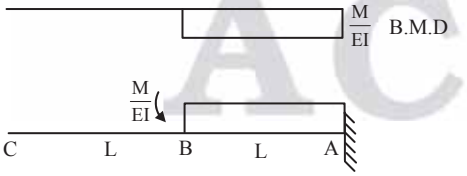
61. A cantilever beam shown in figure is subjected to the loading. The free end deflection of the beam is



(A) $\frac{ML^2}{2EI}$ (B) $\frac{ML^2}{3EI}$ (C) $\frac{2ML^2}{3EI}$ (D) $\frac{ML^2}{EI}$

61. Ans: (A)

Using conjugate beam method



Conjugate beam

Deflection at free end of contilever beam = BM at the free end of conjugate beam

$y_A = (BM)_A$ of conjugate beam

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

62. A circular tube used as a strut in a roof truss is under axial compression with sectional area 2000 mm^2. The yield and ultimate tensile stress of steel are 250 MPa and 410 MPa respectively. The stress reduction factor is 0.62. The partial safety factor against yield and ultimate tensile stress is 1.10 and 1.25 respectivley. The design axial compression load allowed on strut as per LSD of IS 800:2007 is

(A) 462 Kn (B) 406 kN (C) 248 kN (D) 280 kN

62. Ans: (D)

Sol: Design compressive load capacity of strut $P_d = f_{cd}.A_e$

Design stress in axial compression $f_{cd} = \chi \frac{f_y}{\gamma_{mo}} \le \frac{f_y}{\gamma_{mo}}$

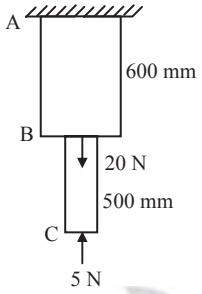
Stress reduction factor account for buckling classification $= \chi = 0.62$

Design stress in axial compression $f_{cd} = \chi \times f_y/\gamma_{mo} = 0.62 \times 250/1.10 = 140.09$ N/mm^2

Design compressive load carrying capacity of strut $= P_d = f_{cd} \times A_e = 140.09 \times 2000$

$= 280.18 \times 10^3$N $= 280.18$ kN

63. A stepped bar is hung from the ceiling as shown in figure. The cross-section of AB = 500 mm^2, and that of BC = 200 mm^2. Assuming density of both the rods are 75,000 N/m^3, the axial force just above B is



(A) 32.5 N (B) 22.5 N (C) 90 N (D) 100 N

63. Ans: (B)

The forces acting just above point-B

$= + 20 - 5 +$ weight of BC

$= + 20 - 5 + \gamma$ (volume of BC)

$= + 20 - 5 + (75000\ N/m^3)(0.5\ m \times 200 \times 10^{-6}\ m^2)$

$= + 20 - 5 + 7.5 = 22.5\ N$●

64. In a Marshall testing of bituminous mix the following ingredients with percentage weights and specific gravities are observed. The weight and volume of Marshall mould is 800 g and 358.74 cm^3

Ingredient	**CA**	**FA**	**Fly ash**	**Bitumen**
% weight	30	40	20	10
Specific gravity	2.63	2.83	2.7	1.1

The percentage voids filled by bitumen (VFB) is

(A) 90.61% (B) 82.32% (C) 72.63% (D) 75.62%

64. **Ans: (A)**

Sol: Theoritical specific gravity

$$\frac{100}{G_t} = \frac{30}{2.63} + \frac{40}{2.83} + \frac{20}{2.7} + \frac{10}{1.1}$$

$$G_t = 2.38$$

Measured specific gravity

$$\gamma_m = \frac{w}{V} = \frac{800g}{358.74\,cm^3} = 2.23\,g/cc$$

$$G_m = \frac{\gamma_m}{\gamma_w} = \frac{2.33}{1} = 2.23$$

Percentage air voids

$$V_a = \frac{G_t - G_m}{G_t} \times 100 = \frac{2.38 - 2.33}{2.38} \times 100 = 2.1\%$$

Percentage volume of bitumen

$$V_b = G_m\left(\frac{W_b}{G_b}\right) = 2.23\left(\frac{10}{1.1}\right) = 20.27\%$$

$$VMA = V_a + V_b = 22.37\%$$

$$VFB = \frac{V_b}{VMA} \times 100 = \frac{20.27}{22.37} \times 100 = 90.61\%$$

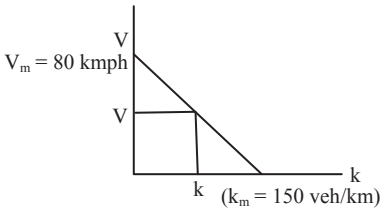
65. In a linear speed density model given by Greenshield, the jam density is 150 veh/km. The free flow speed is 80 kmph. For a traffic volume of 2000 veh/hr, the maximum possible traffic density is _____ (veh/km)

(A) 31.62 (B) 119.3 (C) 162.72 (D) 123.23

65. Ans: (B)

In a linear speed density relation

$$q_m = \frac{V_m}{2}.\frac{k_m}{2} = \frac{80}{2}.\frac{150}{2} = 3000 \text{ veh/hr}$$



For normal condition

$q = V.K$

$$2000 = \frac{80}{150}(150 - k)(k)$$

From similar triangles

$$\tan\theta = \frac{80}{150} = \frac{V}{150 - k}$$

$$V = \frac{80}{150}(150 - k)$$

$2000 = k\,(80 - 0.53\,k)$

$0.53\,k^2 - 80\,k + 2000 = 0$

$k_1 = 119.3$ veh/km

$k_2 = 31.62$ veh/km

The required density = 119.3 veh/km