Mock Test 2

Number of Questions: 65 **Total Marks: 100**

Section – I: General Aptitude

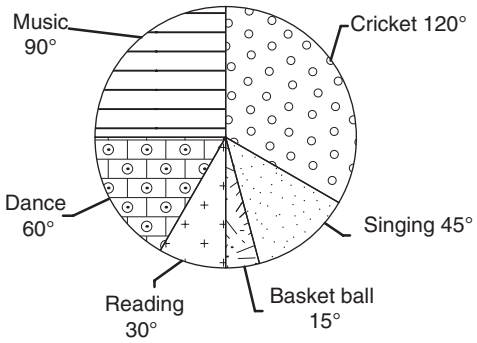
Questions 1 to 5 carry One Mark each.

Directions for question 1: Select the correct alternative from the given choices.

1. If $\left(x^2+\frac{1}{x^2}\right) = 79$, then find $x^3 + \frac{1}{x^3}$.

(A) ±692 (B) ±702
(C) ±712 (D) ±756

2. The following pie-chart gives the split up of number of students having different hobbies in a college of 1800 students.



Every student has exactly one of the above mentioned hobbies. The difference in the number of students with cricket and music as their hobbies is _____

Directions for question 3: The question given below gives a word followed by four choices. From the choices, select the most suitable **synonym** (word which means the same) for the question word and mark its number as the answer.

3. ADJOURN
(A) prevent
(B) withhold
(C) postpone
(D) abrogate

Directions for question 4: The question given below has a sentence with two blanks, followed by four pairs of words as choices. From the choices, select the pair of words that can best complete the given sentence.

4. Reason accepts the _____ of spontaneous intuition but asks that we check our intuition and _____ whether they be correct.
(A) problem . . . evaluate
(B) tranquility . . . promulgate
(C) challenge . . . question
(D) existence . . . ascertain

Directions for question 5: In the question below, determine the relationship between the pair of capitalised words and then select the pair of words which has a **similar** relationship to the capitalized words and mark the number of that pair as your answer.

5. ACRID : BITTER
(A) Mythical : Shallow
(B) Suave : Urbane
(C) Clairvoyant : Disgraceful
(D) Diminutive : Gargantuan

Questions 6 to 10 carry Two Marks each.

Directions for questions 6 to 8: Select the correct alternative from the given choices.

6. Pointing at a photograph Ms. Sudha told Mr. Bhujbal, "the person in the photograph is your father's wife's mother-in-law's only son and my mother's brother's only brother-in-law". How is Bujbal related to Sudha?
(A) Brother (B) Cousin
(C) Uncle (D) Brother-in-law

7. log cot1° + log cot2° + log cot3° + . . . + log cot 89° = _____.
(A) 1 (B) – 1
(C) 0 (D) None of these

8. It is high time that we address the problem of obesity with more seriousness as the ill effects of obesity is more diverse and more harmful than it was thought earlier.
Which of the following can be inferred from the above statement?
(A) Obesity was not considered a disease earlier.
(B) Obesity is the reason for all health related problems.
(C) An obese person cannot be free from a disease.
(D) Measures to address the problem of obesity has been initiated in the past.

Directions for question 9: In the question below, four different ways of writing a sentence are indicated. Choose the best way of writing the sentence.

9. A. The report discusses growth stories in sectors like IT and pharma where Indian companies have made a mark and describes how domestic industry has profitably restructured through the past ten years as economic reforms saw tariff wall fall and the license permit raj dismantled.
B. The report discusses growth stories in sectors like IT and pharma where Indian companies have made a mark and describes how domestic industry has profitably restructured over the past ten years into economic reforms seeing tariff walls fall and the license permit raj dismantled.

C. The report discusses growth stories in sectors like IT and pharma where Indian companies have made a mark and describes how domestic industry has profitably restructured over the past ten years as economic reforms saw tariff walls fall and the license permit raj dismantled.

D. The report discusses growth stories in sectors like IT and pharma where Indian companies have made a mark and describes how domestic industry has restructured profitably through the past ten years when economic reforms have seen tariff walls fall and the license permit raj dismantling.

Directions for question 10: Choose the best answer for the following question:

10. Media watchers (and readers) have found that there has been a sudden increase of 25% in crimes reported after laws were recently passed to reduce the punishment for crimes by lessening prison terms. Clearly the new laws have been solely responsible for the sudden spurt in crimes reported.

Which of the following can be logically inferred from argument above?

(A) As a part of the recent measures undertaken by the state, almost 20% of the entire police force has been laid off.

(B) There has been no appreciable increase in crimes reported in other countries where similar laws were passed.

(C) The crime rate is still 10% lower than that in any other country of comparable size.

(D) The state has recently increased the strength of judges in the courts from 10 to 20%.

SECTION – II: CIVIL ENGINEERING

Directions for questions 1 to 55: Select the correct alternative form the given choices.

Questions 11 to 35 carry One Mark each.

11. Which of the following statements is ALWAYS true with reference to the LU – decomposition $A = LU$ of a square matrix A with L and U being the lower triangular and upper triangular matrices respectively?

(A) All the principal diagonal elements will be equal to 1 for only L.

(B) All the principal diagonal elements will be equal to 1 for any U.

(C) All the principal diagonal elements will be equal to 1 for both L and U.

(D) All the principal diagonal elements will be equal to 1 for any one of L and U.

12. If $u(x, y) = \tan^{-1}\left(\frac{x}{y}\right)$, then the ratio of the first partial derivatives of $u(x, y)$ with respect to x and y is same as the ratio of _____

(A) x and y,

(B) $-y$ and x

(C) x^2 and y^2

(D) $-y^2$ and x^2

13. In the process of finding the reciprocal value of 23 by the Newton – Raphson method with 0.08 as the initial guess, the value of the reciprocal of 23, after the first iteration will be _____

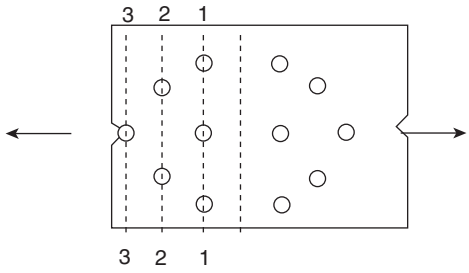
14. If $f(x) = \begin{cases} \pi + x; & -\pi < x < 0 \\ 0; & 0 \le x \le \pi \end{cases}$ and $f(x + 2\pi) = f(x)$, then the Fourier series expansion of $f(x)$ at $x = 0$ converges to _____.

15. The value of $\underset{x\to 0}{Lim} \dfrac{\sqrt{9+x^7} - \sqrt{9-x^7}}{x^7}$ is _____

(A) $\sqrt{7}$ (B) 3

(C) $\dfrac{1}{\sqrt{7}}$ (D) $\dfrac{1}{3}$

16. Two steel plates each of 10 mm thickness, are connected by a double cover butt joint by bolts as shown in figure. If bolt diameter is 20 mm and steel is of grade 410, which of the following section is the most critical section for a main plate?



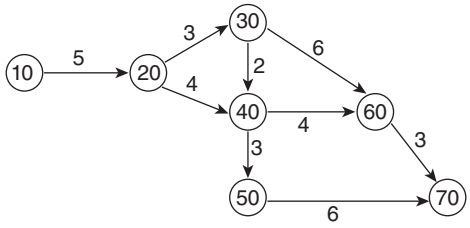
(A) section 1 – 1

(B) section 2 – 2

(C) section 3 – 3

(D) section 1 – 1 and 3 – 3

17.



For the network shown in figure, find the critical path?

(A) 10 – 20 – 30 – 60 - 70
(B) 10 – 20 – 30 – 40 – 50 – 70
(C) 10 – 20 – 40 – 60 – 70
(D) 10 – 20 – 30 – 40 – 60 – 70

18. The following constituent imparts plasticity to brick earth ___
(A) Alumina (B) Silica
(C) Lime (D) Magnesia

19. The contribution compounds of cement in decreasing order of rate of hydration are _____
(A) C_3S, C_3A, and C_2S
(B) C_2S, C_3S, and C_3A
(C) C_3A, C_2S, C_3S
(D) C_3A, C_3S, C_2S

20. The critical section considered for the shear design, if the end of beam is subjected to tension due to support reaction?
(A) section at a distance of effective depth (d) from the support
(B) section at a face of the support
(C) section at a distance $\frac{d}{2}$ from the support
(D) section at a distance $2d$ from the support

21. The equation of A line is ____
(A) $I_p = 0.83\ (W_L - 20)$ (B) $I_p = 0.63\ (W_L - 20)$
(C) $I_p = 0.53\ (W_L - 20)$ (D) $I_p = 0.73\ (W_L - 20)$

22. For a dense packing of regular spheres at the maximum density the void ratio is _____
(A) 0.91 (B) 0.81
(C) 0.65 (D) 0.35

23. In case of soil mechanics the following head is neglected
(A) Pressure head (B) Velocity head
(C) Elevation head (D) Total head

24. Consolidation of soil is due to load which is
(A) Static and short term
(B) Dynamic and short term
(C) Dynamic and long term
(D) Static and long term

25. A fully compensated raft foundation for a building is ____
(A) Designed as a completely flexible footing
(B) Designed as a completely Rigid footing
(C) Designed such that weight of excavated soil is equal to the load due to building
(D) None of these

26. The missing data (X_1 and X_2 respectively) from the table given below is

Station	BS	FS	HI	RL
BM	1.175		X_1	100
A		X_2		98.975

(A) 100.1 m, 1.9 m (B) 100.1 m, 2.2 m
(C) 101.173 m, 2.2 m (D) 101.175 m, 1.9 m

27. If the magnetic bearing = 40°30^1 and magnetic declination is 6° 30^1 E then true bearing is
(A) 47°0^1 (B) 34°
(C) 42° (D) 50°

28. If 10 ml of water sample is diluted with 190 ml distilled water at which odour is just detectable, then TON of sample is
(A) 10 (B) 20
(C) 40 (D) 30

29. A source emitting 40 dB, 20 dB and 90 dB at different times in a day. What is average noise produced by source in a day
(A) 96.2 dB (B) 96.4 dB
(C) 94 dB (D) None of the above

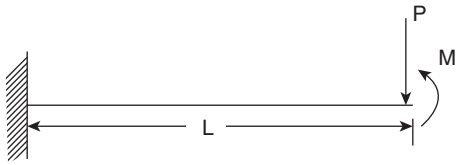
30. The concentration of dissolved oxygen (DO) may fall down to zero, causing anaerobic conditions in river zone known as
(A) zone of degradation
(B) zone of active decomposition
(C) zone of recovery
(D) zone of clear water

31. Determine the amount of lime required for treatment of one million liters of water per day if raw water contains 200 mg/L of total hardness is
(A) 110 kg/day (B) 140 kg/day
(C) 120 kg/day (D) 112 kg/day

32. Find the width of grit chamber to handle a waste water flow of 20 MLD with $V_H = 0.3$ m/sec, detention time = 1 min, depth = 0.8 m is
(A) 0.8 m (B) 1 m
(C) 0.6 m (D) 0.4 m

33. A wire of radius r is stretched by a force P. If another wire of radius $2r$ of same material is stretched by the same load, its modulus of elasticity will
(A) be doubled (B) be halved
(C) become 4 times (D) not be changed

34.



A cantilever beam of span L is subjected to a concentrated load P and a moment M as shown in the figure. Deflection at the free end is given by

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

35. Diameter of an air bubble in water is 0.01 mm. If the surface tension at air water interface is 0.07 N/m, the pressure difference between inside and outside of the air bubble is

(A) 14 kPa (B) 28 kPa
(C) 56 kPa (D) 62 kPa

Questions 36 to 65 carry Two Mark each.

36. The least possible value of the determinant of a 3 × 3 matrix A with all entries being either 0 or 1 is _____.

(A) 0 (B) −1
(C) −2 (D) −3

37. The value of the line integral $\int_c \bar{F} \cdot d\bar{r}$ where $\bar{F} = xy\,\bar{i} + 2yz\,\bar{j} - z^2\,\bar{k}$ and the curve c is given by $x = t$, $y = t^2$, $z = 3t$, $0 \le t \le 2$ is _____.

38. Rajeev goes to office either by car, scooter, bus or train with various possibilities as shown in the table below.

Mode of transport	Percentage chance of using	Chance of reaching the office lately
Car	20%	1 out of 25
Scooter	40%	2 out of 25
Bus	30%	1 out of 10
Train	10%	1 out of 5

If Rajeev reached the office lately, then the probability that he travelled by scooter is _____.

(A) $\frac{1}{3}$ (B) $\frac{8}{9}$
(C) $\frac{14}{27}$ (D) $\frac{16}{45}$

39. The value of the definite integral $\int_0^4 \frac{x}{1+3x^2}dx$ obtained by the Simpson's rule with step size $h = 1$ is _____.

(A) 0.6059 (B) 0.6486
(C) 0.6687 (D) 0.6984

40. The value of y at $x = 3$, if y satisfies the differential equation $x\frac{dy}{dx} - 2y = x^3$ and $y = 0$ at $x = 1$ is _____

(A) 9 (B) 18
(C) 27 (D) 36

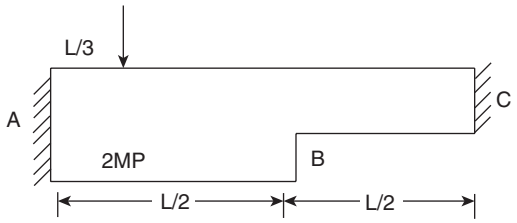
41. Velocity potential function for a flow is given by $\phi = x^2 - y^2$. The stream function for the flow is

(A) $2xy + f(y)$ (B) $2xy + f(x)$
(C) $2xy$ + constant (D) $2x - 2y$ + constant

42. In a 3 dimensional incompressible fluid flow, velocity components in x and y directions are
$u = x^2 + y^2z^3$
$v = -(xy + yz + zx)$
Velocity component in the z direction is

(A) $-xz + \frac{z^2}{2} + f(x, y)$ (B) $-xz + \frac{z^2}{2}$
(C) $xz - \frac{z^2}{2} + C$ (D) $-x + z$

43. A fixed beam subjected to load w at $\frac{1}{3}$ rd span as shown in figure. Estimate the collapse load?



(A) $12\frac{M_p}{L}$ (B) $9\frac{M_p}{L}$
(C) $15\frac{M_p}{L}$ (D) $6\frac{M_p}{L}$

44. For a particular activity of a project, time estimates received from engineers x, y and z are as follows

	Optimistic time	Most likely time	Pessimistic time
Engineer x	4	6	8
Engineer y	3	5	8
Engineer z	5	7	10

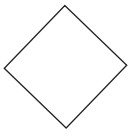
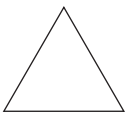
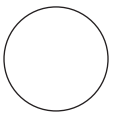
Who is more certain about time of completion of job?

(A) Engineer x (B) Engineer y
(C) Engineer z (D) Can't say

45. A concrete beam of 200 mm × 400 mm is pre-stressed with a force of 600 kN at an eccentricity of 120 mm. The maximum and minimum stresses developed are ____

(A) 21 MPa and 6 Mpa (B) 15 MPa and 9 MPa
(C) 6 MPa and 1.5 MPa (D) 12 MPa and 21 MPa

46. Identify the correct relation with respect to "shape factor" for different shapes in increasing order

(i) 
(ii) 
(iii) 
(iv) 

(A) iii, iv, ii, i (B) ii, iii, iv, i
(C) iv, iii, i, ii (D) iv, i, ii, iii

47. A saturated clay stratum draining both at the top and bottom undergoes 50 percent consolidation in 24 years under an applied load. If an additional drainage layer

were present at the middle of the clay stratum, 50 percent consolidation would occur in _____ years.

48. An unconfined compression test yielded a strength of 0.2 N/mm^2. If the failure plane is inclined at 60° to the horizontal, what are the values of shear strength parameters?
(A) 0.057 N/mm^2; 30°
(B) 0.35 N/mm^2; 60°
(C) 0.15 N/mm^2; 30°
(D) 0.4 N/mm^2; 60°

49. A 6 m high retaining wall is supporting a saturated sand (saturated due to capillary action) of bulk density 21 KN/m^3 and angle of shearing resistance 30°. The change in magnitude of earth pressure at the base due to rise in ground water table from the base of footing to the ground surface shall (γ_w = 10 kN/m^3)
(A) increases by 20 kN/m^2
(B) increases by 40 kN/m^2
(C) decreases by 20 kN/m^2
(D) decrease by 40 kN/m^2

50. A bed of sand consists of three horizontal layers of equal thickness. The value of Darcy's K for the upper and lowest layers is 1 × 10^{-1} cm/sec and that for the middle layer is 1 × 10^{-2} cm/sec. The ratio of permeability of the bed in the horizontal direction to that in vertical direction is _____.

51. If a square footing of size 4m × 4m is resting on the surface of a deposit of soft clay having cohesion of 13.5 kPa, the ultimate bearing capacity of the footing (as per Terzahi's equation) is _____.

52. Find the capacity of digester from the following data
Q = 20 ML, SS in waste water flow 200 mg/L
% of SS removed from clarifier= 70
Moisture content in fresh sludge P_1 = 98%
Moisture content of digested sludge P_2 = 90%
Specific gravity of fresh sludge = 1.06
Specific gravity of digested sludge = 1.02
Digestion period = 60 days

53. The specific gravities and weight proportions are given as under for the preparation of marshall mould. The volume and weight of marshall mould are 475 cc and 1100 g respectively

Specimen	Weight (g)	Specific gravity
A1	825	2.63
A 2	1200	2.51
A 3	325	2.46
A 4	150	2.43
Bitumen	100	1.05

The % voids in mineral aggregates is
(A) 15.25 (B) 16.85
(C) 12.49 (D) 13.42

54. Find the extra widening necessary for horizontal curves having R = 100 m, wheel base 6.1 m, pavement width = 7 m, Design speed, V = 70km/hr
(A) 1.112 m (B) 1.14 m
(C) 1.11 m (D) 1.32 m

55. A design speed of traffic lane is 80 kmph. Average length of vehicle is 6m. The capacity of the road when reaction time of driver is 2 sec and coefficient of longitudinal friction is 0.35 is
(A) 523veh/hr
(B) 656veh/hr
(C) 832veh/hr
(D) 932veh/hr

56. The rate of super elevation on a highway in plain terrain with design speed of 100 kmph with radius of curve 500 m under mixed traffic condition is
(A) 7% (B) 9.2%
(C) 8.8% (D) 15.72%

57. Consider
1. Creation of central road fund
2. National highway act
3. Formation of Indian Road congress
4. Creation of highway research board
The correct chronological order of the events is
(A) 4, 3, 2, 1 (B) 2, 1, 3, 4
(C) 1, 3, 2, 4 (D) 2, 3, 1, 4

58. Following test results were obtained by a CBR test on a subgrade soil?

Penetration in "mm"	0	2.5	5.0
Load (kg)	0	55	78

Area of plunger is 19.6 cm^2
The aggregates pressures at 2.5 mm and 5mm are 70 kg/cm^2 and 105 kg/cm^2 respectively. The CBR of the soil is?
(A) 3.8% (B) 3.5%
(C) 4% (D) 4.4%

59. From the analysis of rainfall data at a particular station it was found that a rainfall of 400mm had a return period of 20 years. What is the probability of rainfall equal to or greater than 400 mm occurring at least once in 10 successive years is
(A) 50.43 (B) 40.12
(C) 20.32 (D) 26.23

60. Route the following flood hydrograph through a river reach for which Muskingum coefficient k = 8 and x = 0.25

Time (h)	0
Inflow cm^3/s	8

If the initial out flow discharge from the reach is 8 m^3/s. Find the final outflow

(A) 10 m^3/s (B) 8 m^3/s
(C) 6 m^3/s (D) 4 m^3/s

61. In an irrigated plot the net irrigation requirement of crop is found to be 14.9 cm, the application efficiency is 80 % and the water conveyance efficiency is 70%. What is the gross irrigation requirement?
(A) 29.8 cm (B) 25.2 cm
(C) 31.3 cm (D) 26.60 cm

62. The area of the irrigation channel in alluvial soil according to lacey's sit theory with the following data, discharge is 50m^3/sec lacey's silt factor = 1, side slope = $0.5H : 1V$
(A) 56.4 m^2 (B) 62.3 m^2
(C) 64.3 m^2 (D) 59.38m^2

63.

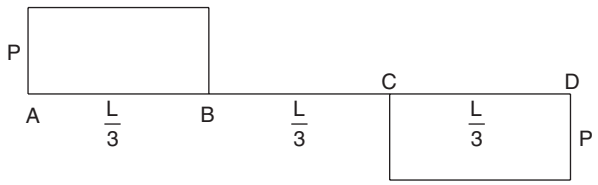
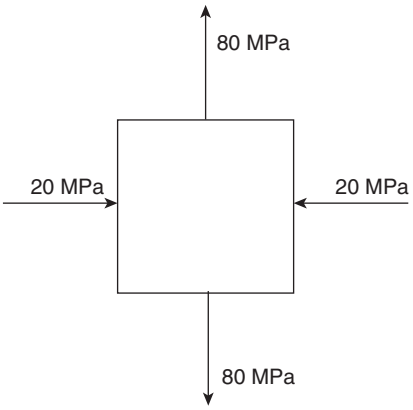


Figure shows shear force diagram of a beam *ABCD* of length *L*. Bending moment at the centre of the beam is

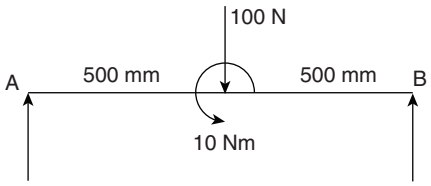
(A) 0 (B) $\frac{PL}{3}$
(C) $\frac{PL}{2}$ (D) $\frac{2PL}{3}$

64.



For the state of stress at a point in a stressed body, shown in figure radius of the Mohr's circle is
(A) 80 MPa (B) 60 MPa
(C) 50 MPa (D) 40 MPa

65.



A simply supported beam of 1 m length is loaded at the mid span as shown in the figure. Maximum bending moment is
(A) 30 Nm (B) 35 Nm
(C) 40 Nm (D) 45 Nm

Answer Keys

1. B	**2.** 150	**3.** C	**4.** D	**5.** B	**6.** A	**7.** C	**8.** D	**9.** C	**10.** A
11. D	**12.** B	**13.** 0.011 to 0.014		**14.** 1.55 to 1.59		**15.** D	**16.** C	**17.** B	**18.** A
19. D	**20.** B	**21.** D	**22.** D	**23.** B	**24.** D	**25.** C	**26.** C	**27.** A	**28.** B
29. D	**30.** B	**31.** D	**32.** B	**33.** D	**34.** C	**35.** B	**36.** C	**37.** 8.7 to 8.9	
38. D	**39.** A	**40.** B	**41.** C	**42.** A	**43.** C	**44.** A	**45.** A	**46.** C	
47. 6 years		**48.** A	**49.** B	**50.** 2.8	**51.** 100 – 102 Kpa		**52.** 478.35 m^3		**53.** C
54. C	**55.** B	**56.** A	**57.** C	**58.** C	**59.** B	**60.** B	**61.** D	**62.** D	**63.** B
64. C	**65.** A								

Hints and Explanations

1. Given $x^2 + \frac{1}{x^2} = 79$

$$x^2 + \frac{1}{x^2} + 2 = 81$$

$$\left(x + \frac{1}{x}\right)^2 = 81$$

$$\Rightarrow \quad x + \frac{1}{x} = \pm 9$$

$$x^3 + \frac{1}{x^3} = \left(x + \frac{1}{x}\right)^3 - 3x.\frac{1}{x}\left(x + \frac{1}{x}\right)$$

$$= (\pm 9)^3 - 3(\pm 9)$$

$$= \pm[729 - 27] = \pm 702 .$$ Choice (B)

2. Required difference = $\frac{(120-90)}{360} \times 1800 = 150.$

Ans: 150

3. 'Adjourn' means 'put off' as in "The meeting was adjourned until December 4". So 'postpone' is apt. 'Abrogate' means override / revoke or cancel.

Choice (C)

4. The second blank needs a word synonymous with the word "check" since the sentence talks about how one needs to check whether one's intuition is correct. Hence, it could be "ascertain". Though evaluate also suits, the former suits better in this context. The first blank can take "existence". Tranquility means peace.

Choice (D)

5. 'Suave' means sophisticated, polished, 'urbane'. The question words 'acrid' and 'bitter' are synonyms too.

Choice (B)

6. Bhujbal's father's wife's mother-in-law is Bhujbal's father's mother, whose only child is Bhujbal's father. Hence, the person in the photograph is Bhujbal's father. Bhujbal's father is Sudha's mother's brother's only brother-in-law, i.e. Sudha is Bhujbal's father's daughter.

$\therefore$ Bhujbal is Sudha's brother. Choice (A)

7. log cot1° + log cot 2° + . . . log cot 89°
= log (cot1° . cot2° . . . cot 89°)
Now cot 89° = cot (90° – 1) = tan 1°
cot 88° = cot (90° – 2) = tan 2°
$\therefore$ log (cot 1° cot 2° . . . .cot 88° cot 89°)
= log (cot 1° cot 2° . . . .tan 2° tan 1°)
= log 1 = 0 ($\because$ cot 1° tan 1° = 1
cot 2° tan 2° = 1) Choice (C)

8. From the statement it is clear that certain action is being taken to address obesity. Hence, (D) can be inferred from the statement. Choice (A) is in contradiction to the statement. From the statement we know that obesity leads to certain problems. But the information does not allow us to infer that every health problem is caused by obesity. Hence, (C) cannot be inferred. Hence, (D) can be inferred. Choice (D)

9. In (A) and (D) the usage of 'through the past ten years' is incorrect. Further the usage of 'wall' in (A) is incorrect. Also in (D) 'dismantling' is awkward. In (B) the usage of the 'ing' form of the verb 'see' is incorrect. Choice (C) is correct in all ways. Choice (C)

10. Only (A) can be logically inferred from the sentences. If the laws have been changed to reduce punishment and prison terms, obviously it follows that some of the police staff will not be needed as there will be fewer prisoners. The other statements (B) and (C) are outside the scope of the text as what happens in other countries is beyond our scope of understanding. Choice (D) only weakens / goes against the arguments in the text.

Choice (A)

11. From the procedure of LU – decomposition

Choice (D)

12. Given $u(x, y) = \tan^{-1}\left(\frac{x}{y}\right)$

$$\Rightarrow \frac{\partial u}{\partial x} = \frac{1}{1+\left(\frac{x}{y}\right)^2}\cdot\left(\frac{1}{y}\right) = s\frac{y}{x^2+y^2}$$

$$\text{and } \frac{\partial u}{\partial y} = \frac{1}{1+\left(\frac{x}{y}\right)^2}\cdot\left(\frac{-x}{y^2}\right) = \frac{-x}{x^2+y^2}$$

$$\therefore \frac{\partial u}{\partial x} : \frac{\partial u}{\partial y} = \frac{y}{x^2+y^2} : \frac{-x}{x^2+y^2} = -y : x$$

Choice (B)

13. We have to find x such that

$$x = \frac{1}{23} \Rightarrow \frac{1}{x} = 23$$

$$\text{Let } f(x) = \frac{1}{x} - 23 = 0$$

$$\Rightarrow f'(x) = \frac{-1}{x^2}$$

Given the initial guess = $x_0 = 0.08$

$$\therefore f(x_0) = \frac{1}{0.08} - 23 = -10.5$$

$$\text{and } f'(x_0) = \frac{-1}{(0.08)^2} = -156.25$$

By Newton – Raphson method, the reciprocal value of 23 after first iteration is given by

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

$$= 0.08 - \frac{(-10.5)}{(-156.25)}$$

$$\therefore x_1 = 0.0128.$$

Ans: 0.011 to 0.014

14. Given $f(x) = \begin{cases} \pi + x; & -\pi < x < 0 \\ 0; & 0 \le x < \pi \end{cases}$

and $f(x + 2\pi) = f(x)$
Clearly, $f(x)$ is discontinuous at $x = 0$,

$\therefore$ Fourier series of $f(x)$ at $x = 0$ converges to $\frac{1}{2}\left[f(0+) + f(0-)\right]$

where $f(0+) = \underset{x\to 0+}{Lt} f(x) = \underset{x\to 0+}{Lt} 0 = 0$

and $f(0-) = \underset{x\to 0-}{Lt} f(x) = \underset{x\to 0-}{Lt} (\pi + x) = \pi$

Hence the Fourier series of $f(x)$ at $x = 0$ converges to

$$\frac{1}{2}[0 + \pi] = \frac{\pi}{2} = 1.57$$

Ans: 1.55 to 1.59

15. We have $\underset{x\to 0}{Lt}\dfrac{\sqrt{9+x^7}-\sqrt{9-x^7}}{x^7}$

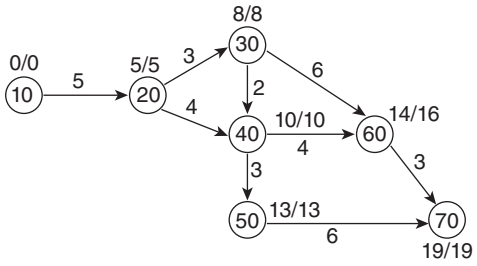
$= \underset{x\to 0}{Lim}\left[\dfrac{\sqrt{9+x^7}-\sqrt{9-x^7}}{x^7}\right]\times\left[\dfrac{\sqrt{9+x^7}+\sqrt{9-x^7}}{\sqrt{9+x^7}+\sqrt{9-x^7}}\right]$

$= \underset{x\to 0}{Lt}\dfrac{(9+x^7)-(9-x^7)}{\sqrt{9+x^7}+\sqrt{9-x^7}}$

$= \underset{x\to 0}{Lt}\dfrac{2}{\sqrt{9+x^7}+\sqrt{9-x^7}}=\dfrac{1}{3}$ Choice (D)

16. For cover plate, 1 – 1 is critical and for main plate 3 – 3 is critical section. Choice (C)

17.



Critical path: 10 – 20 – 30 – 40 – 50 – 70 (or) Critical path is the path along which duration is maximum.
From options, the path 10 – 20 – 30 – 40 – 50 – 70 has maximum duration. Choice (B)

18. Alumina imparts plasticity to brick earth. Choice (A)

19. $C_3A > C_3S > C_2S$. Choice (D)

20. If end of beam is subjected to tension; critical section is at face of the support. If end of beam is subjected to compression; critical section is at a distance of d, effective depth from the support. Choice (B)

21. $I_p = 0.73\ (W_L - 20)$. Choice (D)

22. Void ratio for diagonal packing (for densest condition) is 0.35 where as for loose packing (cubical array) void ratio is 0.91. Choice (D)

23. Velocity head is neglected in soil mechanics. Choice (B)

24. Consolidation is due to static and long term loading. Choice (D)

26. $X_1 = RL + BS = 100 + 1.175 = 101.175$m
$HI - X_2 = 98.975$
$X_2 = HI - 98.975 = X_1 - 98.975$
$= 101.175 - 98.975 = 2.2$m. Choice (C)

27. Forbearing $= 40°30^1 + 6°30^1 = 47°01$. Choice (A)

28. TON $= \dfrac{A+B}{A}=\dfrac{10+190}{10} = 20$ Choice (B)

29. $L = 20\log_{10}\dfrac{1}{3}\left[10^{\frac{40}{20}}+10^{\frac{20}{20}}+10^{\frac{90}{20}}\right]$

$= 96.69$dB. Choice (D)

31. Molecular weight of lime (CaO) = 56 mol.wt
100mg of TH requires 56mg of quick lime
200mg of TH requires 56mg of quick lime

$\Rightarrow \dfrac{200\times 56}{100} = 112$mg/lit

$\Rightarrow$ Total lime dosage required = $Q \times$ dosage
$= 1 \times 112 = 112$kg/day. Choice (D)

32. Volume of grit chamber = $Q_1 \times D_T$

$= \dfrac{20\times 10^6}{(10^3\times 24\times 60)}\times 1 = 13.86\text{m}^3$

Length of grit chamber = $V_H \times D_T$
$= 0.3 \times 1 \times 60 = 18$ m

$\dfrac{C}{S} = \dfrac{\text{volume}}{\text{length}} = \dfrac{13.86}{18} = 0.771$m

$\therefore$ Width $= \dfrac{0.771}{0.8} = 0.96\text{m} \backsimeq 1$ m. Choice (B)

35. $\sigma = 0.07$ N/m, d = 0.01 mm

$\Delta P = \dfrac{4\sigma}{d} = \dfrac{4\times 0.07}{0.01\times 10^{-3}}$

$= 28 \times 10^3$ N/m^2 $= 28$ kN/m^2 $= 28$ kPa. Choice (B)

36. Let $A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}$ be a 3 × 3 matrix with all entries being either 0 or 1.

$\therefore$ Det $A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}$

$= a_1(b_2c_3 - b_3c_2) - b_1(a_2c_3 - a_3c_2) + c_1(a_2b_3 - a_3b_2)$

$\therefore$ Det $A = a_1b_2c_3 + a_3b_1c_2 + a_2b_3c_1 - a_1b_3c_2$
$- a_2b_1c_3 - a_3b_2c_1$ $\rightarrow (1)$

As the entries of A being 0 or 1 only and from (1), we can observe that the least possible value for $|A|$ cannot be less than −3.
Also, from (1), we can observe that for no possible set of values of a_i, b_j and c_k ($i = 1$ to 3, $j = 1$ to 3 and $k = 1$ to 3), determinant of A can be −3.

And let $A = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix}$,

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

$\therefore$ The least possible value of determinant of $A = -2$ Choice (C)

37. Given $\overline{F} = xy\,\overline{i} + 2yz\,\overline{j} - z^2\,\overline{k}$

and C is $x = t$, $y = t^2$, $z = 3t$; $0 \le t \le 2$

$\Rightarrow$ $dx = dt$, $dy = 2tdt$ and $dz = 3dt$

$\therefore$ $\int_c \overline{F}.d\overline{r} = \int_c (xy\overline{i} + 2yz\overline{j} - z^2\overline{k}).(dx\overline{i} + dy\overline{j} + dz\overline{k})$

$= \int_{t=0}^{2} (t^3\overline{i} + 6t^3\overline{j} -).(dt\overline{i} + 2tdt\overline{j} + 3dt\overline{k})$

$= \int_{t=0}^{2} (12t^4 + t^3 - 27t^2)\,dt$

$= 12\frac{t^5}{5} + \frac{t^4}{4} - 27\frac{t^3}{3}\Big]_0^2$

$= 12 \times \frac{32}{5} + \frac{16}{4} - 9 \times 8$

$= \frac{384}{5} + 4 - 72 = \frac{44}{5} = 8.8.$ Ans: 8.7 to 8.9

38. Let B_1, B_2, B_3 and B_4 denote the events of Rajeev going to office by car, scooter, bus and train respectively.
Let A be the event of Rajeev reaching the office lately.

$\therefore$ $P(B_1) = 0.2$, $P(B_2) = 0.4$, $P(B_3) = 0.3$, $P(B_4) = 0.1$

$P\left(\frac{A}{B_1}\right) = \frac{1}{25} = 0.04$; $P\left(\frac{A}{B_2}\right) = \frac{2}{25} = 0.08$

$P\left(\frac{A}{B_3}\right) = \frac{1}{10} = 0.1$; $P\left(\frac{A}{B_4}\right) = \frac{1}{5} = 0.2$

$\therefore$ Probability that Rajeev reached the office lately given that he travelled by scooter.

$= P\left(\frac{B_2}{A}\right) = \frac{P(B_2)P\left(\frac{A}{B_2}\right)}{\sum_{i=1}^{4} P(B_i)P\left(\frac{A}{B_i}\right)}$

(By Bayes' theorem)

$= \frac{0.4 \times 0.08}{0.2 \times 0.04 + 0.4 \times 0.08 + 0.3 \times 0.1 + 0.1 \times 0.2}$

$= \frac{0.032}{0.09} = \frac{32}{90} = \frac{16}{45}$ Choice (D)

39. We have to evaluate $\int_0^4 \frac{x}{1+3x^2}\,dx$ by Simpson's rule.

Here $y = f(x) = \frac{x}{1+3x^2}$; $h = 1$; $a = 0$ and $b = 4$

x	0	1	2	3	4
y = f(x)	0	0.25	0.1538	0.1071	0.0816

$\therefore$ By Simpson's rule, we have

$\int_0^4 \frac{x}{1+3x^2}\,dx = \int_a^b y\,dx = \frac{h}{3}$

$[(y_0 + y_4) + 4(y_1 + y_3) + 2y_2]$

$= \frac{1}{3}[(0 + 0.0816) + 4(0.25 + 0.1071) + 2(0.1538)]$

$= 0.6059$ Choice (A)

40. Given differential equation is

$x\frac{dy}{dx} - 2y = x^3$ $\rightarrow$ (1)

$\Rightarrow$ $\frac{dy}{dx} - \frac{2y}{x} = x^2$ $\rightarrow$ (2)

Clearly, (2) is a linear equation of first order in y of the form $\frac{dy}{dx} + P(x)y = Q(x)$

where $P(x) = \frac{-2}{x}$ and $Q(x) = x^2$

$\therefore$ Integrating factor = I.F. $= e^{\int \frac{-2}{x}dx} = e^{\ln x^{-2}}$

IF $= \frac{1}{x^2}$

$\therefore$ The general solution of (1) is

$y \times (I.F) = \int [Q(x) \times \text{I.F}]\,dx + c$

$\Rightarrow$ $y \times \frac{1}{x^2} = \int \left[x^2 \times \frac{1}{x^2}\right]dx + c$

$\Rightarrow$ $\frac{y}{x^2} = \int dx + c$

$\Rightarrow$ $\frac{y}{x^2} = x + c$ $\rightarrow$ (3)

Given $y = 0$ at $x = 1$

$\therefore$ From (3),

$\frac{0}{1^2} = 1 + c$

$\Rightarrow$ $c = -1$

Substituting the value of c in (3), we have

$\frac{y}{x^2} = x - 1 \Rightarrow y = x^3 - x^2$ $\rightarrow$ (4)

From (4), at $x = 3$, we have

$y = 3^3 - 3^2 = 18$ Choice (B)

41. Potential function $\phi = x^2 - y^2$

$\frac{\partial \phi}{\partial x} = u$ and $\frac{\partial \phi}{\partial y} = v$

$\therefore$ $2x = u$ or $u = 2x$
and $-2y = v$ or $v = -2y$

For stream function ψ

$\frac{\partial \psi}{\partial x} = -v$ -----(1)

$\frac{\partial \psi}{\partial y} = u$ ----(2)

From (1)

$\partial \psi = -v\,dx = (2y)dx$

$$\psi = \int 2y dx = 2xy + f(y)$$

$$\frac{\partial \psi}{\partial y} = 2x + f'(y)$$

Equating with (2)

$u = 2x + f'(y)$

or $2x = 2x + f'(y)$

$\Rightarrow \quad f'y = 0$

Or $f(y) = C$(constant)

$\therefore \quad \psi = 2xy + C$ Choice (C)

42. For a three dimensional, incompressible fluid flow the continuity equation must be satisfied

i.e., $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$

$u = x^2 + y^2z^3$

$$\frac{\partial u}{\partial x} = 2x$$

$v = -(xy + yz + zx)$

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

$$\therefore \quad 2x - (x + z) + \frac{\partial w}{\partial z} = 0$$

$$\Rightarrow \quad \frac{\partial w}{\partial z} = -2x + x + z = -x + z$$

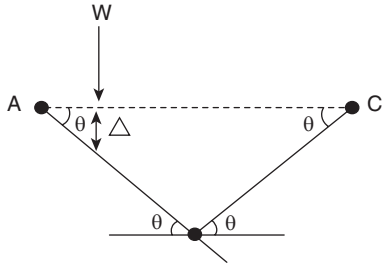
Integrating with respect to z

$w = -xz + \frac{z^2}{2} + C$ where $C = f(x, y)$

or $w = -xz + \frac{z^2}{2} + f(x, y)$. Choice (A)

43. No of plastic hinges required = $D_S + 1 = 2 + 1 = 3$

Case I: Two plastic hinges at supports, and one at point where cross section changes



Internal work done = $2M_p\theta + M_p(\theta + \theta) + M_p\theta$

External work done = $W.\Delta$

$\Rightarrow \quad 5M_p\theta = W.\Delta$

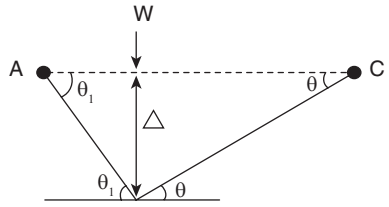
$$\tan\theta = \frac{\Delta}{\frac{L}{3}}$$

$$\Delta = \theta.\frac{L}{3}$$

$$5M_p\theta = W.\theta.\frac{L}{3}$$

$$\therefore \quad W = \frac{15M_p}{L}$$

Case II: Two plastic hinges at supports and one under concentrated load



$$\theta_1 = \frac{\Delta}{\frac{L}{3}} \text{ and } \theta = \frac{\Delta}{\frac{2L}{3}}$$

$$\Delta = \theta_1 \times \frac{L}{3} = \theta \times \frac{2L}{3}$$

$\Rightarrow \quad \theta_1 = 2\theta$

Internal work done = $2M_p\theta_1 + 2M_p(\theta + \theta_1) + M_P.\theta$

$= 4M_p\theta + 6M_p\theta + M_p\theta = 11\ M_p\theta$

$$M_p\theta = W.\frac{2L}{3}\theta$$

$$\therefore \quad W = \frac{16.5M_p}{L}$$

The collapse load will be minimum of above two values

So; collapse load = $\frac{15M_p}{L}$. Choice (C)

44. The degree of uncertainty is indicated by the variance of time estimates

$$\text{Variance} = \left(\frac{t_p - t_o}{6}\right)^2$$

Variance of time estimates given by

$$x\text{: } \sigma_x^{\ 2} = \left(\frac{8-4}{6}\right)^2 = 0.4356$$

Similarly: $\sigma_y^{\ 2} = \left(\frac{10-5}{6}\right)^2 = 0.69$ and $\sigma_z^{\ 2} = 0.69$

Greater than variance; greater the uncertainty. So, Engineer X's time estimates have less variance, hence more certain. Choice (A)

45. $\sigma = \frac{P}{A} \pm \frac{P.e}{z}$

Given: $P = 600$ KN

$A = 200 \times 400 = 80 \times 10^3 mm^2$

$E = 120$mm

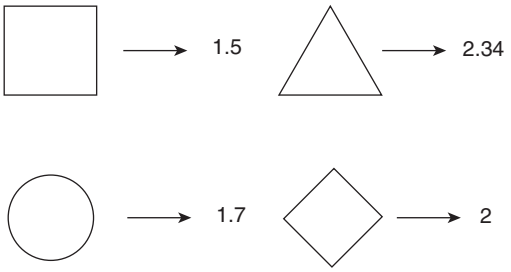
$$Z = \frac{bd^2}{6} = \frac{200 \times 400^2}{6} = 5.33 \times 10^6 mm^3$$

$$\therefore \quad \sigma = \frac{600\times10^3}{80\times10^3} \pm \frac{600\times10^3\times120}{5.33\times10^6} = 7.5 \pm 13.5$$

$\sigma_{max} = 21$ Mpa

$\sigma_{min} = -6$ Mpa. Choice (A)

46. Shape factor different shapes are



Choice (C)

47. For same degree of consolidation

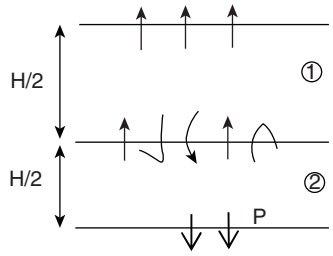
T_v is same

$$\frac{C_v t}{d^2} = \text{constant}$$

$\therefore \quad t \;\&\; d^2$

In, 1st case $d = \frac{H}{2}$

In 2nd case; an additional drainage layer is provided



So, d should be taken as higher of (1) and (2)

$$\therefore \quad d_2 = \frac{H}{4}$$

$$\therefore \quad \frac{t_1}{t_2} = \left(\frac{\frac{H}{2}}{\frac{H}{4}}\right)^2$$

$$\frac{24}{t_2} = 2^2$$

$T_2 = 6$yrs Ans: 6 years

48. $q_u = 0.2$ N/mm^2

$q_u = 2c\tan\alpha$

$$C = \frac{q_u}{2\tan\alpha} = \frac{0.2}{2\times\tan 60}$$

$C = 0.057$ N/mm^2

$$45 + \frac{\phi}{2} = 60$$

$\theta = 30°$. Choice (A)

49. $K_a = \frac{1-\sin 30}{1+\sin 30} = \frac{1}{3}$

Case I: $W.T$ at base

$$(P_o)_{\text{at base}} = K_a\,\gamma H = \frac{1}{3}\times 21 \times 6$$

$(P_a)_{\text{at base}} = 42$ kN/m^2

Case 2: $W.\ T$ at ground surface

$(P_a)_{\text{at base}} = ka\gamma^1 H + \gamma_w H$

$$= \frac{1}{3}\times(21-10)\times 6 + 10\times 6 = 22 + 60$$

$(P_a)_{\text{atbase}} = 82$KN/m^2

$\therefore$ From case (1) and case (2), P_a increased by 40 KN/m^2 Choice (B)

50. $$K_H = \frac{K_1Z_1 + K_2Z_2 + K_3Z_3}{Z_1+Z_2+Z_3}$$

$$= \frac{\left(1\times10^{-1}\right)1 + \left(1\times10^{-2}\right)1 + \left(1\times10^{-1}\right)1}{1+1+1}$$

$K_H = 0.07$ cm/sec

$$K_V = \frac{Z_1+Z_2+Z_3}{\frac{Z_1}{K_1}+\frac{Z_2}{K_2}+\frac{Z_3}{K_3}}$$

$$= \frac{1+1+1}{\frac{1}{1\times10^{-1}}+\frac{1}{1\times10^{-2}}+\frac{1}{1\times10^{-1}}}$$

$K_v = 0.025$

$$\frac{K_H}{K_V} = \frac{0.07}{0.025} = 2.8$$ Ans: 2.8

51. $Q_u = 1.3\,CN_c + \gamma DN_q + 0.4\gamma BN_r$

For pure clay; ($\phi = 0$)

$N_c = 5.7$; $N_q = 1$ and $N_r = 0$

$\therefore \quad q_u = 1.3 \times 13.5 \times 5.7 + \gamma\,(0)\,(1) + 0$

$q_u = 100.$kPa Ans: 100 – 102 Kpa

52. $M = 20 \times 200 \times \frac{70}{100} = 280$ kg/day

$e_f = S_f \times e_w = 1.06 \times 1000 = 1060$ kg/m^3

$ed = S_d \times e_w = 1.02 \times 1000 = 1020$ kg/m^3

$$V_f = \frac{100}{100-p1} \times \frac{M}{e_f}$$

$$= \frac{100}{100-98} \times \frac{280}{1060}$$

$= 13.2$ m^2/day

$$V_d = \frac{100}{100-P_2} \times \frac{M}{e_d}$$

$$= \frac{100}{100-90} \times \frac{280}{1020} = 2.745\text{m}^3/\text{day}$$

Capacity of digester $= \left[\frac{V_f + V_d}{2}\right] \times t$

$= \left[\frac{13.2 + 2.745}{2}\right] \times 60 = 478.35 m^3$

Ans : $478.35 m^3$

53. $VMA = \frac{v_a + v_b}{v_t} \times 100$

$V_a = \frac{G_t - G_m}{G_t} \times 100$

$G_t = \frac{100}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4}}$

$W = w_1 + w_2 + w_3 + w_4 + w_5 = 825 + 1200 + 325 + 150 + 100 = 2600$

$W_1 = \frac{825}{2600} \times 100 = 31.7\%$

$W_2 = \frac{1200}{2600} \times 100 = 46.1\%$

$W_3 = \frac{325}{2600} \times 100 = 12.5\%$

$W_4 = \frac{150}{260} \times 100 = 5.76\%$

$W_5 = \frac{100}{2600} \times 100 = 3.84\%$

$G_t = \frac{100}{\frac{31.7}{2.63} + \frac{46.1}{2.51} + \frac{12.5}{2.46} + \frac{5.76}{2.43} + \frac{3.84}{1.05}} = 2.405,$

$G_m = \frac{1100}{475} = 2.315$

$V_a = \frac{2.405 - 2.315}{2.405} \times 100 = 3.74\ \%,$

$V_b = \frac{G_m \times W_b}{G_b} = \frac{2.315 \times 3.84}{1.05} = 8.479\%$

$VMA = 3.74 + 8.749 = 12.491.$ Choice (C)

54. Total extra widening on the road

7m wide road has two lanes as per IRC

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

$= \frac{2 \times (6.1)^2}{2 \times 100} + \frac{70}{9.5\sqrt{100}} = 1.11m.$ Choice (C)

55. $SSD = vt + \frac{v^2}{2gf}$

$= 22.2\ (2) + \frac{22.22^2}{2 \times 9.81 \times 0.35} = 116m$

$S = SSD + L = 116 + 6 = 122m$

$C = \frac{1000\ V}{S} = \frac{1000 \times 80}{122} = 656 veh/hr.$ Choice (B)

56. $e = \frac{(0.75v)^2}{gR}$

$= \frac{(0.75 \times 27.77)^2}{9.81 \times 500} = 0.08 = 8\%$ is greater than 7% as per IRC in plain terrain. Choice (A)

58. $CBR = \frac{\text{load at 2.5 mm penetration}}{\text{standard load at 2.5 mm penetration}}$

$= \frac{55}{(19.6 \times 70)} = 4.0\%$

$CBR\ (\%) = \frac{\text{load at 5.0 mm penetration}}{\text{standard load}}$

$= \frac{78 \times 100}{19.6 \times 105} = 3.79\%$

CBR (%) = 4.0% Choice (C)

59. $T = 20$ years

$P = \frac{1}{T} = \frac{1}{20} = 0.05$

$N = 10$ years

$Q = 1 - p = 1 - 0.05 = 0.95$

Probability of occuring at least once $= 1 - q^n$

$= 1 - (0.95)^{10}$

$= 0.4012 = 40.12\%.$ Choice (B)

60. $C_0 = \frac{-kx + 0.5\Delta t}{k - kx + 0.5\Delta t} = \frac{(-8 \times 0.25) + (0.5 \times 4)}{8 - (8 \times 0.25) + (0.5 \times 4)} = 0$

$C_1 = \frac{kx + 0.5\Delta t}{k - kx + 0.5\Delta t} = \frac{(8 \times 0.25) + (0.5 \times 4)}{8 - (8 \times 0.25) + (0.5 \times 4)} = 0.5$

$C_2 = 1 - C_0 - C_1 = 1 - 0 - 0.5 = 0.5$

$Q_2 = C_O I_2 + C_1 I_1 + C_2 Q_1$

$= 0 + (0.5 \times 8) + (0.5 \times 8)$

$= 8 m^3/sec.$ Choice (B)

61. $\eta_a = 0.8$, $\eta_c = 0.7$

Net irrigation requirement, NIR = 14.9

$FIR = \frac{NIR}{n_a} = \frac{14.9}{0.8} = 18.65cm$

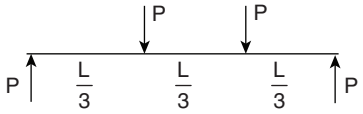
$GIR = \frac{FIR}{n_c} = \frac{18.625}{0.7} = 26.607cm.$ Choice (D)

62. $Q = 50 m^3/sec.$ $f = 1$, $x = 0.5$

$V = \left(\frac{Qf^2}{140}\right)^{\frac{1}{6}} = \left(\frac{50 \times 1^2}{140}\right)^{\frac{1}{6}} = 0.842 m/s$

$A = \frac{50}{0.842} = 59.38 m^2.$ Choice (D)

63.



Space diagram is as shown in the figure.
Bending moment at the centre

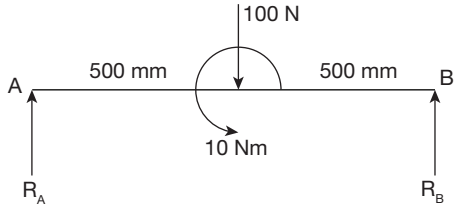
$$= P \times \frac{L}{2} - P \times \frac{L}{6} = PL\left(\frac{1}{2} - \frac{1}{6}\right) = \frac{PL}{3}$$ Choice (B)

64. As there is no shear stress the stresses shown may be taken as principal stresses
$p_1 = 80$ MPa; $p_2 = -20$ MPa

Radius of Mohr's circle $= \frac{p_1 - p_2}{2} = \frac{80 + 20}{2}$

$= 50$ MPa Choice (C)

65.



$R_A + R_B = 100$ N
Taking moment about A,

$R_B \times 1 + 10 - 100 \times 0.5 = 0$

$\Rightarrow R_B = 50 - 10 = 40$ N

$\Rightarrow R_A = 100 - 40 = 60$ N

Maximum bending moment $= 60 \times 0.5 = 30$ Nm

Choice (A)