Mock Test 1

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

Section – I: General Aptitude

Questions 1 to 5 carry One Mark each.

Directions for questions 1 and 2: Select the correct alternative from the given choices.

1. $P = \{4, 6, 8, 10\}$
$Q = \{8, 10, 12, 14, 16\}$
Two integers were randomly selected such that one was selected from set P and the other was selected from set Q. What is the probability of the sum of these integers not being equal to 18?
(A) 0.67 (B) 0.70
(C) 0.75 (D) 0.80

2. In a certain code language, if the word SPRING is coded as TSWPWR, then how is the word ELASTIC coded in that language?
(A) FMBTUJD
(B) FOFZEVT
(C) FOFZTCZ
(D) FOFZCTP

Directions for question 3 and 4: Choose the word from the options given below, that is most nearly **similar** in meaning to the given word.

3. REIMBURSE
(A) Offset (B) Outshine
(C) Emanate (D) Indemnify

4. RAUCOUS
(A) Hoarse (B) Risky
(C) Phonetic (D) Bitter

Directions for question 5: Fill in the blank with the correct idiom/phrase.

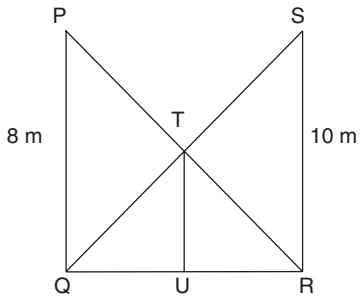
5. His association with bad companions got him _____.
(A) a piece of cake
(B) into hot water
(C) back to the drawing board
(D) beating around the bush

Questions 6 to 10 carry Two Marks each.

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

6. A right angled triangle GHI is to be formed in a rectangular coordinate system such that the triangle is right angled at H and HI is parallel to the y-axis. It is also intended for the x-and the y-coordinates of G, H and I to satisfy the inequalities $-8 \le x \le 8$ and $7 \le y \le 15$. How many triangles can be formed such that the above conditions are satisfied?
(A) 78 (B) 1224
(C) 19584 (D) 20566

7.



In the figure above, angle PQR = angle QRS = angle $TUR = 90°$, $PQ = 8$ m and $SR = 10$ m. Find TU (in m).
(A) $\frac{29}{9}$ (B) $\frac{31}{9}$
(C) $\frac{40}{9}$ (D) $\frac{34}{9}$

8. There are few pens in one box, few pencils in another box and a mixture of pens and pencils in a third box. But each of these boxes is wrongly labeled and the labels on the boxes are 'Pens' 'Pencils' and 'Mixture'. You are allowed to select only one box and only one item from that box. Which labeled box would you select to determine what each box contains?
(A) Pens
(B) Pencils
(C) Mixture
(D) Any one of the above

Directions for question 9: Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence.

9. The child had a _____ birth defect in the form of a cleft palate.
(A) hereditary (B) compulsive
(C) congenial (D) congenital

10. Mr. Dutta, a politician, said that he had visited England and he wanted to float the first green party in India. He said his greens were going to replace red in Bengal.
Which of the following can be inferred from the sentence above?
I. There is a green party in England.
II. Green party is not the name of a party.
III. The green party is going to be floated in Bengal.
(A) All follow
(B) Only I and III follow
(C) Only III follows
(D) Only II and III follow

SECTION – II: CIVIL ENGINEERING

Direction for questions 11 to 65: Select the correct alternative form the given choices.

Questions 11 to 35 carry One Mark each.

11. The length of the curve $x = y\sqrt{y}$ from (0, 0) to (8, 4) is _____
(A) 8.06 (B) 9.07
(C) 10.07 (D) 7.08

12. If 2, – 4 and 7 are the eigenvalues of a 3 × 3 square matrix A, then the rank of A is _____
(A) 3 (B) 2
(C) 1 (D) None of these

13. If the inverse Laplace transform of a function $F(s)$ is $L^{-1}[F(s)] = t^2 + 3t - 2\sin t$, then $L^{-1}[s\,F(s)]$ is _____.
(A) $t + 3 - \frac{2}{t}\sin t$
(B) $\frac{t^3}{3} + \frac{3}{2}t^2 + 2\cos t$
(C) $t^3 + 3t^2 - 2t\sin t$
(D) $2t + 3 - 2\cos t$

14. For larger values of the degrees of freedom υ, x^2 – distribution can be approximated to _____
(A) Poisson distribution
(B) Normal distribution
(C) F – distribution
(D) Exponential distribution

15. The order and degree of the partial differential equation $\frac{\partial^2 u}{\partial t^2} - 3\left(\frac{\partial^2 u}{\partial x^2}\right)^2 + 4\frac{\partial^3 u}{\partial x \partial t^2} - 6\frac{\partial u}{\partial x} + 4u^2 = 0$ respectively are _____
(A) 2 and 1 (B) 2 and 2
(C) 3 and 1 (D) 3 and 2

16. The shear test that is more suitable in the field is _____.
(A) Unconfined compression test.
(B) Tri axial shear test.
(C) Box shear test.
(D) Vane shear test.

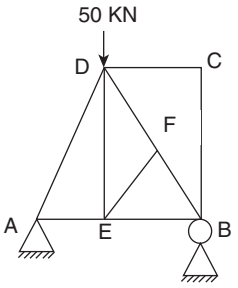
17. The camber provided on a sloping road is 1 in 28. Which of the following is ruling gradient?
(A) 1 in 15 (B) 1 in 14
(C) 1 in 41 (D) 1 in 28

18. EMD in contracts refer to
(A) Earlier Money Draft
(B) Earnest Money Draft
(C) Emergency Money Deposit
(D) Earnest Money Deposit

19. The return period for annual maximum flood of a given magnitude is 10 years. The probability that this flood will be exceeded once during next 5 years is
(A) 0.402 (B) 0.483
(C) 0.409 (D) 0.408

20. MPN index is a measure of _____.
(A) Hardness. (B) Turbidity.
(C) Coliform bacteria. (D) Sludge.

21.



The number of zero force members in the given truss is _____.
(A) 3 (B) 4
(C) 5 (D) 6

22. Shear force in a beam under load is
(A) Rate of change of loading
(B) Rate of change of bending moment
(C) Rate of change of slope
(D) Rate of change of deflection

23. In a two dimensional incompressible flow, x-component of velocity $u = y^2 + 4xy$. If y component of velocity $v = 0$ at $y = 0$ expression for v is
(A) $2xy$ (B) $-2y^2$
(C) $2y^2$ (D) $4y$

24. The target mean strength of concrete mix is give by (follow usual notations)
(A) $fck + s$ (B) $k.fck + s$
(C) $fck + ks$ (D) $k(fck + s)$

25. Match the List-I with List-II

	List–I (Type of transition curves)		List–II (Characteristics)
a.	Glover's spiral	1.	An autogenous curve of automobile
b.	Cubic spiral	2.	Radius of curve at any point varies inversely as the distance from the beginning of curve.
c.	Froude's transition curve	3.	$\sin\phi = \phi$
d.	Bernoulli's lemniscates	4.	X = L, $\cos\phi$=1

Codes:

	a	b	c	d		a	b	c	d
(A)	3	4	2	1	(B)	2	3	4	1
(C)	4	3	2	1	(D)	1	2	3	4

26. A column is fixed at the bottom and free at the top end. If L is the length of the column, EI is the flexural rigidity, Euler's critical load for the column is

(A) $\frac{\pi^2 EI}{4L^2}$ (B) $\frac{\pi^2 EI}{L^2}$

(C) $\frac{2\pi^2 E}{L^2}$ (D) $\frac{4\pi^2 EI}{L^2}$

27. The minimum area of tension reinforcement in a beam shall be greater than which of the following for the grade of Fe415 steel

(A) 0.002 bd (B) 0.0002 bd

(C) 0.003 bd (D) 0.0003 bd

28. The expression for specific speeds of a hydraulic turbine and a pump respectively are

(A) $\frac{N\sqrt{Q}}{H^{\frac{5}{4}}}, \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$ (B) $\frac{N\sqrt{P}}{H^{\frac{3}{4}}}, \frac{N\sqrt{Q}}{H^{\frac{5}{4}}}$

(C) $\frac{N\sqrt{P}}{H^{\frac{5}{4}}}, \frac{N\sqrt{Q}}{H^{\frac{3}{4}}}$ (D) $\frac{N\sqrt{Q}}{H^{\frac{3}{4}}}, \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$

29. The instrument used to measure contour interval is called

(A) Roughometer

(B) Gradienmeter

(C) Auto level

(D) Thacheometer

30. The phenomenon of salts coming in solution and forming a thin crust on surface of soil after evaporating of water is called _____.

(A) white alkali

(B) saline soil

(C) black alkali

(D) red alkali

31. The ultimate BOD of the waste water, whose 5 – day BOD and rate constant (base e) are respectively 180 mg/l and 0.23/day, is

(A) 164 mg/l (B) 204 mg/l

(C) 224 mg/l (D) 264 mg/l

32. In case of passive earth pressure, what would be the angle (in degrees) of failure plan with respect to horizontal plane (Take ϕ of the soil as 30°) _____.

(A) 30° (B) 45°

(C) 60° (D) 90°

33. For the soil having specific gravity 2.65 and void ratio as 0.4; the critical gradient would be _____.

(A) 1.89 (B) 1.18

(C) 1.03 (D) 1.65

34. Generally, fatigue life of welded steel structure to fatigue life of riveted steel structure ratio is

(A) smaller than 1

(B) equal to 1

(C) greater than 1

(D) greater than 2.1

35. The length of the runway under standard conditions is 1480. The airport site has on elevation of 260 m. Its reference temperature is 32°C. Assuming all over conditions to be under standard level then correction for elevation is _____.

(A) 1400 m (B) 1470 m

(C) 1500 m (D) 1570 m

Questions 36 to 65 carry Two Marks each.

36. The value of $\oint_C \left(xydy - \frac{3}{2} y^2 dx \right)$, C being the boundary of the region enclosed by the circle $x^2 + y^2 = 9$ and the coordinate axes in the first quadrant is _____

(A) 9 (B) 18

(C) 27 (D) 36

37. If the characteristic equation of a 3 × 3 matrix A is $\lambda^3 - 3\lambda^2 + \lambda - 3 = 0$, then the determinant of the matrix $B = 2A^7 - 6A^6 + 2A^5 - 6A^4 - 3A^3 + 7A^2 - 3A + 9I_3$ is _____

(A) 72 (B) –72

(C) 36 (D) –36

38. The Taylor's series expansion of $f(x) = x^3 - 5x^2 + 6x - 2$ about $x = -1$ is _____

(A) $(x-1)^3 - 8(x-1)^2 + 19(x-1) - 14$

(B) $(x+1)^3 + 16(x+1)^2 - 19(x+1) + 14$

(C) $(x+1)^3 - 8(x+1)^2 + 19(x+1) - 14$

(D) $(x-1)^3 + 16(x-1)^2 - 19(x-1) + 14$

39. In a binomial experiment, the chances of getting success and failure are in the ratio 1:2, then the probability of getting the 5th success in the 8th trial is _____

(A) $\frac{280}{2187}$ (B) $\frac{140}{6561}$

(C) $\frac{280}{6561}$ (D) $\frac{140}{2187}$

40. Consider the following table of values of x and $f(x)$

x	–1	0	3	6	7
f(x)	3	–6	39	822	1611

The 4th divided difference value is _____

(A) 1 (B) 13

(C) 132 (D) 789

41. A simply supported pre stressed concrete beam of 6m long, 300mm wide and 600mm of depth is pre stressed by horizontal cable tensioned at eccentricity of 100mm. If the pre stressing tensile force in the cable tendon is given as 1000 KN, what will be the maximum and minimum normal stress developed in beam at transfer?

(A) 11.11Mpa, 5.55Mpa

(B) 11.11Mpa, 0

(C) 0, 5.5Mpa

(D) 11.11Mpa, 11.11Mpa.

42. The following are the rates of rainfall of successive 20min period of a 150min storm 5.0, 4.0, 11.0, 8.5, 1.45, 1.85, 7.0 cm/hr. Taking the value of ϕ - index as 4.5 cm/hr, find the net runoff in cm.

(A) 2.3 cm (B) 6.4 cm
(C) 4.82 cm (D) 4.51 cm

43. Chose the correct pairs from the following

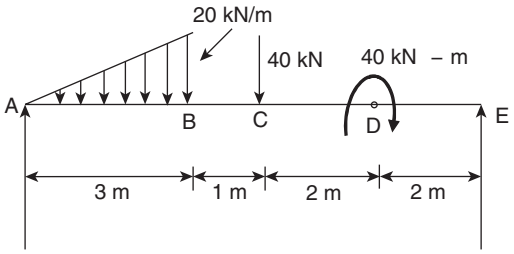
	Group–I		Group–II
1.	HC	a.	Primary air pollutant
2.	O_3	b.	Secondary pollutant
3.	PAN		
4.	NO_x		

(A) 1 – b, 2 – b, 3 – a, 4 – a
(B) 1 – b, 2 – a, 3 – a, 4 – b
(C) 1 – a, 2 – b, 3 – b, 4 – a
(D) 1 – a, 2 – a, 3 – b, 4 – b

44. A soil has a bulk density of 2.05 g/cc and water content of 21%. If G = 2.64, the degree of saturation of the soil is _____.

(A) 50% (B) 75%
(C) 100% (D) 0%

45.



A simply supported beam is loaded as shown above. Maximum bending at point *D* is

(A) 25 kNm
(B) 35 kNm
(C) 65 kNm
(D) 45 kNm

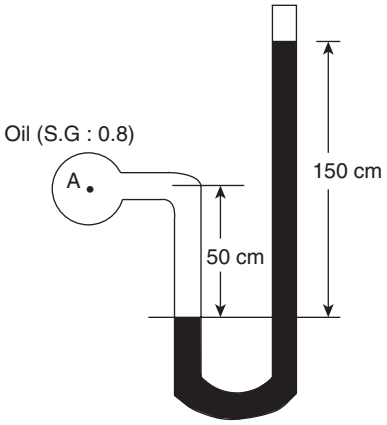
46. Match List-I with List-II and select correct answer using the codes given

	List–I		List–II
a.	Pelton turbine (single jet)	1.	Medium discharge, low head
b.	Francis turbine	2.	High discharge, low head
c.	Kaplan turbine	3.	Medium discharge, medium head
		4.	Low discharge, high head

Codes:

	a	b	c
(A)	1	2	3
(B)	4	3	2
(C)	2	3	4
(D)	3	4	1

47. A U-tube mercury manometer is used to measure pressure of oil flowing through a pipe at a point. Specific gravity of oil is 0.8 and the level of mercury is as shown in the figure. The pressure in kPa is



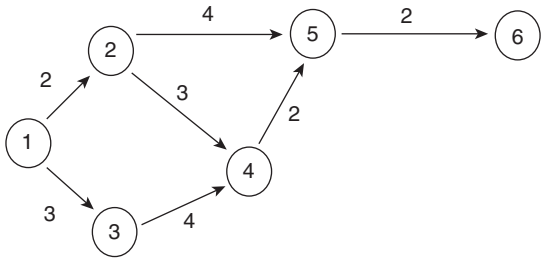
(A) 196.20
(B) 147.15
(C) 110.36
(D) 73.58

48. The development length of a deformed reinforced bar under compression can be expressed as $K.\left(\frac{\phi.\sigma_s}{4\tau_{bd}}\right)$.

From the IS 456:2000, the value of *K* can be calculated as _____.

(A) 2 (B) 0.75
(C) 0.5 (D) 0.125

49.



Critical path of the give network is _____.

(A) 1 - 2 - 4 – 5- 6
(B) 1 - 2 - 5 - 6
(C) 1 - 3 - 4 - 5 - 6
(D) None of the above

50. During a leveling work along a falling gradient using a dumpy level and a staff of 3m length, following successive readings were taken:-

1.745, 2.765, 0.243, 1.432. What will be the correct order of booking these four readings in level book (*BS*: Back Sight, *IS*: Intermediate Sight, *FS*: Fore Sight).

(A) *BS*, *FS*, *BS*, *FS*
(B) *BS*, *IS*, *FS*, *FS*
(C) *BS*, *IS*, *IS*, *FS*
(D) *BS*, *IS*, *BS*, *FS*.

51.

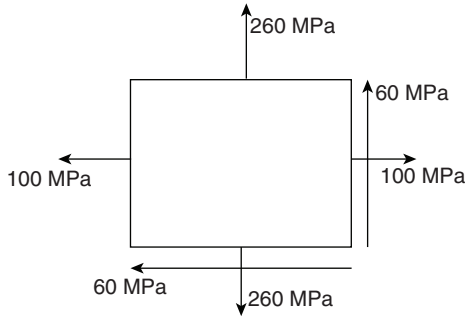


Figure shows state of stress at a point in a stressed body. Radius of Mohr's circle representing the state of stress is

(A) 60 (B) 80
(C) 120 (D) 100

52. A single lane unidirectional highway has design speed of 55 kmph. The perception brake reaction time of driver's is 2.5 seconds and average length of vehicles is 6m. The capacity of this road in terms of kmph is.

(A) 604 veh/hr/lane (B) 743 veh/hr/lane
(C) 402 veh/hr/lane (D) 516 veh/hr/lane

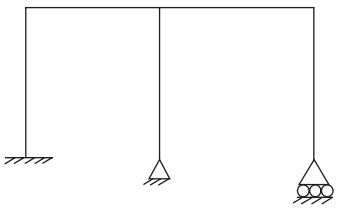
53. If the actual observed value of standard penetration resistance, N in a fine sand layer below water table is 25. What will be the equivalent penetration resistance after correction _____.

(A) 10 (B) 15
(C) 20 (D) 25

54. A water treatment plant of capacity 5 m^3/s has filter boxes of dimensions 8m × 15m. Loading rate to the filter is 240 $m^3/day/ m^2$. When three of the filters are out of service for back washing, the loading rate (in $m^3/day/ m^2$) is _____.

(A) 200 (B) 300
(C) 400 (D) 500

55. The static and kinematic indeterminacy of the frame shown below is _____.



(A) 3 and 3 (B) 6 and 9
(C) 6 and 7 (D) 3 and 7

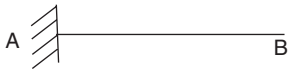
56. If the wheel base of a train moving on broad gauge track is 5.5m, the diameter of wheel base is 1.4m and depth of flanges below the top of rail is 3.2cm. The extra width of provided gauge, if radius of curve is 100m is _____.

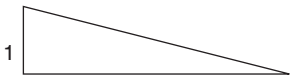
(A) 4.6 cm (B) 5.6 cm
(C) 6.6 cm (D) 7.2 cm

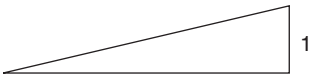
57. In a certain situation, waste water is discharged into a river mixes with the river water instantaneously and completely. Following is the data available.
Waste water DO = 2mg/l
Discharge rate = 1.5 m^3/sec
River water DO = 8.4 mg/l
Flow rate = 8.8 m^3/sec
Temperature = 20°C
What will be the initial amount of DO in the mixture of waste and river water?

(A) 7.39 mg/l
(B) 7.47 mg/l
(C) 5.29 mg/s
(D) 7.29 mg/l

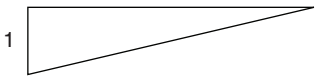
58. For a given beam AB, ILD for vertical reaction at fixed end A is _____.



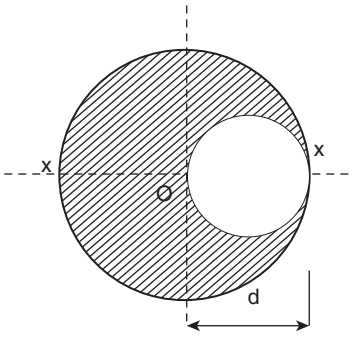
(A) 

(B) 

(C) 

(D) 

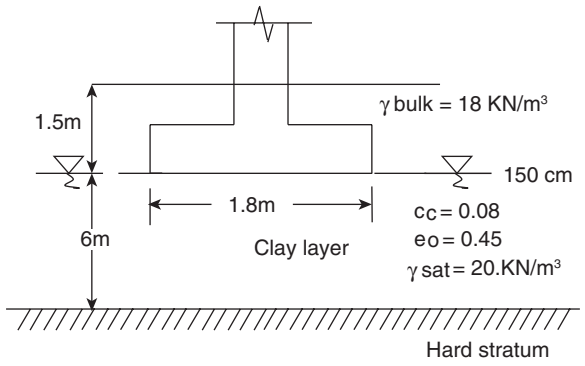
59.



Centroid of the shaded area shown in figure, is at a distance of _____ from O

(A) $\frac{d}{8}$ (B) $\frac{d}{6}$
(C) $\frac{d}{3}$ (D) $\frac{d}{2}$

60. Figure shows the geometry of a strip footing supporting the load bearing walls of a multi storied building and the properties of clay layer.
(Take γ_w = 10 KN/m^3)



If the pressure acting on the footing is 40 Kpa, the consolidation settlement of the footing will be _____

(A) 7.64 mm
(B) 76.4 mm
(C) 54.38 mm
(D) 5.43 mm

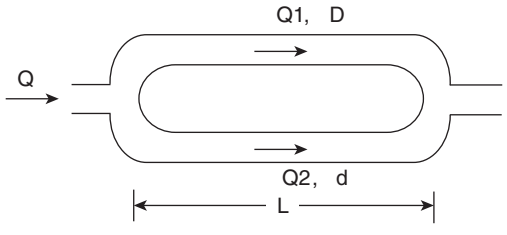
61. The gross commanded area for a distributary is 8000 hectares, 70% of which culturable irrigable. The intensity of irrigation for karif season is 35% and that for rabi season is 60%. If average duty of head of distributary is 800 hectares/cumec for karif season and 1500 hectares/cumec for rabi season, find the discharge required for design at head of distributary.

(A) 2.24 m^3/sec
(B) 2.45 m^3/sec
(C) 2.52 m^3/sec
(D) 2.25 m^3/sec

62. A non-homogeneous soil deposit consists of a clay layer sandwiched between a fine sand layer at top and a silt layer below. Permeability of the silt layer is given as five times the permeability of clay layer and $\frac{1}{10}$th of the sand layer. Thickness of sand layer is 2 times the thickness of the silt layer and half of the thickness of clay layer. Then, what will be the ratio of equivalent horizontal and vertical permeability of the deposit ____ (Round up to nearest integer)

(A) 5 (B) 10
(C) 15 (D) 20

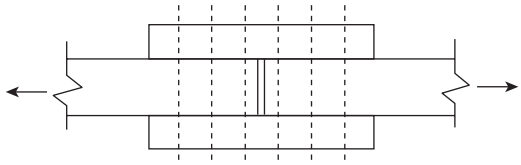
63.



Two pipes of equal length L are connected in parallel. Rate of flow through pipe of diameter D is Q_1 and pipe of diameter d is Q_2. If $d = 0.5\ D$, the ratio of $\frac{Q_1}{Q_2}$ is equal to

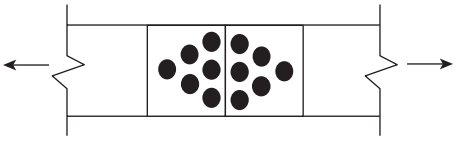
(A) 3.462 (B) 4.683
(C) 5.657 (D) 6.448

64. Identify the most effective but joint (with double cover plates) for a plate in tension from the patterns (plan view) shown below, each comprising 6 identical bolts with the same pitch and gauge:

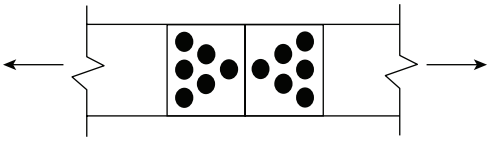


Common Elevation
(all plates have same thickness)

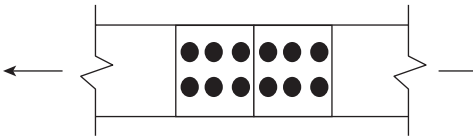
(A)



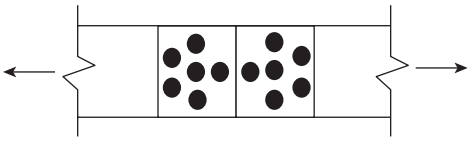
(B)



(C)



(D)



65. The following data pertains to number of commercial vehicles per day for the design flexible pavement for national highway as per *IRC*: 37-1984.

Type of commercial no. of vehicles per day	Vehicles considering no. of lanes	Vehicles damaging factor
Two axle trucks	3000	7
Tanden axle trucks	400	8

Assuming a traffic growth factor of 7.5% per annum for both the types of vehicles, the cumulative number of standard axle load repetitions for a design life of ten years is

(A) 13.42 msa
(B) 14.26 msa
(C) 12.49 msa
(D) 15.3 msa

Answer Keys

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

Hints and Explanations

1. Probability (The sum not being equal to 18) = 1 – Probability (The sum being equal to 18)
The number of ways of selecting two integers one from each set is $4 \times 5 = 20$.
The sum can be 18 when the integers selected are 4 and 14, 6 and 12, 8 and 10, 10 and 8.

$\therefore$ Probability that the sum being $18 = \frac{4}{20}$

$\therefore$ Required probability $= 1 - \frac{4}{4 \times 5} = 0.8$

Choice (D)

2. Word: *S P R I N G*
Logic: +1 +3 +5 +7 +9 + 11
Code: *T S W P W R*
Similarly,
Word: *E L A S T I C*
Logic: +1 +3 +5 +7 +9 +11 +13
Code: *F O F Z C T P* Choice (D)

3. To 'reimburse' is to pay back the money spent. To 'indemnify' is also to pay back money (for some loss or damage). 'Offset' is an amount that diminishes or balances the effect of an opposite one. It does not mean a guarantee, as does 'indemnity'. Choice (D)

4. 'Raucous' is harsh or 'hoarse'. Other synonyms are, grating, discordant, jarring or strident. Choice (A)

5. When we get into bad company we get into hot water or get into trouble. Other idioms do not work in the context. 'A piece of cake' is a job/task that is very easy while 'back to the drawing board' means a failed attempt that has to be started again. To 'beat around the bush' is to avoid speaking openly/directly about an issue. Choice (B)

6. *HI* is parallel to the *y*-axis. Any line parallel to the *y*-axis must have its equation of the form $x = a$ constant.
$\therefore$ *HI* can be any of the lines $x = -8$ or $x = -7$ or …. $x = -1$ or $x = 0$ or $x = 1$ or ….. $x = 8$. ($\because -8 \le x \le 8$, $7 \le y \le 15$).
Suppose *HI* is the line $x = 8$. Then *H* can be any of (8, 7), (8, 8), …… (8, 15). $\therefore$ *H* has 9 possible positions. For each of these possible positions *I* can have any of the remaining 8 possible positions.
$\therefore$ *HI* has $9 \times 8 = 72$ possibilities.
As explained above, it similarly follows that when *HI* is the line $x = 7$ or $x = 6$ or ….. $x = -8$, *HI* has 72 possibilities in each case.
Total number of possibilities for *HI* = (72) (17) = 1224
The triangle is right angled at *H*.
$\therefore$ The *y*-coordinate of *G* must be the same as that of *H* and its *x*-coordinate can be any possible value other than that of *H*.
$\therefore$ The *x*-coordinate of *G* has 17 – 1 = 16 possibilities.
$\therefore$ *G* has 16 possible positions.
From (1) and (2)
$\therefore$ The triangle *GHI* has 1224 × 16 = 19584 possible arrangements i.e., 19584 triangles can be formed satisfying the given conditions.
Alternate Solution:
Given $-8 \le x \le 8$ and $7 \le y \le 15$ i.e. there are 17 vertical lines and 9 horizontal lines. The number of rectangles formed with these lines is ${}^{17}C_2 \times {}^{9}C_2$.

We know that one rectangle gives 4 right angled triangles.
$\therefore$ Total number of right angled triangles formed is $4 \times {}^{17}C_2 \times {}^{9}C_2 = 19584$. Choice (C)

7. In ΔTUR and ΔPQR,
$\angle R$ is common.
$\angle TUR = \angle PQR = 90°$
The above conclusions mean the third pair of angles of both Δ's must be equal. The third angle of each Δ = 180° − (sum of the other two of its angles).
$\therefore$ $\Delta TUR \sim \Delta PQR$.

$\therefore$ $\frac{TU}{PQ} = \frac{UR}{QR}$ ---------- (1)

Similarly $\Delta TUQ \equiv \Delta SRQ$.

$\therefore$ $\frac{TU}{SR} = \frac{QU}{QR}$ --------- (2)

$\frac{(1)}{(2)} \Rightarrow \frac{SR}{PQ} = \frac{UR}{QU}$

$\therefore$ $\frac{QU}{UR} = \frac{8}{10} = \frac{4}{5}$

$$\Rightarrow \quad 1+\frac{QU}{UR}=1+\frac{4}{5}$$

$$\Rightarrow \quad \frac{UR+QU}{UR}=\frac{9}{5}$$

$$\Rightarrow \quad \frac{QR}{UR}=\frac{9}{5}$$

$$\frac{UR}{QR}=\frac{5}{9}$$

From (1) $\Rightarrow \frac{TU}{8}=\frac{5}{9}$

$$TU=\frac{40}{9}\text{m}$$ Choice (C)

8. We have to select the box that is labeled as mixture. Now if we get a pen, as the box cannot have a mixture, it has pens. Now the box which is labeled as pens cannot have mixture. [$\because$If it happens then the box with label pencil must contain pencils]
$\Rightarrow$ The box with label pens has pencils and that with pencils has a mixture of them. Choice (C)

9. Birth defects are congenital (present from birth) and not hereditary, compulsive, or congenial (affable; friendly). Choice (D)

10. Mr. Dutta has decided to float the first green party in India after visiting England. It is clear that there is a green party in England and Mr. Dutta is impressed with the party. Assume the case where Mr. Dutta learnt about the green party while in England but there is no green party in England; in such a case, there would not be any relevance to the visit to England. Hence I follows.
According to the statement, Mr. Dutta wants to float the first green party. It implies that there can be several green parties. There cannot be more than one party with the same name. Hence, II follows.
Mr. Dutta says his green would replace the reds in Bengal. From this, it can be concluded that the green party in going to be floated in Bengal as well. Hence, III too follows.
Therefore all follow. Choice (A)

11. Given curve is $x = y\sqrt{y}=y^{\frac{3}{2}}$

$$\Rightarrow \quad \frac{dx}{dy}=\frac{3}{2}y^{\frac{1}{2}}$$

$\therefore$ The length of the curve $x = y\sqrt{y}$ from (0, 0) to

$$(8,4)=\int_{y=0}^{4}\sqrt{\left(1+\left(\frac{dx}{dy}\right)^2\right)}dy$$

$$=\int_{y=0}^{4}\sqrt{\left(1+\left(\frac{3}{2}y^{\frac{1}{2}}\right)^2\right)}dy$$

$$=\int_{0}^{4}\sqrt{\left(1+\frac{9}{4}y\right)}dy$$

$$=\frac{2}{3}\left(1+\frac{9}{4}y\right)^{\frac{3}{2}}\times\frac{4}{9}\Big]_0^4$$

$$=\frac{8}{27}\left(1+\frac{9}{4}\times4\right)^{\frac{3}{2}}-\frac{8}{27}\left(1+\frac{9}{4}\times0\right)^{\frac{3}{2}}$$

$= 9.0734.$ Choice (B)

12. Since none of the eigenvalues of A are zero, A is a non-singular matrix.
$\therefore$ The rank of A = The order of $A = 3$. Choice (A)

13. Given $L^{-1}[F(s)] = t^2 + 3t - 2\sin t = f(t)$, (say)
$\therefore \quad f(0) = 0^2 + 3 \times 0 - 2 \sin 0 = 0$
We know that, if $L^{-1}[F(s)] = f(t)$ and
$f(0) = 0$, then $L^{-1}[s\,F(s)] = f^1(t)$

$\therefore \quad L^{-1}[s\,F(s)] = f^1(t) = \frac{d}{dt}\,[t^2 + 3t - 2\sin t] = 2t + 3 - 2\cos t.$ Choice (D)

14. Standard Result. Choice (B)

15. For the partial differential equation

$$\frac{\partial^2 u}{\partial t^2}-3\left(\frac{\partial^2 u}{\partial x^2}\right)^2+4\frac{\partial^3 u}{\partial x\,\partial t^2}-6\frac{\partial u}{\partial x}+4u^2=0$$

Order = order of the highest ordered partial derivative = 3
Degree = Degree (power) of the highest ordered partial derivative = 1. Choice (C)

17. $G = 2C = 2\times\frac{1}{28}=\frac{1}{14}$ Choice (B)

19. $p^1 = 1 - q^n$

$$p=\frac{1}{T}=\frac{1}{10}=0.1$$

$q = 1 - 0.1 = 0.9$

$p=1-(0.9)^5=0.409$ Choice (C)

21. Zero force members are:
DC, BC, EF, DE Choice (B)

23. Continuity equation must be satisfied for the flow

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

$u = y^2 + 4xy$

$$\frac{\partial u}{\partial x}=4y$$

To satisfy continuity equation

$$\frac{\partial v}{\partial y}=-4y$$

On integration, $v=-\frac{4y^2}{2}+C=-2y^2+C$

It is given that $v = 0$ at $y = 0$

$\therefore \quad C = 0$

$\therefore$ The expression for v is $v = -2y^2$ Choice (B)

26. Euler's critical load $P_{cr} = \dfrac{\pi^2 EI}{L_e^2}$

where L_e = effective length

For the given case, $L_e = 2L$

$\therefore \quad P_{Cr} = \dfrac{\pi^2 EI}{4L^2}$ Choice (A)

27. $\dfrac{As}{bd} = \dfrac{0.85}{fy}$

$\therefore \quad \text{As} = \dfrac{0.85}{415} \times bd = 0.002\ bd$ Choice (A)

31. $y_t = y_0(1 - e^{-kt})$

$y_5 = y_0\left(1 - e^{-(0.23\times 5)}\right)$

$180 = y_0(0.683)$

$\therefore \quad y_0$ 263.4 mg/l

$y_0 = 263.4$ mg/l Choice (D)

32. Passive earth pressure case,

45 + ϕ/2 w.r.t. major principal plane (vertical)

45 – ϕ/2 w.r.t. minor principal plane (horizontal)

Choice (A)

33. $G = 2.65$ and $e = 0.4$

$i_c = \dfrac{G-1}{1+e} = \dfrac{1.65}{1.4} = 1.18$ Choice (B)

35. Correction for elevation

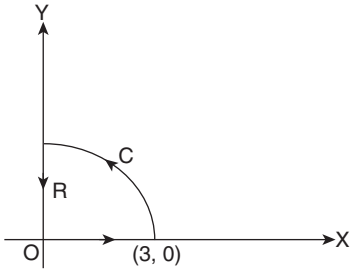
$= \dfrac{7}{100} \times 1480 \times \dfrac{260}{300} = 89.78\text{m}$

Corrected length = 1480 + 89.78m = 1569.7m

Choice (D)

36. We have $\oint_C \left(xy\,dy - \dfrac{3}{2}y^2 dx \right)$

$= \oint_C \left[\dfrac{-3}{2} y^2 dx + xy dy \right]$



By Green's theorem, we know that

$$\oint_C M dx + N dy = \iint_R \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y} \right) dx dy \quad \rightarrow (1)$$

Here $M = \dfrac{-3}{2} y^2$ and $N = xy$

$\therefore \quad \dfrac{\partial M}{\partial y} = -3y$ and $\dfrac{\partial N}{\partial x} = y$

In the region R,

y varies from $y = 0$ to $y = \sqrt{9 - x^2}$ and x varies from $x = 0$ to $x = 3$

$\therefore \quad \oint_C xy dy - \dfrac{3}{2} y^2 dx = \oint_C M\,dx + N\,dy$

$= \iint_R \left(\dfrac{\partial N}{\partial x} - \dfrac{\partial M}{\partial y} \right) dx\,dy$ [From (1)]

$= \iint_R \left(y - (-3y) \right) dx\,dy$

$= \int_{x=0}^{3} \left(\int_{y=0}^{\sqrt{9-x^2}} 4y\,dy \right) dx$

$= \int_{x=0}^{3} 2y^2 \Big]_{y=0}^{\sqrt{9-x^2}}\ dx$

$= \int_0^3 2\left(9 - x^2\right) dx$

$= 18x - \dfrac{2}{3}x^3 \Big]_0^3 = 36.$ Choice (D)

37. Given the characteristic equation of a 3×3 matrix A is $\lambda^3 - 3\lambda^2 + \lambda - 3 = 0$

$\therefore$ By Cayley – Hamilton theorem, we have $A^3 - 3A^2 + A - 3I_3 = O \rightarrow (1)$

Consider $B = 2A^7 - 6A^6 + 2A^5 - 6A^4 - 3A^3 + 7A^2 - 3A + 9I_3 = 2A^4(A^3 - 3A^2 + A - 3I_3) - 3(A^3 - 3A^2 + A - 3I_3) - 2A^2 = 2A^4 \times 0 - 3 \times 0 - 2A^2.$ (From (1))

$\therefore \quad B = -2A^2$

Now Det(B) = Det$(-2A^2)$

$= (-2)^3 |A^2|$ ($\because$ $|ka| = k^n |A|$, where n = order of A)

$= -8|A|^2$

($\because$ $|A^m| = |A|^m$ for any positive integer m)

$\therefore \quad |B| = -8|A|^2 \quad \rightarrow (2)$

We know that

$|A|$ = Product of the eigenvalues of $A = (-1)^n \times$ constant term in the characteristic equation of A (where n = order of A)

$= (-1)^3 \times (-3)$

$\therefore \quad |A| = 3$

Hence from (2), $|B| = -8 \times 3^2 = -72.$ Choice (B)

38. We have $f(x) = x^3 - 5x^2 + 6x - 2$

We know that the Taylor's series expansion of $f(x)$ about $x = a$ is

$$f(x) = f(a) + (x - a) f^1(a) + \frac{(x-a)^2}{2!} f^{11}(a) + \frac{(x-a)^3}{3!} f^{111}(a) + \ldots\ldots \infty \rightarrow (1)$$

Here $a = -1$

$f(x) = x^3 - 5x^2 + 6x - 2 \Rightarrow f(-1) = -14$

$f^1(x) = 3x^2 - 10x + 6 \Rightarrow f^1(-1) = 19$

$f^{11}(x) = 6x - 10 \Rightarrow f^{11}(-1) = -16$

$f^{111}(x) = 6 \Rightarrow f^{111}(-1) = 6$

And $f^{(IV)}(x) = f^{(V)}(x) = \ldots. = 0$

$\therefore$ From (1), the Taylor's series expansion of $f(x)$ about $x = -1$ is

$$f(x) = f(-1) + (x - (-1)) f^1(-1) + \frac{(x-(-1))^2}{2!} f^{11}(-1) + \frac{(x-(-1))^3}{3!} f^{111}(-1) + \ldots\ldots \infty$$

$$= -14 + (x + 1) \times 19 + \frac{(x+1)^2}{2!} \times (-16) + \frac{(x+1)^3}{3!} \times 6 + 0 + 0 + \ldots\ldots..$$

$\therefore$ $f(x) = (x + 1)^3 - 8(x + 1)^2 + 19(x + 1) - 14$

Alternative solution:

We know that the Taylor's series expansion of $f(x)$ about $x = -1$ is same as that of the Taylor's series expansion of $f(x)$ in powers of $x + 1$.

$\therefore$ $f(x) = x^3 - 5x^2 + 6x - 2$

$= [(x + 1) - 1]^3 - 5[(x + 1) - 1]^2 + 6[(x + 1) - 1] - 2$

$= [(x + 1)^3 - 3(x + 1)^2 + 3(x + 1) - 1] - 5[(x + 1)^2 - 2(x + 1) + 1] + 6(x + 1) - 6 - 2$

$= (x + 1)^3 - 8(x + 1)^2 + 19(x + 1) - 14$. Choice (C)

39. Given the ratio of success and failure in a binomial experiment is 1 : 2

$\therefore$ The probability of success $= p = \frac{1}{1+2} = \frac{1}{3}$

The probability of failure $= q = 1 - p = \frac{2}{3}$

Probability of getting the 5th success in the 8th trial = Probability of getting 4 successes in first 7 trails and a success in the 8th trial.

$$= \left({}^7C_4 \left(\frac{1}{3}\right)^4 \left(\frac{2}{3}\right)^3 \right) \times \frac{1}{3}$$

$$= \frac{280}{3^8} = \frac{280}{6561}.$$ Choice (C)

40. Given pairs of values of x and $f(x)$ are

x	-1	0	3	6	7
f(x)	3	-6	39	822	1611

The divided difference table for this data is as shown below.

x	f(x)	1st divided differences	2nd divided differences	3rd divided differences	4th divided differences
-1	3	$\frac{-6-3}{0-(-1)} = -9$			
0	-6	$\frac{39-(-6)}{3-0} = 15$	$\frac{15-(-9)}{3-(-1)} = 6$		
3	39	$\frac{822-39}{6-3} = 261$	$\frac{261-15}{6-0} = 41$	$\frac{41-6}{6-(-1)} = 5$	
6	822	$\frac{1611-822}{7-6} = 789$	$\frac{789-261}{7-3} = 132$	$\frac{132-41}{7-0} = 13$	$\frac{13-5}{7-(-1)} = 1$
7	1,611				

$\therefore$ The 4th divided difference value for the given data is 1. Choice (A)

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

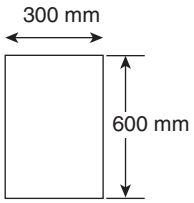
$z = \frac{bd^2}{6}$

$= \frac{300 \times 600^2}{6}$

$= 18 \times 10^6 \text{ mm}^3$

$\sigma = \frac{1000 \times 10^3}{300 \times 600} \pm \frac{1000 \times 10^3 \times 100}{18 \times 10^6} \text{Mpa}$

$= 5.55 \pm 5.55$



$\therefore \quad \sigma \max = 11.11$ Mpa and

$\sigma_{\min} = 0$ Mpa Choice (B)

42. The total rainfall is

$\left[5+4+11+8.5+1.45+1.85+7\right] \times \frac{20}{60} = 12.93 \text{cm}$

$\phi = 4.5 \text{cm/hr}$

$P_e = \left[5+11+8.5+7\right] \times \frac{20}{60} = 10.5 \text{cm}$

$\phi \text{ index} = \frac{P_e - R}{t_e}$

$t_e = \frac{4 \times 20}{60} = 1.33$

$4.5 = \frac{10.5 - R}{1.33}$

$R = 4.515$ cm Choice (D)

43. Primary pollutants: NO_x, HC
Secondary pollutants: O_3, PAN Choice (C)

44. $\gamma = 2.05$ g/cc
$w = 21\%$
$G = 2.64$

$\gamma = \frac{\gamma_w \left(G + e.s_\gamma\right)}{1+e}$

$2.05 = \frac{1\left(2.64 + e.s_\gamma\right)}{1+e}$

$e = \frac{wG}{s_\gamma}$

$\Rightarrow 2.05 = \frac{1\left(2.64 + wG\right)}{1 + \frac{wG}{s_\gamma}}$

$wG = 0.21 \times 2.64 = 0.55$

$S\gamma = 100\%$

(or)

$\gamma d = \frac{\gamma}{1+w} = \frac{2.05}{1+0.21} = 1.70$

$\gamma_d = \frac{\gamma_{wG}}{1+e}$

$1.70 = \frac{1 \times 2.64}{1+e}$

$e = 0.55$

$e = \frac{wG}{s_\gamma} \Rightarrow s_\gamma = \frac{0.21 \times 2.64}{0.55}$

$\therefore \quad S\gamma = 100\%$ Choice (C)

45. $R_A + R_E = \frac{20 \times 3}{2} + 40 = 70$ kN

Taking moment about E

$R_A \times 8 - \frac{20 \times 3}{2} \times 6 - 40 \times 4 + 40 = 0$

$R_A \times 8 = 180 + 160 - 40 = 300$
$R_A = 37.5$ kN
$R_E = 70 - 37.5 = 32.5$kN
Minimum bending moment at D
$= R_E \times 2 - 40 = 32.5 \times 2 - 40 = 25$ kNm
Maximum bending moment at D
$= R_E \times 2 = 32.5 \times 2 = 65$ kNm. Choice (C)

47. Equating pressure heads above the line passing through A

$h_A + \frac{50}{100} \times 0.8 = \frac{150}{100} \times 13.6$

$\therefore \quad h_A + 0.4 = 20.4$

$\Rightarrow \quad h_A = 20$ m of water

Pressure $p_A = wh_A = 9810 \times 20$ N/m^2
$= 9.81 \times 20$ kN/m$^2 = 196.2$ kN/m^2
$= 196.2$ kPa Choice (A)

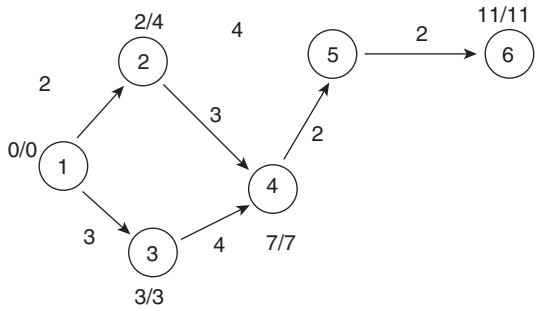
48. $Ld = \frac{\phi.\sigma_s}{4\tau_{bd}}$

For the deformed bars τ_{bd} can be increased by 60% and for bars under compression, τ_{bd} can further increased by 25% as per IS 456 : 2000.
So; τ_{bd} becomes $(1.6 \times 1.25)\tau_{bd}$

$\therefore \quad Ld = \frac{\phi}{4} \frac{\sigma_s}{2\tau_{bd}}$

$\Rightarrow \quad k = 0.5$ Choice (C)

49.



$\therefore$ Critical path = 1 – 3 – 4 – 5 – 6 Choice (C)

50. $BS = 1.745$
$IS = 2.765$
$IS = 0.243$
$FS = 1.432$ Choice (C)

51. Radius of Mohr's circle is $= \sqrt{\left(\frac{p_x - p_y}{2}\right)^2 + q^2}$

$= \sqrt{\left(\frac{260-100}{2}\right)^2 + 60^2}$

$= \sqrt{80^2 + 60^2}$

$= \sqrt{6400 + 3600}$

$= \sqrt{1000} = 100.$ Choice (D)

52. $V = \frac{CS}{1000}$

$S = vt + \frac{v^2}{2gf}$

$= (0.278 \times 55 \times 2.5) + \frac{(0.278 \times 55)^2}{2 \times 9.8 \times 0.4}$

$= 68.04\text{m} = 68.04 + 6 = 74.04$ m

$C = \frac{1000 \times 55}{(68.01+6)} = 743$ veh/hr/lane Choice (B)

53. When $N_R > 15$ and fine sand present below the water table; diletancy correction should be applied.

Equivalent $N = 15 + \left(\frac{N_R - 15}{2}\right)$

$\therefore \quad N_{eq} = 15 + \left(\frac{25-15}{2}\right) = 20$ Choice (C)

54. Plant capacity = 5 m³/s = 5 × 24 × 60 × 60 m³/day/
= 43200 m³/day

Area of filter $= 8 \times 15 = 120$ m²

Surface loading rate = 240/m³/day/m²

$\Rightarrow$ Area required $= \frac{432000\,\text{m}^3/\text{day}}{240\ \text{m}^3/\text{day}/\text{m}^2} = 1800\text{m}^2$

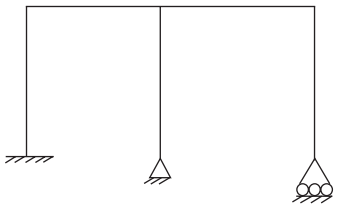
No. of filters $= \frac{1800}{120} = 15$

But, Given that 3 are out of service

$\therefore$ Surface loading rate $= \frac{43200\,\text{m}^3/\text{day}}{12 \times 120\ \text{m}^2}$

$= 300\text{m}^3/\text{day}/\text{m}^2$ Choice (B)

55.



$D_s = (3 + 2 + 1) - 3 = 3$
$D_k = (0 + 1 + 2 + 3 + 3 + 3) - \text{m}$
$= 12 - 5 = 7$ Choice (D)

56. $h = 3.2$cm
$D = 140$cm
$B = 5.5$m
$R = 100$m

$L = \sqrt{h^2 + D.h} = 0.02\sqrt{(3.2)^2 + (140 \times 3.2)} = 0.428$m

Extra width of gauge (d)

$d = \frac{13(B+L)^2}{R} = \frac{13(5.5+0.428)^2}{100}$

$= 4.568$cm Choice (A)

57. $\text{DO}_{\text{mix}} = \frac{Q_W.DO_W + Q_R.DO_R}{Q_W + Q_R}$

$= \frac{1.5(2) + 8.8(8.4)}{1.5 + 8.8} = 7.47$ mg/l Choice (B)

58. According to Muller-Breslau principle to find reaction at A, remove the constraint at A & apply unit force in the direction of reaction. But, here the other end B is not hinged, it is a free end. So, end B also lifted up along with end A when we apply unit reaction at A. Choice (C)

59. $\bar{x} = \frac{A_1 x_1 - A_2 x_2}{(A_1 - A_2)}$

$= \frac{\left[\frac{\pi(2d)^2}{4} \times 0\right] - \frac{\pi d^2}{4} \times \frac{d}{2}}{\frac{\pi(2d)^2}{4} - \frac{\pi d^2}{4}}$

$= \frac{-\frac{\pi d^3}{8}}{\frac{3\pi d^2}{4}} = -\frac{d}{6} = \frac{d}{6}$ to left of O. Choice (B)

60. $\Delta H = H.\dfrac{c_c}{1+e_0}\log\left(\dfrac{\sigma_f}{\sigma_0}\right)$

At the middle of the clay layer,

$\sigma_0 = (1.5\times 18)+(3\times(20-10))$

$= 27 + 30 = 57$ Kpa

$\sigma_f = 57 + 40 = 97$ Kpa

$\Delta H = \dfrac{6000\times 0.08}{1+0.45}\log_{10}\left(\dfrac{97}{57}\right)$

$\therefore \quad \Delta H = 76.43$mm Choice (B)

61. $GCA = 8000$ Ha

$CCA = 8000\times\dfrac{70}{100} = 5600$ha

Area under kharif $= \dfrac{35}{100}\times 5600 = 1960$ha

Area under rabi $= \dfrac{60}{100}\times 5600 = 3360$ha

Discharge required for kharif $Q = \dfrac{A}{D}$

$= \dfrac{1960}{800} = 2.45$ m^3/sec

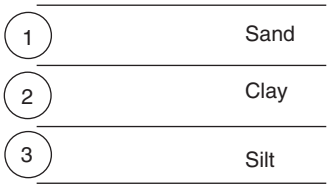
Discharge required rabi $Q = \dfrac{A}{D}$

$= \dfrac{3360}{1500} = 2.24$ m^3/sec

Design discharge = higher of both the discharge

$= 2.45$m^3/sec Choice (B)

62.



$K_3 = 5K_2 = \dfrac{1}{10}K_1$

$\Rightarrow \quad K_1 = 10K_3,\ K_2 = \dfrac{K_3}{5}$

$H_1 = 2H_3 = \dfrac{H_2}{2}$

$\Rightarrow \quad H_2 = 2H_1, H_3 = \dfrac{H_1}{2}$

$k_H = \dfrac{K_1H_1 + K_2H_2 + K_3H_3}{H_1 + H_2 + H_3}$

$= \dfrac{(10K_3)H_{1_{+\frac{K_3}{5}(2H_1)+K_3}}\left(\dfrac{H_1}{2}\right)}{H_1 + 2H_1 + \dfrac{H_1}{2}}$

$= 3.114K_3$

$K_V = \dfrac{H_1 + 2H_1 + \dfrac{H_1}{2}}{\dfrac{H_1}{10K_3} + \dfrac{2H_1}{\left(\dfrac{K_3}{5}\right)} + \dfrac{H_1}{K_3}}$

$= 0.315\ K_3$

$K_H : K_V = 9.87 \cong 10$ Choice (B)

63. When pipes are connected in parallel, head lost is same in both pipes

$\therefore \quad h = \dfrac{4fL}{D} = \dfrac{V_1^2}{2g} = \dfrac{4fl}{d}\dfrac{V_2^2}{2g}$

$\Rightarrow \quad \dfrac{flQ_1^2}{3D^5} = \dfrac{fLQ_2^2}{3d^5} \Rightarrow \dfrac{Q_1^2}{D^5} = \dfrac{Q_2^2}{d^5}$

$\Rightarrow \quad \left(\dfrac{Q_1}{Q_2}\right)^2 = \left(\dfrac{D}{d}\right)^5 = (2)^5 = 32$

$\Rightarrow \quad \dfrac{Q_1}{Q_2} = \sqrt{32} = 5.657$ Choice (C)

64. The most common type of rivet patterns are chain riveting and diamond riveting. Staggered pattern in option (a) yields more net area of the section and because of this reason this pattern is most suitable for tension members. Staggered and diamond pattern better as compared to the chain pattern. Choice (A)

65. $A_1 = 3000 \quad F_1 = 7 \quad r = 0.075$

$A_2 = 400 \quad F_2 = 8 \quad n = 10$yrs

$N = \dfrac{365\left[(1+0.075)^{10}-1\right]\left[(3000\times 7)+(400\times 8)\right]}{0.075}$

$= 12.49$msa Choice (C)