Mock Test 4

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

Section – I: General Aptitude

Questions 1 to 5 carry One Mark each.

Directions for questions 1 to 3: Select the correct alternative from the given choices.

1. A bag contains a total of 12 kg of wheat, which is a mixture of three varieties of wheat x, y, z. If 4 kg of wheat comprising x and y in the ratio 3 : 1 and 12 kg of wheat comprising y and z in the ratio 1 : 3 are poured into the bag, the resulting wheat mixture in the bag will have x, y and z in the ratio 3 : 4 : 9. Find the ratio of x, y and z in the wheat mixture presently in the bag.

(A) 4 : 6 : 11
(B) 3 : 5 : 13
(C) 3 : 4 : 9
(D) Cannot be determined

2. Mohan and Sohan can complete a job in 12 days and 15 days respectively. With the help of Rohan, they completed the job in 3 days. The wage paid to Rohan for completing his part of the job was ₹ 320 more than the total wage paid to the other two for completing their parts of the job. Find Rohan's wage.

(A) ₹ 2340 (B) ₹ 1760
(C) ₹ 2520 (D) ₹ 1540

3. Six wrestlers – A, B, C, D, E, and F participated in a competition called "who is stronger" and at end of the competition they were ranked based on their strength, C and B are less stronger than D and they have atleast one wrestlers who is weaker than them. F is ranked second and E is ranked third in strength. How many wrestlers are stronger than A?

(A) 2 (B) 3
(C) 1 (D) 5

Directions for question 4: The question has a word followed by four choices. From the choices, identify the one which is **opposite** in meaning (antonym) to the question word and mark its number as your answer.

4. RISIBLE

(A) Grave (B) Funny
(C) Jovial (D) Insecure

Directions for question 5: Fill in the blank with the most suitable options from the choices given.

5. In places, the trunks of the fallen trees have been _____ white and ghostly by the strong sunlight.

(A) bleached (B) stained
(C) considered (D) furnished

Questions 6 to 10 carry Two Marks each.

Directions for questions 6 to 7: Select the correct alternative from the given choices.

6.

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The number of triangles can be formed, whose vertices lie on the dots shown in the above pattern is _____

7. Most scientists now believe that the near extinction of the cobra in the North Indian forests was due to the extensive hunting down of the poor creature by the tribals of the forest. During the 40s and the 50s cobra was in great demand for its medicinal use which the tribals exploited greatly, the scientists say.

Which of the following, weakens the above argument?

(A) During the 40s and the 50s claws, antlers, horns, tusks, and other animal parts were in great demand for their medicinal uses which prompted most tribals to kill animals.
(B) During 40s and the 50s, the government built a dam in the vicinity of North Indian forests.
(C) The extensive government sponsored logging operations of the 40s and the 50s in the North Indian forests led to the immediate extinction of rodents, a major prey of snakes.
(D) The government undertook afforestation to revive the forests to prevent extinction of snakes in the North India but failed miserably.

Directions for question 8: In the following question, a part of a sentence is in bold. Indicate which among the answer choices given below the sentence can best replace the bold part to make it grammatically and logically correct. If the sentence is correct as it is, mark (*D*), i.e., 'No correction required' as the answer.

8. The next batch in which I am placed, will start 9 o' clock in the mornings.

(A) would start at 9 o' clock in the mornings
(B) starts at 9 o'clock in the morning
(C) will have started at 9 o'clock in the morning
(D) No correction required

Directions for question 9: In the following question given below, statements 1 and 6 are respectively the first and the last sentences of a paragraph and statements (2), (3), (4) and (5) come in between them. Rearrange (1), (2), (3) and (4) in such a way that they make a coherent paragraph together with statements 1 and 6. Select the correct order from the given choices and mark its number as your answer.

9. (1) With the decline of feudalism in ancient society, some important developments like merchant capital, emergence of wage labour, putting out system and enclosure movement set the stage for the industrial revolution.
(2) A new cyclical pattern of growth took place.
(3) Increased agricultural production and new technology further contributed to its growth.
(4) Though industrial development was marked by periods of depression, gradually this problem was overcome.
(5) With industrial development, the composition of capital also underwent changes.
(6) Soon the increased industrial production gave rise to capitalism and new social classes.
(A) 2345 (B) 4532
(C) 3524 (D) 5234

Directions for question 10: Select the correct alternative from the given choices.

10. The killings of Dalits in Uttar Pradesh proves that things have not improved over the years and the plight of Dalits is the same everywhere. The tragedy in UP is that despite the state having a Dalit Chief Minister who is seen by many as a future Prime Minister, the atrocities against Dalits continue.
Which of the following can be inferred from the above statement?
(A) A Dalit Chief Minister understands the agony of Dalits better.
(B) The chances of a Dalit Chief Minister becoming a Prime Minister will not be paralysed due to these events.
(C) Even a Dalit Chief Minister cannot prevent Dalits from being derogated.
(D) None of the above.

SECTION – II: CIVIL ENGINEERING

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

Questions 11 to 35 carry One Mark each.

11. Which among the following types of matrices is always non – singular?
(A) Symmetric matrix (B) Idempotent matrix
(C) Involutory matrix (D) Nilpotent matrix

12. If the Laplace transform of $f(t)$ is $F(s)$, then which of the following is necessary for $L^{-1}[sF(s)] = \frac{d}{dt}(f(t))$?
(A) $F(0) = 0$ (B) $f(0) = 0$
(C) $\left(\frac{dF}{ds}\right)_{at\ s=0}$ (D) $\left(\frac{df}{dt}\right)_{at\ t=0}$

13. The greatest value of C such that the partial differential equation

$$3\frac{\partial^2 u}{\partial x^2} - 6\frac{\partial^2 u}{\partial x \partial y} + C\frac{\partial^2 u}{\partial y^2} - 7x\frac{\partial u}{\partial x} + 5x^2 y\frac{\partial u}{\partial y} + 3u = 0$$

is not hyperbolic is _____.

14. Which of the following is a sufficient condition for the cross product of two vector point functions $\overline{F}$ and $\overline{G}$ to be solenoidal?
(A) Both $\overline{F}$ and $\overline{G}$ have to be solenoidal.
(B) $\overline{F}$ has to be solenoidal and $\overline{G}$ has to be irrotational.
(C) Both $\overline{F}$ and $\overline{G}$ have to be irrotational.
(D) $\overline{F}$ has to be irrotational and $\overline{G}$ has to be solenoidal.

15. The life time of bulbs manufactured by a company is normally distributed with mean 450 hours and standard deviation 30 hours. If a random sample of 36 bulbs has an average life time of 440 hours, then the test statistic in the process of testing the average life of bulbs is 450 hours or not is _____.

16. The contact pressure for a rigid footing resting on clay, at the centre and the edges are respectively _____.
(A) Maximum and zero
(B) Maximum and Minimum
(C) Zero and Maximum
(D) Minimum and Maximum

17. The width and depth of a footing are 2 and 1.5 m respectively. The water table at the site is at a depth of 2.5 m below the ground level. The water table correction factor for calculation of bearing capacity will be _____
(A) 1.0 (B) 0.75
(C) 0.50 (D) 0.25

18. The creep is caused due to _____.
(A) Initial Consolidation
(B) Primary Consolidation
(C) Secondary Consolidation
(D) Tertiary Consolidation

19. When water table rises _____
(A) Total stress increases, effective and pore pressures decreases.
(B) Effective stress decreases, total and pore pressures increases
(C) Pore pressure decreases, total and effective pressure increases
(D) Total stress decreases, effective and pore pressure increases.

20. If a R.C. beam fails in bond, its bond strength can be increased by _____
(A) Increasing the depth of beam
(B) Using thinner bars but more in numbers
(C) Using thicker bars but less in numbers
(D) Providing vertical stirrups

21. A 2 – way RCC slab is simply supported on all its edges with corners not free to lift. The area of steel in shorter span is 812 mm^2. The torsional reinforcement required at corner is _____.

(A) 0 mm^2 (B) 609 mm^2
(C) 406 mm^2 (D) 203 mm^2

22. The moisture content in a well seasoned timber is _____.
(A) 4 to 6% (B) 10 to 12%
(C) 15 to 20% (D) 50%

23. The most appropriate method to specify the concrete mix is by _____.
(A) Nominal mix ratio (B) Design mix ratio
(C) Degree of control (D) Grade of concrete

24. A combined sewer is the one which transports
(A) domestic sewage and storm water
(B) domestic sewage and industrial wastes
(C) domestic sewage and over head flow
(D) domestic sewage, industrial wastes and storm water.

25. The main constituents of gas generated during anaerobic digestion of sewage sludge are
(A) carbon dioxide and methane
(B) methane and ethane
(C) carbon dioxide and carbon monoxide
(D) carbon monoxide and nitrogen

26. The type of surveying in which the curvature of the earth is taken into account is called.
(A) Geodetic surveying
(B) Plane surveying
(C) Preliminary surveying
(D) Topographical surveying

27. A lysimeter is used to measure
(A) Infiltration (B) Evaporation
(C) Evapotranspiration (D) Radiation

28. The standard project flood is
(A) same as the probable maximum flood
(B) same as the design flood
(C) smaller than the probable maximum flood
(D) larger than the probable maximum flood by a factor implying safety factor

29. Stopping slight distance and frictional coefficients are
(A) directly proportional to each other
(B) inversely proportional to each other
(C) unrelated
(D) either directly (or) inversely proportional to each other depending on nature of pavement.

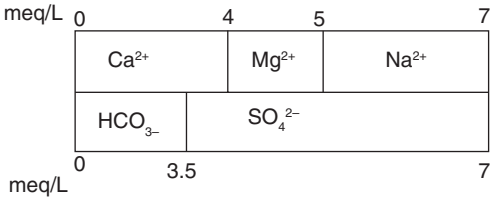
30. The traffic survey data plotted by means of desire lines is
(A) Accident (B) Classified volume
(C) Origin and destination (D) Speed and delay

31. The shape of stop sign as per IRC : 67 – 2001 is
(A) Circular (B) Triangular
(C) Octagonal (D) Rectangular

32. A thin walled spherical shell of diameter 500 mm and thickness 8 mm is subjected to an internal pressure of 6 MPa. The average hoop stress (in N/mm^2) is _____.

33. A fine grained soil has 40% (by weight) silt content. The Liquid limit, plastic limit and shrinkage limit of soil are given as 45%, 30% and 18% respectively. Using this data available, identify the correct statement from the following.
(A) The given fine grained soil is inactive soil.
(B) The given fine grained soil is normal active soil.
(C) The given fine grained soil is active soil.
(D) Data insufficient.

34. For a sample of water with ionic composition, the carbonate and non – carbonate hardness concentrations (in mg/L as $CaCO_3$) respectively are :



(A) 200 and 50 (B) 175 and 75
(C) 75 and 175 (D) 50 and 200

35. A wastewater sample has an initial BOD of 222 mg/l. The first order BOD decay coefficient is 0.4/day. The BOD consumed (in mgu) in 5 days is
(A) 150 (B) 192
(C) 30 (D) 50

Questions 36 to 65 carry Two Marks each.

36. If $g(x) = (x + 5)(x + 2)(x - 1)(x - 6)$ and $f(x) = \int g(x)dx$, then the number of local maxima for $f(x)$ is _____.

37. If the system of linear equations

$$a_1 x_1 + b_1 x_2 + c_1 x_3 = 0$$
$$a_2 x_1 + b_2 x_2 + c_2 x_3 = 0$$
$$a_3 x_1 + b_3 x_2 + c_3 x_3 = 0$$

(where a_i, b_i and c_i, $i = 1, 2, 3$ are all constants) has only a trivial solution, then the number of solutions of the system of linear equations

$$a_1 x_1 + b_1 x_2 + c_1 x_3 = 5$$
$$a_2 x_1 + b_2 x_2 + c_2 x_3 = 3$$
$$a_3 x_1 + b_3 x_2 + c_3 x_3 = 2 \text{ is } \_\_\_\_\_.$$

(A) 0 (B) 1
(C) infinitely many (D) Cannot be determined

38. If X_1 and X_2 are two independent normal variates with means 100 and 60 respectively and variances 16 and 9 respectively, then which of the following statements is true?
(A) $X_1 - X_2$ is a normal variate with mean 40 and standard deviation 7.
(B) $X_1 - X_2$ is a normal variate with mean 40 and standard deviation 5.
(C) $X_1 - X_2$ is a normal variate with mean 20 and standard deviation 1.
(D) $X_1 - X_2$ need not be a normal variate.

39. The area bounded by the curve $y = x^3$ and the line $y = x$ in square units is _____
(A) 0.25 (B) 0.5
(C) 0.75 (D) 1

40. Which of the following statements are true with reference to the evaluation of a definite integral

$I = \int_a^b f(x)dx$ by numerical integration methods?

I. If $[a, b]$ is divided into 5 subintervals, then we can use any of the Trapezoidal rule or Simpson's rule to evaluate the definite integral I.

II. If $y = f(x)$ represents a parabola, then the value of I obtained by the Simpson's $\frac{1}{3}$rd rule and by direct integration are same.

III. While evaluating by the Trapezoidal rule, the accuracy can be increased by dividing [a, b] into large number of sub intervals.

(A) All of I, II and III (B) Only I and II
(C) Only II and III (D) Only I and III

41. Match List - I with List - II

	List – I		List – II
a.	Coriolis effect	1.	Rotation of earth
b.	Fumigation	2.	Lapse rate and vertical temp. profile
c.	Ozone layer	3.	Inversion
d.	Max. mixing depth (mixing height)	4.	Dobson

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

42. The tests on soil determines, following properties of a the particular sample.
Degree of saturation = 85%
Water content = 12%
Specific gravity = 2.65
If the factor of safety (FOS) against the quick sand condition is adopted as 2.5; the hydraulic gradient provided will be _____.

(A) 3 (B) 2.52
(C) 0.48 (D) 3.48

43. Two straight lines intersect at an angle of 60^0. The radius of a curve joining the two straight lines is 600 m. The length of long chord and mid – ordinates in meters of the curve are

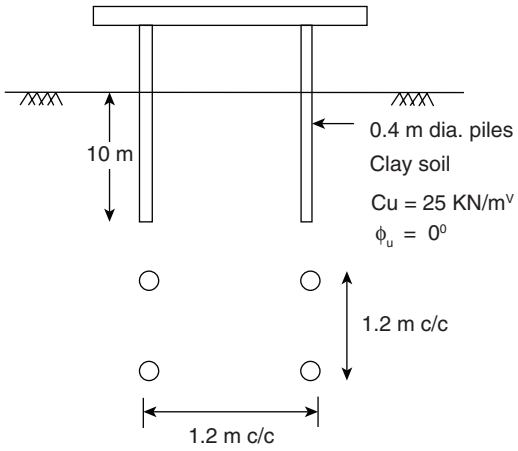
(A) 80.4, 600 (B) 600, 80.4
(C) 600, 39.89 (D) 49.89, 300

44. Match the following:

	Group – I		Group – II
P.	Alidade	1.	Chain surveying
Q.	Arrow	2.	Leveling
R.	Bubble tube	3.	Plain table surveying
S.	Stadia hair	4.	Teodilite surveying

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

45. What is ultimate capacity of the pile group shown in figure assuming the group to fail as a single block



(A) 2861 KN (B) 2681 KN
(C) 2176 KN (D) 1874 KN

46. During sub surface investigation of the soil, the following record of number of blows were given, which was obtained from the standard penetration test conducted at certain depth.

Penetration depth (cm)	Number of blows
0 – 7.5	3
7.5 – 15	3
15 – 22.5	6
22.5 – 30	6
30.0 – 37.5	8
37.5 – 45	7

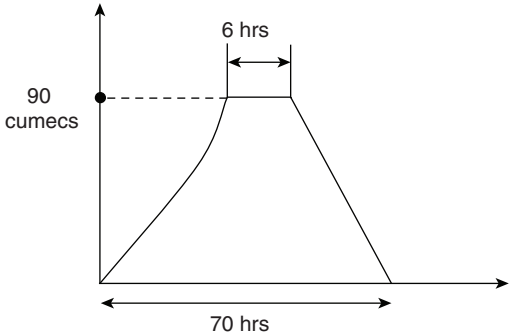
Assuming water table at ground level, soil as fine sand and correction for overburden pressure as 0.926; the corrected value of '*N*' for the soil would be _____.

(A) 27 (B) 21
(C) 20 (D) 15

47. A 1 hr rainfall of 10 cm has return period of 50 yr. The 1 hour of rainfall 10 cm (or) more will occur in each of two successive year is

(A) 0.04 (B) 0.2
(C) 0.02 (D) 0.0004

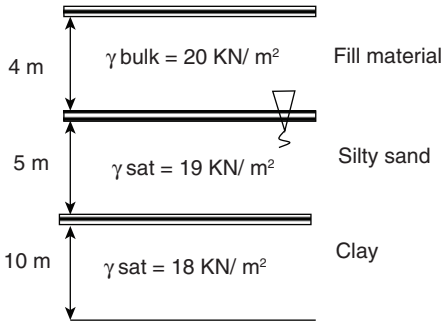
48. A direct runoff hydrograph due to an isolate storm with an effective rainfall of 2 cm was trapezoidal in shape as shown in figure. The hydrograph corresponds to a catchment area (in sq. km) of



(A) 790.2 km^2 (B) 615.6 km^2
(C) 599.4 km^2 (D) 435.3 km^2

49. An outlet irrigates an area of 40 ha. The discharge (L/S) required at this outlet to met the evaportransiration requirement of 40 mm occurring uniformly in 40 days neglecting other field losses is _____.

50. At a reclamation site having soil strata as shown in the figure, 4 m thick layer of fill material is to be laid instantaneously on the top surface. If the coefficient of volume compressibility, m_v for clay is 2.2×10^{-4} m^2/KN, the consolidation settlement of clay layer due to placing fill material will be _____.



(A) 211 mm (B) 189 mm
(C) 176 mm (D) 142 mm

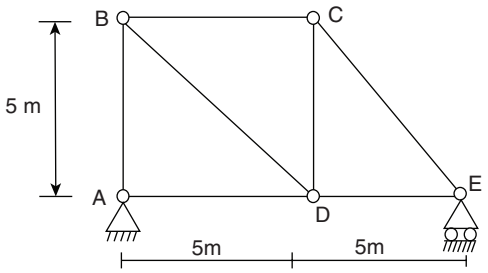
51. A homogeneous dam is 21.5 m high and has a free board of 1.5 m. A flow net was constructed and the following results were observed.
No. of potential drops = 12
No. of flow channels = 3
The discharge/m length of the dam if the coefficient of permeability of the dam material is 2×10^{-6} m/sec is _____ $\times 10^{-5}$ cumecs/m

52. An isolated T – beam has effective span of 10 m. Actual width of flange is 2 m, width of web is 250 mm; then effective flange width will be _____.
(A) 1.36 m (B) 1.57 m
(C) 1.82 m (D) 2 m

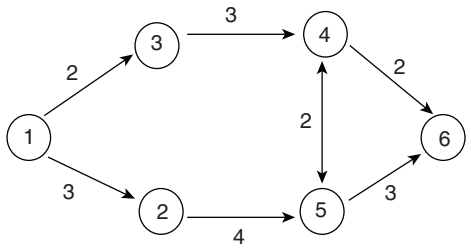
53. During CBR test, the load sustained by a remolded soil specimen at 5 mm penetration is 50 kg. The CBR value of the soil will be
(A) 10% (B) 5%
(C) 3.6% (D) 2.4%

54. For a road with camber of 3% an design speed of 80 kmph, the min radius of a curve beyond which no super elevation is needed is
(A) 1680 m (B) 948 m
(C) 406 m (D) 280 m

55. Determine the vertical displacement of joint D (in mm) if member BC of the pin – jointed frame as shown below is long by an amount 4×10^{-3} from the original length 5 m. All the members of frame have same AE value [$AE = 10 \times 10^0$ kN]

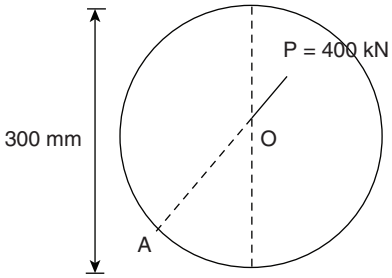


56. From the given network, the Inference float and independent float for the activity 5 – 4 will be _____



(A) Negative and Positive (B) Both positive
(C) Both negative (D) Both equals to zero

57.



On a short masonry column of circular cross section of diameter 300 mm a load of 400 kN acts axially at a radial distance of 100 mm from centre as shown in the figure. Strain developed at point A in N/mm^2 is
(A) 9.43(compressive) (B) 9.43(Tensile)
(C) 20.75(compressive) (D) 20.75 (Tensile)

58. A rod of length 1.2 m tapered from 100 mm. diameter to 50 mm diameter. If a torque of 3 kN m is applied, the angular rotation of free end (in radians) is.
(Take modulus of rigidity = 80 kN/mm^2)

59. For a Pelton wheel, head at the base of the nozzle is 80 m, discharge through nozzle is 0.3 m^3/s at a jet velocity of 38.2 m/s. Loss of power in the nozzle in kW) is
(A) 12.76 (B) 16.55
(C) 18.49 (D) 20.36

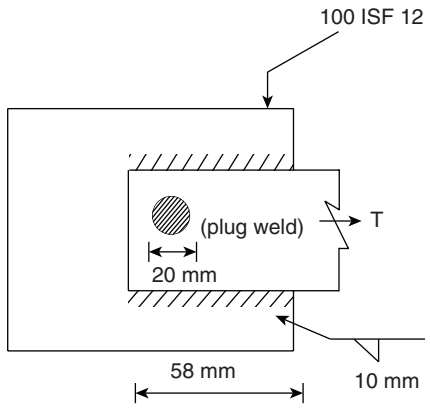
60. For a surface of area A immersed in a liquid of specific weight w, if $\bar{x}$ is the depth of centre of area and $\bar{h}$ is the depth of centre of pressure from the liquid surface, the total pressure acting on the surface is given by
(A) $wA\bar{x}$ (B) $wA\bar{h}$
(C) $wA\bar{x}^{-2}$ (D) $wA\dfrac{(\bar{x}+\bar{h})}{2}$

61. If velocity potential satisfies, the Laplace equation, it is a case of
(A) unsteady, compressible and rotational flow
(B) steady, incompressible and irrotational flow.
(C) unsteady, incompressible and rotational flow.
(D) steady, incompressible and rotational flow.

62. A piping system consists of 3 pipes of lengths 1000 m, 800 m and 600 m arranged in series. Diameters of the pipes are 750 mm, 600 mm and 450 mm respectively. If the system is to be replaced by an equivalent pipe of diameter 600 mm, length of the equivalent pipe (in m) will be _____

63. A close coiled helical spring has to carrying a load of 800 N. Mean diameter of the spring is to be 75 mm. If the allowable shear stress is 100 N/mm^2 wire diameter required for the spring (in mm) is.
(A) 9.64 (B) 11.52
(C) 13.47 (D) 15.26

64. The service load permitted on the connection shown for the fig. below in kN is _____. Assume field welding and Fe 410 steel.



(A) 105 (B) 212
(C) 441 (D) 145

65. The stiffness matrix of a beam is given as $k\begin{bmatrix}4 & 3\\ 3 & 5\end{bmatrix}$. The flexibility matrix is _____.

(A) $\frac{k}{11}\begin{bmatrix}5 & -3\\ -3 & 4\end{bmatrix}$ (B) $\frac{11}{k}\begin{bmatrix}5 & -3\\ -3 & 4\end{bmatrix}$

(C) $\frac{1}{11\times k}\begin{bmatrix}5 & -3\\ -3 & 4\end{bmatrix}$ (D) $11k\begin{bmatrix}5 & -3\\ -3 & 4\end{bmatrix}$

Answer Keys

1. C	**2.** B	**3.** D	**4.** A	**5.** A	**6.** 6800	**7.** C	**8.** B	**9.** B	**10.** D
11. C	**12.** B	**13.** 3	**14.** C	**15.** –2	**16.** D	**17.** B	**18.** C	**19.** B	**20.** B
21. B	**22.** B	**23.** D	**24.** D	**25.** A	**26.** A	**27.** C	**28.** C	**29.** B	**30.** C
31. C	**32.** 93.25 to 94.25		**33.** A	**34.** B	**35.** C	**36.** 2	**37.** B	**38.** B	**39.** B
40. C	**41.** D	**42.** C	**43.** B	**44.** A	**45.** C	**46.** C	**47.** D	**48.** B	
49. 0.925 lit/sec		**50.** C	**51.** 1	**52.** A	**53.** D	**54.** B	**55.** 2 mm	**56.** D	**57.** B
58. 0.02135 to 0.02145			**59.** B	**60.** A	**61.** B	**62.** 3655.5 to 3656.5		**63.** B	**64.** A
65. C									

Hints and Explanations

1. In the conditional case (as opposed to the actual case) the 4 kg mixture will have 3 kg of x and 1 kg of y. Also the 12 kg mixture will have 3 kg of y and 9 kg of z. ∴ Total quantities of x, y and z added are 3 kg, 4 kg and 9 kg respectively, i.e., in the quantity added, (if it is added), the ratio of x, y, z is 3 : 4: 9. In the final mixture also, it is 3 : 4 : 9. Therefore, the ratio in the present mixture also, it has to be 3 : 4 : 9. Choice (C)

2. Part of the job completed by

(i) Mohan $= 3\left(\frac{1}{12}\right) = \frac{1}{4}$

(ii) Sohan $= 3\left(\frac{1}{15}\right) = \frac{1}{5}$

(iii) Rohan $= 1 - \left(\frac{1}{4}+\frac{1}{5}\right) = \frac{11}{50}$

Let the total wage paid to the three be ₹T.

$\frac{11}{20}T = \frac{T}{4}+\frac{T}{5} + 320$

$\Rightarrow T = 3200$

$\frac{11}{20}T = 1760$

∴ Wage of Rohan = ₹ 1760. Choice (B)

3. E and F are ranked 2nd and 3rd. There is at least one wrestler weaker than B, C and D. This indicates that A is the weakest among all. Hence, five wrestlers are stronger than A. Choice (D)

4. Something that is hilarious, funny or ludicrous is said to be 'risible'. The antonym of 'risible' is 'grave' or serious. Choice (A)

5. The blank is best filled by 'bleached', meaning, 'make the appearance white'. Other options fall short of representing the blank properly. Choice (A)

6. Number of combinations of three dots which can be taken is ${}^{36}C_3$. But for some combinations, all the 3 dots may be collinear, and we cannot form a triangle. In the given arrangement, by joining the dots we will have the following:
(1) 6 horizontal lines having 6 points each
(2) 6 vertical lines having 6 points each
(3) 2 diagonal lines having 6 points each
(4) 4 diagonal lines having 5 points each
(5) 4 diagonal lines having 4 points each and
(6) 4 diagonal lines having 3 points each.
Number of triangles which can be formed
$= {}^{36}C_3 - [6({}^6C_3 + {}^6C_3) + 2({}^6C_3) + 4\,({}^5C_3 + {}^4C_3 + {}^3C_3)]$
$= 7140 - [14(20) + 4(15)] = 6800.$ Ans: 6800

7. The correct answer is C. To weaken an argument, we should show the assumption in the argument to be false. The assumption in the given argument is that there is no other cause for the near extinction of the cobra. If we prove this wrong, it weakens the argument. Choice (C), by showing an alternative cause, does this. Others are either irrelevant or out of scope. Choice (C)

8. We use the verb in the simple present tense for a future event that is part of a fixed time table. Hence, choice (B) is apt. The reference is to a specific morning and hence 'mornings' is incorrect. Choice (B)

9. Statement 1 ends with '… set the stage for industrial revolution'. So it is followed by (4) which talks of 'industrial revolution.' (2) and (3) do not talk of industries. Though (5) talks of 'industrial development', the word 'also' indicates it follows something else. The sentences 4532 in that order tell us chronologically the steps that followed the industrial revolution and the growth of capitalism. Choice (B)

10. Choice (A) is an assumption of the people / the writer. Choice (B) is false. It is evident that the Chief Minister failed in his duties so it will hamper his chances of becoming the Prime Minister. 'Will not' in (B) rules it out. (C) is not an inference as it is openly stated that even a Dalit CM could not stop the killing of Dalits. The last word of the paragraph 'continue' suggests that in the past too Dalits were killed. Among the given sentences none of them qualify as inferences. Choice (D)

11. We know that, a matrix A is an involutory matrix, if $A^2 = I$ (OR) $A^{-1} = A$
$\therefore$ Every involutory matrix is non – singular
Counter Example for (A):
Let $A = \begin{bmatrix} 4 & 6 \\ 6 & 9 \end{bmatrix}$
Clearly, $A^T = A$ but $|A| = 0$
$\therefore$ A is symmetric but not non – singular
Counter Example for (B):
Let $B = \begin{bmatrix} 3 & 3 \\ -2 & -2 \end{bmatrix}$
Clearly, $B^2 = B$ but $|B| = 0$
$\therefore$ B is idempotent but not non – singular
Also, we know that every nilpotent matrix is a singular matrix. Choice (C)

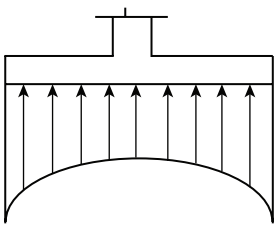
12. We know that if $L[f(t)] = F(s)$, then
$L^{-1}[sF(s)] = \dfrac{d}{dt}(f(t))$ only if $f(0) = 0$. Choice (B)

13. Given PDE is
$$3\frac{\partial^2 u}{\partial x^2} - 6\frac{\partial^2 u}{\partial x \partial y} + C\frac{\partial^2 u}{\partial y^2} - 7x\frac{\partial u}{\partial x} + 5x^2 y\frac{\partial u}{\partial y} + 3u = 0$$
$\rightarrow (1)$
Comparing (1) with the general second order linear partial differential equation, we have
$A = 3, B = -6, C = C$
For (1) not to be hyperbolic, we have
$B^2 - 4AC \not> 0$
$\Rightarrow$ $B^2 - 4AC \leq 0$
$\Rightarrow$ $(-6)^2 - 4 \times 3 \times C \leq 0$
$\Rightarrow$ $36 - 12C \leq 0$
$\Rightarrow$ $C - 3 \leq 0$
$\Rightarrow$ $C \leq 3$
$\therefore$ The greatest value of C such that (1) is not hyperbolic is 3 Ans: 3

14. $\overline{F} \times \overline{G}$ is solenoidal
$\Rightarrow$ Div $(\overline{F} \times \overline{G}) = 0$
$\Rightarrow$ $\overline{G}$. curl $\overline{F}$ $-$ $\overline{F}$. Curl $\overline{G} = 0$
So, $\overline{F} \times \overline{G}$ is solenoidal when curl $\overline{F} = \overline{0}$ and curl $\overline{G} = \overline{0}$
i.e., Both $\overline{F}$ and $\overline{G}$ have to be irrotational. Choice (C)

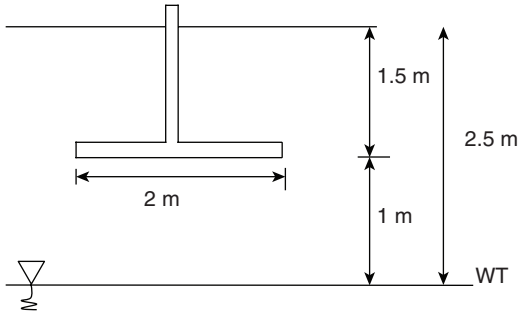
15. Population mean = μ = 450 hours
Population standard deviation = σ = 30 hours
Sample mean = $\bar{x}$ = 440 hours
Sample size = n = 36
$\therefore$ Test statistic $= Z = \dfrac{\bar{x} - \mu}{\dfrac{\sigma}{\sqrt{n}}}$
$$= \frac{440 - 450}{\left(\frac{30}{\sqrt{36}}\right)} = \frac{-2}{6} \times \sqrt{36}$$
$\therefore$ $Z = -2$ Ans: –2

16.



Minimum at centre, Maximum at edges. Choice (D)

17.



Correction factor = $0.5 + 0.5 \times \frac{1}{2} = 0.75$ Choice (B)

19. If water table rises; Total pressure and pure water pressure increases but effective pressure decreases.

Choice (B)

21. Torsional reinforcement = $\frac{3}{4} \times$ steel in shorter span

$= \frac{3}{4} \times 812 = 609 \text{ mm}^2$ Choice (B)

32. For a thin spherical shell, hoopstress (circumferential stress) = $\frac{pd}{4t}$

where p = internal pressure.
d = diameter
t = thickness.
$p = 6$ MPa $= 6$ N/mm^2
$d = 500$ mm
$t = 8$ mm

$\therefore$ Hoop stress = $\frac{6 \times 500}{4 \times 8}$

$= 93.75$ N/mm^2 Ans: 93.25 to 94.25

33. % clay content in the soil = 100 – 40 = 60%
Plasticity index = Liquid limit – Plastic limit
= 45 – 30 = 15

$\Rightarrow$ Activity number = $\frac{\text{Plasticity index, } I_P}{\%\text{ clay fraction}}$

$= \frac{15}{60} = 0.25$

The activity number is less than 0.75. So, the given soil is said to be inactive soil. Choice (A)

34. Carbonate harness = 3.5×10^{-3} g eq [if NCH is present sodium alkalikrity will be absent i.e., $NaHCO_3$ absent]
$= 3.5 \times 10^{-3} \times 50$ g/L as $CaCO_3$
$= 175$ mg/L as $CaCO_3$
Non – Carbonate hardness = Total hardness – Carbonate hardness
Total hardness = 5×50 mg/L as $CaCO_3$ = 250 mg/L as $CaCO_3$
NCH = 250 – 175 = 75 mg/L as $CaCO_3$. Choice (B)

35. $K_D = 0.4 \times 0.434 = 0.1736$
$BOD_5 = L[1 - (10)^{-K_D t}]$
$= 222[1 - (10)^{-5 \times 0.1736}]$
$= 192$ mg/L
BOD remaining = 192 mg/L
Hence, BOD consumed = 222 – 192 = 30 mg/L
Choice (C)

36. Given $g(x) = (x + 5)(x + 2)(x - 1)(x - 6)$ and $f(x) = \int g(x)dx$

$\Rightarrow$ $g(x) = f^1(x) = (x + 5)(x + 2)(x - 1)(x - 6)$
$f^1(x) = 0 \Rightarrow (x + 5)(x + 2)(x - 1)(x - 6) = 0$
$\therefore$ The critical values of $f(x)$ are –5, –2, 1 and 6
Also, $f^1(x) > 0$ for $x < -5$
$f^1(x) < 0$ for $-5 < x < -2$
$f^1(x) > 0$ for $-2 < x < 1$
$f^1(x) < 0$ for $1 < x < 6$
and $f^1(x) > 0$ for $x > 6$
As $f^1(x) > 0$ for $x < -5$, $f^1(x) < 0$ for $-5 < x < -2$ and $f^1(x) = 0$ for $x = -5$, $f(x)$ has a local maximum at $x = -5$
Similarly, as $f^1(x) > 0$ for $-2 < x < 1$,
$f^1(x) < 0$ for $1 < x < 6$ and $f^1(x) = 0$ for $x = 1$
$f(x)$ has a local maximum at $x = 1$
$\therefore$ The number of local maxima is 2. Ans: 2

37. Given that the system of linear equations

$$a_1 x_1 + b_1 x_2 + c_1 x_3 = 0$$
$$a_2 x_1 + b_2 x_2 + c_2 x_3 = 0 \quad \rightarrow(1)$$
$$a_3 x_1 + b_3 x_2 + c_3 x_3 = 0$$

has only a trivial solution.

$\therefore$ Its coefficient matrix $A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}$ is non – singular.

Consider the system of linear equations

$$a_1 x_1 + b_1 x_2 + c_1 x_3 = 5$$
$$a_2 x_1 + b_2 x_2 + c_2 x_3 = 3 \quad \rightarrow(2)$$
$$a_3 x_1 + b_3 x_2 + c_3 x_3 = 2$$

The augmented matrix of (2) is

$$[A/B] = \begin{bmatrix} a_1 & b_1 & c_1 & : & 5 \\ a_2 & b_2 & c_2 & : & 3 \\ a_3 & b_3 & c_3 & : & 2 \end{bmatrix}.$$

As A is non – singular, we have
$\rho(A) = \rho([A/B]) = 3$(= The number of unknowns)
$\therefore$ The system (2) has a unique solution. Choice (B)

38. We know that, if X_1 and X_2 are two independent normal variates, then $X_1 - X_2$ is also a normal variate.
Mean of $X_1 = \mu_{X_1} = 100$

Mean of $X_2 = \mu_{X_2} = 60$

Variance of $X_1 = \sigma_{X_1}^2 = 16$

Variance of $X_2 = \sigma_{X_2}^2 = 9$

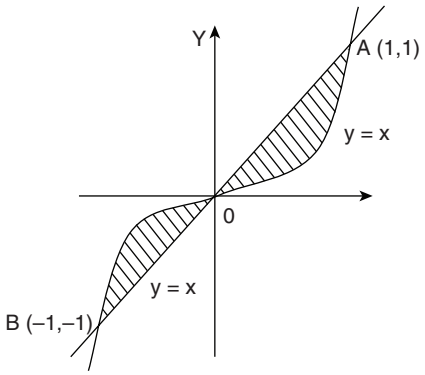
$\therefore$ Mean of $X_1 - X_2 = \mu_{X_1 - X_2} = \mu_{X_1} - \mu_{X_2}$

$= 100 - 60 = 40$

Standard deviation of $X_1 - X_2$

$= \sigma_{X_1 - X_2} = \sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2} = \sqrt{16+9} = 5$ Choice (B)

39. The area bounded by the curve $y = x^3$ and the line $y = x$ is the shaded region shown in the figure. Also, the required area = 2 × The shaded region in the first quadrant.



$\therefore$ The required area $= 2\int_{x=0}^{1} \left(x - x^3\right) dx$

$= 2\left[\frac{x^2}{2} - \frac{x^4}{4}\right]_0^1$

$= 2\left[\frac{1}{2} - \frac{1}{4}\right] = \frac{1}{2}$ square units Choice (B)

40. We know that $[a, b]$ must be divided into even number of subintervals in order to apply the Simpson's Rule.
So, when $[a, b]$ is divided into 5 subintervals, we can't use the Simpson's rule.

$\therefore$ I is not true

II and III are properties of the respective numerical integration methods and are always true. Choice (C)

42. $G = 2.65$, $S_r = 85\%$ and $w = 12\%$

$e = \frac{WG}{S_r}$

$e = \frac{0.12 \times 2.65}{0.85} = 0.374$

critical hydraulic gradient, $i_c = \frac{(G-1)}{1+e} = \frac{1.6}{1.374} = 1.2$

$F\,O\,S = \frac{i_c}{i}$

$\therefore$ The hydraulic gradient provided $= \frac{1.2}{FOS} = \frac{1.2}{2.5}$

$\Rightarrow$ $i = 0.48$ Choice (C)

43. Length of long chart $T_1\,T_2 = 2R\sin(D/2)$

$= 2 \times 600 \times \sin(60/2) = 600$ m

Length of mid – ordinate $= R[1 - \cos(D/2)]$

$= 600[1 - \cos(60/2)]$

$= 600 \times 0.134 = 80.4$ m Choice (B)

45. $Q_{ug} = C_u N_c \,.\, A_b + P_b\, L\, .C_u$

P_b = Perimeter of block = 4(1.2 + 0.4) = 6.4 m

A_b = area of block = $(1.2 + 0.4)^2 = 2.56$ m^2

$\Rightarrow$ $Q_{ug} = (25 \times 9 \times 2.56) + (6.4 \times 10 \times 25)$

$= 2176$ KN Choice (C)

46. The number of blows for first 15 cm is not taken into consideration, only blows required for last 30 cm of penetration is taken.

$\therefore$ Number of blows = 6 + 6 + 8 + 7 = 27

(i) Correction of over burden pressure

corrected value, $N^1 = 0.926 \times 27 = 25$

(ii) Correction for dilatancy

$N = 15 + \left(\frac{25-15}{2}\right) = 20$

$\therefore$ The correct value for N is 20. Choice (C)

47. Return period of rainfall $T = 50$ yrs

$\therefore$ Probability of occurrence once in 50 yrs.

$P = \frac{1}{50} = 0.02$

Probability of occurrence in each of 2 successive year $= P^2 = (0.02)^2 = 0.0004$ Choice (D)

48. Area of given DRH = Volume of direct runoff

$= \left[\frac{1}{2}(70+6) \times 60 \times 60 \times 90\right]$

$= 12312000$ m^3

Effective rainfall = 2 cm

$\therefore$ Catchment are $= \frac{\text{Volume of } DRH}{\text{Effective rainfall}}$

$= \left(\frac{12312000}{2 \times 10^{-2}}\right)$

$= 615.6$ km^2 Choice (B)

49. Volume of water required for evapotranspiration

$= 40 \times 10^4 \times 40 \times 10^{-3} \times 10^3$

$= 16 \times 10^5$ lit

$\therefore$ Discharge required at outlet

$= \frac{16 \times 10^5}{20 \times 24 \times 60 \times 60} = 0.925$ lit/sec

Ans: 0.925 lit/ sec

50. $m_v = 2.2 \times 10^{-4}$ m^2/KN

$\sigma_i^1 = 4(20) + 5(19 - 10) + 10(18 - 10) = 205$ KN/m

$\Delta\sigma^1 = 4 \times 20 = 80$ KN/m

$\sigma_f = \sigma_i + \Delta\sigma = 285$ KN/m

$\Delta H = m_v \,.\, H_0 \,.\, \Delta\sigma^1 = 2.2 \times 10^{-4} \times 10 \times 80$

$\therefore$ $\Delta H = 176$ mm Choice (C)

51. $q(\text{m}^3/\text{sec/m}) = K.H.\dfrac{N_f}{N_d}$

$= 2 \times 10^{-6} \times 20 \times \dfrac{3}{12}$

$= 1 \times 10^{-5}$ cumecs/m Ans: 1

52. For isolated T – beam;

Effective flange width, $b_f = \dfrac{l_0}{\frac{l_0}{b}+4} + b_w$

$l_0 = 10$ m, $b = 2$m and $b_w = 250$ mm

$\Rightarrow \quad b_f = \dfrac{10000}{\frac{10000}{2000}+4} + 250 = 1.36$ m Choice (A)

53. CBR(%) =

$$\frac{\text{load sustained by specimen at 5mm penetration}}{\text{load sustained by std aggregates at 5mm penetration}} \times 100$$

$= \dfrac{50}{2055} \times 100 = 2.4\%$ Choice (D)

54. Taking camber as super elevation

$e = \dfrac{3}{100} = 0.33 = \dfrac{v^2}{225R}$

$0.33 = \dfrac{(80)^2}{225R}$

$R = 948.14$ m Choice (B)

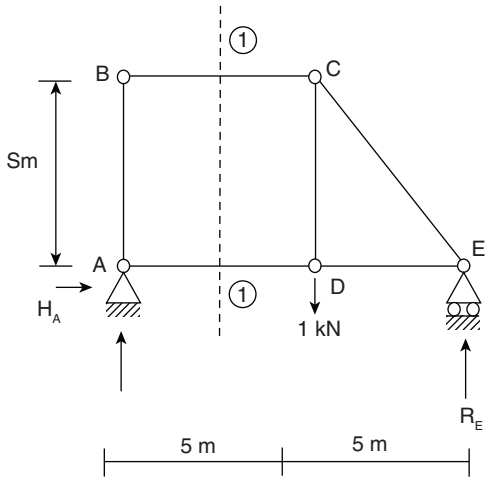
55. $S_D = \Sigma k\delta^1$

Where

k = force in members due to unit load applied where deflection is desired.

δ^1 = deformation of a members due to lack of fit.

Since only in member BC, there is lack of fit. So find force in member due to unit load in member BC only. Forces in other members are not required.



Reactions

Due to symmetry;

$R_A = R_B = \dfrac{1}{2}$kN

$\Sigma F_X = 0$

$H_A = 0$

Force in member BC:

Pass a section (1) – (1) through member BC.

Considering equilibrium of RHS

Taking moment at point 'D'

$(F_{BC}) \times 5 - R_E \times 5 = 0 \Rightarrow F_{BC} = +R_E = \dfrac{1}{2}$kN

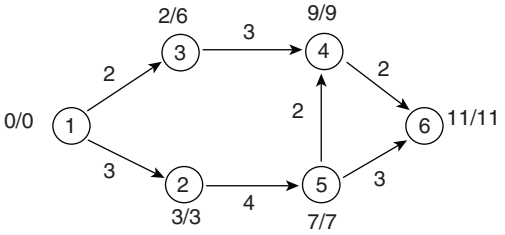
Table

Member	K	δ^1	k. δ^1
BC		4 mm	2.0 mm
AB	–	0	0
BD	–	0	0
CD	–	0	0
DE	–	0	0
AD	–	0	0

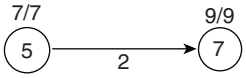
$\Sigma k\delta^1 = 2.0$ mm

$\therefore \quad S{=}D = 2.0$ mm Ans : 2 mm

56.



Activity:



Inference float = Total float – Free float

Total float = (9 – 7) – 2 = 0

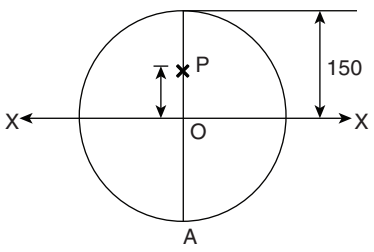
Free float = (9 – 7) – 2 = 0

$\therefore$ Inference float = 0

Independent float = (9 – 7) – 2 = 0

$\therefore$ Both inference float and independent floats are zero. Choice (D)

57.



The stress at a point is the sum of the compressive stress $\frac{P}{A}$ and stress due to moment $P \times 100$

Area of cross section $A = \pi R^2$
$= \pi \times (150)^2$
$= 22500\ \pi\ mm^2$

Direct stress $\frac{P}{A} = \frac{400 \times 10^3}{22500\pi} = 5.6588\ N/mm^2$

Stress at A due to moment (compressive)

$$= \frac{PeR}{I} = \frac{400 \times 10^3 \times 100 \times 150}{\left(\frac{\pi}{64}\right)(300)^4}$$

$= 15.0902$ (Tensile)

Resultant stress at A
$= -15.0902 + 5.6588$
$= -9.4314$
$= 9.4314$ (Tensile) Choice (B)

58. For a tapered rod angular rotation (angle of twist)

$$\theta = \frac{2TL}{3\pi G}\frac{r_1^2 + r_1 r_2 + r_2^2}{r_1^3 r_2^3}$$

where T = torque applied
L = length
r_1, r_2 = radii.

$$\therefore \quad \theta = \frac{2 \times 3 \times 10^6 \times 1200}{3\pi \times 80 \times 10^3} \times \frac{50^2 + 50 \times 25 + 25^2}{50^3 \times 25^3}$$

$= 0.02139$ radian Ans: 0.02135 to 0.02145

59. Discharge $Q = 0.3\ m^3/s$
Jet velocity $v = 38.2$ m/s
Power at the base of nozzle
$= wQH$
$= 9.81 \times 0.3 \times 80$
$= 235.44$ kN

Kinetic energy of jet $= \frac{1}{2}\left(\frac{wQ}{g}\right)v^2$

$$= \frac{1}{2} \times \frac{9.81 \times 0.3}{9.81} \times (38.2)^2$$

$= 218.89$ kW

Loss of power in nozzle
$=$ Power at base $-$ Kinetic energy in nozzle
$= 235.44 - 218.89$
$= 16.55$ kW Choice (B)

62. Diameter of the equivalent pipe $D = 600$ mm $= 0.6$ m
Using Dupit's equation.

$$\frac{L}{D^5} = \frac{L_1}{D_1^5} + \frac{L_2}{D_2^5} + \frac{L_3}{D_3^5}$$

$$\therefore \quad \frac{L}{(0.6)^5} = \frac{1000}{(0.75)^5} + \frac{800}{(0.6)^5} + \frac{600}{(0.45)^5}$$

$= 4213.99 + 10288.07 + 32{,}515.37$
$= 47{,}017.43$

$\Rightarrow \quad L = 3656.08$ m Ans: 3655.5 to 3656.5

63. $W = 800$ N
$\tau = 100\ N/mm^2$
Mean radius $= \frac{75}{2} = 37.5$ mm

$\tau = \frac{16WR}{\pi d^3}$ where d = wire diameter

$$\therefore \quad 100 = \frac{16 \times 800 \times 37.5}{\pi d^3}$$

$\Rightarrow \quad d = 11.52$ mm Choice (B)

64. Design strength of side fillet weld $= \frac{L_w (KS) f_u}{\sqrt{3} r_{mw}}$

L_w = Effective length of fillet weld
$= 50 + 50 = 100$ mm
t_t = Effective throat thickness
$= k \times s = 0.7 \times 10 = 7$
$fu = 410\ N/mm^2$
r_{mw} = (for field welding) $= 1.50$

$$\therefore \quad (P_{dw})_{\substack{side \\ fillet}} = \frac{100 \times 0.7 \times 10 \times 410}{\sqrt{3} \times 1.50} = 110.46\ kN$$

Design strength of plug weld $= (P_{dw})_{plug}$

$$(P_{dw})_{plug} = \frac{\frac{\pi}{4} \times (20)^2 \times 410}{\sqrt{3} \times 1.5}$$

$(P_{dw})_{plug} = 49.577$ kN

$\therefore$ Design strength of fillet weld
$= P_{dw} = (P_{dw})_{sidefillet} + (P_{dw})_{plug} = 110.46 + 49.577$

$P_{dw} = 160.037$ kN

$\therefore$ Service load carrying capacity $= \frac{160.037}{1.5}$

$= 106.69$ KN Choice (A)

65. $[F]$ = inverse of stiffness matrix

$$= \frac{1}{(ad - bc)} k \begin{bmatrix} 5 & -3 \\ -3 & 4 \end{bmatrix}$$

$$[F] = \frac{1}{11 \times k} \begin{bmatrix} 5 & -3 \\ -3 & 4 \end{bmatrix}$$ Choice (C)