Mock Test 5

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. A, B, C, D are four points on a plane. $AB = 5$, $AC = 7$ and $AD = 10$. Which of the following is not a possible value of $BC + CD$?

(A) 6.5 (B) 10.5
(C) 24 (D) 30

2. Seven persons – A, B, C, D, E, F and G – are sitting in a row. A, B and C are women, D and E are children, and F and G are men. No two children or no two men or no two women sit next to each other. B and A have two persons sitting between them. F is two places away from A. D has two persons sitting to his right. G has two persons sitting to his left. If the maximum number of people sit between the two children, then who sits to the right of F?

(A) D (B) C
(C) E (D) B

Directions for question 3: In the following question, 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. Mark the number of that pair as your answer.

3. SICKLE : FARMER : :

(A) Shears : Gardener
(B) Painter : Brush
(C) Computer : Whizkid
(D) Workshop : Lathe

Directions for question 4: The following statement has a part missing. Choose the best option from those given below the statement to make up the missing part.

4. Not only was the tone and tenor of the interaction especially positive, the two principals and their delegations _____.

(A) managed to generate specific outcomes also on any number of issues
(B) also manage to generate specific outcomes on a number of issues
(C) also managed to generate specific outcomes on a number of issues
(D) will also manage to generate specific outcomes of any number of issues

Directions for question 5: In the following question, four alternatives are given for the idiom/phrase printed in bold in the sentence. Choose the alternative which best expresses the meaning of the idiom/phrase.

5. Although Jack volunteered to help me cook the dinner, he threw a spanner in the works when it came to the actual cooking.

(A) started laughing
(B) left the place
(C) caused hindrance
(D) wholeheartedly assisted

Questions 6 to 10 carry Two Marks each.

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

6. If a, b, c, p, q, r are non-zero integers, $a^p = b$, $b^q = c$, $c^r = a$ and $pqr = 15$, the possible values of $a + b + c$ are _____.

(A) 1, –1 (B) 3, –3
(C) 1 (D) 3

7. A dealer in travel goods sells four types of suitcases – Standard, Deluxe, Super-deluxe and Premium. The number of each type of suitcase sold during the four quarters of 2015 are tabulated below. The costs of four types are ₹ 700, ₹ 900, ₹ 1000 and ₹ 1200 per suitcase respectively.

Type/ Quarter	Standard	Deluxe	Super-deluxe	Premium
Q_1	18,500	17,500	15,010	13,000
Q_2	16,060	16,800	15,590	13,400
Q_3	19,800	18,900	16,040	12,500
Q_4	20,740	19,500	16,090	12,800

Which suitcase accounts for the greatest part of the revenue for the dealer?

(A) Standard (B) Deluxe
(C) Super - deluxe (D) Premium

8. Vikram, his brother, his daughter and his son are playing doubles tennis match. Vikram's son is diagonally across the net from the tallest player's sibling. Vikram's brother is directly across the net from Vikram's daughter. The shortest and the tallest players are on the same side of the net. Who is the shortest player?

(A) Vikram (B) Vikram's brother
(C) Vikram's son (D) Vikram's daughter

Directions for question 9: In each of the following questions, 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 2, 3, 4 and 5 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. A lot of us do not realize that to carry out our day-to-day functions we need a minimum amount of endurance strength and flexibility in our bodies.
2. Adding to this, 21st century seems to have many an unforeseen emergency in store for all of us; whether it be the 9/11 attack, outbreak of epidemics, or strikes of terrorism – one never knows where and when what might happen.
3. Our current ways of life in general, are no longer providing our bodies with sufficient exercise to maintain adequate levels of fitness.
4. The realization of this dawns only when the necessity occurs, and that could be too late.
5. When we give in to the comforts of modern day living and inadvertently let our bodies deteriorate, our abilities to carry out physical activities are so adversely affected that one may not derive the full pleasure of living.
6. In such circumstances proving the quality and most likely the longevity of our lives is a matter of personal choice, and depends greatly on how well we are able to pursue sound physical fitness programmes that help maintain a strong body and mind.

(A) 5432 (B) 3254
(C) 2345 (D) 5243

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

10. Over the years, there is a change in the attitude of disciples. While some are symbols of dedication and grace, others want to become superstars overnight, and in the process, defocus from their path to the extent of questioning the guru.
Which of the following can be inferred from the above?
(A) Those disciples who question the guru cannot become superstars.
(B) Earlier all the disciples were graceful and dedicated.
(C) Gurus are always right.
(D) For the disciples who are graceful and dedicated, becoming super stars overnight is not the priority.

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. The order and degree of the partial differential equation

$$\frac{\partial^2 z}{\partial x^2}+5\left(\frac{\partial^2 z}{\partial x\partial y}\right)^3-4\left(\frac{\partial z}{\partial x}\right)^5+3\frac{\partial z}{\partial y}=4z$$ respectively

are _____.
(A) 2 and 1 (B) 2 and 3
(C) 2 and 5 (D) 1 and 5

12. If f and g are any two scalar point functions that are continuous and have continuous first partial derivatives and if $\overline{G}$ = grad g, then curl($f\,\overline{G}$) is equal to _____.
(A) f(curl $\overline{G}$) (B) grad $f\times\overline{G}$
(C) g(grad f) (D) None

13. 8 books are placed at random in a shelf. The probability that three books B_1, B_2 and B_3 are together is _____.

14. If A is a 3 × 4 matrix with rank 3, then for any system of linear equations $AX = B$ has
(A) a unique solution,
(B) no solution
(C) infinitely many solutions
(D) exactly three solutions

15. If $f(x)+f(6-x)=0$ and $f(x)$ is continuous in [0, 6], then the value of $\int_0^6 f(x)dx$ is _____.

16. Lateral ties in *RCC* columns are provide to resist _____.
(A) Bending moment
(B) Shear
(C) Buckling of longitudinal bars
(D) Bothe bending moment and shear

17. Anchorage value of hook in RCC is _____ (ϕ = diameter of bar)
(A) 16ϕ (B) 12ϕ
(C) 8ϕ (D) 4ϕ

18. The most active clay mineral in shrinkage and swelling is _____.
(A) Kaolinite (B) Illite
(C) Hollysite (D) Montmorillonite

19. Following the usual notations, the flow value $N\phi$ is given as _____.
(A) $\tan^2(45+\phi/2)$ (B) $\tan^2(45-\phi/2)$
(C) $\tan(45+\phi/2)$ (D) $\tan(45-\phi/2)$

20. For a soil, the void ratio is given as 0.68. If the specific gravity of soil is 2.75, the shrinkage limit of the soil is _____
(A) 24.7% (B) 2.7%
(C) 40.4% (D) 12.3%

21. The soil "loam" means,
(A) Silt with little sand
(B) Sandy silt with little clay
(C) Clayey silt exhibiting slight cohesion
(D) Mixture of sand, silt and clay sized particles in approximately equal proportion.

22. The organism, with exhibits very nearly the characteristics of an ideal pathogenic indicator is
(A) Entamoeba histolytica
(B) Escherichia coli
(C) Salmonella typhi
(D) Vibrio conma

23. Pathogens are usually removed by
(A) Chemical precipitation
(B) Sedimentation
(C) Activated sludge process
(D) Chlorination

24. The reoxygenation coefficient K of stream is 0.5 at 20^0C. Its K value at 32^0C is likely to be _____.

25. The load transfer to the lower layers of flexible pavements is by
(A) Bending action of layers
(B) Shear deformation
(C) Grain to grain contact
(D) Consolidation of sub grade

26. Camber on highway pavement is provided to take care of
(A) Centrifugal force
(B) Drainage
(C) Sight distance
(D) Off tracking

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

28. The ratio of actual evapotraspiration to potential evapotranspiration is in the range of
(A) 0 to 0.4
(B) 0.6 to 0.9
(C) 0 to 1.0
(D) 1.0 to 2.0

29. At a point in a strained body, normal stresses are zero and shear stresses are 100 MPa. Value of principal stress are
(A) 50 MPa
(B) 100 MPa
(C) 150 MPa
(D) 20 MPa

30. In laminar flow through a pipe, the pressure drop per unit length of pipe is given by
(A) $\frac{32\mu\bar{u}}{D}$ (B) $\frac{16\mu\bar{u}}{D^2}$
(C) $\frac{128\mu Q}{\pi D^4}$ (D) $\frac{128\mu Q}{\pi D^2}$

31. A closed cylindrical vessel of radius R completely filled with a liquid of density ρ is rotated at an angular velocity ω about its vertical axis. The total fluid pressure force acting on the top is
(A) $\frac{\rho}{4}\omega^2\pi R^4$ (B) $\frac{\rho}{4}\omega^2\pi R^3$
(C) $\frac{\rho}{4}\omega^2\pi R^2$ (D) $\frac{\rho}{4}\omega^2\pi R$

32. A three hinged parabolic arch of span 4 m and rise 8 m carries a uniformly distributed load of 8 KN per unit over the whole span. The horizontal thrust at each support (in KN) is _____.

33. As per 1S : 800, the maximum bending moment for design of purlins can be taken as
(A) $\frac{WL}{8}$ (B) $\frac{WL}{4}$
(C) $\frac{WL}{10}$ (D) $\frac{WL}{12}$

34. When length of side fillet weld is 400 times the effective throat thickness, the design shear capacity of fillet weld is
(A) Decreased by 33% (B) increased by 33%
(C) Increased by 66% (D) Decreased by 66%

35. State of stress at a point is as follows. $\sigma_x = 900$ MPa, $\sigma_y = 300$ MPa. Maximum shear stress = 500 MPa. Value of maximum principal stress (in MPa) is
(A) 900 (B) 1000
(C) 1100 (D) 1200

Questions 36 to 65 carry Two Marks each.

36. The system of linear equations
$2x + 3y - 4z = 0$
$4x + 5y + z = 0$
$2x + 4y - 13z = 0$
has
(A) only a trivial solution
(B) exactly one linearly independent solution.
(C) exactly two linearly independent solutions.
(D) exactly three linearly independent solutions.

37. The coefficient of x^8 in the Taylor's series expansion of $f(x) = 1 + \cos^2(x^2)$ about $x = 0$ is _____
(A) $\frac{2}{3!}$ (B) $\frac{3}{4!}$
(C) $\frac{5}{6!}$ (D) $\frac{7}{8!}$

38. Which of the following is a value of the function $f(x, y) = \frac{x^2y^2 + 8(x+y)}{xy}$ at one of its local extreme points?
(A) 12 (B) 23
(C) 17 (D) 10

39. If $y(x)$ satisfies the differential equation $y^{11} + 8y^1 + 7y = 49$, then the value of $\lim_{x\to\infty} y(x)$ is _____.

40. For a set of 5 pairs of values of x and y,
$\sum x = 20$, $\sum y = 325$, $\sum xy = 366$ and $\sum x^2 = 120$
If a straight line of the form $y = a + bx$ is fitted to this data using the method of least squares, then the value of y at $x = 10$ is _____
(A) –25 (B) –75.10
(C) 41.32 (D) 30.50

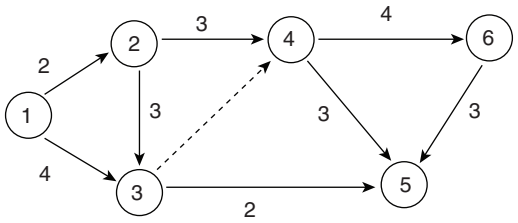
41. An *RC* short column 400 mm × 600 mm is made of M30 concrete and has 6 no's of 16 mm Fe500 steel bars. The ultimate load carrying capacity of the column is _____,

(A) 1478 KN (B) 3270 KN
(C) 3837 KN (D) 4904 KN

42. A pre stressing concrete beam 150 mm × 300 mm supports a load of 5 KN/m over a simply supported span of 8 m. The beam has parabolic cable of zero eccentricity at ends and 50 mm towards soffit at the central span. The pre – stressing force required to balance external load is _____.

(A) 800 KN (B) 850 KN
(C) 875 KN (D) 900 KN

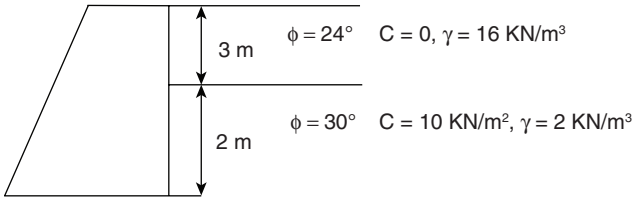
43.



Identify the critical path, for the given network.

(A) 1 – 2 – 3 – 4 – 5 – 6
(B) 1 – 3 – 4 – 5 – 6
(C) 1 – 2 – 3 – 5 – 6
(D) All the above

44. A retaining wall is shown below.
The active earth pressure at 5 m. depth is _____.



(A) 17.8 kpa (B) 29.3 kpa
(C) 40.8 kpa (D) 229.4 kpa

45. Two soil samples *A* and *B*, each weighing 1 kg and having water contents of 50% and 75% are mixed together. The resulting water content of the mixture is _____.

(A) 63.8% (B) 62.5%
(C) 61.7% (D) 60.8%

46. A clay sample originally 30 mm thick at a void ratio of 1.10 was subjected to a compressive load. After some period of time the clay sample was measured as 25 mm. The void ratio is _____.

(A) 0.385 (B) 1.45
(C) 0.68 (D) 0.75

47. A continuous footing of width 2.5 m rests at 1.5 m below the ground surface in clay. The unconfined compressive strength of the clay is 150 kpa and unit weight of soild is 16 KN/m³. For using factor of safety of 3, the safe bearing capacity of the footing as per terezaghi's theory is _____.

(A) 150.3 kpa
(B) 451 kpa
(C) 142.5 kpa
(D) 166.5 kpa

48. The composition of a certain *MSW* sample and specific weight of its various components are as given below:

Component	Percentage by weight	Specific weight (kg/m³)
Food	50	300
Dirt and Ash	30	500
Plastic	210	65
Wood and yard waste	20	125

(A) 319 (B) 139
(C) 217 (D) 199

49. A setting tank is designed for a surface overflow rate of 40 m²/day m². Assuming specific gravity of sediment particles = 2.65. Density of water γ_w = 1000 kg/m³, dynamic velocity of water = 0.00 NS/m² and stoke's law's valid. The approximate minimum size of particles which can be completely removed is _____.

50. Match

	List – I		List – II
a.	Evapora transpiration	1.	Penman method
b.	Infiltration	2.	Snyder's method
c.	Synthetic unit hydrograph	3.	Museingham method
d.	Channel routing	4.	Horton's method

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

51. A road is being designed for a speed of 110 km/hr on a horizontal curve with a super elevation of 8%. If the coefficient of side friction is 0.1, the minimum radius of curve 9 in m) required for safe vehicular movement is ____.

52. Match the following:

P.	Resistance to impact	1.	Hardness
Q.	Resistance of wear	2.	Strength
R.	Resistance to weathering action	3.	Toughness
S.	Resistance to crushing	4.	Soundness

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

53. In a cylindrical bituminous mix VMA = 15% and V_v = 4.5%. The magnitude of VFB is
(A) 24 (B) 54
(C) 40 (D) 70

54. The speed density ($v - k$) relationship on a single lane road with uni directional flow is $v = 70 - 0.7\,k$, where v is km/hr and k is in veh/km. The capacity of road (in veh/hr) is _____.

55. The width of expansion joint gap is 2.5 cm in a cement concrete pavement. The spacing between expansion joint for a maximum rise in temperature of 25^0C is (Assuming coefficient of thermal expansion of concrete as 10×10^{-6} per degree C)
(A) 5 m
(B) 50 m
(C) 100 m
(D) 25 m

56. In a leveling work, sum of back sight (B S) and fore-sight (F S) have been found to be 3.985 m and 5.725 m respectively. If R.L of the starting station is 100.00 m, the RL (in m) of the last station is _____

57. The chainage of the intersection point of two straight is 1585.6 m and angle of intersection is 150^0. If the radius of a circular curve is 600.0 m, the tangent distance and length of the curve respectively are
(A) 418.88 and 1466.08
(B) 218.38 and 1648.49
(C) 314 m and 160.79
(D) 418.88 and 218.38

58. A hydraulic turbine is to develop 1010 kW while running at 120 rpm under a head of 12 m. Overall efficiency of the turbine at the best operating point is 90%. For the prediction of performance a 1 : 10 scale model is tested under a head of 7 m. Power output (in kW) of the model turbine for similar conditions of prototype is.

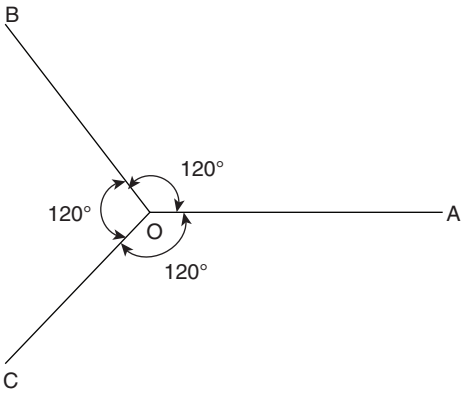
59. A Kaplan turbine works under the following conditions
Head = 20 m
Speed = 150 rpm.
Hydraulic efficiency = 95%
Outer diameter of runner = 4.5 m.
Hub diameter = 2 m
Velocity of flow = 10.2 m/s
Runner inlet vane angle (in degree) at outer periphery of the runner is
(A) 160.7
(B) 155.2
(C) 150.4
(D) 144.3

60. An inward flow reaction turbine has an external diameter of 1 m. Speed of the runner is 210 rpm and guide blades make an angle of 10° to the wheel tangent. If velocity of flow at inlet is 2.2 m/s, the runner vane a _____.

61. A cylindrical vessel 3 m long and 1 m diameter is subjected to an internal pressure of 1.5 N/mm^2. The hoop stress developed was 50 N/mm^2. If Young's modulus and Poisson's ratio are 2×10^5 N/mm^2 and 0.3 respectively change in volume (in cm^3) is _____.

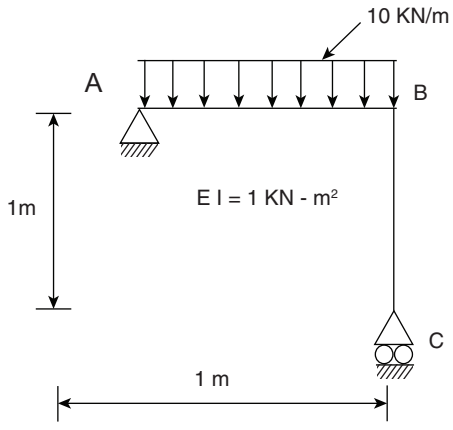
62. A cylindrical vessel of 1.5 m internal diameter and 4 m length has 10 mm shell thickness. If it is subjected to a fluid pressure of 2 MPa, maximum shear stress induced (in N/mm^2) is
(A) 25
(B) 37.5
(C) 50
(D) 62.5

63.



At a stressed point in a two dimensional stress system, strain were measured to 3 directions OA, OB and OC, 120° to each other. The observed strains are
$e_A = 300 \times 10^{-6}$, $e_B = -225 \times 10^{-6}$ and
$e_C = 100 \times 10^{-6}$.
Value of strain at an angle 90° clockwise to OA (in micron) is _____.

64. The rigid jointed plane frame ABC is as shown below. The deflection at center of AB is _____ (in mm)



65. The design bending strength of laterally supported beam of ISLB 350 @ 486 N/m, when the design shear force (V) is less than the design shear strength is _____. (in KN – m). (Assume plastic section, Z_{PZ} = 850 10^3 mm^3 Z_{ez} = 750 10^3 mm^3 and steel of grade Fe410]

Answer Keys

1. D	**2.** D	**3.** A	**4.** C	**5.** C	**6.** B	**7.** B	**8.** B	**9.** A	**10.** D
11. B	**12.** B	**13.** 0.106 to 0.108		**14.** C	**15.** 0	**16.** C	**17.** A	**18.** D	**19.** A
20. A	**21.** B	**22.** B	**23.** D	**24.** 0.604	**25.** C	**26.** B	**27.** A	**28.** C	**29.** B
30. C	**31.** A	**32.** 2	**33.** D	**34.** A	**35.** C	**36.** B	**37.** A	**38.** A	**39.** 7
40. B	**41.** B	**42.** A	**43.** A	**44.** A	**45.** C	**46.** B	**47.** D	**48.** B	
49. 5.14×10^{-9} m		**50.** B	**51.** 0.071	**52.** B	**53.** D	**54.** 1750 veh/hr		**55.** B	
56. 98.26		**57.** C	**58.** 4.49 to 5.55		**59.** A	**60.** 56.0 to 56.1			
61. 1119.15 to 1119.25			**62.** B	**63.** 183 to 184		**64.** 13.00 to 13.05			
65. 190 – 195 KN – m									

Hints and Explanations

1. $AB = 5, AC = 7 \therefore 2 \le BC \le 12$
$BC = 7, AD = 10 \therefore 3 \le CD \le 17$
$\therefore \quad 5 \le BC + CD \le 29$
Among the choices, 30 is not a possible value.
Choice (D)

2. Let us take down the data as given below:
(i) Seven persons – A, B, C, D, E, F and G - sit in a row.
(ii) 3 women : A, B and C
2 children : D and E
2 men : F and G
(iii) No two persons of the same gender (or no two children) sit next to each other.
(iv) $\frac{B}{A} - - \frac{A}{B}$
(v) $\frac{F}{A} - \frac{A}{F}$
(vi) D _ _ (2 persons sitting to the right of D)
(vii) _ _ G (G has two persons sitting on his left).
The positions of G and D are located as shown:

$G \quad D$
– – – – – – –
$(m) \quad (c)$

Here, $m \rightarrow$ Man, $w \rightarrow$ Woman and $c \rightarrow$ Child.
For the maximum number of people to sit between the two children, the other child has to be seated at the extreme left end. Also, other conditions are used to get the following arrangement:

E	C	G	A	D	F	B
---	---	---	---	---	---	---
(1)	(w)	(m)	(w)	(c)	(m)	(w)
$x(f)$		$x(f)$				

Hence, B sits to the right of F. Choice (D)

3. A 'sickle' is used by the farmer to cut the weeds i.e. for weeding. In the same way 'shears' are used by the 'gardener' to cut the bushes. (Shears are large pair of scissors). Hence option A is the correct answer. Option B can be ruled out as the order is reversed, it should be (Brush : Painter). A 'whizzkid' is a person who is successful at a very young age, not necessarily in computers. A 'lathe' is a machine that shapes pieces of wood or metal by holding and turning them against a fixed cutting tool and a 'workshop' is a place where things are repaired or made. Choice (A)

4. Since we have 'was' in the beginning of the sentence it should be 'managed' (past tense) in the second half. So we look at choices A and C. 'A number of' is better than 'any number of' since the latter suggests a very high number. Choice (C)

5. The idiom 'throw a spanner in the works' means 'to cause hindrance'. It means to do something that prevents a plan or activity from succeeding. Choice (C)

6. $a^p = b, b^q = c, c^r = a$ .... (1)
and $pqr = 15$ .... (2)
$a^p = b \Rightarrow c^{rp} = b \Rightarrow b^{qrp} = b$
$\therefore$ Either $b = 1, 0, -1$ or $pqr = 1$. As $pqr \neq 1$, $b = 1$ or -1
($\because$ a, b, c are nonzero integers). If $b = 1$, then $c = 1$ and $a = 1$
If $b = -1$, (as p, q, r are odd integers), it follows that $c = -1$ and $a = -1$
$\therefore \quad a + b + c = 3$ or -3. Choice (B)

7. The total sales (number), the cost of each type of suitcase and the total revenue from the four types of suitcases are tabulated below.

Type	Number	Cost	Revenue
S	75,100	700	5,25,70,000
D	72,700	900	6,54,30,000
SD	62,730	1000	6,27,30,000
P	51,700	1200	6,20,40,000

The greatest revenue is from Deluxe. Choice (B)

8. Let Vikram, his brother, his son, and his daughter be V, B, S and D.
If S is diagonally opposite to D, then S is the taller player. The arrangement is as follows:

S	B
V	D

And now, B is the shortest player ($\because$ shortest and tallest players are on same side)

If S is diagonally opposite to V, then D and B cannot be directly opposite.

If S is diagonally opposite to B, then V is the taller player. The arrangement is as follows:

S	D
V	B

And now, B is the shortest player. Choice (B)

9. Statement 1 says to carry out our day-to-day activities a minimum amount of endurance and flexibility in our bodies is needed. If we look at the statements, '5' is the most appropriate one to follow 1. '5' emphasizes on the fact that our physical activities are adversely affected, which is a continuation of the idea expressed in '1'. The words "the realization of this ...." refers to the reason for our abilities to be adversely affected. Hence '4' is a better statement to follow '5'. Further in '3' we find emphasis on the current ways of life. Thus '543' is the logical order which is further followed by '2'.

Choice (A)

10. According to the passage a disciple becomes defocused to the extent of questioning the guru once they want to become superstars overnight. But the statement does not explicitly indicate whether they would be successful or not. Hence, (A) cannot be inferred. The passage describes the attitude of present disciples but not the past ones. Hence, (B) cannot be inferred. The passage did not discuss about the gurus, hence, (C) cannot be inferred. The passage demarks the disciples as those who are dedicated and graceful and the other as those who want to become super stars overnight. From this it can be understood that one group is different from the other. Hence, (D) can be inferred. Choice (D)

11. Order = 2 and degree = 3. Choice (B)

12. Given $\overline{G} = G\text{rad } g$

Now $\text{curl}(f\overline{G}) = \text{Grad } f \times \overline{G} + f(\text{curl } \overline{G})$

$= \text{Grad } f \times \overline{G} + f(\text{curl (grad } g))$

$= \text{Grad } f \times . \overline{G} . + f(\overline{0})$

($\because$ curl (Grad g) = $\overline{0}$)

$= \text{Grad } f \times \overline{G}$. Choice (B)

13. Total number of ways of placing 8 books in a shelf = 8!

As three books B_1, B_2 and B_3 has to be together, take the three books as a single entity.

The number of ways of arranging the three books among themselves = 3!

The number of ways of arranging the remaining 5 books and this entity (The three books together) = 6!

$\therefore$ The number of ways of arranging the 8 books such that the three books are together = 3! × 6!

$\therefore$ Required probability $= \dfrac{3! \times 6!}{8!} = \dfrac{3}{28} = 0.1071$

Ans: 0.106 to 0.108

14. Given that A is a 3 × 4 matrix with rank 3.

$\therefore$ Any system of linear equations $AX = B$ will consist of 4 unknowns

Also, as $\rho(A) = 3$, we have

$\rho([A/B]) = 3$

$\therefore$ $\rho(A) = \rho([A/B]) = 3 < 4$ (The number of unknowns), the system of equations $AX = B$ has infinitely many solutions. Choice (C)

15. We know that, if $f(x) = -f(2a - x)$, then

$$\int_0^{2a} f(x)dx = 0$$

Now $f(x) + f(6 - x) = 0 \Rightarrow f(x) = -f(6 - x)$

$\therefore$ $a = 3$

Hence $\displaystyle\int_0^6 f(x)dx = 0$ Ans: 0

16. Lateral ties in columns are provided, to avoid buckling of longitudinal (main) steel. Choice (C)

17. 180^0 bend is called Hook

Anchorage value for 180^0 bend is 16ϕ Choice (A)

20. $e = \dfrac{WG}{S_\gamma}$

At shrinkage limit, $S\gamma = 1$

$0.68 = \dfrac{W \times 2.75}{1}$

$\therefore$ $W = 24.7\%$ Choice (A)

24. $K_{R(T^0C)} = K_{R(20^0C)}[1.016]^{T-20C}$

$= 0.5\,[1.016]^{32-20}$

$= 0.604$ Ans: 0.604

29. $p_x = 0$, $p_y = 0$, $\tau = 100$ MPa

$$p_{1,2} = \frac{p_x + p_y}{2} \pm \sqrt{\left(\frac{p_x - p_y}{2}\right)^2 + \tau^2}$$

$= 0 \pm \sqrt{0 + \tau^2} = \tau$

$= 100$ MPa Choice (B)

30. $\dfrac{\Delta P}{L} = \dfrac{32\mu\overline{u}}{D^2}$

Substituting $\overline{u} = \dfrac{Q}{\left(\dfrac{\pi d^2}{4}\right)}$

$\dfrac{\Delta P}{L} = \dfrac{128\mu Q}{\pi D^4}$ Choice (C)

32. Horizontal thrust at each support is $\frac{wl^2}{8h}$

$$\therefore \quad H = \frac{8\text{KN/m} \times (4)^2\,\text{m}^2}{8 \times 8\text{m}} = \frac{8 \times 16}{8 \times 8}$$

$$\boxed{H = 2\ \text{KN}}$$

Ans: 2

33. As per 1*S* : purlins are assumed as continuous beams in design. So maximum bending moment to be taken as $\frac{WL}{12}$. Choice (D)

34. $L_J = 400\ t_t$

If $L_J > 150\ t_t \Rightarrow$ a Reduction factor need to be applied for design shear capacity of fillet weld.

Reduction factor (β_{LW})

$$(\beta_{LW}) = 1.20 - \frac{0.20 L_J}{150 t_t}$$

$$= 1.20 - \frac{0.20 \times 400 t_t}{150 t_t}$$

$$(\beta_{LW}) = 0.66$$

So strength reduced by 33% Choice (A)

35. Maximum principal stress

$$= \left(\frac{\sigma_x + \sigma_y}{2}\right) + (\tau_{\max})$$

$$= \left(\frac{900 + 300}{2}\right) + 500$$

= 1100 MPa Choice (C)

36. Given system of linear equations is

$$\left.\begin{aligned} 2x + 3y - 4z &= 0 \\ 4x + 5y + z &= 0 \\ 2x + 4y - 13z &= 0 \end{aligned}\right\} \quad \rightarrow (1)$$

It can be written in matrix form as

$AX = 0$

Where $A = \begin{bmatrix} 2 & 3 & -4 \\ 4 & 5 & 1 \\ 2 & 4 & -13 \end{bmatrix}$

$R_2 \rightarrow R_2 - 2R_1$ and $R_3 \rightarrow R_3 - R_1$

$$\sim \begin{bmatrix} 2 & 3 & -4 \\ 0 & -1 & 9 \\ 0 & 1 & -9 \end{bmatrix}$$

$R_3 \rightarrow R_3 + R_2$

$$\therefore \quad A \begin{bmatrix} 2 & 3 & -4 \\ 0 & -1 & 9 \\ 0 & 0 & 0 \end{bmatrix}$$

$\therefore \quad \rho(A) = r = 2$

The number of variables = $n = 3$

So, the number of linearly independent solutions is $n - r = 3 - 2 = 1$ Choice (B)

37. We have $f(x) = 1 + \cos^2(x^2)$

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

$$= \frac{3}{2} + \frac{1}{2}\cos 2x^2$$

$$= \frac{3}{2} + \frac{1}{2}\left[1 - \frac{(2x^2)^2}{2!} + \frac{(2x^2)^4}{4!} - \frac{(2x^2)^6}{6!} + \ldots\infty\right]$$

$$= 2 - 2\frac{x^4}{2!} + 2^3\frac{x^8}{4!} - 2^5\frac{x^{12}}{6!} + \ldots\ldots\infty$$

$\therefore$ The coefficient of $x^8 = \frac{2^3}{4!} = \frac{2}{3!}$ Choice (A)

38. Given $f(x,y) = \frac{x^2y^2 + 8(x+y)}{xy} = xy + \frac{8}{x} + \frac{8}{y}$

$$\therefore \quad f_x = y - \frac{8}{x^2} \text{ and } f_y = x - \frac{8}{y^2}$$

$$f_x = 0 \Rightarrow y - \frac{8}{x^2} = 0$$

$$\Rightarrow x^2y = 8 \quad \rightarrow (1)$$

and $f_y = 0 \Rightarrow x - \frac{8}{y^2} = 0$

$$\Rightarrow xy^2 = 8 \quad \rightarrow (2)$$

From (1) and (2), we have

$x^2y = xy^2 \Rightarrow x = y$

$\therefore$ From (1), $x^2 \times x = 8 \Rightarrow x = 2$

$\Rightarrow y = 2$

$\therefore$ The stationary point of $f(x, y)$ is (2, 2)

Now $r = f_{xx} = \frac{16}{x^3}$; $s = f_{xy} = 1$ and $t = f_{yy} = \frac{16}{y^3}$

At (2, 2), $rt - s^2 = 3 > 0$ and $r = 2 > 0$

$\therefore$ $f(x, y)$ has a local minimum at (2, 2) and the value of $f(x, y)$ at (2, 2) is 12. Choice (A)

39. Given differential equation is

$y^{11} + 8y^1 + 7y = 49 \quad \rightarrow (1)$

Its general solution is $y = y_c + y_p \quad \rightarrow (2)$

To find y_c:

The homogenous differential equation corresponding to (1) is

$y^{11} + 8y^1 + 7y = 0$

Its auxiliary equation is

$D^2 + 8D + 7 = 0$

$\Rightarrow (D + 1)(D + 7) = 0$

$\Rightarrow D = -1; D = -7$

$\therefore$ The complementary function of (1) is

$y_c = c_1e^{-x} + c_2e^{-7x} \quad \rightarrow (3)$

To find y_p:

$$y_p = P.I = \frac{1}{f(D)}X = \frac{1}{(D^2+8D+7)}49 = \frac{1}{7}\times 49$$

$y_p = 7$ → (4)

Substituting the values of y_c and y_p in (2)

We get the general solution of (1) as

$y(x) = c_1e^{-x} + c_2e^{-7x} + 7$

Now $\underset{x\to\infty}{Lt}\, y(x) = \underset{x\to\infty}{Lt}\, [c_1e^{-x} + c_2e^{-7x} + 7] = 7$ Ans: 7

40. Given $n = 5$, $\Sigma x = 20$, $\Sigma y = 325$, $\Sigma xy = 366$ and $\Sigma x^2 = 120$

The normal equations in the process of fitting a straight line $y = a + bx$ to the above data are

$\Sigma y = na + b\Sigma x$

and $\Sigma xy = a\Sigma x + b\Sigma x^2$

i.e., $325 = 5a + 20b$

$366 = 20a + 120b$

Solving these equations for a and b, we have

$a = 158.4$ and $b = -23.35$

$\therefore$ The straight line that fits to the given data is $y = 158.4 - 23.35\,x$

$\therefore$ y at $x = 10$ is

$y(10) = 158.4 - 23.35 \times 10 = -75.1$ Choice (B)

41. $A_{SC} = 6 \times \frac{\pi}{4} \times 16^2 = 1206\ m^2$

$A_C = A_g - A_{SC}$

$= (400 \times 600) - 1206$

$= 238794\ mm^2$

$P_u = 0.4\,fck\,A_C + 0.67\,fy\,A_{SC}$

$= 0.4(30)(1206) + 0.67(500)(1206)$

$= 3269838$ N

$\therefore$ $P_u = 3270$ KN Choice (B)

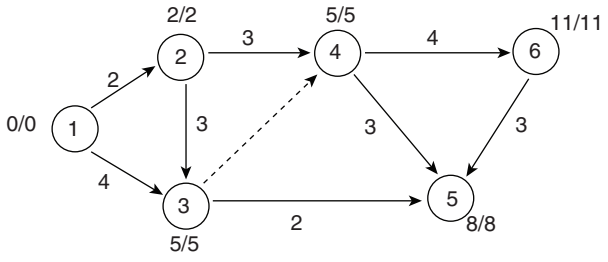
42. $P.e = \frac{wl^2}{8}$

$P(50) = \frac{5\times(8000)^2}{8}$

$P = 8{,}00{,}000$N

$\therefore$ $P = 800$ KN Choice (A)

43.



Total flat for 1 – 3 and 3 – 5 is not zero. Choice (A)

44. At 5m;

$\sigma_V = 3 \times 16 + 2 \times 20 = 88$ KPa

$P_a = K_{a2}\sigma_V - 2C_2\sqrt{Ka_2}$

$K_{a2} = = 0.33$

$\therefore$ $P_a = 0.33 \times 88 - 2(10)\sqrt{0.33}$

$= 17.80$ KPa Choice (A)

45. For sample A;

$W = \frac{W_w}{W_s}$

$W_w = 0.5\ W_s$

$W_w + W_s = 1$kg

$0.5\ W_s + W_s = 1$

$W_s = 0.667$ kg and $W_w = 0.333$ kg

Similarly, for sample B;

$W_s = 0.571$ kg and $W_w = 0.43$ kg

Total water weight; $W_w = 0.333 + 0.43 = 0.763$ kg

Total solids weight $W_g = 0.667 + 0.571 = 1.237$ kg

$\therefore$ Water content $(wg) = \frac{0.763}{1.237}\times 100$

$= 61.68\%$ Choice (C)

46. $\frac{\Delta e}{1+e_0} = \frac{\Delta H}{H_0}$

$\frac{\Delta e}{1+1.1} = \frac{30-25}{30}$

$\Delta e = 0.35$

$e_f = e + \Delta e$

$= 1.1 + 0.35$

$\therefore$ $e_f = 1.45$ Choice (B)

47. $C_u = \frac{150}{2} = 75$ kPa

$Q_s = \frac{1}{F}(CN_c) + r.D$

$= \frac{1}{3}(75 \times 5.7) + 16(1.5) = 166.5$ kPa Choice (D)

48. $\frac{100}{x} = \frac{50}{300} + \frac{30}{500} + \frac{20}{65} + \frac{20}{125}$ (Harmonic mean)

$\frac{100}{x} = 0.72$

$x = \frac{100}{0.72} = 138.8\ kg/m^3 \backsimeq 139\ kg/m^3$. Choice (B)

49. $V_o = V_s$

$V_o = \frac{(G_S - 1)r_w d^2}{18\mu}$

Now $V_o = \dfrac{40\text{m}^3}{\text{day.m}^2} = \dfrac{40}{24\times60\times60}$

$= \dfrac{(2.65-1)\times9.81\times10^3\times d^2}{18\times0.01}$

Solving we get

$d = 5.14\times10^{-9}$ m Ans: 5.14×10^{-9} m

51. $e+f = \dfrac{V^2}{gR}$ (or) $e+f = \dfrac{V^2}{127R}$

$e+f = \dfrac{(60)^2}{127\times128}$

$e = \dfrac{(60)^2}{127\times128} - 0.15$

$= 0.071$ Ans: 0.071

53. $VFB = \dfrac{V_B}{V_V} = \left(\dfrac{15-4.5}{15}\right)\times100 = 70\%$ Choice (D)

54. $C = VK$

$= 70k - 0.7\,kz$

$\dfrac{dc}{dk} = 70 - 1.4k = 0$

$K = 50$

$C = 70\times50 - 0.7(50)^2$

$= 1750$ veh/hr Ans: 1750 veh/hr

55. $\sigma_1 = \dfrac{2.5}{2} = 1.25$ cm $= 1.25\times10^{-2}$ m

$t_2 - t_1 = 25^0$C

coefficient of thermal expansion $\alpha = 10\times10^{-6}$/C

$\sigma_1 = L\alpha\ (t_2 - t_1)$

$\therefore$ spacing of expansion joint $L = \dfrac{\sigma_1}{\alpha(t_2-t_1)}$

$= \dfrac{1.25\times10^{-2}}{10\times10^{-6}\times25} = 50$ metres Choice (B)

56. Using rise and fall method

$\sum FS > \sum BS$

Fall = $\sum F.S - \sum B.S = R.L$ of first station $- R.L$ of last station

$= 5.725 - 3.985$

$= 1.74$ m

$R.L$ (last station = $R.L$ (first station) – fall

$= 100 - 1.74 = 98.26$ Ans: 98.26

57. Length of the curve $= \dfrac{\pi R}{180^0}\Delta$

$= \dfrac{\pi\times600}{180}\times30^0\ (\Delta = 180 - 150 = 30^0)$

$= 314$ m

Tangent distance $= R\tan\dfrac{\Delta}{2} = 600\times\tan(15^0)$

$= 160.79$m Choice (C)

58. Prototype –

$P_p = 1010$ kW

$N_p = 120$ rpm

$H_p = 12$ m

Model –

$H_m = 7$ m

Scale ratio = 1 : 10

Equating the head coefficient

$$\left(\frac{H}{N^2D^2}\right)_p = \left(\frac{H}{N^2D^2}\right)_m$$

$$\Rightarrow \left(\frac{N_m}{N_p}\right) = \frac{H_m}{H_p}\times\left(\frac{D_p}{D_m}\right)^2$$

$$\Rightarrow \left(\frac{N_m}{120}\right)^2 = \frac{7}{12}\times10^2$$

$\Rightarrow N_m = 916.5$ rpm

Equating power coefficient

$$\left(\frac{P}{N^3D^5}\right)_p = \left(\frac{P}{N^3D^5}\right)_m$$

$$\Rightarrow \left(\frac{P_m}{P_p}\right) = \left(\frac{N_m}{N_p}\right)^3\times\left(\frac{D_m}{D_p}\right)^5$$

$$\Rightarrow \frac{P_m}{1010} = \left(\frac{916.5}{120}\right)^3\times\left(\frac{1}{10}\right)^5$$

$\Rightarrow P_m = 4.4996$ kW Ans: 4.49 to 5.55

59. Head $H = 20$ m

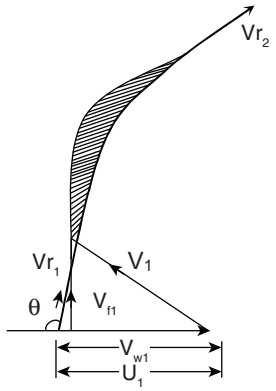
Speed $N = 150$ rpm

Hydraulic efficiency $\eta_h = 95\%$

Outer diameter $D = 4.4$ m

Hub diameter $d = 2$ m

Hydraulic efficiency = 95 %



At the outer periphery of the runner,

Velocity of flow,

$V_{f_1} = 10.2$ m/s

Blade velocity at inlet

$$u_1 = \frac{\pi DN}{60} = \frac{\pi \times 4.4 \times 150}{60} = 34.5575 \text{ m/s}$$

Hydraulic efficiency

$$\eta_h = \frac{V_{w_1} u_1}{gH} \text{ where } V_{w_1} = \text{velocity of whirl}$$

$$\therefore \quad 0.95 = \frac{V_{w_1} \times 34.5575}{9.81 \times 20}$$

$$\Rightarrow \quad V_{w_1} = 5.3936 \text{ m/s}$$

From inlet velocity triangle,

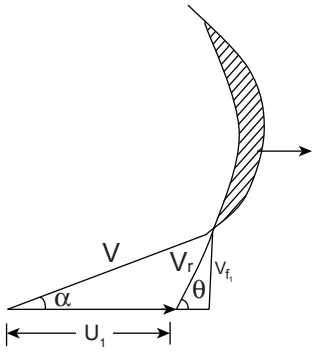
$$\tan(180 - \theta) = \frac{V_{f_1}}{u_1 - V_{w_1}}$$

$$= \frac{10.2}{34.5575 - 5.3936} = 0.3497$$

$$\Rightarrow \quad 180 - \theta = 19.277°$$

$$\Rightarrow \quad \theta = 160.7°$$ Choice (A)

60.



$D_1 = 1.2$ m.
$N = 210$ rpm.

$$u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 1 \times 210}{60}$$

$= 10.9956$ m/s

$V_{f_1} = 2.2$ m/s

Guide blade angle $\alpha = 10°$
Let θ be the runner vane angle at inlet.
From velocity triangle,

$$\tan\theta = \frac{V_{f_1}}{V_1 \cos\alpha - u_1}$$

But $$\frac{V_{f_1}}{V_1 \cos\alpha} = \tan\alpha = \tan 10$$

$$\Rightarrow \quad V_1 \cos\alpha = \frac{V_{f_1}}{\tan\alpha} = \frac{2.2}{\tan 10} = 12.4768$$

$$\therefore \quad \tan\theta = \frac{2.2}{12.4768 - 10.9956} = 1.4853$$

$$\Rightarrow \quad \theta = 56.04870$$ Ans: 56.0 to 56.1

61. $L = 3$ m $= 3000$ mm
$d = 1$ m $= 1000$ mm
$p = 1.5$ N/mm^2
$E = 2 \times 10^5$ N/mm^2
$\mu = 0.3$
Hoop stress $f_1 = 50$ N/mm^2
Longitudinal stress

$$f_2 = \frac{f_1}{2} = 25 \text{ N/mm}^2$$

Diametral strain

$$e_1 = \frac{\delta d}{d} = \frac{f_1}{E} - \mu \frac{f_2}{E}$$

$$= \frac{1}{E}(f_1 - \mu f_2)$$

$$= (50 - 0.3 \times 25) = \frac{42.5}{E}$$

Longitudinal strain

$$e_2 = \frac{\delta L}{L} = \frac{f_2}{E} - \mu \frac{f_1}{E}$$

$$= \frac{1}{E}(f_2 - \mu f_1)$$

$$= \frac{1}{E}(25 - 0.3 \times 50) = \frac{10}{E}$$

Volumetric strain

$$\frac{\delta V}{V} = 2e_1 + e_2 = \frac{2 \times 42.5}{E} + \frac{10}{E} = \frac{95}{E}$$

Change in volume

$$\delta V = \frac{V}{E} \times 95 = \frac{\pi d^2 L}{4E} \times 95$$

$$= \frac{\pi \times (1000)^2 \times 3000 \times 95}{4 \times 2 \times 10^5}$$

$= 1119{,}192.4$ mm^3
$= 1119.19$ cm^3. Ans: 1119.15 to 1119.25

62. $p = 2$ MPa $= 2$ N/mm^2
$d = 1.5$ m $= 1500$ mm
$L = 4$ m $= 4000$ m
$t = 10$ mm

Hoop stress $f_1 = \frac{pd}{2t} = \frac{2 \times 1500}{2 \times 10}$

$= 150$ N/mm^2

Longitudinal stress $f_2 = \frac{pd}{4t} = \frac{f_1}{2} = \frac{150}{2}$

$= 75$ N/mm^2

Maximum shear stress $\frac{f_1 - f_2}{2} = \frac{150 - 75}{2}$

$= 37.5$ N/mm^2 Choice (B)

63. Treating OA as x-axis, 90° clockwise to OA is y-axis

$e_A = e_x = 300$ micron.

$e_B = -225$ micron.

$e_C = 100$ micron.

$$e_B = \frac{e_x + e_y}{2} + \frac{e_x - e_y}{2}\cos 240 + \frac{1}{2}\gamma_{xy}\sin 240$$

$$\Rightarrow \quad -225 = \frac{300 + e_y}{2} + \frac{300 - e_y}{2} \times \left(\frac{-15.5}{2}\right)$$

$$+\frac{1}{2}\gamma_{xy}(-0.866) \qquad \rightarrow (1)$$

$$e_C = \frac{e_x + e_y}{2} + \frac{e_x - e_y}{2}\cos 480 + \frac{1}{2}\gamma_{xy}\sin 480$$

$$\Rightarrow \quad 100 = \frac{300 + e_y}{2} + \frac{300 - e_y}{2}(-0.5)$$

$$\frac{1}{2}\gamma_{xy}(0.866) \qquad \rightarrow (2)$$

Adding (1) and (2)

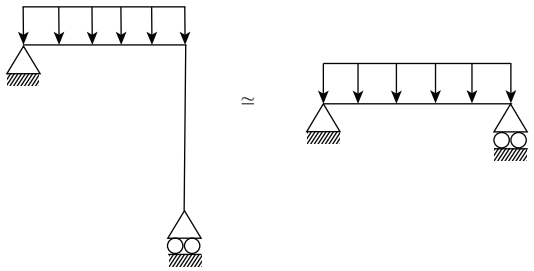
$$-225 + 100 = (300 + e_y) - \frac{(300 - e_y)}{2}$$

$$-125 = \frac{300}{2} + \frac{3}{2}e_y$$

$$\Rightarrow \quad \frac{3}{2}e_y = -125 - 150$$

$$\Rightarrow \quad e_y = 183.33 \text{ micron} \qquad \text{Ans: 183 to 184}$$

64. The above frame can be simplified as



Since there is only vertical load in column BC.

$\therefore$ Deflection at center of $AB = \dfrac{5WL^4}{384 \in \mathrm{I}}$

$$= \frac{5 \times (10)(1)^4}{384 \times 10} = 13.02 \text{ mm} \qquad \text{Ans: 13.00 to 13.05}$$

65. For Laterally supported beam;

Design bending capacity;

$$M_d = \beta_p Z_{pz} \frac{f_y}{r_{mo}} \text{ [For plastic section } \beta_p = 1.0]$$

$$= 1.0 \times 850 \times 10^0 \times \frac{250}{1.1}$$

$$= 193.18 \times 10^6 \text{ N} - \text{mm}$$

$M_d = 193.18$ KN – m

$$M_d < 1.2\, Z_e \frac{f_y}{r_{mo}} = 1.2 \times \frac{750 \times 10^3 \times 250}{1.0}$$

$$= 204.54 \text{ KN} - \text{m}$$

$\therefore$ Hence OK

$M_d = 193$ KN – m Ans: 190 – 195 KN – m