Question 1 to 25 Carry One Mark Each SUBJECT

1. In the simplified design of angle iron purlins, which one of the following assumptions would 'not be valid'

(a) load component acting normal to the slope is considered

(b) bending moment about the minor axis is considered

(c) Allowable bending stress is not reduced

(d) slope of the roof should not exceed 30°

2. A soil sample having void ratio of 1.3 water content of 50% and a specific gravity of 2.60 is an state of

(a) partial saturation (b) full saturation

(c) over saturation (d) under saturation

3. The velocity distribution near the solid wall at a section in a laminar flow is given by $u = 5\sin(5\pi y)$. The shear stress (in Pa) at y = 0.05 m is

[ ] (use μ = 5 Poise)

4. At a node in a framed structure n members are meeting. Far end of all the members meeting are fixed and length of the members are respectively 1m, $\frac{1}{2}$m, $\frac{1}{3}$m, ... $\frac{1}{n}$ meters. If moment M is applied at that joint then moment shared by n^{th} member is

(a) $\frac{2M}{n+1}$ (b) $\frac{M}{n+1}$ (c) $\frac{M}{2(n+1)}$ (d) None

5. A normally consolidation clay settled 10mm when efective stress was increased form 50kN/m^2 to 100 kN/m^2. If the effective stress would have increased from 100 kN/m^2 to 200 kN/m^2, then the settlement of clay would have

[ ] cm

6. Which of the following processes may contributed interception loss

1. Evaporation 2. Transpiration

3. Stream flow

(a) 1 and 2 (b) 1, 2 and 3 (c) 2 and 3 (d) 1 only

7. A vertical cut is made in a clay deposit 30 kN/m2, ϕ = 0 and γ = 16 kN/m3. The maximum height of the cut which can be supported is

[ ] m [For ϕ = 0, Sn = 0.261]

8. Apparent colour of water sample is due to

(a) Suspended solids (b) Dissolved solid (c) Both (a) and (b) (d) None of these

9. The basic principle of structural design in based on

(i) Strong column weak beam concept

(ii) Strong footing weak column concept.

Select correct statement

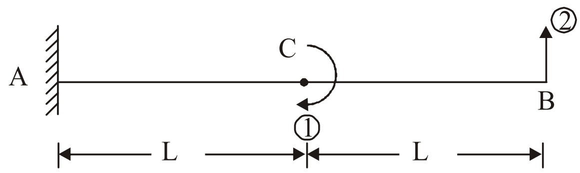
(a) (i) only (b) (ii) only (c) Both (i) and (ii) (d) Neighter (i) and (ii)

10. A vehicle moving on horizontal curved roadway of width 2.5m and height 3.8m, the value of stability factor is (up to three significant digit after decimal)

11. Lacey's scour depth for a stream carrying a discharge of 3 cumecs per meter width and having a silt factor of 1.2 is (up to two significant digit after decimal)

m

12. For a cantilever AB shown in the following figure



Stiffness factor k_{21} will be $= x\left(\frac{EI}{L}\right)$ Where 'x' =

(upto 2 digits after decimals)

13. If total hardness and alkalinity of a water sample is 500 mg/L and 300 mg/L respectively, then non carbonate hardness of the sample is

(a) 200 mg/L (b) 300 mg/L (c) 500 mg/L (d) None of the above

14. An annual flood series contains 100 years of flood data. For a return period of 200 years the Gumble's reduced variate can be taken as

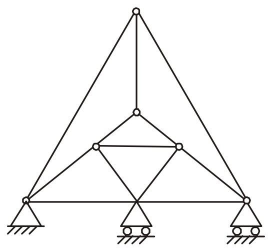
15. A steel bar 15 mm in diameter is pulled axially by a force of 10 kN. If the bar is 250 mm long what is the total strain energy stored by the bar. Take $E = 2 \times 10^5$ N/mm^2

(a) 8.006 N/mm^2 (b) 353.68 N/mm^2 (c) 128.006 N/mm^2 (d) 238.006 N/mm^2

16. The initial length and volume of the test specimen for traixial compression test are L & V respectively, then the area A of the specimen at failure is given by

(a) $\frac{V+\Delta V}{L-\Delta L}$ (b) $\frac{V+\Delta V}{L+\Delta L}$ (c) $\frac{V\pm\Delta V}{L-\Delta L}$ (d) $\frac{V\pm\Delta V}{L\pm\Delta L}$

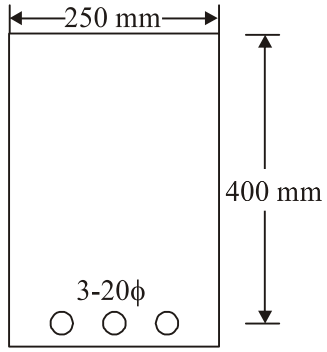
17. Degree of static indeterminacy of pin jointed plane structure will be



18. A uniform solid circular cantilever beam of diameter 'd' and length 'l' carries a uniformly distributed load w kN/m over the entire span. The same beam experience an extension 'e' under same total tensile aload. The ratio of maximum deflection to the elongation

(a) $\sqrt{2}\left(\frac{\ell}{d}\right)^2$ (b) $2\left(\frac{\ell}{d}\right)^2$ (c) $\frac{\ell}{d}$ (d) $\sqrt{\frac{\ell}{d}}$

19. Consider the section given below using M25 grade of concrete and Fe415 steel is used section can be classified based on amount of reinforcement used as per LSM design criteria



(a) Balanced section
(b) Over-reinforced section
(c) Under-reinforced section
(d) data is not sufficient

20. The minimum value of friction factor f that can be occured in laminar flow through a circular pipe is (up to two significant digit after decimal) [ ]

21. A 75 % saturated soil having mass specific gravity of 1.84 and specific gravity of soil particles is 2.70, the void ratio in soil sample is (up to two significant digit after decimal)

[ ]

22. $\lim\limits_{(y,x)\to(0,0)} \dfrac{x+\sqrt{y}}{x^2+y^2}$ is

(a) 0
(b) 1
(c) ∞
(d) limit does not exist

23. $\int_{y=0}^{1}\int_{x=y}^{y^{1/3}} e^{x^2}\,dx\,dy =$

(a) 121e
(b) $\frac{1}{2}(e-2)$
(c) e(e – 1)
(d) e !

24. Let F is a scalar function & $\vec{v}$ is a vector in then which of the following options is incorrect

(a) $\nabla\cdot(\nabla\times\vec{v})=0$

(b) $\nabla\times(\nabla f)=0$

(c) $\nabla\cdot(f\,\vec{v})=f(\nabla.\vec{v})+)\ (\text{grad})\cdot\vec{v}$

(d) $\nabla(\nabla\cdot\vec{v})=\nabla\times(\nabla\cdot\vec{v})-\nabla^2\vec{v}$

25. $u = \dfrac{x^3 + y^3}{x + y}$ then $x\dfrac{\partial^2 u}{\partial x^2} + y\dfrac{\partial^2 u}{\partial x \partial y}$ equal to

(a) $\dfrac{\partial u}{\partial x}$ (b) $\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial y}$

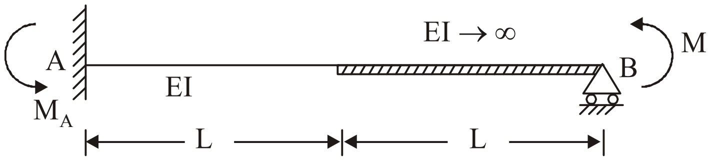
(c) $\dfrac{\partial u}{\partial y}$ (d) $\dfrac{\partial u}{\partial x} - \dfrac{\partial u}{\partial y}$

Question 26 to 55 Carry Two Mark Each SUBJECT

26. The difference of water level in two observation well at a horizontal distance of 60m is 5m. the aquifer inclined at 10° to the horizontal is k = 0.7mm/sec and depth of aquifer normal to the direction of flow is 2.951 m, the discharge through aquifer per unit width is (up to two significant digit after decimal)

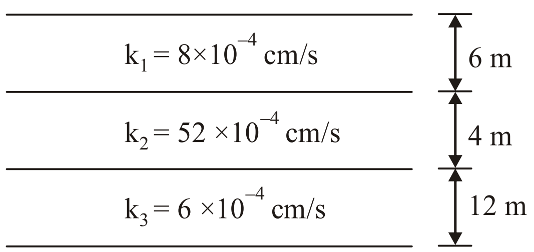
[ ] lit/sec

27. A propped cantilever of span 2L is fixed at A and simply supported at B. Carry over factor $\left(\dfrac{M_A}{M}\right)$ when moment M is applied at B, is



[ ] (upto 2 digits after decimal)

28. A horizontal soil deposit, consists of three uniform layers. The ratio of effective average permeability of the deposit in horizontal direction to the vertical direction] is

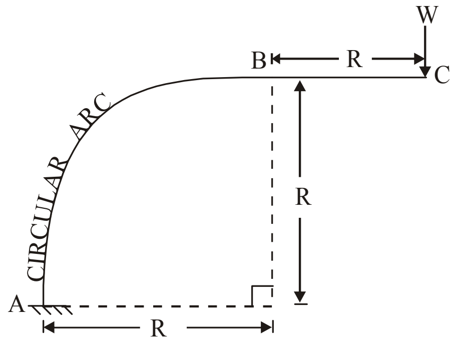


[ ] (up to two significant digit after decimal)

29. Four lane carriage way having stopping sight distance 250m length of curve is being 1500m and radius of curve is 400m. The setback distance from inner edge of the cruve is (up to two significant digit after decimal)

[ ] m

30. In the following arrangement shown AB is circular arc and BC is horizontal. Load W is applied at C.



Deflection at C in vertical direction is

(a) $\frac{WR^3}{3EI}$ (b) $\frac{WR^3}{\pi EI}$ (c) $4.690\frac{WR^3}{EI}$ (d) $8.712\frac{WR^3}{EI}$

31. B & C are two points on the opposite banks of a river along a chain line ABC which crosses the river at right angles to the bank. From a point P which is 150m from B along the bank, the bearing of A is 215° 30' and the bearing of C is 305°30'. If the AB length is 200 m, the width of the river is

[ ] m

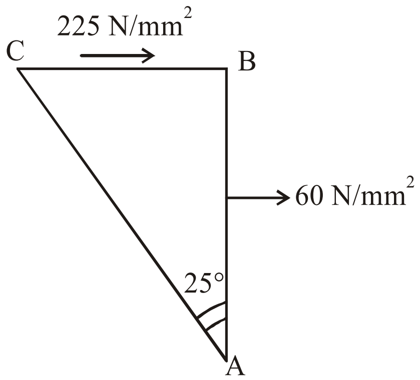
32. For designing a 2-phase fixed type signal at an intersection having north-south and east-west road where only straight ahead traffic is permitted for following available data

Parameter	North	South	East	West
Design Hour flow (PCU/hr)	1000	700	900	550
Saturation flow PCU/hr	2500	2500	3000	3000

Total time lost per cycle is 12 second. The optimum cycle time length (second) as per webester approach is

(a) 67 (b) 91 (c) 87 (d) 77

33. Two planes AB and BC which are at right angles carry shear stresses of intensity 22.5 N/mm^2 while the plane AB carries also a tensile stress of N/mm^2 as shown in figure. The shear stress on plane AC inclined at 25^o to the plane AB is (up to two significant digit after decimal)



[ ] N/mm^2.

34. A foundation i.e. a loose sand is 4 m wide 6 m long and 1.5 m deep. The soil weight 16 kN/m^3 and an effective angle of internal friction 22.6°, the safe bearing capacity of soil in (kN/m^2), adopting a factor of saftey of 2 will be

[for $\phi = 22.6°$, $N_C = 21.55$, $N_q = 10.16$ and $N_\gamma = 7.44$]

(a) 350 (b) 380 (c) 237 (d) 295

35. A rectangular prestressed beam is used over an effective span of 10m. The beam supports an imposed load of 4 kN/m. The prestressing cable is parabolic with an eccentricity of 100 mm at the centre and zero at the ends. The effective prestressing force in (kN) when the load counteracts the bending effect of prestressing force at mid span (neglecting self weight of beam) is [ ]

36. The concrete floor of a hand regulator is level with the channel bed is 13m long. The depth of upstream and down stream cut off wall is 2.5m and 2.0 m respectively. The upstream FSL is 1.5 m above the floor level then the value of exit gradient as per khosla's theory is [ ]

37. A welded plate girder 24m in effective span and simply supported at the two ends. It carries a uniformly distributed load of 100 kN/m. If effective depth of web is 2500 mm. Then the minimum web thickness from shear consideration is

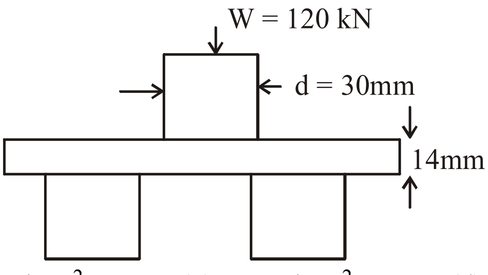
[ ] mm

38. It the settlement ratio of foundation to plate of 30 cm diameter is case of clayey soil is twice that of granular soil, then the width of foundation (in cm) is

(a) 125 (b) 175 (c) 60 (d) 120

39. A solid cylinder of diameter 30 cm and height 15 cm is to float in water with its axis vertical in sea water (s = 1.03). If the density of the cylinder is 900 kg/m^3. The metacentric height (in cm) of the cylinder. [ ]

40. Figure shows a 30 mm diameter punch to make a hole in an 14 mm thick plate. If the force applied on the punch is 120 kN. Find the difference between average compressive stress in the punch to the average shear stress in the plate



(a) 169 N/mm^2 (b) 91 N/mm^2 (c) 39 N/mm^2 (d) 78 N/mm^2

41. A field channel has a culturable commanded area of 3000 ha. The intensities of two crops 30% and 40%. Both of these crops are Rabi crops. Crop X and Y has a kor period 20 days and 15 days while kor depth 17.5 cm and 9 cm respectively. The discharge required in the field channel to supply water to the commanded area during kor period will be (up to one significant digit after decimal)

[ ] m^3/s

42. A 8m thick clay layer with single drainage settles by 120mm in 2years. The coefficient of consolidation for this clay was found to be 6×10^{-3} cm^2/s. The ultimate consolidation settlement is [ ] mm

43. A square column section of size 350 mm × 350 mm is reinforced with 4-25ϕ bars & 4-16ϕ bars, then transverse tie reinforcement would be

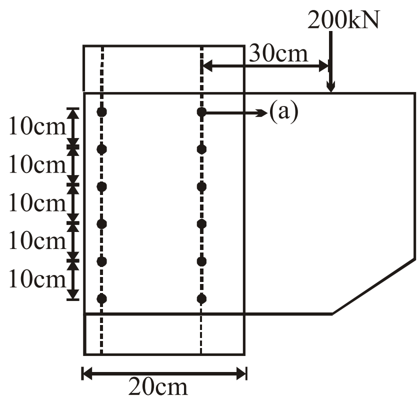
(a) 8 mm dia @ 250 mm c/c
(b) 5 mm dia @ 240 mm c/c
(c) 6 mm dia @ 250 mm c/c
(d) 8 mm dia @ 300 mm c/c

44. A canal, having depth 6 m, is excavated through a soil with c = 15 kN/m^2, e = 0.9, ϕ = 20° and G = 2.67. The side slope is 1 in 1. The factor of safety if canal is rapidly emptied is (up to one significant digit after decimal)

ϕ	Stability number (s_n)
6	0.108
12	0.114
18	0.127
29	0.141

[ ]

45. A load of 200 kN is carried by a plate bracket riveted to coloumn as shown in figure given below. The maximum force taken up by rivet (a) is:



(a) 16.67 kN
(b) 45.83 kN
(c) 54.27 kN
(d) 50 kN

46. The drag force F_D, on a sphere kept in a uniform flow field on the diameter of the sphere, D; flow velocity, V; fluid density, p; and dynamic viscosity, μ. Which of the following options represents the non-dimensional parameters which could be used to analyze this problem?

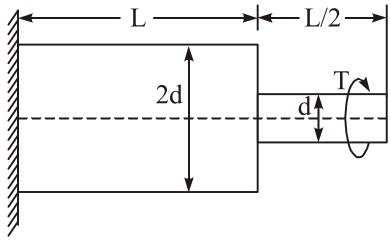
(a) $\frac{F_D}{VD}$ and $\frac{\mu}{\rho VD}$

(b) $\frac{F_D}{\rho V D^2}$ and $\frac{\rho VD}{\mu}$

(c) $\frac{F_D}{\rho V^2 D^2}$ and $\frac{\rho VD}{\mu}$

(d) $\frac{F_D}{\rho V^3 D^3}$ and $\frac{\mu}{\rho VD}$

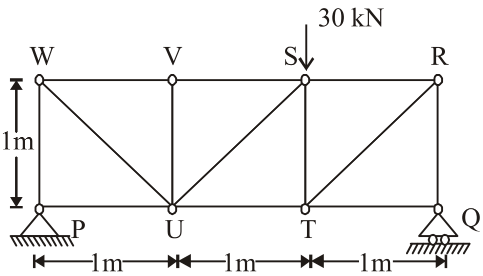
47. A torque T is applied at the free end of a stepped rod of circular cross-sections as shown in the figure. The shear modulus of the material of the rod is G. The expression for d to produce an angular twist θ at the free end is



(a) $\left(\frac{32TL}{\pi\theta G}\right)^{\frac{1}{4}}$ (b) $\left(\frac{18TL}{\pi\theta G}\right)^{\frac{1}{4}}$

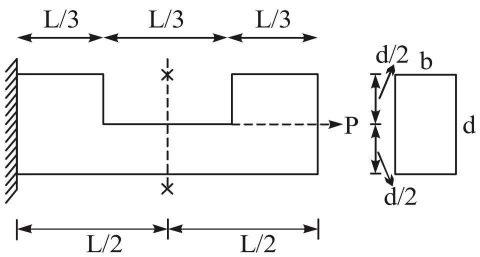
(c) $\left(\frac{16TL}{\pi\theta G}\right)^{\frac{1}{4}}$ (d) $\left(\frac{2TL}{\pi\theta G}\right)^{\frac{1}{4}}$

48. For the truss shown in the figure, the magnitude of the force (in kN) in the member SR is



(a) 10 (b) 14.14 (c) 20 (d) 28.28

49. The maximum tensile stress at the section X-X shown in the figure below is



(a) $\frac{8P}{bd}$ (b) $\frac{6P}{bd}$ (c) $\frac{4P}{bd}$ (d) $\frac{2P}{bd}$

50. What is the equivalent single wheel load of a dual wheel assemble carrying 20,440N each for pavement thickness of 20 cm. Centre spacing of types is 27 cm and the distance between the walls of tyres is 11 cm

(a) 32,300 N (b) 27,600 N (c) 48,880 N (d) 30240 N

51. If probability of a rainfall to be equalled or exceeded in a given year is 0.02. Probability that given rainfall will be exceeded or equalled exactly twice is (up to three significant digit after decimal) [ ] in 20 years.

52. The solution of integration $\int_0^1 \frac{dx}{\sqrt{-\ln x}}$ is

(a) π (b) $\sqrt{2\pi}$ (c) $\pi\sqrt{2}$ (d) $\sqrt{\pi}$

53. The minimum value of the function $xy + \frac{9}{x} + \frac{3}{y}$ is [ ]

54. $\begin{bmatrix} 4 & 9 & 3 \\ 2 & 3 & 1 \\ 2 & 6 & 2 \end{bmatrix}\begin{bmatrix} x \\ y \\ 7 \end{bmatrix} = \begin{bmatrix} 6 \\ 2 \\ 7 \end{bmatrix}$. This system is

(a) Consistent with unique solutions

(b) Consistent with infinite solutions

(c) Inconsistent with no solution

(d) Consistent with 2 solutions.

55. The random variable x is normally distributed with mean 9 and standard deviation 3 and z is standard normal variate with $P(0 \le z \le 2) = 0.4772$ and $P(0 \le z \le 3) = 0.4987$ then $P(x \le 15)$ is (up to three significant digit after decimal)

[ ]

Question 1 to 5 Carry One Mark Each APPTI

1. The population of a town is increased by $16\frac{2}{3}\%$ in first year, decreased $37\frac{1}{2}\%$ in second year and increased $57\frac{1}{7}\%$ in third year then find the population of this town before three year if present population is 137500 :

(a) 110000 (b) 125500 (c) 120000 (d) 144000

2. Find the remainder of the division $\frac{2^{189}}{5}$:

(a) 2 (b) 3 (c) 4 (d) 1

3. A group of men decided to do a job in 4 days but 20 men dropped out everyday, the job was completed at the end of 7^{th} day. Find the men who are in the work initially :

(a) 120 (b) 100 (c) 160 (d) 140

4. What is the opposite of **'Tremulous'**

(a) Healthy (b) Obese (c) Young (d) Steady

5. Which of the following option can replace the underline section

Scarcely <u>we had reached</u> the office when it started raining cats and dogs

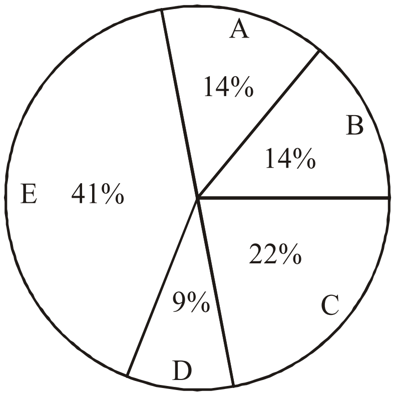
(a) had we reached (b) we reached (c) we reach (d) did we reach

Question 6 to 10 Carry Two Mark Each APPTI

6. A company give 12% commission to his sales man on his total sales and above sales of 15000, 1% bonus if the salesman deposited 52350 Rs. in the company after deducting his commission from total sales then find total sales :

(a) 52200 Rs. (b) 502200 Rs. (c) 60000 Rs. (d) 64000 Rs.

7. Revenue earned by the central government is given in pie-chart



A = Custom duty B = Other

C = Income tax D = Corporation Tax

E = Excise duty

If the percentage of revenue earned by the central government from corporation Tax is x times to that of the percentage of money earned excise duty, then the value of x is :

(a) $\frac{41}{9}$ (b) $\frac{9}{41}$ (c) $\frac{14}{41}$ (d) $\frac{41}{14}$

8. $\sqrt{-\sqrt{3}+\sqrt{3+8\sqrt{7+4\sqrt{3}}}}$?

(a) $\sqrt{3}$ (b) 2 (c) 4 (d) 1

9. JRD Tata used to say, "while profit motive, no doubt, provides the main spark for any economic activity any enterprisen which is not motivated by considerations of urgent service to the community becomes obsolete soon and cannot fulfill its real role in modern society.

Which of the following is the view of JRD Tata as described by the author?

(a) Consideration of urgent service to community should be side-lined

(b) The main purpose for any economic activity should be only profitability

(c) Profit should be earned with due consideration to social service

(d) Motivation to earn profit has become an outdated concept

10. Government have traditionally equated economic progress with steel mills and cement factories. While urban centers thrive and city dwellers get rich, hundreds of millions of farmers remain mired in poverty. Another green revolution is the need of the hour and to make if a reality, the global community still has much back breaking farm work to do.

What is the author's main objective in writing the passage

(a) Criticizing developed countries for not bolstering economic growth in poor nations

(b) Analyzing the disadvantages of the Green Revolution

(c) Persuading experts that a strong economy depends on industrialization and not agriculture

(d) Making a case for the international society to engineer a second Green Revolution

❍❍❍

ANSWERS KEY

Ans 1 to 25 Carry One Mark Each SUBJECT

1. ***Ans.(b)***

2. ***Ans. (b)***

$$e = 1.3, \quad w = 50\ \%$$
$$G = 2.60$$
$$S = \frac{\omega.G_s}{e}$$
$$S = \frac{2.6 \times 0.5}{1.3} \times 100$$

S = 100 % hence it is fully saturated

3. ***Ans* [27 to 28]Pa**

$$\tau = \mu.\left(\frac{\partial u}{\partial y}\right)_{y=0.05}$$
$$\tau = 27.76 \text{ Pa}$$

4. ***Ans (c)***

5. ***Ans. (1)cm***

$$\because \Delta H = \frac{H_O C_C}{1+e_o} \log_{10}\left(\frac{\bar{\sigma}_0 + \Delta\bar{\sigma}}{\bar{\sigma}_o}\right)$$
$$\Delta H \;\; \alpha \;\; \log_{10}\left(\frac{\bar{\sigma}_o + \Delta\bar{\sigma}}{\bar{\sigma}_o}\right)$$
$$\frac{10}{x} = \frac{\log_{10}\left(\frac{100}{50}\right)}{\log_{10}\left(\frac{200}{100}\right)} = x = 10 \text{ mm} = 1\text{cm}$$

6. ***Ans. (d)***

7. ***Ans. (7.10 to 7.30) m***

$$Sn = \frac{C}{F_c.\gamma H}$$
$$H = \frac{30}{1.0 \times 16 \times 0.261} \quad \{F_C = 1.0\}$$
$$H = 7.18 \text{ m}$$

8. ***Ans.(a)***

Apparent colour → suspanded solid

True colour → dissolved solid

9. ***Ans.(c)***

10. ***Ans.(0.655 to 0.680)***

the value of stability factor is $\frac{b}{2h}$

$$= \frac{2.5}{2\times\frac{3.8}{2}}$$

$$= 0.657$$

11. ***Ans.*** **(2.60 to 2.68) m**

Lacey's scour depth = $1.35\left(\frac{q^2}{f}\right)^{1/3}$

$$= 1.35\left(\frac{3^2}{1.2}\right)^{1/2}$$

= 2.64 m

12. ***Ans (0.60-0.67)***

13. ***Ans.(a)***

Carbonate hardness = Alkalinity = 300 ppm
min total hardness = 500 ppm
Carbonate hardness = 300 ppm
Nor carbonate hardness = 500 – 300 = 200 ppm

14. ***Ans. (5.2 - 5.3)***

Gumbel's reduced variate

$$Y_T = -\left[ln\cdot ln\left(\frac{T}{T-1}\right)\right] = -\left[ln\cdot ln\left(\frac{200}{199}\right)\right] = 5.29$$

15. ***Ans. (b)***

Area of the bar = A = $\frac{\pi\times15^2}{4} = 176.71mm^2$

Stress in the bar = $\sigma = \frac{10\times10^3}{176.71} = 56.59N/mm^2$

Total strain energy stored = $\frac{\sigma^2}{2E}Al$

$$= \frac{(56.59)^2}{2\times2\times10^5}\times176.71\times250 = 353.688\ N/mm^2$$

16. ***Ans. (c)***

17. ***Ans (2)***

$D_S = M + R - 2J = 12 + 4 - 14 = 2$

18. ***Ans. (b)***

$$\frac{\text{Maximum defection}}{\text{Maximum elongation}} = \frac{\dfrac{WL^4}{8BI}}{\dfrac{WL^2}{AB}}$$

$$= \frac{AL^2}{8I} = \frac{\dfrac{\pi}{4}d^2 \times L^2}{8 \times \dfrac{\pi}{64}d^4}$$

$$= 2\left(\frac{1}{d}\right)^2$$

19. ***Ans.(c)***

$(x_u)_{lim} = 0.53d = 0.53 \times 400 = 192$ mm

$$(x_u)_{lim} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b} = \frac{0.87 \times 415 \times 3 \times \dfrac{\pi}{4} \times (20)^2}{0.36 \times 25 \times 250} = 151 \text{ mm}$$

$(x_u) < (x_u)_{lim} \rightarrow$ under reinforced

20. ***Ans. (0.01 to 0.04)***

$$f = \frac{64}{2000}$$

$$f = 0.032$$

21. ***Ans. (0.75 to 0.8)***

$$\gamma_b = \left(\frac{G + Se}{1 + e}\right)\gamma_w$$

$$1.84 = \left(\frac{2.70 + 0.75e}{1 + e}\right)1.0$$

$$e = 0.78$$

22. ***Ans. (c)***

Let $I = \lim_{(x,y)\to(0,0)} \dfrac{x + \sqrt{y}}{x^2 + y^2}$

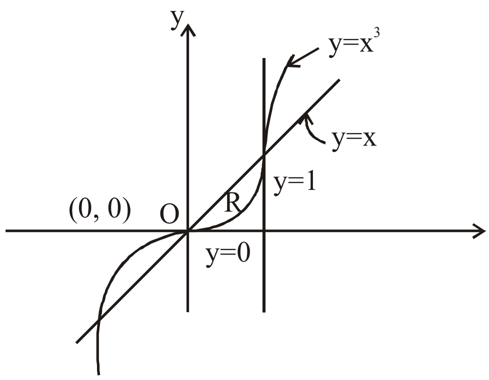
Put $y = mx$

$\Rightarrow \quad I = \lim_{x\to 0} \dfrac{x+\sqrt{mx}}{x^2+m^2x^2} \qquad I = \lim_{x\to 0} \dfrac{\sqrt{x}\left(\sqrt{x}+\sqrt{m}\right)}{x^2(1+m^2)}$

$I = \infty$

23. *Ans. (b)*

$$I = \int_{y=0}^{1}\int_{x=y}^{y^{\frac{1}{3}}} e^{x^2}\,dx\,dy$$



$$I = \iint_R e^{x^2}\,dx\,dy \quad ; \; I = \int_{x=0}^{1}\int_{y=x^3}^{x} e^{x^2}\,dy\,dx$$

$$I = \int_{x=0}^{1} (y)_{y=x^3}^{x} e^{x^2}\,dx$$

$$I = \int_{x=0}^{1} xe^{x^2}\,dx - \int_{x=0}^{1} x^3e^{x^2}\,dx$$

Put $x^2 = t$

$2xdx = dt$

$$I = \frac{1}{2}\int_{t=0}^{1} e^t dt - \frac{1}{2}\int_{t=0}^{1} te^t dt$$

$$= \frac{1}{2}(e^t)_{t=0}^{1} - \frac{1}{2}\int_{t=0}^{1} te^t dt = \frac{1}{2}(e^t)_{t=0}^{1} - \frac{1}{2}\left[e^t(t-1)\right]_{t=0}^{1}$$

$$= \frac{1}{2}(e-1) - \frac{1}{2}[1] = \frac{1}{2}(e-2)$$

24. (d) $\nabla\cdot(\nabla\times\vec{v}) = 0$

$$\nabla \times (\nabla f) = 0$$

$$\nabla\cdot(f\,\vec{v}) = f(\nabla\cdot\vec{v}) + (\nabla f)\cdot\vec{v}$$

$$\nabla(\nabla\cdot\vec{v}) = \nabla \times (\nabla \times \vec{v}) + \nabla^2\vec{v}$$

$\Rightarrow$ option (d) is wrong

25. (a)

$$u = \frac{x^3 + y^3}{x + y}$$

It is homogeneous function of degree n = 2 in x and y.

$$x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = nu = 2u$$

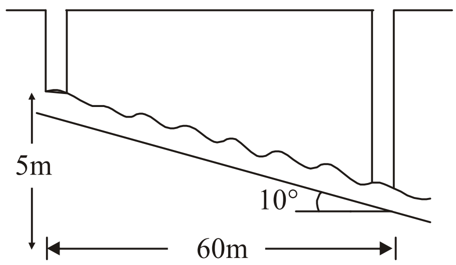
differentiating partially with respect to x

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

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

Ans 26 to 55 Carry Two Marks Each

26. ***Ans. (0.12 to 0.18)***



Length of aquifer between two observation wells

$= 60/\cos 10° = 60.296$ m

hydraulic gradient

$$= \frac{h}{L} = \frac{5.0}{60.296} = 0.082$$

From darcy law, discharge per unit width

$$q = kiA$$
$$= 0.7\times10^{-3} \times 0.082 \times (2.92\times1)$$
$$= 0.169\times10^{-3}\ m^3/s$$
$$= 0.169\ L/sec$$

27. ***Ans (0.25 to 0.29)***

28. ***Ans. (1.90 to 1.95)***

In vertical flow (normal to bedding plane)

Total head loss = h

$$h = h_1 + h_2 + h_3$$

$$\frac{k_v h}{H} = \frac{K_1 h_1}{H_1} + \frac{k_2 h_2}{H_2} + \frac{k_3 h_3}{H_3}$$

$$K_v = \frac{H}{\frac{H_1}{k_1} + \frac{H_3}{k_3} + \frac{H_3}{k_3}}$$

$$K_v = \frac{22\times10^{-4}}{\frac{6}{8} + \frac{4}{52} + \frac{12}{6}}$$

$$K_v = 7.782\times10^{-4}\ cm/s$$

Horizontal flow

$$Q = Q_1 + Q_2 + Q_3$$

$$K_H = \frac{k_1 H_1 + k_2 H_2 + k_3 H_3}{H_1 + H_2 + H_3}$$

$$= \frac{(8\times6 + 52\times4 + 6\times12)\times10^{-4}}{22}$$

$$= 14.90\ cm/s$$

$$\frac{(k_H)}{(k_v)} = \frac{14.90}{7.782} = 1.915$$

29. ***Ans.(17.50 to 17.90)m***

L = 1500m, SSD = 250m, R = 400m

$$\frac{\alpha}{360} = \frac{SSD}{2\pi(R-d)}$$

$$\frac{\alpha}{2} = \frac{250\times180}{2\pi\left(400-3.5+\frac{3.5}{2}\right)}$$

$= 18.143°$

setback distance from centre line

$$m = R-(R-d)\cos\frac{\alpha}{2}$$

$$= 400-\left(400-3.5+\frac{3.5}{2}\right)\cos(18.143°)$$

$= 24.876$ m

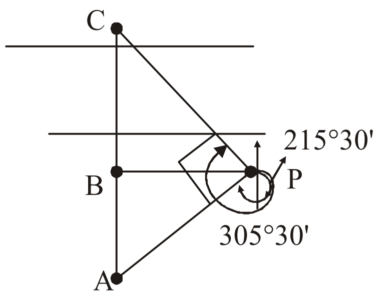
Set back distance from inner edge is

$= (24.876 - 7.00)$

$= 17.87$ m

30. ***Ans (c)***

31. ***Ans.(111 to 114)***



bearing of AP is 215°30'

bearing of PC is 305° 30'

$\angle APC = 90°$

is $\angle PAB = Q$ then $\angle BCP = 90–Q$

Δ BCP are similirly Δ BAP

$$\frac{BC}{BP} = \frac{BP}{AB}$$

$$BC = \frac{BP^2}{AB}$$

$$BC = \frac{(150)^2}{200}$$

$= 112.5$ m

32. ***Ans.(d)***

As per Webster's Method -

optimum cycle time = $\left[\frac{1.5^{L}+5}{1-Y}\right]$

L = 2n + R = lost time

L = 12 sec

Y_1 = maximum of Y_N and Y_S = 0.4

Y_2 = maximum of Y_E and Y_W = 0.3

$Y = Y_1 + Y_2$ $\qquad Y_N = \frac{1000}{2500} = 0.4$

$= 0.4 + 0.3$ $\qquad Y_S = \frac{700}{2500} = 0.28$

$= 0.7$ $\qquad Y_E = \frac{900}{3000} = 0.3$

$Y_W = \frac{500}{3000} = 0.18$

optimum cycle time

$= \frac{1.5\times 12+5}{1-0.7}$ = 77 sec.

33. ***Ans. (8.40 to 8.60)***

(8.45 to 8.60) N/mm^2

Given

σ_x = 60 N/mm^2

σ_y = 0

τ = 22.5 N/mm^2

Q = 25^o

Shear stress on the plane AC will be given by

$$\tau = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta - \tau\cos 2\theta$$

$$= \frac{60}{2}\sin 50^o - 22.5\cos 50^o$$

$$= 22.98 - 14.46$$

$$\tau = 8.52 \text{ N/mm}^2$$

34. ***Ans. (c)***

B = um $\qquad N_C = 21.55$ $\qquad D_F$ = 1.5 m

L = 6m $\qquad N_q = 10.16$ $\qquad$ Y = 16 kN/m^3

C = 0 (for sand) $\qquad N_\gamma = 7.44$ $\qquad$ fos = 2

for rectangular footing

$$q_u = \left(1+0.3\frac{B}{L}\right)CN_C + qNq + \left(1-0.2\frac{B}{L}\right)\frac{1}{2}B\gamma N_\gamma$$

= 0+16×1.5×10.16

$$+ \left(1-0.2\times\frac{4}{6}\right)\times\frac{1}{2}\times 4\times 16\times 7.4$$

q4 = 449.06 kN/m^2

q_{nu} = q_u–16×1.5 = 425.06 kN/m^2

Net safe ultimate capacity = $\frac{q_{nu}}{FOS} = \frac{425}{2}$ = 212.53 kN/m^2

safe bearing capacity = $\frac{q_{nu}}{FOS} + 16\times 1.6$

= 212.53 + 16×1.5

= 236.53 kN/m^2

35. ***Ans.(500)***

$$Pe = \frac{WL^2}{8}$$

$$\frac{P\times 100}{10^3} = \frac{4\times(10)^2}{8} \quad = \quad P = 500 \text{ kN}$$

36. ***Ans. (0.10 to 0.15)***

Given data

d = depth of downstream pile = 2m

H = Total seepage head = 1.5 m

b = Total horizontal length of floor = 13 m

GE = Exit gradient = $\frac{H}{d}\times\frac{1}{\pi\sqrt{\lambda}}$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}, \ \alpha = \frac{b}{d} = \frac{13}{2}$$

$$\lambda = \frac{1+\sqrt{1+\left(\frac{13}{2}\right)^2}}{2} = 3.78$$

$$GE = \frac{1.5}{2}\times\frac{1}{\pi\sqrt{3.78}} = 0.12$$

37. ***Ans.(5 to 6)mm***

Self weight of plate girder

$$= \frac{w\ell}{400} = \frac{(100\times 24)24}{400} = 144 \text{ kN}$$

Self-weight of plate girder per metre length

$$= \frac{144}{24} = 6.0 \text{ kN/m}$$

Total uniform load

$$w' = 100 + 6 = 106 \text{ kN/m}$$

Maximum shear force

$$= \frac{w'\ell}{2} = \frac{106\times 24}{2} = 1272 \text{ kN}$$

$$\therefore \quad \tau_{va} = 0.4 f_y = 100 \text{ N/mm}^2$$

Minimum web thickness

$$t = \frac{1272\times 10^3}{100\times 2500} = 5.08$$

$$\simeq 6 \text{ mm}$$

38. ***Ans. (b)***

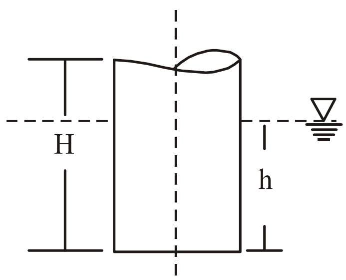
$$\left(\frac{SR}{SP}\right)_{clay} = 2\left(\frac{SR}{SP}\right)_{sand}$$

$$\left(\frac{BR}{BP}\right) = 2\left[\frac{BR}{BP}\left(\frac{BP+0.3}{BR+0.3}\right)\right]^2$$

$$\frac{BR}{0.3} = {}^2\left[\frac{BF}{0.3}\left(\frac{0.3+0.3}{BR+0.3}\right)\right]^2$$

BR = 175 cm

39. ***Ans. (3 to 4) m***



$$F_B = W$$

$$d_f g v_d = \delta_b g v$$

$h = 0.131\text{ m}$

$$GM = \frac{I}{v_d} - BG$$

$GM = 0.0334\text{m} = 3.34\text{ cm}$ BF = 1.748 m $\simeq$ 175 cm

40. ***Ans. (d)***

Shear area of the plate = π dt

$= \pi \times 30 \times 14$

$= 1318.8\text{ mm}^2$

Average shear stress in the plate

$$= \frac{120\times1000}{1318.8} = 91\text{N/mm}^2$$

Average compressive stress

in the punch $= \dfrac{120\times1000}{\frac{\pi}{4}(30)^2} = 169\text{N/mm}^2$

Difference = 169 − 91

$= 78\text{ N/mm}^2$

41. ***Ans. (1.5 to 2.0) cumec***

Discharge required for crop 'X' = $\dfrac{A}{D_X}$

$$D_X = \frac{8.64\times20}{\left(\frac{17.5}{100}\right)} = 987.4 = \text{Ha/cumec}$$

$$Q_X = \frac{3000\times0.30}{987.4} = 0.91\text{ cumec}$$

$$D_y = \frac{8.64\times15}{\left(\frac{9}{100}\right)} = 1400\text{ ha/cumec}$$

$$= Q_y = \frac{3000\times0.4}{1440} = 0.83\text{cumec}$$

$Q = Q_x + Q_y = 0.91 + 0.83 = 1.74$ cumec

42. ***Ans. (146 to 148)mm***

h = 8m (single drainage)

t = 2 × 365 ×24 × 60 × 60 S

c_v = 6 × 10–7 cm²/s

$$T_v = \frac{C_v.t}{d^2}$$

$$T_v = \frac{6\times10^{-7}\times2\times365\times24\times60\times60}{64}$$

$T_v = 0.5913$

as we known

$T_v = 1.781 - 0.933 \log(100 - V\%)$

$0.5913 - 1.781 = -0.933 \log(100 - V)$

$$(S_C)_f = \frac{(S_C)_t}{v_f}$$

$$= \frac{120}{0.815} \Rightarrow 147 \text{ mm}$$

43. ***Ans. (a)***

Dia of lateral ties > $\frac{\phi_{max}}{4} = \frac{25}{4} = 6.25\text{mm}$

max = 6m

ϕ = 8mm

spacing $\leq$ min least lateral dimension = 350 mm

16ϕ min = 16×16 = 256 mm = 300 mm

spacing = 250 mm

So provide lateral reinforcement of 8 mmϕ @ 250 mm c/c

44. ***Ans. (1.10 to 1.40)***

$$r_{sat} = \left(\frac{G+e}{1+e}\right)r_w$$

$$\Rightarrow \left(\frac{2.67+0.9}{1+0.9}\right)9.81$$

$r_{sat} = 18.43 \text{ kN/m}^3$

$r' = 18.43 - 9.81$

$= 8.62 \text{ kN/m}^3$

in case of sudeen dradown angle f empirically reduce to ϕ_w,

ϕ_w = Weighted friction angle

$$\phi_w = \frac{r'}{r_{sat}}\phi.$$

$= \left(\frac{8.62}{18.43}\right)20°$

$= 9.35°$

For $\beta = 45°$, $\phi_w = 9.35°$, $s_n = 0.111$

$F_C = \frac{c_u}{s_n r_{sat} H}$; $F_C = \frac{15}{0.111 \times 18.43 \times 6}$

$F_C = 1.22$

45. ***Ans. (c)***

Force in each rivet due to sheer $\boxed{\frac{200}{12} = 16.67\text{kw}}$

force due to torsional moment = $\frac{(p.e)r_i}{\Sigma\rho_i^2}$

$$r_1 = \sqrt{(100)^2 + (250)^2} = 269.26\text{mm}$$
$$r_2 = \sqrt{(100)^2 + (150)^2} = 180.28\text{mm}$$
$$r_3 = \sqrt{(100)^2 + (10)^2} = 111.80\text{mm}$$

$$\sum_{i=1}^{12} r^2 = 470004.26\text{mm}^2;\ e = 300\text{mm}$$

$$F_T = \frac{200 \times 300 \times 269.26}{47004.26} = 45.83\text{kw}$$

Angle Q between F_T and F_D is = $\frac{100}{269.26} = 0.3714$

So resultent force in rivet

$1 = \sqrt{(F_D)^2 + (F_T)^2 + 2F_D.F_T.\cos Q}$

= 54.27 kw

46. ***Ans. (c)***

Dimensionless parameters

$$\text{Re} = \frac{\rho VD}{\mu} = \text{dimensionless}$$

Also

$$\frac{F_D(\text{kg} - \text{m/s}^2)}{s\left(\frac{\text{kg}}{\text{m}^3}\right)v^3\left(\frac{\text{m}^2}{\text{s}^2}\right) \times D^2(\text{m}^2)} = \text{dimensionless}$$

47. ***Ans. (b)***

$$\theta = \theta_1 + \theta_2$$

$$= \frac{TL}{G\frac{\pi}{32}(2d)^4} + \frac{T\left(\frac{L}{2}\right)}{G\frac{\pi}{32}d^4}$$

$$\theta = \frac{TL}{\pi G d^4}\left[\frac{32}{16}+\frac{32}{2}\right]$$

$$d = \left(\frac{18TL}{\pi\theta G}\right)^{\frac{1}{4}}$$

48. ***Ans. (c)***

$$R_P + R_X = 30000$$

$$\Sigma M_P = 0$$

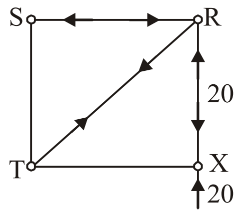
$$R_X \times 3 = 2 \times 30000$$

$\Rightarrow$ $R_X = 20$ kN

and $R_P = 10$ kN

For balance at 'X' $\rightarrow F_{RX} = 20$ kN

at 'RT'$\rightarrow F_{RT}\cos 45° = 20$



$\Rightarrow$ $F_{RT} = \dfrac{20}{\cos 45°}$ ...(1)

Also $F_{SR} = F_{RT}\cos 45°$ ...(2)

From equation (1) and (2)

$$\boxed{F_{SR} = 20\,kN}$$

49. ***Ans. (a)***

The load 'p' will be acting like as eccentric load at c/s x – x

$$e = \left(\frac{d}{4}\right);\quad \sigma = \frac{P}{A}+\frac{Pe}{Z}$$

$$= \frac{P}{b\left(d/2\right)} + \frac{P\left(d/4\right)}{\left(\frac{b\left(d/2\right)^2}{6}\right)}$$

$$= \frac{2P}{bd}+\frac{6P}{bd}=\frac{8P}{bd}$$

50. ***Ans. (d)***

51. ***Ans. (0.050 to 0.053)***

$$P_1 = {}^{20}C_2 \times (0.02)^2 \times (0.98)^{18}$$
$$= 0.0528$$

52(d) $I = \int_0^1 \frac{dx}{\sqrt{-\ln x}}$

Put $-\ln x = t^2$

or $\ln x = -t^2$

or $x = e^{-t^2}$

Hence, $dx = -2te^{-t^2}dt$

$$I = -2\int_\infty^0 e^{-t^2}dt = 2\int_0^\infty e^{-t^2}dt$$

Put $t^2 = y$

or $t = y^{1/2}$

$$dt = \frac{1}{2}y^{-\frac{1}{2}}dy$$

$$I = \int_0^\infty e^{-y}y^{-\frac{1}{2}}dy = \int_0^\infty e^{-y}y^{\frac{1}{2}-1}dy$$

$$= \left\lceil\frac{1}{2} = \sqrt{\pi}\right.$$

53. ***Ans. (9)***

$$z = f(x, y) = xy + \frac{9}{x} + \frac{3}{y}$$

$$P = \frac{\partial z}{\partial x} = y - \frac{9}{x^2}, \; q = \frac{\partial z}{\partial y} = x - \frac{3}{y^2}$$

$$r = \frac{\partial^2 z}{\partial x^2} = \frac{18}{x^3}, \; s = \frac{\partial^2 z}{\partial x \partial y} = 1,$$

$$t = \frac{\partial^2 z}{\partial y^2} = \frac{6}{y^3}$$

Putting $p = q = 0$

$$y - \frac{9}{x^2} = 0 \text{ or } x^2 = \frac{9}{y} \quad \ldots(1)$$

$$x - \frac{3}{y^2} = 0 \quad \ldots(2)$$

Put $x = \frac{3}{y^2}$ in equation (1)

$$\frac{9}{y^4} = \frac{9}{y}$$

$\Rightarrow \quad y^4 = y$

or $y(y^3 - 1) = 0$

$y = 0$ or $y = 1$

when $y = 0;\ x = 0$

when $y = 1;\ x = \pm 3$

$\Rightarrow$ critical points are (3, 1), (–3, 1) and (0, 0)

At (3, 1), $rt - s^2 > 0$ & $r > 0$

$\Rightarrow$ (3, 1) is point of minimum

At (3, 1), $(rt - s^2) < 0$

$\Rightarrow$ (–3, 1) is point of inflection

At (0, 0), $(rt - s^2) < 0$

$\Rightarrow$ (0, 0) is point of inflection

$$\Rightarrow \quad f_{min} = f(3, 1) = (3)(1) + \frac{9}{3} + \frac{3}{1}$$

$$= 3 + 3 + 3 = 9$$

54.(c)
$$(A|B) = \begin{bmatrix} 4 & 9 & 3 & 6 \\ 2 & 3 & 1 & 2 \\ 2 & 6 & 2 & 7 \end{bmatrix}$$

$R_2 \to 2R_2 - R_1,\ R_3 \to 2R_3 - R_1$

$$\approx \begin{bmatrix} 4 & 9 & 3 & 6 \\ 0 & -3 & -1 & -2 \\ 0 & 3 & 1 & 8 \end{bmatrix}$$

$R_3 \to R_3 + R_2$

$$\approx \begin{bmatrix} 4 & 9 & 3 & 6 \\ 0 & -3 & -1 & -2 \\ 0 & 0 & 0 & 6 \end{bmatrix}$$

$\rho(A) = 2$, $\rho(A|B) = 3$, No. of unknown = n = 3

$\because \quad \rho(A) < \delta(A|B)$

Hence, system is inconsistent and have no solution.

55. ***Ans. (0.976 to 0.978)***

$\mu = 9, \quad \sigma = 3$

$$P(x \le 15 = P\left(\frac{x-\mu}{\sigma} \le \frac{15-\mu}{\sigma}\right)$$

$$= P\left(z \le \frac{15-9}{3}\right)$$

$$= P(z \le 2)$$

$$= 0.5 + P(0 \le z \le 2)$$

$$= 0.5 + 0.4772$$

$$= 0.9772$$

Ans 1 to 5 Carry One Mark Each APPTI

1. ***Ans. (c)***

$$16\frac{2}{3}\% = \frac{1}{6}$$

$$37\frac{1}{2}\% = \frac{3}{8}$$

$$57\frac{1}{7}\% = \frac{4}{7}$$

Let population $\Rightarrow$ x

$$x \times \frac{7}{6} \times \frac{5}{8} \times \frac{11}{7} = 137500$$

$$x = 120000$$

2. ***Ans. (a)***

$$\frac{2^{189}}{5} \text{ is written as } \frac{2.(2^2)^{94}}{5} = 2\left[\frac{(5-1)^{94}}{5}\right] = 2$$

3. ***Ans. (d)***

Total work = m × 4 = 4m

m + (m – 20) + ... are in A.P.

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

$$\Rightarrow \frac{7}{2}[2m + (7-1)(-20)] = 4m$$

$$m = 140$$

4. ***Ans. (d)***

5. ***Ans. (a)***

Ans 6 to 10 Carry Two Marks Each APPTI

6. ***Ans. (c)***

Total sales = x

$$\text{Commission} = \frac{x \times 12}{100}$$

$$\text{Bonus} = (x - 15000) \times \frac{1}{100}$$

Total earning = Commission + Bonus

$$= \frac{12x}{100} + (x - 15000)\frac{1}{100}$$

$$= \frac{12x}{100} + \frac{x}{100} - 150$$

$$= \frac{13x}{100} - 150$$

Total sales – Earning = 52350

$$x - \left(\frac{13x}{100} - 150\right) \Rightarrow \frac{87x}{100} = 52350 - 150$$

$$= 52200$$

x = 60,000 Rs.

7. ***Ans. (b)***

D = 9%, D = x

E = 41%

D = xE

9% = 41% x

$$x = \frac{9}{41}$$

8. ***Ans. (b)***

$$\sqrt{-\sqrt{3} + \sqrt{3 + 8\sqrt{(2+\sqrt{3})^2}}} = \sqrt{-\sqrt{3} + \sqrt{19 + 8\sqrt{3}}}$$

$$= \sqrt{-\sqrt{3} + \sqrt{(4+\sqrt{3})^2}}$$

$$= \sqrt{-\sqrt{3} + 4 + \sqrt{3}} = \sqrt{4} = 2$$

9. ***Ans. (c)***

10. ***Ans. (d)***