GATE - 2006

CE : CIVIL ENGINEERING

Time Allowed : 3 Hours *Maximum Marks : 150*

Q.1–Q.20 Carry One Mark Each

1. Solution for the system defined by the set of equations $4y + 3z = 8$; $2x - z = 2$; and $3x + 2y = 5$ is

   (*a*) $x = 0; y = 1; z = \frac{4}{3}$ (*b*) $x = 0; y = \frac{1}{2}; z = 2$

   (*c*) $x = 1; y = \frac{1}{2}; z = 2$ (*d*) nonexistent

2. The differential equation $\frac{dy}{dx} = 0.25\, y^2$ is to be solved using the backward (implicit) Euler's method with the boundary condition $y = 1$ at $x = 0$ and with a step size of 1. What would be the value of y at $x = 1$?

   (*a*) 1.33 (*b*) 1.67

   (*c*) 2.00 (*d*) 2.33

3. The necessary and sufficient condition for a surface to be called as a free surface is

   (*a*) no stress should be acting on it

   (*b*) tensile stress acting on it must be zero

   (*c*) shear stress acting on it must be zero

   (*d*) no point on it should be under any stress

4. Mohr's circle for the state of stress defined by $\begin{bmatrix} 30 & 0 \\ 0 & 30 \end{bmatrix}$ MPa is a circle with

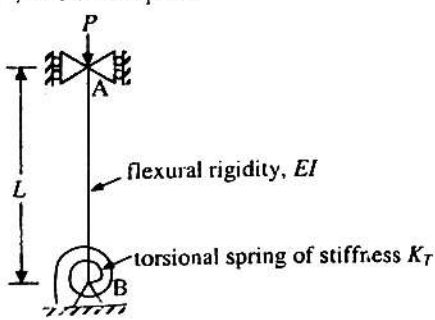
   (*a*) center at (0, 0) and radius 30 MPa

   (*b*) center at (0, 0) and radius 60 MPa

   (*c*) center at (30, 0) and radius 30 MPa

   (*d*) center at (30, 0) and zero radius

5. The buckling load $P = P_{cr}$ for the column AB in the figure, as K_T approaches infinity, become $\alpha \frac{\pi^2 EI}{L^2}$, where α is equal to



   (*a*) 0.25 (*b*) 1.00

   (*c*) 2.05 (*d*) 4.00

6. A long shaft of diameter d is subjected to twisting moment T at its ends. The maximum normal stress acting at its cross-section is equal to

   (*a*) zero (*b*) $\frac{16T}{\pi d^3}$

   (*c*) $\frac{32T}{\pi d^3}$ (*d*) $\frac{64T}{\pi d^3}$

7. If the characteristic strength of concrete f_{ck} is defined as the strength below which not more than 50% of the test results are expected to fall, the expression for f_{ck} in terms of mean strength f_m and standard deviation S would be

   (*a*) $f_m - 0.1645S$ (*b*) $f_m - 1.645S$

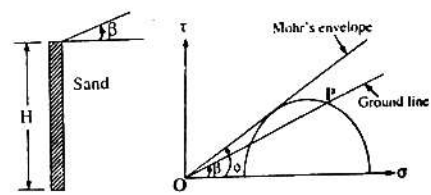
   (*c*) f_m (*d*) $f_m + 1.645S$

8. The range of void ratio between which quick sand condition occurs in cohesionless granular soil deposits is

   (*a*) 0.4 – 0.5 (*b*) 0.6 – 0.7

   (*c*) 0.8 – 0.9 (*d*) 1.0 – 1.1

9. Figure given below shows a smooth vertical gravity retaining wall with cohesionless soil backfill having an angle of internal friction ϕ. In the graphical representation of Rankine's active earth pressure for the retaining wall shown in figure, length OP represents



(a) vertical stress at the base

(b) vertical stress at a height H/3 from the base

(c) lateral earth pressure at the base

(d) lateral earth pressure at a height H/3 from the base

10. Which of following statement is NOT true in the context of capillary pressure in soils?

(a) Water is under tension in capillary zone

(b) Pore water pressure is negative in capillary zone

(c) Effective stress increases due to capillary pressure

(d) Capillary pressure is more in coarse grained soils

11. A channel with a mild slope is followed by a horizontal channel and then by a steep channel. What gradually varied flow profiles will occur?

(a) M_1, H_1, S_1 (b) M_2, H_2, S_2

(c) M_1, H_2, S_3 (d) M_1, H_2, S_2

12. To provide safety against piping failure, with a factor of safety of 5, what should be the maximum permissible exit gradient for soil with specific gravity of 2.5 and porosity of 0.35?

(a) 0.155 (b) 0.167

(c) 0.195 (d) 0.213

13. Identify the FALSE statement from the following: The specific speed of the pump increases with

(a) increase in shaft speed

(b) increase in discharge

(c) decrease in gravitational acceleration

(d) increase in head

14. For steady flow to a fully penetrating well in a confined aquifer, the drawdowns at radial distances of r_1 and r_2 from the well have been measured as s_1 and s_2 respectively, for a pumping rate of Q. The transmissivity of the aquifer is equal to

(a) $\frac{Q}{2\pi}\frac{\ln\frac{r_2}{r_1}}{(s_1 - s_2)}$ (b) $\frac{Q}{2\pi}\frac{\ln(r_2 - r_1)}{(s_1 - s_2)}$

(c) $\frac{Q}{2\pi}\ln\left(\frac{r_2/r_1}{s_2/s_1}\right)$ (d) $2\pi Q\frac{r_2 - r_1}{\ln\left(\frac{s_2}{s_1}\right)}$

15. To determine the BOD_5 of a wastewater sample, 5, 10 and 50 mL aliquots of the wastewater were diluted to 300 mL and incubated at 20°C in BOD bottles for 5 days.

The results were as follows.

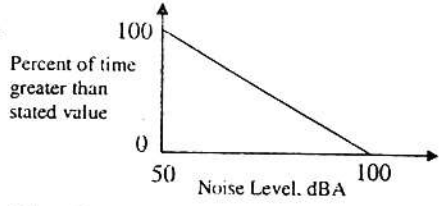
Sl. No.	Wastewater Volume, mL	Initial DO, mg/L	DO After 5 days, mg/L
1.	5	9.2	6.9
2.	10	9.1	4.4
3.	50	8.4	0.0

Based on the data, the average BOD_5 of the wastewater is equal to

(a) 139.5 mg/L (b) 126.5 mg/L

(c) 109.8 mg/L (d) 72.2 mg/L

16. The cumulative noise power distribution curve at a certain location is given below.



The value of L_{40} is equal to

(a) 90 dBA (b) 80 dBA

(c) 70 dBA (d) 60 dBA

17. A synthetic sample of water is prepared by adding 100 mg Kaolinite (a clay mineral), 200 mg glucose, 168 mg NaCl, 120 mg $MgSO_4$, and 111 mg $CaCl_2$ to 1 liter of pure water. The concentrations of total solids (TS) and fixed dissolved solids (FDS)respectively in the solution in mg/L are equal to

(a) 699 and 599 (b) 599 and 399

(c) 699 and 199 (d) 699 and 399

18. If aggregate size of 50-40 mm is to be tested for finding out the portion of elongated aggregates using length gauge, the slot length of the gauge should be

(a) 81 mm (b) 45 mm

(c) 53 mm (d) 90 mm

19. Name the traffic survey data which is plotted by means of "Desire lines".

(a) Accident

(b) Classified volume

(c) Origin and Destination

(d) Speed and Delay

20. In case of governing equations for calculating wheel load stresses using Westergaard's approach, the following statements are made.

I. Load stresses are inversely proportional to wheel load

II. Modulus of subgrade reaction is useful for load stress calculation

(a) Both statements are TRUE

(b) I is TRUE and II is FALSE

(c) Both statements are FALSE

(d) I is FALSE and II is TRUE

Q.21 to Q.75 carry two marks each

21. For a given matrix $A = \begin{bmatrix} 2 & -2 & 3 \\ -2 & -1 & 6 \\ 1 & 2 & 0 \end{bmatrix}$, one of the eigenvalues is 3. The other two eigenvalues are

(a) 2, – 5 (b) 3, – 5

(c) 2, 5 (d) 3, 5

22. The directional derivative of $f(x, y, z) = 2x^2 + 3y^2 + z^2$ at the point P: (2, 1, 3) in the direction of the vector $a = i - 2k$ is

(a) – 2.785 (b) – 2.145

(c) – 1.789 (d) 1.000

23. A class of first year B. Tech. students is composed of four batches A, B, C and D, each consisting of 30 students. It is found that the sessional marks of students in Engineering Drawing in batch C have a mean of 6.6 and standard deviation of 2.3. The mean and standard deviation of the marks for the entire class are 5.5 and 4.2, respectively. It is decided by the course instructor to normalize the marks of the students of all batches to have the same mean and standard deviation as that of the entire class. Due to this, the marks of a student in batch C are changed from 8.5 to

(a) 6.0 (b) 7.0

(c) 8.0 (d) 9.0

24. A 2nd degree polynomial, $f(x)$, has values of 1, 4, and 15 at $x = 0$, 1, and 2, respectively. The integral $\int_0^2 f(x)\,dx$ is to be estimated by applying the trapezoidal rule to this data. What is the error (defined as "true value – approximate value") in the estimate ?

(a) $-\frac{4}{3}$ (b) $-\frac{2}{3}$

(c) 0 (d) $\frac{2}{3}$

25. What is the area common to the circles $r = a$ and $r = 2a\cos\theta$?

(a) $0.524\,a^2$ (b) $0.614\,a^2$

(c) $1.047\,a^2$ (d) $1.228\,a^2$

26. Using Cauchy's integral theorem, the value of the integral (integration being taken in counter clockwise direction) $\oint_c \frac{z^3 - 6}{3z - i}\,dz$ is

(a) $\frac{2\pi}{81} - 4\pi i$ (b) $\frac{\pi}{8} - 6\pi i$

(c) $\frac{4\pi}{81} - 6\pi i$ (d) 1

27. There are 25 calculators in a box. Two of them are defective. Suppose 5 calculators are randomly picked for inspection (*i.e.*, each has the same chance of being selected), what is the probability that only one of the defective calculators will be included in the inspection ?

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$

(c) $\frac{1}{4}$ (d) $\frac{1}{5}$

28. A spherical naphthalene ball exposed to the atmosphere loses volume at a rate proportional to its instantaneous surface area due to evaporation. If the initial diameter of the ball is 2 cm and the diameter reduces to 1 cm after 3 months, the ball completely evaporates in

(a) 6 months (b) 9 months

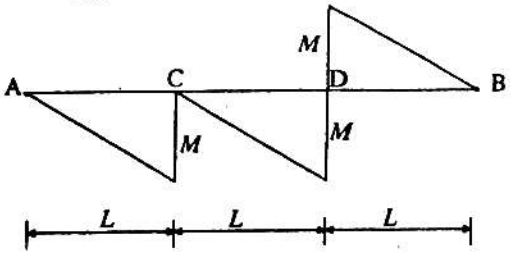
(c) 12 months (d) infinite time

29. The solution of the differential equation, $x^2\frac{dy}{dx} + 2xy - x + 1 = 0$, given that at $x = 1$, $y = 0$ is

(a) $\frac{1}{2} - \frac{1}{x} + \frac{1}{2x^2}$ (b) $\frac{1}{2} - \frac{1}{x} - \frac{1}{2x^2}$

(c) $\frac{1}{2} + \frac{1}{x} + \frac{1}{2x^2}$ (d) $-\frac{1}{2} + \frac{1}{x} + \frac{1}{2x^2}$

30. A simply supported beam AB has the bending moment diagram as shown in the following figure.



The beam is possibly under the action of following loads:

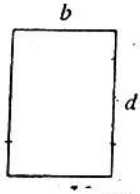
(a) Couples of M at C and 2M at D

(b) Couples of 2M at C and M at D

(c) Concentrated loads of M/L at C and 2M/L at D

(d) Concentrated load of M/L at C and couple of 2M at D

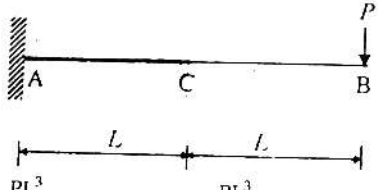
31. For the section shown below, second moment of the area about an axis $d/4$ distance above the bottom of the area is



(a) $\frac{bd^3}{48}$ (b) $\frac{bd^3}{12}$

(c) $\frac{7bd^3}{48}$ (d) $\frac{bd^3}{3}$

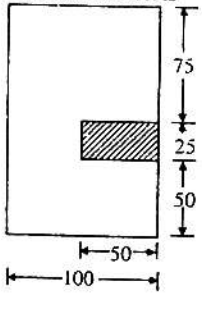
32. Consider the beam AB shown in the figure below. Part AC of the beam is rigid while Part CB has the flexural rigidity EI. Identify the correct combination of deflection at end B and bending moment at end A, respectively.



(a) $\frac{PL^3}{3EI}$, 2PL (b) $\frac{PL^3}{3EI}$, PL

(c) $\frac{8PL^3}{3EI}$, 2PL (d) $\frac{8PL^3}{3EI}$, PL

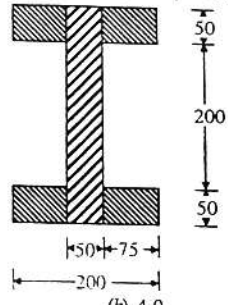
33. A beam with the cross-section given below is subjected to a positive bending moment (causing compression at the top) of 16 kN-m acting around the horizontal axis. The tensile force acting on the hatched area of the cross-section is



(a) zero (b) 5.9 kN

(c) 8.9 kN (d) 17.8 kN

34. T-section of a beam is formed by gluing wooden planks as shown in the figure below. If this beam transmits a constant vertical shear force of 3000 N, the glue at any of the four joints will be subjected to a shear force (in kN per meter length)of



(a) 3.0 (b) 4.0

(c) 8.0 (d) 10.7

35. If a beam of rectangular cross-section is subjected to a vertical shear force V, the shear force carried by the upper one-third of the cross-section is

(a) zero (b) $\frac{7V}{27}$

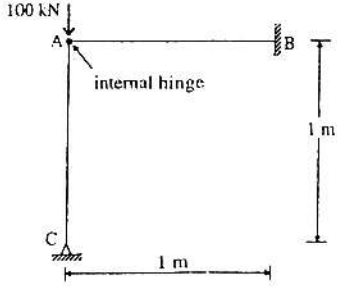
(c) $\frac{8V}{27}$ (d) $\frac{V}{3}$

36. A thin-walled long cylindrical tank of inside radius r is subjected simultaneously to internal gas pressure p and axial compressive force F at its ends. In order to produce 'pure shear' state of stress in the wall of the cylinder, F should be equal to

(a) πpr^2 (b) $2\pi pr^2$

(c) $3\pi pr^2$ (d) $4\pi pr^2$

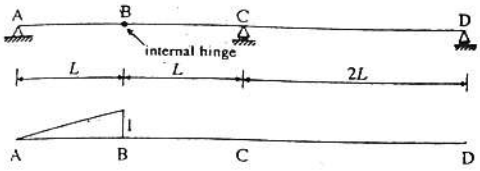
37. Vertical reaction developed at B in the frame below due to the applied load of 100 kN (with 150, 000 mm^2 cross-sectional area and 3.125×10^9 mm^4 moment of inertia for both members)is



(a) 5.9 kN (b) 302 kN

(c) 66.3 kN (d) 94.1 kN

38. Consider the beam ABCD and the influence line as shown below. The influence line pertains to



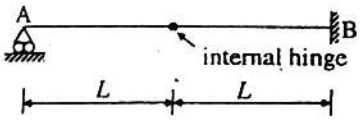
(a) reaction at A, R_A

(b) shear force at B, V_B

(c) shear force on the left of C, V_C^-

(d) shear force on the right of C, V_C^+

39. Carry-over factor C_{AB} for the beam shown in the figure below is



(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) $\frac{3}{4}$ (d) 1

40. Assuming concrete below the neutral axis to be cracked, the shear stress across the depth of a singly-reinforced rectangular beam section

(a) increases parabolically to the neutral axis and then drops suddenly to zero value

(b) increases parabolically to the neutral axis and then remains constant over the remaining depth

(c) increases linearly to the neutral axis and then remains constant up to the tension steel

(d) increases parabolically to the neutral axis and then remains constant up to the tension steel

41. As per IS: 456-2000, consider the following statements

I The modular ratio considered in the working stress method depends on the type of steel used

II There is an upper limit on the nominal shear stress in beams (even withshear reinforcement) due to the possibility of crushing of concrete in diagonal compression.

III A rectangular slab whose length is equal to its width may not be a two-way slab for some support conditions.

The TRUE statements are

(a) only I and II (b) only II and III

(c) only I and III (d) I, II and III

42. In the design of welded tension members, consider the following statements :

I The entire cross-sectional area of the connected leg is assumed to contribute to the effective area in case of angles.

II Two angles back-to-back and tack-welded as per the codal requirements may be assumed to behave as a tee section.

III A check on slenderness ratio may be necessary in some cases.

The TRUE statements are

(a) only I and II (b) only II and III

(c) only I and III (d) I, II and III

43. Consider the following statements

I Effective length of a battened column is usually increased to account for the additional load on battens due to the lateral expansion of columns.

II As per IS: 800-1984, permissible stress in bending compression depends on both Euler buckling stress and the yield stress of steel.

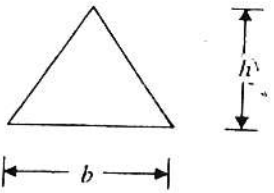
III As per IS: 800-1984, the effective length of a column effectively held in position at both ends but not restrained against rotation, is taken to be greater than that in the ideal end conditions.

The TRUE statements are

(a) only I and II (b) only II and III

(c) only I and III (d) I, II and III

44. When the triangular section of a beam as shown below becomes a plastic hinge, the compressive force acting on the section (with σ_y denoting the yield stress) becomes



(a) $\frac{bh\sigma_y}{4}$ (b) $\frac{2bh\sigma_y}{9}$

(c) $\frac{bh\sigma_y}{2}$ (d) $\frac{bh\sigma_y}{3}$

45. Consider the following statements:

I. The width-to-thickness ratio limitations on the plate elements under compression in steel members are imposed by IS: 800-1984 in order to avoid fabrication difficulties.

II. In a doubly reinforced concrete beam, the strain in compressive reinforcement is higher than the strain in the adjoining concrete.

III. If a cantilever I-section supports slab construction all along its length with sufficient friction between them, the permissible bending stress in compression will be the same as that in tension.

The TRUE statements are

(a) only I and II (b) only II and III

(c) only I and III (d) I, II and III

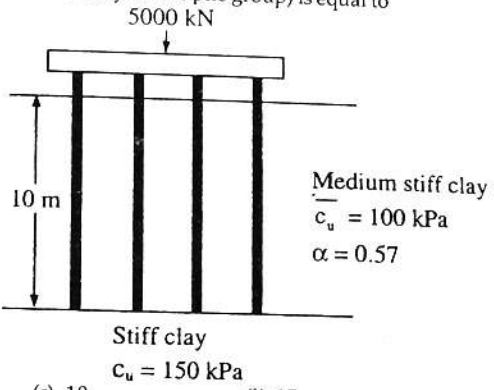
46. List – I below gives the possible types of failure for a finite soil slope and List – II gives the reasons for these different types of failure. Match the items in List – I with the items in List – II

List – I	List – II
P Base failure	1 Soils above and below the toe have same strength
Q Face failure	2 Soil above the toe is comparatively weaker
R Toe failure	3 Soil above the toe is comparatively stronger

(a) P-1 Q-2 R-3 (b) P-2 Q-3 R-1

(c) P-2 Q-1 R-3 (d) P-3 Q-2 R-1

47. For the soil profile shown in figure below, the minimum number of precast concrete piles of 300 mm diameter required to safely carry the load for a given factor of safety of 2.5 (assuming 100% efficiency for the pile group) is equal to



(a) 10 (b) 15

(c) 20 (d) 25

48. In a standard proctor test, 1.8 kg of moist soil was filling the mould (volume = 944 cc) after compaction. A soil sample weighing 23 g was taken from the mould and ovendried for 24 hours at a temperature of 110°C. Weight of the dry sample was found to be 20 g. Specific gravity of soil solids is G = 2.7. The theoretical maximum value of the dry unit weight of the soil at that water content is equal to

(a) 4.67 kN/m^3 (b) 11.5 kN/m^3

(c) 16.26 kN/m^3 (d) 18.85 kN/m^3

49. A sample of saturated cohesionless soil tested in a drained triaxial compression test showed an angle of internal friction of 30°. The deviatoric stress at failure for the sample at a confining pressure of 200 kPa is equal to

(a) 200 kPa (b) 400 kPa

(c) 600 kPa (d) 800 kPa

50. The thickness of the laminar boundary layer on a flat plate at a point A is 2 cm and at a point B, 1m downstream of A, is 3 cm. What is the distance of A from the leading edge of the plate?

(a) 0.50 m (b) 0.80 m

(c) 1.00 m (d) 1.25 m

51. The velocity field for flow is given by

$\vec{V} = (5x + 6y + 7z)\,\hat{i} + (6x + 5y + 9z)\hat{j} + (3x + 2y + \lambda z)\hat{k}$

and the density varies as $\rho = \rho_0 \exp(-2t)$. In order that the mass is conserved, the value of λ should be

(a) – 12 (b) – 10

(c) – 8 (d) 10

52. In a cultivated area, the soil has porosity of 45% and field capacity of 38%. For a particular crop, the root zone depth is 1.0 m, the permanent wilting point is 10% and the consumptive use is 15 mm/d. If the irrigation efficiency is 60%, what should be the frequency of irrigation such that the moisture content does not fall below 50% of the maximum available moisture ?

(a) 5 d (b) 6 d

(c) 9 d (d) 15 d

53. A hydraulic jump occurs in a rectangular, horizontal, frictionless channel. What would be the pre-jump depth if the discharge per unit width $2 m^3/s/m$ and the energy loss is 1 m ?

(a) 0.2 m (b) 0.3 m

(c) 0.8 m (d) 0.9 m

54. During a 3 hour storm event, it was observed that all abstractions other than infiltration are negligible. The rainfall was idealized as 3 one hour storms of intensity 10 mm/hr, 20 mm/hr and 10 mm/hr respectively and the infiltration was idealized as a Horton curve, $f = 6.8 + 8.7 \exp(-t)$ (f in mm/hr and t in hr). What is the effective rainfall?

(a) 10.00 mm (b) 11.33 mm

(c) 12.43 mm (d) 13.63 mm

55. A very wide rectangular channel is designed to carry a discharge of $5 m^3/s$ per meter width. The design is based on the Manning's equation with the roughness coefficient obtained from the grain size using Strickler's equation and results in a normal depth of 1.0 m. By mistake, however, the engineer used the grain diameter in mm in the Strickler's equation instead of in meter. What should be the correct normal depth ?

(a) 0.32 m (b) 0.50 m

(c) 2.00 m (d) 3.20 m

56. The flow of glycerin (kinematic viscosity $v = 5 \times 10^{-4} m^2/s$) in an open channel is to be modeled in a laboratory flume using water ($v = 10^{-6} m^2/s$) as the flowing fluid. If both gravity and viscosity are important, what should be the length scale (*i.e.* ratio of prototype to model dimensions) for maintaining dynamic similarity?

(a) 1 (b) 22

(c) 63 (d) 500

57. The mean indoor airborne Chloroform ($CHCl_3$) concentration in a room was determined to be 0.4 $\mu g/m^3$. Use the following data: T = 293 K, P = 1 atmosphere, $R = 82.05 \times 10^{-6}$ atm.m^3/mol-K, Atomic weights: C = 12, H = 1, Cl = 35.5. This concentration expressed in parts per billion (volume basis, ppbv) is equal to

(a) 1.00 ppbv (b) 0.20 ppbv

(c) 0.10 ppbv (d) 0.08 ppbv

58. The composition of a certain MSW sample and specific weights of its various components are given below.

Component	Percent by Weight	Specific Weight (kg/m^3)
Food waste	50	300
Dirt and Ash	30	500
Plastics	10	65
Wood and Yard waste	10	125

Specific weight (kg/m^3) of the MSW sample is

(a) 319 (b) 217

(c) 209 (d) 199

59. A subgrade soil sample was tested using standard CBR apparatus and the observations are given below.

Load, kg	Penetration, mm
60.5	2.5
80.5	5.0

Assuming that the load-penetration curve is convex throughout, the CBR value (%) of the sample is

(a) 6.5 (b) 5.5

(c) 4.4 (d) 3.9

60. A vehicle moving at 60 kmph on an ascending gradient of a highway has to come to stop position to avoid collision with a stationary object. The ratio of lag to brake distance is 6 : 5. Considering total reaction time of the driver as 2.5 seconds and the coefficient of longitudinal friction as 0.36, the value of ascending gradient (%) is

(a) 3.3 (b) 4.8

(c) 5.3 (d) 6.8

61. 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, the following data is available.

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

Total time lost per cycle is 12 seconds. The cycle length (seconds) as per webster's approach is

(a) 67 (b) 77

(c) 87 (d) 91

62. On an urban road, the free mean speed was measured as 70 kmph and the average spacing between the vehicles under jam condition as 7.0 m. The speed-flow -density equation is given by

$$U = U_{sf}\left[1 - \frac{k}{k_j}\right] \text{ and } q = Uk$$

where U = space-mean speed (kmph); U_{sf} = free mean speed (kmph); k = density (veh/km); k_j = jam density (veh/km); q = flow (veh/hr). The maximum flow (veh/hr) per lane for this condition is equal to

(a) 2000 (b) 2500

(c) 3000 (d) None of these

63. At a horizontal curve portion of a 4 lane undivided carriageway, a transition curve is to be introduced to attain required superelevation. The design speed is 60 kmph and radius of the curve is 245 m. Assume length of wheel base of a longest vehicle as 6 m, superelevation rate as 5% and rate of introduction of this superelevation as 1 in 150. The length of the transition curve (m) required, if the pavement is rotated about inner edge is

(a) 81.4 (b) 85.0

(c) 91.5 (d) 110.2

64. Using IRC: 37 - 1984 "Guidelines for the Design of Flexible Pavements" and the following data, choose the total thickness of the pavement.

No. of commercial vehicles when construction is completed= 2723 veh/day

Annual growth rate of the traffic = 5.0%

Design life of the pavement = 10 years

Vehicle damage factor = 2.4

CBR value of the subgrade soil = 5%

Data for 5% CBR value

No. of Standard Axles, msa	Total Thickness, mm
20	620
25	640
30	670
40	700

(a) 620 mm (b) 640 mm

(c) 670 mm (d) 700 mm

65. The observed magnetic bearing of a line OE was found to be 185°. It was later discovered that station O had a local attraction of + 1.5°. The true bearing of the line OE, considering a magnetic a magnetic declination of 3.5° E shall be

(a) 180° (b) 187°

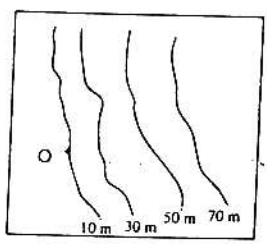
(c) 190° (d) 193°

66. A Bench Mark (BM) with Reduced Level (RL) = 155.305 m has been established at the floor of a room. It is required to find out the RL of the underside of the roof (R) of the room using Spirit Leveling. The Back Sight (BS) to the BM has been observed as 1.500 m whereas the Fore Sight (FS) to R has been observed as 0.575 m (Staff held inverted). The RL (m) of R will be

(a) 155.880 (b) 156.230

(c) 157.380 (d) 157.860

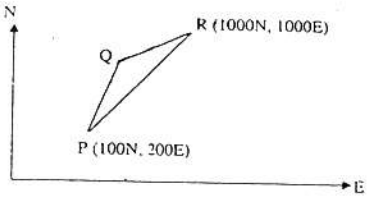
67. Consider the following figure, which is an extract from a contour map (scale = 1:20,000) of an area. An alignment of a road at a ruling gradient of 4% is to be fixed from the point O and beyond. What should be the radius of the arc with O as the center to get the point of alignment on the next contour on the map.



(a) 0.025 cm (b) 0.25 cm

(c) 2.5 cm (d) 5.0 cm

68. In the figure given below, the lengths PQ (WCB: 30°) and QR (WCB: 45°) respectively up to three places of decimal are



(a) 273.205, 938.186 (b) 273.205, 551.815

(c) 551.815, 551.815 (d) 551.815, 938.186

69. During a leveling work along a falling gradient using a Dumpy Level and a Staff of 3m length, following successive readings were taken : 1.785, 2.935, 0.360, 1.320. What will be the correct order of booking these four readings in a level book ?

(BS : Back Sight, IS : Intermediate Sight, FS : Fore Sight)

(a) BS, FS, BS, FS (b) BS, IS, FS, FS

(c) BS, IS, IS, FS (d) BS, IS, BS, FS

Common Data Questions

Common Data for Question 70, 71 :

Laboratory sieve analysis was carried out on a soil sample using a complete set of standard IS sieves. Out of 500g of soil used in the test, 200g was retained on IS 600μ sieve, 250g was retained on IS 500μ sieve and the remaining 50g was retained on IS 425μ sieve.

70. The coefficient of uniformity of the soil is

(a) 0.9 (b) 1.0

(c) 1.1 (d) 1.2

71. The classification of the soil is

(a) SP (b) SW

(c) GP (d) GW

Common Data for Questions 72, 73:

For a catchment, the S-curve (or S-hydrograph) due to a rainfall of intensity 1 cm/hr is given by

$Q = 1 - (1 + t) \exp(-t)$ (t in hr and Q in m^3/s).

72. What is the area of the catchment ?

(a) 0.01 km^2 (b) 0.36 km^2

(c) 1.00 km^2 (d) 1.28 km^2

73. What will be the ordinate of a 2-hour unit hydrograph for this catchment at $t = 3$ hour ?

(a) 0.13 m^3/s (b) 0.20 m^3/s

(c) 0.27 m^3/s (d) 0.54 m^3/s

Common Data for Questions 74, 75:

In a rapid sand filter, the time for reaching particle breakthrough (T_B) is defined as the time elapsed from start of filter run to the time at which the turbidity of the effluent from the filter is greater than 2.5 NTU. The time for reaching terminal head loss (T_H) is defined as the time elapsed from the start of the filter run to the time when head loss across the filter is greater than 3 m.

74. The effect of increasing the filter depth (while keeping all other conditions same) on T_B and T_H is

(a) T_B increases and T_H decreases

(b) both T_B and T_H increase

(c) T_B decreases and T_H increases

(d) both T_B and T_H decrease

75. The effect of increasing the filter loading rate (while keeping all other conditions sames) on T_B and T_H is

(a) T_B increases and T_H decreases

(b) both T_B and T_H increase

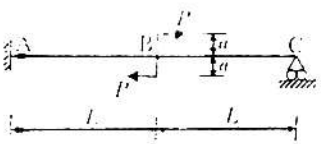
(c) T_B decreases and T_H increases

(d) both T_B and T_H decrease

Linked Answer questions : Q.76 to Q.85 carry two marks each

Statement of Linked Answer Questions 76 and 77

Consider a propped cantilever beam ABC under two loads of magnitude P each as shown in the figure below. Flexural rigidity of the beam is EI



76. The reaction at C is

(a) $\frac{9Pa}{16L}$ (upwards) (b) $\frac{9Pa}{16L}$ (downwards)

(c) $\frac{9Pa}{8L}$ (upwards) (d) $\frac{9Pa}{8L}$ (downwards)

77. The rotation at B is

(a) $\frac{5PL\alpha}{16EI}$ (clockwise)

(b) $\frac{5PL\alpha}{16EI}$ (anticlockwise)

(c) $\frac{59PL\alpha}{16EI}$ (clockwise)

(d) $\frac{59PL\alpha}{16EI}$ (anticlockwise)

Statement for Linked Answer Questions 78 and 79:

In the design of beams for the limit state of collapse in flexure as per IS: 456-2000, let the maximum strain in concrete be limited to 0.0025 (in place of 0.0035). For this situation, consider a rectangular beam section with breadth as 250 mm, effective depth as 350 mm, area of tension steel as 1500 mm^2, and characteristic strengths of concrete and steel as 30Mpa and 250 MPa respectively.

78. The depth of neutral axis for the balanced failure is

(a) 140 mm (b) 156 mm

(c) 168 mm (d) 185 mm

79. At the limiting state of collapse in flexure, the force acting on the compression zone of the section is

(a) 326 kN (b) 389 kN

(c) 424 kN (d) 542 kN

Statement for Linked Answer Questions 80 and 81

The average effective overburden pressure on 10 m thick homogeneous saturated clay layer is 150 kPa. Consolidation test on an undisturbed soil sample taken from the clay layer showed that the void ratio decreased from 0.6 to 0.5 by increasing the stress intensity from 100 kPa to 300 kPa. (G = 2.65)

80. The initial void ratio of the clay layer is

(a) 0.209 (b) 0.563

(c) 0.746 (d) 1.000

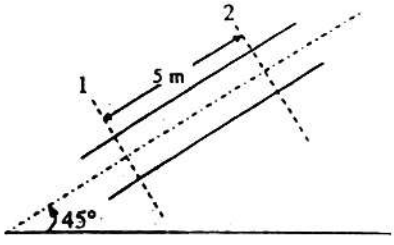
81. The total consolidation settlement of the clay layer due to the construction of a structure imposing an additional stress intensity of 200 kPa is

(a) 0.10 m (b) 0.25 m

(c) 0.35 m (d) 0.50 m

Statement for Linked Answer Questions 82 and 83

An upward flow of oil (mass density 800 kg/m^3, dynamic viscosity 0.8 kg/m-s) takes place under laminar conditions in an inclined pipe of 0.1 m diameter as shown in the figure. The pressures at sections 1 and 2 are measured as $p_1 = 435\ kN/m^2$ and $p_2 = 200\ kN/m^2$



82. The discharge in the pipe is equal to

(a) 0.100 m^3/s

(b) 0.127 m^3/s

(c) 0.144 m^3/s

(d) 0.161 m^3/s

83. If the flow is reversed, keeping the same discharge, and the pressure at section 1 is maintained as 435 kN/m^2, the pressure at section 2 is equal to

(a) 488 kN/m^2 (b) 549 kN/m^2

(c) 586 kN/m^2 (d) 614 kN/m^2

Statement for Linked Answer Questions 84 and 85

A water sample contains the following dissolved ions. $[Na^+] = 56$ mg/L; $[Ca^{2+}] = 40$ mg/L; $[Mg^{2+}] =$ 30 mg/L; $[Al^{3+}] = 3$ mg/L; $[HCO_3^-]$ = 190 mg/L; $[Cl^-] = 165$ mg/L; Water pH is 7.

Atomic weights: Ca: 40; Mg: 24; Al: 27; H: 1; C: 12; O: 16; Na: 23; Cl:35.5

84. The total hardness of the sample in mg/L as $CaCO_3$ is

(a) 484 (b) 450

(c) 242 (d) 225

85. The non-arbonate hardness of the sample in mg/L as $CaCO_3$ is

(a) 225 (b) 156

(c) 86 (d) 0

ANSWERS

1. (*d*)	2. (*c*)	3. (*a*)	4. (*d*)	5. (*d*)	6. (*b*)	7. (*c*)	8. (*c*)	9. (*a*)	10. (*d*)
11. (*d*)	12. (*c*)	13. (*d*)	14. (*a*)	15. (*c*)	16. (*b*)	17. (*d*)	18. (*a*)	19. (*c*)	20. (*d*)
21. (*b*)	22. (*c*)	23. (*d*)	24. (*a*)	25. (*d*)	26. (*a*)	27. (*b*)	28. (*a*)	29. (*a*)	30. (*a*)
31. (*c*)	32. (*a*)	33. (*c*)	34. (*b*)	35. (*b*)	36. (*c*)	37. (*a*)	38. (*b*)	39. (*d*)	40. (*d*)
41. (*b*)	42. (*d*)	43. (*a*)	44. (*a*)	45. (*a*)	46. (*d*)	47. (*c*)	48. (*c*)	49. (*b*)	50. (*b*)
51. (*b*)	52. (*c*)	53. (*b*)	54. (*d*)	55. (*b*)	56. (*c*)	57. (*d*)	58. (*b*)	59. (*c*)	60. (*b*)
61. (*b*)	62. (*b*)	63. (*d*)	64. (*c*)	65. (*b*)	66. (*c*)	67. (*c*)	68. (*a*)	69. (*a*)	70. (*d*)
71. (*a*)	72. (*b*)	73. (*)	74. (*a*)	75. (*d*)	76. (*c*)	77. (*a*)	78. (*b*)	79. (*b*)	80. (*b*)
81. (*d*)	82. (*b*)	83. (*d*)	84. (*c*)	85. (*c*)					

EXPLANATIONS

1. Given, the set of equations, $0.x + 4.y + 3.z = 8$

$2.x + 0.y - 1.z = 2$

$3.x + 2.y + 0.z = 5$

$$\begin{bmatrix} 0 & 4 & 3 \\ 2 & 0 & -1 \\ 3 & 2 & 0 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 8 \\ 2 \\ 5 \end{bmatrix}$$

$AX = B$, where B = Argument matrix of A.

Applying $R_3 \to R_3 - R_2$, we get

$$\begin{bmatrix} 0 & 4 & 3 \\ 2 & 0 & -1 \\ -3 & 2 & 0 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 8 \\ 2 \\ 5 \end{bmatrix}$$

Applying $R_2 \leftrightarrow R_1$, $R_2 \leftrightarrow R_3$, we get

$$\begin{bmatrix} 2 & 0 & -1 \\ 3 & 2 & 0 \\ 0 & 4 & 3 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 2 \\ 5 \\ 8 \end{bmatrix}$$

Applying $R_2 \to R_2 - \frac{3R_1}{2}$, we get

$$\begin{bmatrix} 2 & 0 & -1 \\ 0 & 2 & \frac{3}{2} \\ 0 & 4 & 3 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 8 \end{bmatrix}$$

Applying $R_3 \to R_3 - 2R_2$, we get

$$\begin{bmatrix} 2 & 0 & -1 \\ 0 & 2 & \frac{3}{2} \\ 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 4 \end{bmatrix}$$

$\therefore$ Rank of A $\neq$ Rank of B

As incosistent, thus there is no solution.

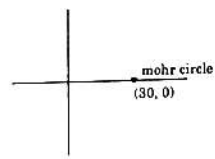
3. No stress should be acting on it.

4. Given, $I = \begin{bmatrix} 30 & 0 \\ 0 & 30 \end{bmatrix}$

where $p_1 = 30$ MPa,

$p_2 = 30$ MPa

and $q = 0$



Therefore diagram is

$\therefore$ Centre $\equiv$ (30, 0) Radius = 0 m.

5. Since, column B likes both end fixed, therefore

$$l_{eff} = \frac{L}{2}$$

$$\therefore \quad P = P_{cr} = \frac{\pi^2 EI}{\left(\frac{L}{2}\right)^2} = \frac{4\pi^2 EI}{L^2}$$

$$\Rightarrow \quad \alpha = 4$$