GATE 2024 Civil Engineering (CE) Question Paper

Graduate Aptitude Test in Engineering (GATE)

General Aptitude (GA)

Q.1 – Q.5 Carry ONE mark Each

Q.1 If '→' denotes increasing order of intensity, then the meaning of the words [simmer → seethe → smolder] is analogous to [break → raze → _____]. Which one of the given options is appropriate to fill the blank?

(A) obfuscate

(B) obliterate

(C) fracture

(D) fissure

Q.2 In a locality, the houses are numbered in the following way:

The house-numbers on one side of a road are consecutive odd integers starting from 301, while the house-numbers on the other side of the road are consecutive even numbers starting from 302. The total number of houses is the same on both sides of the road.

If the difference of the sum of the house-numbers between the two sides of the road is 27, then the number of houses on each side of the road is

(A) 27

(B) 52

(C) 54

(D) 26

Q.3 For positive integers p and q, with $\frac{p}{q} \neq 1$, $\left(\frac{p}{q}\right)^{\frac{p}{q}} = p^{\left(\frac{p}{q}-1\right)}$. Then,

(A) $q^p = p^q$

(B) $q^p = p^{2q}$

(C) $\sqrt{q} = \sqrt{p}$

(D) $\sqrt[p]{q} = \sqrt[q]{p}$

Q.4 Which one of the given options is a possible value of x in the following sequence?

3, 7, 15, x, 63, 127, 255

(A) 35

(B) 40

(C) 45

(D) 31

Q.5 On a given day, how many times will the second-hand and the minute-hand of a clock cross each other during the clock time 12:05:00 hours to 12:55:00 hours?

(A) 51

(B) 49

(C) 50

(D) 55

Q.6 – Q.10 Carry TWO marks Each

Q.6 In the given text, the blanks are numbered (i)–(iv). Select the best match for all the blanks.

From the ancient Athenian arena to the modern Olympic stadiums, athletics (i)_____ the potential for a spectacle. The crowd (ii)_____ with bated breath as the Olympian artist twists his body, stretching the javelin behind him. Twelve strides in, he begins to cross-step. Six cross-steps (iii)_____ in an abrupt stop on his left foot. As his body (iv)_____ like a door turning on a hinge, the javelin is launched skyward at a precise angle.

(A)	(i) hold	(ii) waits	(iii) culminates	(iv) pivot
(B)	(i) holds	(ii) wait	(iii) culminates	(iv) pivot
(C)	(i) hold	(ii) wait	(iii) culminate	(iv) pivots
(D)	(i) holds	(ii) waits	(iii) culminate	(iv) pivots

Q.7 Three distinct sets of indistinguishable twins are to be seated at a circular table that has 8 identical chairs. Unique seating arrangements are defined by the relative positions of the people.

How many unique seating arrangements are possible such that each person is sitting next to their twin?

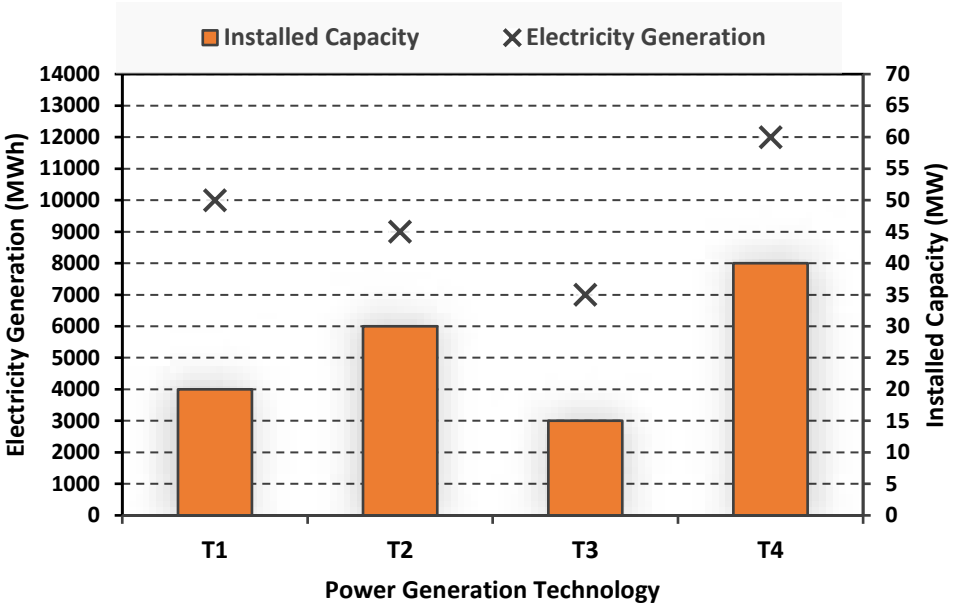
(A) 12

(B) 14

(C) 10

(D) 28

Q.8 The chart given below compares the Installed Capacity (MW) of four power generation technologies, T1, T2, T3, and T4, and their Electricity Generation (MWh) in a time of 1000 hours (h).



The Capacity Factor of a power generation technology is:

$$\text{Capacity Factor} = \frac{\text{Electricity Generation (MWh)}}{\text{Installed Capacity (MW)} \times 1000\ \text{(h)}}$$

Which one of the given technologies has the highest Capacity Factor?

(A) T1

(B) T2

(C) T3

(D) T4

Q.9 In the 4 × 4 array shown below, each cell of the first three columns has either a cross (X) or a number, as per the given rule.

1	1	2	
2	X	3	
2	X	4	
1	2	X	

Rule: The number in a cell represents the count of crosses around its immediate neighboring cells (left, right, top, bottom, diagonals).

As per this rule, the **maximum** number of crosses possible in the empty column is

(A) 0

(B) 1

(C) 2

(D) 3

Q.10 During a half-moon phase, the Earth-Moon-Sun form a right triangle. If the Moon-Earth-Sun angle at this half-moon phase is measured to be 89.85°, the ratio of the Earth-Sun and Earth-Moon distances is closest to

(A) 328

(B) 382

(C) 238

(D) 283

Q.11 – Q.35 Carry ONE mark Each

Q.11 The smallest positive root of the equation

$$x^5 - 5\,x^4 - 10\,x^3 + 50\,x^2 + 9\,x - 45 = 0$$

lies in the range

(A) $0 < x \leq 2$

(B) $2 < x \leq 4$

(C) $6 \leq x \leq 8$

(D) $10 \leq x \leq 100$

Q.12 The second-order differential equation in an unknown function $u: u(x, y)$ is defined as

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

Assuming $g: g(x), f: f(y)$, and $h: h(y)$, the general solution of the above differential equation is

(A) $u = x^2 + f(y) + g(x)$

(B) $u = x^2 + x\,f(y) + h(y)$

(C) $u = x^2 + x\,f(y) + g(x)$

(D) $u = x^2 + f(y) + y\,g(x)$

Q.13 The probability that a student passes only in Mathematics is $\frac{1}{3}$. The probability that the student passes only in English is $\frac{4}{9}$. The probability that the student passes in both of these subjects is $\frac{1}{6}$. The probability that the student will pass in at least one of these two subjects is

(A) $\frac{17}{18}$

(B) $\frac{11}{18}$

(C) $\frac{14}{18}$

(D) $\frac{1}{18}$

Q.14 The three-dimensional state of stress at a point is given by

$$\sigma = \begin{pmatrix} 10 & 0 & 0 \\ 0 & 40 & 0 \\ 0 & 0 & 0 \end{pmatrix} \text{MPa.}$$

The maximum shear stress at the point is

(A) 20 MPa

(B) 15 MPa

(C) 5 MPa

(D) 25 MPa

Q.15 Concrete of characteristic strength 30 MPa is required. If 40 specimens of concrete cubes are to be tested, the minimum number of specimens having at least 30 MPa strength should be

(A) 35

(B) 37

(C) 38

(D) 39

Q.16 Consider the statements P and Q.

P: Client's Preliminary Estimate is used for budgeting costs toward the end of planning and design phase.

Q: Client's Detailed Estimate is used for controlling costs during the execution of the project.

Which one of the following options is CORRECT?

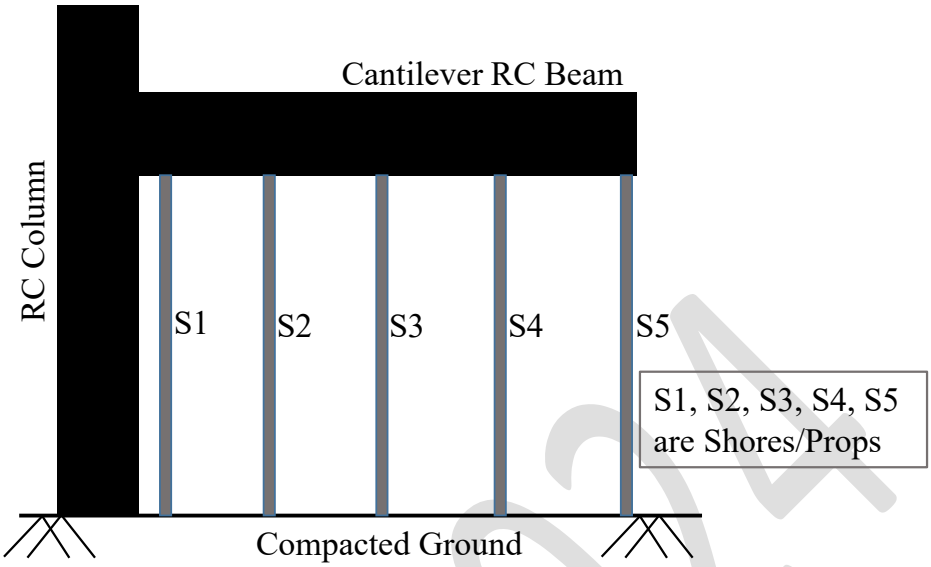
(A) Both P and Q are TRUE

(B) P is TRUE and Q is FALSE

(C) Both P and Q are FALSE

(D) P is FALSE and Q is TRUE

Q.17 The following figure shows the arrangement of formwork for casting a cantilever RC beam.



The correct sequence of removing the Shores/Props is

(A) S1→S2→S3→S4→S5

(B) S5→S4→S3→S2→S1

(C) S3→S2→S4→S1→S5

(D) S3→S4→S2→S5→S1

Q.18 A 2 m wide strip footing is founded at a depth of 1.5 m below the ground level in a homogeneous pure clay bed. The clay bed has unit cohesion of 40 kPa. Due to seasonal fluctuations of water table from peak summer to peak monsoon period, the net ultimate bearing capacity of the footing, as per Terzaghi's theory, will

(A) remain the same

(B) decrease

(C) increase

(D) become zero

Q.19 Consider the statements P and Q.

P: Soil particles formed by mechanical weathering, and close to their origin are generally subrounded.

Q: Activity of the clay physically signifies its swell potential.

Which one of the following options is CORRECT?

(A) Both P and Q are TRUE

(B) P is TRUE and Q is FALSE

(C) Both P and Q are FALSE

(D) P is FALSE and Q is TRUE

Q.20 The number of degrees of freedom for a natural open channel flow with a mobile bed is

(A) 2

(B) 3

(C) 4

(D) 5

Q.21 The following table gives various components of Municipal Solid Waste (MSW) and a list of treatment/separation techniques.

Component of MSW	Treatment/separation technique
P - Ferrous metals	i - Incineration
Q - Aluminum and copper	ii - Rapid composting
R - Food waste	iii - Eddy current separator
S - Cardboard	iv - Magnetic separator

The CORRECT match is

(A) P-iii, Q-iv, R-i, S-ii

(B) P-iv, Q-iii, R-ii, S-i

(C) P-iii, Q-iv, R-ii, S-i

(D) P-iv, Q-iii, R-i, S-ii

Q.22 A car is travelling at a speed of 60 km/hr on a section of a National Highway having a downward gradient of 2%. The driver of the car suddenly observes a stopped vehicle on the car path at a distance 130 m ahead, and applies brake. If the brake efficiency is 60%, coefficient of friction is 0.7, driver's reaction time is 2.5 s, and acceleration due to gravity is 9.81 m/s^2, the distance (in meters) required by the driver to bring the car to a safe stop lies in the range

(A) 126 to 130

(B) 41 to 45

(C) 33 to 37

(D) 75 to 79

Q.23 As per the International Civil Aviation Organization (ICAO), the basic runway length is increased by x (%) for every y (m) raise in elevation from the Mean Sea Level (MSL). The values of x and y, respectively, are

(A) 7% and 300 m

(B) 5% and 200 m

(C) 4% and 500 m

(D) 10% and 1000 m

Q.24 Which one of the following statements related to bitumen is FALSE?

(A) Kinematic viscosity is a measure of resistance to the flow of molten bitumen under gravity.

(B) Softer grade bitumen possesses higher softening point than hard grade bitumen.

(C) Flash point of bitumen is the lowest temperature at which application of a test flame causes vapours of the bitumen to catch an instant fire in the form of flash under specified test conditions.

(D) Ductility test is carried out on bitumen to test its adhesive property and ability to stretch.

Q.25 If the number of sides resulting in a closed traverse is increased from three to four, the sum of the interior angles increases by

(A) 90^{o}

(B) 180^{o}

(C) 270^{o}

(D) 360^{o}

Q.26 A surveyor observes a zenith angle of $93^{o}\ 00'\ 00''$ during a theodolite survey. The corresponding vertical angle is

(A) $-\ 03^{o}\ 00'\ 00''$

(B) $+\ 03^{o}\ 00'\ 00''$

(C) $-\ 87^{o}\ 00'\ 00''$

(D) $+\ 87^{o}\ 00'\ 00''$

Q.27 Among the following statements relating the fundamental lines of a transit theodolite, which one is CORRECT?

(A) The line of collimation must be perpendicular to the horizontal axis at its intersection with the vertical axis.

(B) The axis of altitude level must be perpendicular to the line of collimation.

(C) The axis of plate level must lie in a plane parallel to the vertical axis.

(D) The Vernier of vertical circle must read zero when the line of collimation is vertical.

Q.28 For the following partial differential equation,

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

which of the following option(s) is/are CORRECT?

(A) elliptic for $x > 0$ and $y > 0$

(B) parabolic for $x > 0$ and $y > 0$

(C) elliptic for $x = 0$ and $y > 0$

(D) hyperbolic for $x < 0$ and $y > 0$

Q.29 The elements that DO NOT increase the strength of structural steel are

(A) Carbon

(B) Manganese

(C) Sulphur

(D) Chlorine

Q.30 Consider a balanced doubly-reinforced concrete section. If the material and other sectional properties remain unchanged, for which of the following cases will the section becomes under-reinforced?

(A) Area of tension reinforcement is increased.

(B) Area of compression reinforcement is increased.

(C) Area of tension reinforcement is decreased.

(D) Area of compression reinforcement is decreased.

Q.31 The primary air pollutant(s) is/are

(A) Sulphur dioxide

(B) Lead

(C) Ozone

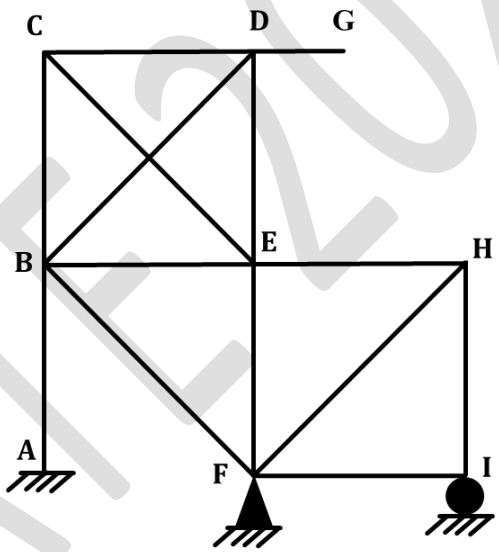
(D) Sulphuric acid

Q.32 Consider the data of $f(x)$ given in the table.

i	0	1	2
x_i	1	2	3
$f(x_i)$	0	0.3010	0.4771

The value of $f(1.5)$ estimated using second-order Newton's interpolation formula is _____ (*rounded off to 2 decimal places*).

Q.33 The plane frame shown in the figure has fixed support at joint A, hinge support at joint F, and roller support at joint I. In the figure, A to I indicate joints of the frame.



If the axial deformations are neglected, the degree of kinematic indeterminacy is _____ (*in integer*).

Q.34 An embankment is constructed with soil by maintaining the degree of saturation as 75% during compaction. The specific gravity of soil is 2.68 and the moisture content is 17% during compaction. Consider the unit weight of water as 10 kN/m^3. The dry unit weight (in kN/m^3) of the compacted soil is _____ (*rounded off to 2 decimal places*).

Q.35 A 30 cm diameter well fully penetrates an unconfined aquifer of saturated thickness 20 m with hydraulic conductivity of 10 m/day. Under the steady pumping rate for a long time, the drawdowns in two observation wells located at 10 m and 100 m from the pumping well are 5 m and 1 m, respectively. The corresponding pumping rate (in m^3/day) from the well is _____ (*rounded off to 2 decimal places*).

Q.36 – Q.65 Carry TWO marks Each

Q.36 What are the eigenvalues of the matrix $\begin{bmatrix} 2 & 1 & 1 \\ 1 & 4 & 1 \\ 1 & 1 & 2 \end{bmatrix}$?

(A) $1, 2, 5$

(B) $1, 3, 4$

(C) $-5, 1, 2$

(D) $-5, -1, 2$

Q.37 A vector field $\vec{p}$ and a scalar field r are given by

$\vec{p} = (2x^2 - 3xy + z^2)\,\hat{\imath} + (2y^2 - 3yz + x^2)\,\hat{\jmath} + (2z^2 - 3xz + x^2)\,\hat{k}$

$r = 6x^2 + 4y^2 - z^2 - 9xyz - 2xy + 3xz - yz$

Consider the statements P and Q.

P: Curl of the gradient of the scalar field r is a null vector.

Q: Divergence of curl of the vector field $\vec{p}$ is zero.

Which one of the following options is CORRECT?

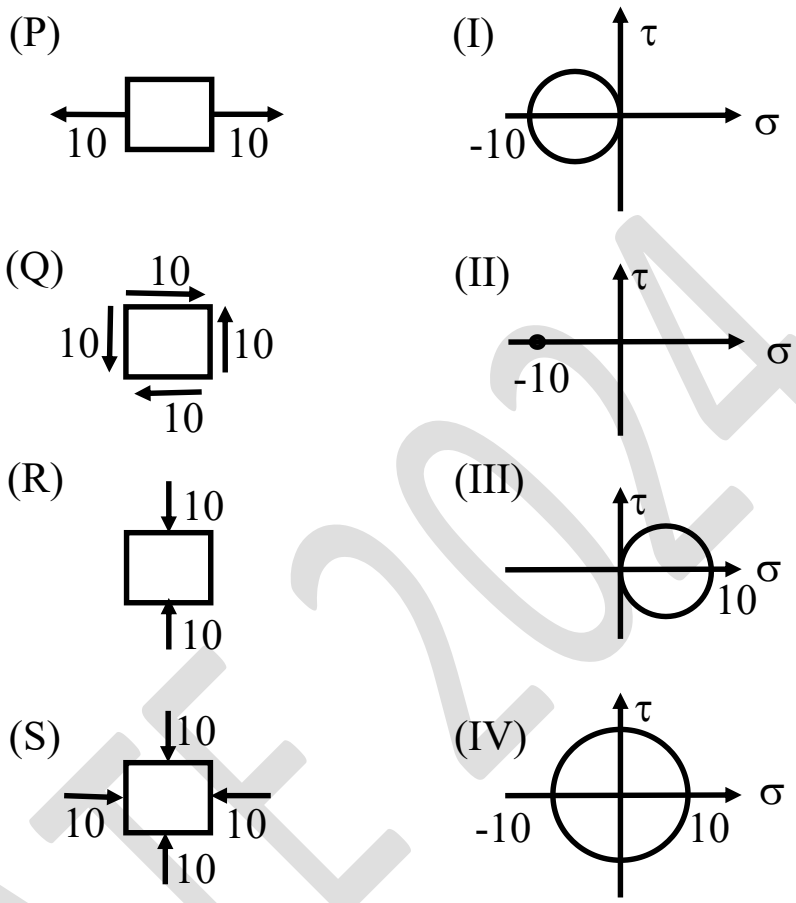
(A) Both P and Q are FALSE

(B) P is TRUE and Q is FALSE

(C) P is FALSE and Q is TRUE

(D) Both P and Q are TRUE

Q.38 Find the correct match between the plane stress states and the Mohr's circles.



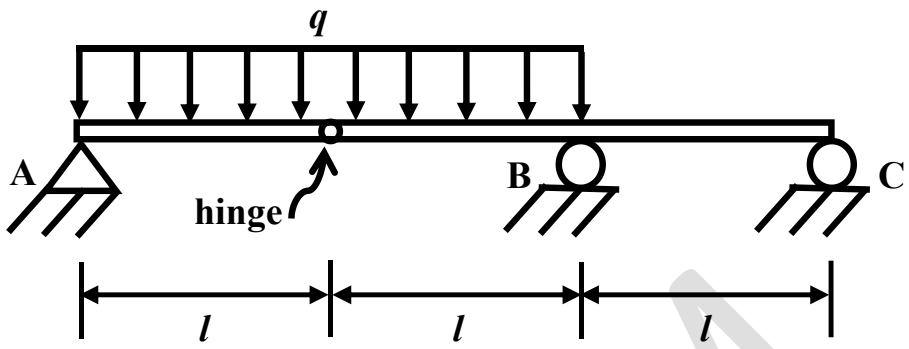
(A) (P)-(III); (Q)-(IV); (R)-(I); (S)-(II)

(B) (P)-(III); (Q)-(II); (R)-(I); (S)-(IV)

(C) (P)-(I); (Q)-(IV); (R)-(III); (S)-(II)

(D) (P)-(I); (Q)-(II); (R)-(III); (S)-(IV)

Q.39 The beam shown in the figure is subjected to a uniformly distributed downward load of intensity q between supports A and B.



Considering the upward reactions as positive, the support reactions are

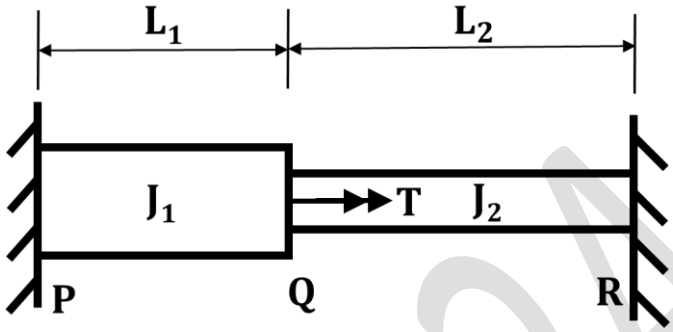
(A) $R_A = \frac{ql}{2}$; $R_B = \frac{5ql}{2}$; $R_C = -ql$

(B) $R_A = -ql$; $R_B = \frac{5ql}{2}$; $R_C = \frac{ql}{2}$

(C) $R_A = -\frac{ql}{2}$; $R_B = \frac{5ql}{2}$; $R_C = 0$

(D) $R_A = \frac{ql}{2}$; $R_B = ql$; $R_C = \frac{ql}{2}$

Q.40 A homogeneous shaft PQR with fixed supports at both ends is subjected to a torsional moment T at point Q, as shown in the figure. The polar moments of inertia of the portions PQ and QR of the shaft with circular cross-sections are J_1 and J_2, respectively. The torsional moment reactions at the supports P and R are T_P and T_R, respectively.



(Figure NOT to scale)

If $T_P/T_R = 4$ and $J_1/J_2 = 2$, the ratio of the lengths L_1/L_2 is

(A) 0.50

(B) 0.25

(C) 4.00

(D) 2.00

Q.41 A vertical smooth rigid retaining wall is supporting horizontal ground with dry cohesionless backfill having a friction angle of 30°. The inclinations of failure planes with respect to the major principal plane for Rankine's active and passive earth pressure conditions, respectively, are

(A) 30° and 30°

(B) 60° and 60°

(C) 30° and 60°

(D) 60° and 30°

Q.42 A flow velocity field $\vec{V}$: $\vec{V}(x, y)$ for a fluid is represented by

$$\vec{V} = 3\,\hat{\imath} + (5x)\,\hat{\jmath}$$

In the context of the fluid and the flow, which one of the following statements is CORRECT?

(A) The fluid is incompressible and the flow is rotational.

(B) The fluid is incompressible and the flow is irrotational.

(C) The fluid is compressible and the flow is rotational.

(D) The fluid is compressible and the flow is irrotational.

Q.43 For assessing the compliance with the emissions standards of incineration plants, a correction needs to be applied to the measured concentrations of air pollutants. The emission standard (based on 11% Oxygen) for HCl is 50 mg/Nm^3 and the measured concentrations of HCl and Oxygen in flue gas are 42 mg/Nm^3 and 13%, respectively.

Assuming 21% Oxygen in air, the CORRECT statement is:

(A) No compliance, as the corrected HCl emission is greater than the emission standard.

(B) Compliance is there, as the corrected HCl emission is lesser than the emission standard.

(C) Compliance is there, as there is no need to apply the correction since Oxygen is greater than 11% and HCl emission is lesser than the emission standard.

(D) No compliance, as the Oxygen is greater than 11% in the flue gas.

Q.44 The free mean speed is 60 km/hr on a given road. The average space headway at jam density on this road is 8 m. For a linear speed-density relationship, the maximum flow (in veh/hr/lane) expected on the road is

(A) 1875

(B) 938

(C) 2075

(D) 1038

Q.45 A map is prepared with a scale of 1: 1000 and a contour interval of 1 m. If the distance between two adjacent contours on the map is 10 mm, the slope of the ground between the adjacent contours is

(A) 30%

(B) 10%

(C) 35%

(D) 40%

Q.46 Which of the following statement(s) is/are CORRECT?

(A) Swell potential of soil decreases with an increase in the shrinkage limit.

(B) Both loose and dense sands with different initial void ratios can attain similar void ratio at large strain during shearing.

(C) Among the several corrections to be applied to the SPT-N value, the dilatancy correction is applied before all other corrections.

(D) In electrical resistivity tomography, the depth of current penetration is half of the spacing between the electrodes.

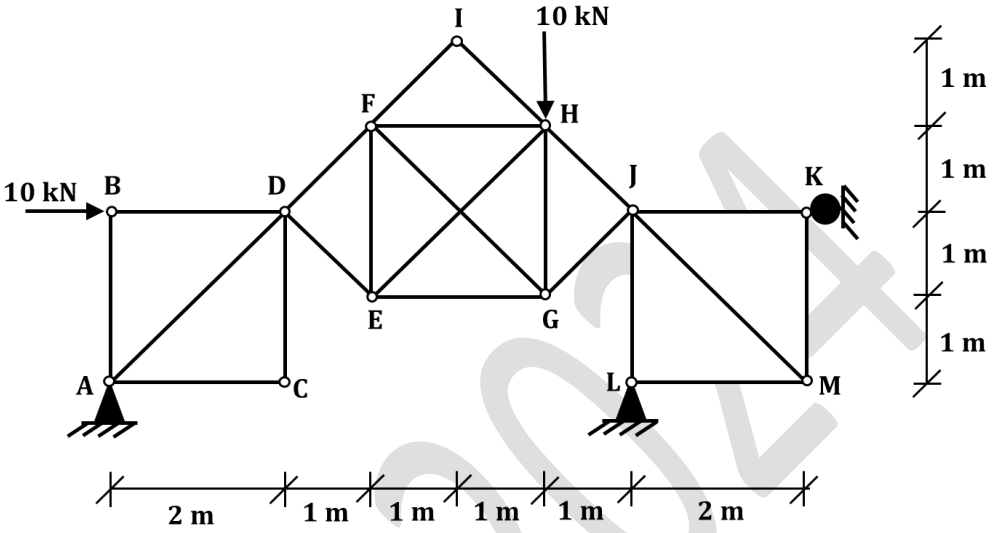
Q.47 The return period of a large earthquake for a given region is 200 years. Assuming that earthquake occurrence follows Poisson's distribution, the probability that it will be exceeded at least once in 50 years is _____ %
(*rounded off to the nearest integer*).

Q.48 A 2 m × 2 m tank of 3 m height has inflow, outflow and stirring mechanisms. Initially, the tank was half-filled with fresh water. At t = 0, an inflow of a salt solution of concentration 5 g/m^3 at the rate of 2 litre/s and an outflow of the well stirred mixture at the rate of 1 litre/s are initiated. This process can be modelled using the following differential equation:

$$\frac{dm}{dt} + \frac{m}{6000 + t} = 0.01$$

where m is the mass (grams) of the salt at time t (seconds). The mass of the salt (in grams) in the tank at 75% of its capacity is _____
(*rounded off to 2 decimal places*).

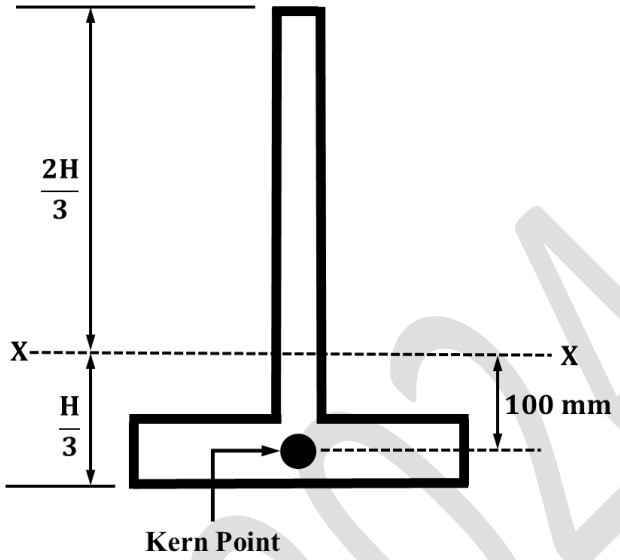
Q.49 The plane truss shown in the figure has 13 joints and 22 members. The truss is made of a homogeneous, prismatic, linearly elastic material. All members have identical axial rigidity. A to M indicate the joints of the truss. The truss has pin supports at joints A and L and roller support at joint K. The truss is subjected to a 10 kN vertically downward force at joint H and a 10 kN horizontal force in the rightward direction at joint B as shown.



(Figure NOT to scale)

The magnitude of the reaction (in kN) at the pin support L is _____ (*rounded off to 1 decimal place*).

Q.50 An inverted T-shaped concrete beam (B1) in the figure, with centroidal axis X – X, is subjected to an effective prestressing force of 1000 kN acting at the bottom kern point of the beam cross-section. Also consider an identical concrete beam (B2) with the same grade of concrete but without any prestressing force.



(Figure NOT to scale)

The additional cracking moment (in kN. m) that can be carried by beam B1 in comparison to beam B2 is _____ (*rounded off to the nearest integer*).

Q.51 The initial cost of an equipment is Rs. 1,00,000. Its salvage value at the end of accounting life of 5 years is Rs. 10,000. The difference in depreciation (in Rs.) computed using 'double-declining balance method' and 'straight line method' of depreciation in Year-2 is _____ (*in positive integer*).

Q.52 A slab panel with an effective depth of 250 mm is reinforced with 0.2% main reinforcement using 8 mm diameter steel bars. The uniform center-to-center spacing (in mm) at which the 8 mm diameter bars are placed in the slab panel is _____ (*rounded off to the nearest integer*).

Q.53 The total primary consolidation settlement (S_c) of a building constructed on a 10 m thick saturated clay layer is estimated to be 50 mm. After 300 days of the construction of the building, primary consolidation settlement was reported as 10 mm. The additional time (in days) required to achieve 50% of S_c will be _____ (*rounded off to the nearest integer*).

Q.54 An infinite slope is made up of cohesionless soil with seepage parallel to and up to the sloping surface. The angle of slope is 30° with respect to horizontal ground surface. The unit weights of the saturated soil and water are 20 kN/m^3 and 10 kN/m^3, respectively.

The minimum angle of shearing resistance of the soil (in degrees) for the critically stable condition of the slope is _____ (*rounded off to the nearest integer*).

Q.55 A soil sample was consolidated at a cell pressure of 20 kPa and a back pressure of 10 kPa for 24 hours during a consolidated undrained (CU) triaxial test. The cell pressure was increased to 30 kPa on the next day and it resulted in the development of pore water pressure of 1 kPa. The soil sample failed when the axial stress was gradually increased to 50 kPa. The pore water pressure at failure was recorded as 21 kPa. The value of Skempton's pore pressure parameter *B* for the soil sample is _____ (*rounded off to 2 decimal places*).

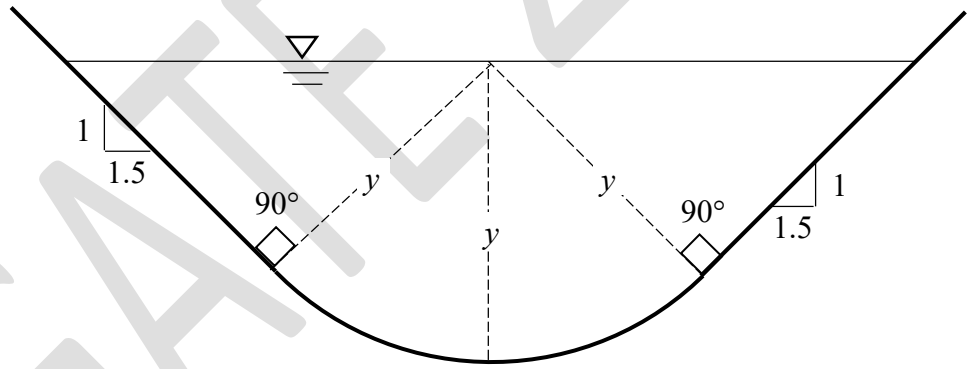
Q.56 The ordinates of a 1-hour unit hydrograph (UH) are given below.

Time (hours)	0	1	2	3	4	5
Ordinates of 1-hour UH (m^3/s)	0	13	50	80	95	85

Time (hours)	6	7	8	9	10	11
Ordinates of 1-hour UH (m^3/s)	55	35	15	10	3	0

These ordinates are used to derive a 3-hour UH. The peak discharge (in m^3/s) for the derived 3-hour UH is _____ (*rounded off to the nearest integer*).

Q.57 A standard round bottom triangular canal section as shown in the figure has a bed slope of 1 in 200. Consider the Chezy's coefficient as 150 $m^{1/2}/s$.

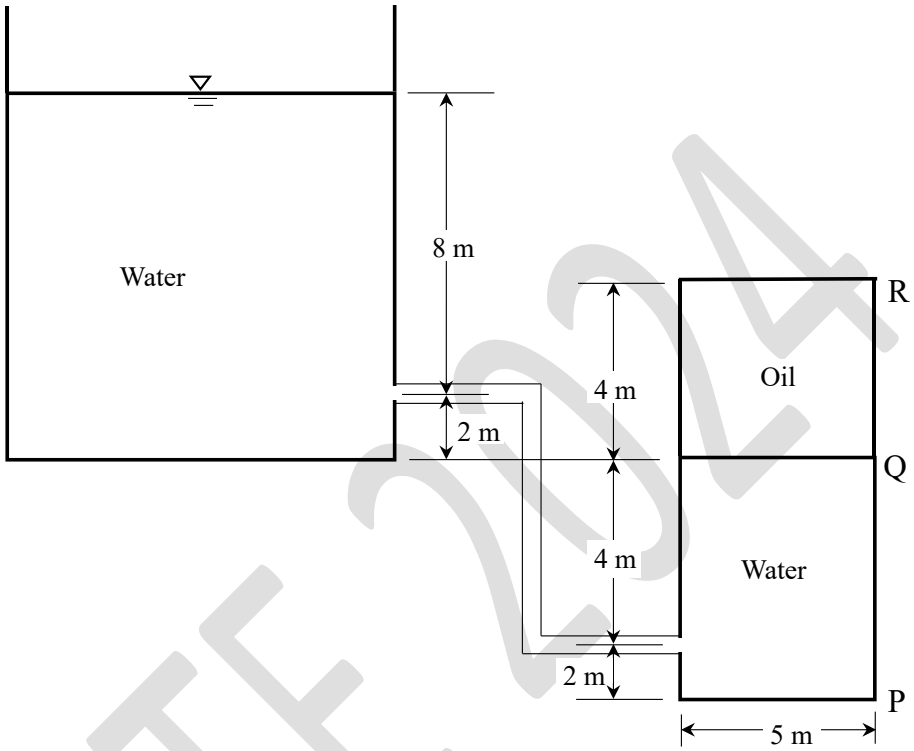


(Figure NOT to scale)

The normal depth of flow, y (in meters) for carrying a discharge of 20 m^3/s is _____ (*rounded off to 2 decimal places*).

Q.58 A spillway has unit discharge of 7.5 $m^3/s/m$. The flow depth at the downstream horizontal apron is 0.5 m. The tail water depth (in meters) required to form a hydraulic jump is _____ (*rounded off to 2 decimal places*).

Q.59 A 5 m × 5 m closed tank of 10 m height contains water and oil, and is connected to an overhead water reservoir as shown in the figure. Use γ_w = 10 kN/m^3 and Specific gravity of oil = 0.8.



(Figure NOT to scale)

The total force (in kN) due to pressure on the side PQR of the tank is _____ (*rounded off to the nearest integer*).

Q.60 Activated carbon is used to remove a pollutant from wastewater in a mixed batch reactor, which follows first-order reaction kinetics.

At a reaction rate of 0.38 /day, the time (in days) required to remove the pollutant by 95% is _____ (*rounded off to 1 decimal place*).

Q.61 A water treatment plant treats 25 MLD water with a natural alkalinity of 4.0 mg/L (as $CaCO_3$). It is estimated that, during coagulation of this water, 450 kg/day of calcium bicarbonate ($Ca(HCO_3)_2$) is required based on the alum dosage.

Consider the atomic weights as: Ca-40, H-1, C-12, O-16.

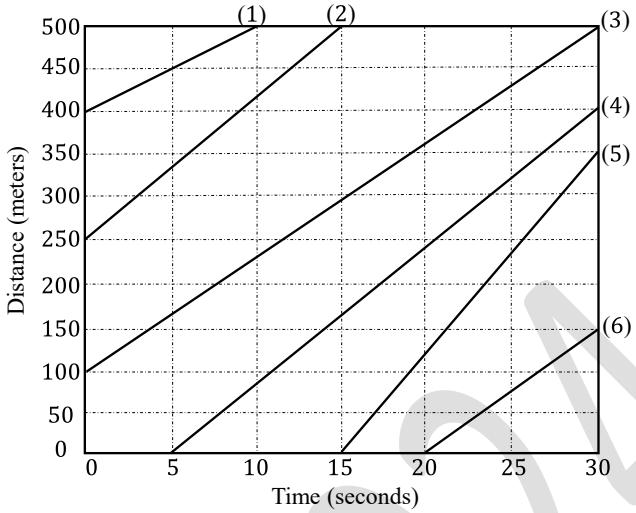
The quantity of pure quick lime, CaO (in kg) required for this process per day is_____ (*rounded off to 2 decimal places*).

Q.62 The number of trains and their corresponding speeds for a curved Broad Gauge section with 437 m radius, are

- 20 trains travel at a speed of 40 km/hr
- 15 trains travel at a speed of 50 km/hr
- 12 trains travel at a speed of 60 km/hr
- 8 trains travel at a speed of 70 km/hr
- 3 trains travel at a speed of 80 km/hr

If the gauge (center-to-center distance between the rail heads) is taken as 1750 mm, the required equilibrium cant (in mm) will be _____ (*rounded off to the nearest integer*).

Q.63 The figure presents the trajectories of six vehicles within a time-space domain. The number in the parentheses represents unique identification of each vehicle.



(Figure NOT to scale)

The mean speed (in km/hr) of the vehicles in the entire time-space domain is _____ (*rounded off to the nearest integer*).

Q.64 The following data is obtained from an axle load survey at a site:

Average rear axle load = 12000 kg
Number of commercial vehicles = 800 per day

The pavement at this site would be reconstructed over a period of 5 years from the date of survey. The design life of the reconstructed pavement is 15 years. Use the standard axle load as 8160 kg and the annual average vehicle growth rate as 4.0%. Assume that Equivalent Wheel Load Factor (EWLF) and Vehicle Damage Factor (VDF) are equal.

The cumulative standard axle (in msa) for the pavement design is _____ (*rounded off to 2 decimal places*).

Q.65 A bird is resting on a point P at a height of 8 m above the Mean Sea Level (MSL). Upon hearing a loud noise, the bird flies parallel to the ground surface and reaches a point Q which is located at a height of 3 m above MSL. The ground surface has a falling gradient of 1 in 2. Ignoring the effects of curvature and refraction, the horizontal distance (in meters) between points P and Q is _____ (*in integer*).

General Aptitude (GA)

Q.1 – Q.5 Carry ONE mark Each

Q.1 If '→' denotes increasing order of intensity, then the meaning of the words [drizzle → rain → downpour] is analogous to [_____ → quarrel → feud]. Which one of the given options is appropriate to fill the blank?

(A) bicker

(B) bog

(C) dither

(D) dodge

Q.2 Statements:

1. All heroes are winners.
2. All winners are lucky people.

Inferences:

I. All lucky people are heroes.
II. Some lucky people are heroes.
III. Some winners are heroes.

Which of the above inferences can be logically deduced from statements 1 and 2?

(A) Only I and II

(B) Only II and III

(C) Only I and III

(D) Only III

Q.3 A student was supposed to **multiply** a positive real number p with another positive real number q. Instead, the student **divided** p by q. If the percentage error in the student's answer is 80%, the value of q is

(A) 5

(B) $\sqrt{2}$

(C) 2

(D) $\sqrt{5}$

Q.4 If the sum of the first 20 consecutive positive odd numbers is divided by 20^2, the result is

(A) 1

(B) 20

(C) 2

(D) 1/2

Q.5 The ratio of the number of girls to boys in class VIII is the same as the ratio of the number of boys to girls in class IX. The total number of students (boys and girls) in classes VIII and IX is 450 and 360, respectively. If the number of girls in classes VIII and IX is the same, then the number of girls in each class is

(A) 150

(B) 200

(C) 250

(D) 175

Q.6 – Q.10 Carry TWO marks Each

Q.6 In the given text, the blanks are numbered (i)–(iv). Select the best match for all the blanks.

Yoko Roi stands (i) _____ as an author for standing (ii) _____ as an honorary fellow, after she stood (iii) _____ her writings that stand (iv) _____ the freedom of speech.

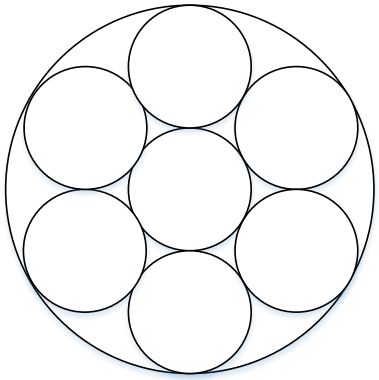
(A) (i) out (ii) down (iii) in (iv) for

(B) (i) down (ii) out (iii) by (iv) in

(C) (i) down (ii) out (iii) for (iv) in

(D) (i) out (ii) down (iii) by (iv) for

Q.7 Seven identical cylindrical chalk-sticks are fitted tightly in a cylindrical container. The figure below shows the arrangement of the chalk-sticks inside the cylinder.



The length of the container is equal to the length of the chalk-sticks. The ratio of the occupied space to the empty space of the container is

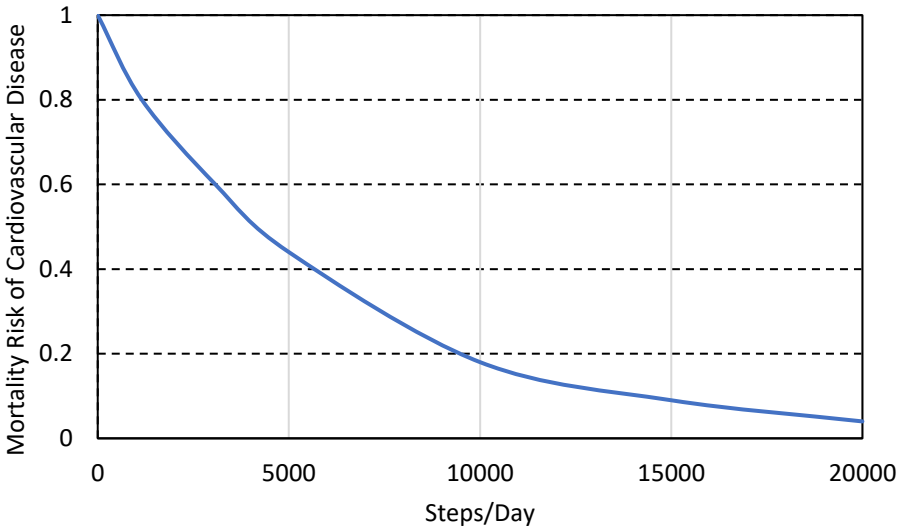
(A) 5/2

(B) 7/2

(C) 9/2

(D) 3

Q.8 The plot below shows the relationship between the mortality risk of cardiovascular disease and the number of steps a person walks per day. Based on the data, which one of the following options is true?



(A) The risk reduction on increasing the steps/day from 0 to 10000 is less than the risk reduction on increasing the steps/day from 10000 to 20000.

(B) The risk reduction on increasing the steps/day from 0 to 5000 is less than the risk reduction on increasing the steps/day from 15000 to 20000.

(C) For any 5000 increment in steps/day the largest risk reduction occurs on going from 0 to 5000.

(D) For any 5000 increment in steps/day the largest risk reduction occurs on going from 15000 to 20000.

Q.9 Five cubes of identical size and another smaller cube are assembled as shown in Figure A. If viewed from direction X, the planar image of the assembly appears as Figure B.

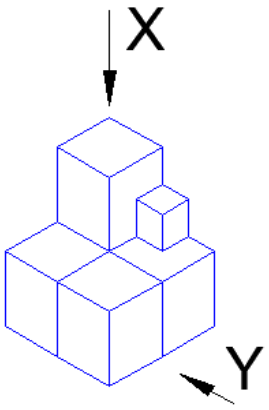


Figure A

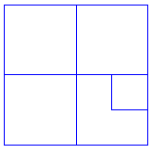
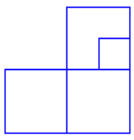
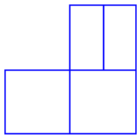
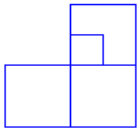


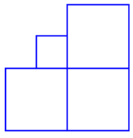
Figure B

If viewed from direction Y, the planar image of the assembly (Figure A) will appear as

(A) 

(B) 

(C) 

(D) 

Q.10 Visualize a cube that is held with one of the four body diagonals aligned to the vertical axis. Rotate the cube about this axis such that its view remains unchanged. The magnitude of the minimum angle of rotation is

(A) 120°

(B) 60°

(C) 90°

(D) 180°

Q.11 – Q.35 Carry ONE mark Each

Q.11 A partial differential equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$$

is defined for the two-dimensional field $T: T(x, y)$, inside a planar square domain of size 2 m × 2 m. Three boundary edges of the square domain are maintained at value $T = 50$, whereas the fourth boundary edge is maintained at $T = 100$.

The value of T at the center of the domain is

(A) 50.0

(B) 62.5

(C) 75.0

(D) 87.5

Q.12 The statements P and Q are related to matrices **A** and **B**, which are conformable for both addition and multiplication.

P: $(\mathbf{A}+\mathbf{B})^{\mathrm{T}} = \mathbf{A}^{\mathrm{T}} + \mathbf{B}^{\mathrm{T}}$

Q: $(\mathbf{AB})^{\mathrm{T}} = \mathbf{A}^{\mathrm{T}}\mathbf{B}^{\mathrm{T}}$

Which one of the following options is CORRECT?

(A) P is TRUE and Q is FALSE

(B) Both P and Q are TRUE

(C) P is FALSE and Q is TRUE

(D) Both P and Q are FALSE

Q.13 The second derivative of a function f is computed using the fourth-order Central Divided Difference method with a step length h.

The CORRECT expression for the second derivative is

(A) $\frac{1}{12h^2}\left[-f_{i+2}+16\,f_{i+1}-30\,f_i+16\,f_{i-1}-\,f_{i-2}\,\right]$

(B) $\frac{1}{12h^2}\left[\,f_{i+2}+16\,f_{i+1}-30\,f_i+16\,f_{i-1}-\,f_{i-2}\,\right]$

(C) $\frac{1}{12h^2}\left[-f_{i+2}+16\,f_{i+1}-30\,f_i+16\,f_{i-1}+\,f_{i-2}\,\right]$

(D) $\frac{1}{12h^2}\left[-f_{i+2}-16\,f_{i+1}+30\,f_i-16\,f_{i-1}-\,f_{i-2}\,\right]$

Q.14 The function $f(x)=x^3-27x+4\,,\ 1\le x\le 6$ has

(A) Maxima point

(B) Minima point

(C) Saddle point

(D) Inflection point

Q.15 Consider two Ordinary Differential Equations (ODEs):

P: $\frac{dy}{dx} = \frac{x^4+3x^2y^2+2y^4}{x^3y}$

Q: $\frac{dy}{dx} = \frac{-y^2}{x^2}$

Which one of the following options is CORRECT?

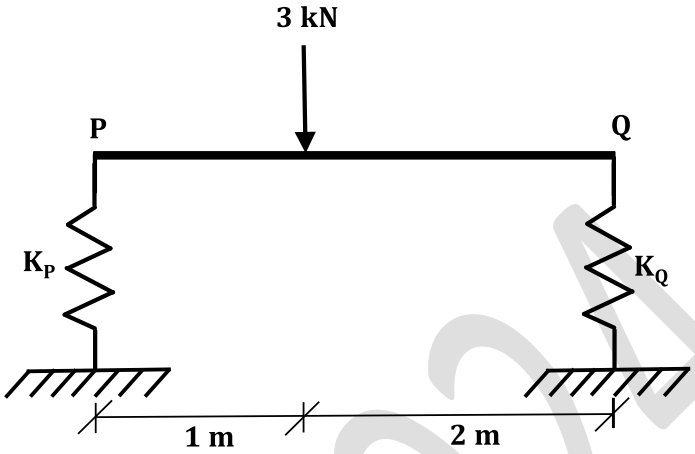
(A) P is a homogeneous ODE and Q is an exact ODE.

(B) P is a homogeneous ODE and Q is not an exact ODE.

(C) P is a nonhomogeneous ODE and Q is an exact ODE.

(D) P is a nonhomogeneous ODE and Q is not an exact ODE.

Q.16 A 3 m long, horizontal, rigid, uniform beam PQ has negligible mass. The beam is subjected to a 3 kN concentrated vertically downward force at 1 m from P, as shown in the figure. The beam is resting on vertical linear springs at the ends P and Q. For the spring at the end P, the spring constant $K_P = 100$ kN/m.



(Figure NOT to scale)

If the beam DOES NOT rotate under the application of the force and displaces only vertically, the value of the spring constant K_Q (in kN/m) for the spring at the end Q is

(A) 150

(B) 100

(C) 50

(D) 200

Q.17 Consider the statements P and Q.

P: In a Pure project organization, the project manager maintains complete authority and has maximum control over the project.

Q: A Matrix organization structure facilitates quick response to changes, conflicts, and project needs.

Which one of the following options is CORRECT?

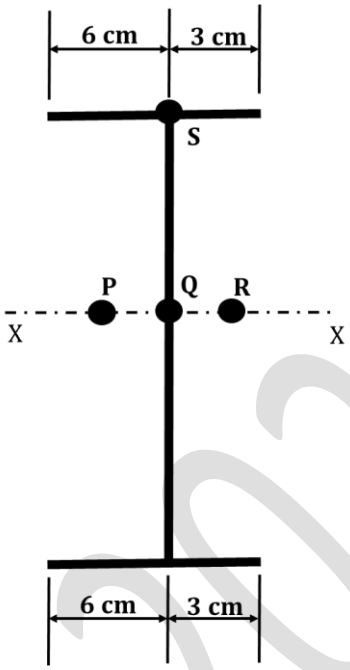
(A) Both P and Q are TRUE

(B) P is TRUE and Q is FALSE

(C) Both P and Q are FALSE

(D) P is FALSE and Q is TRUE

Q.18 For a thin-walled section shown in the figure, points P, Q , and R are located on the major bending axis X – X of the section. Point Q is located on the web whereas point S is located at the intersection of the web and the top flange of the section.



(Figure NOT to scale)

Qualitatively, the shear center of the section lies at

(A) P

(B) Q

(C) R

(D) S

Q.19 Consider the following data for a project of 300 days duration.

Budgeted Cost of Work Scheduled (BCWS) = Rs. 200
Budgeted Cost of Work Performed (BCWP) = Rs. 150
Actual Cost of Work Performed (ACWP) = Rs. 190

The 'schedule variance' for the project is

(A) (–)Rs. 50

(B) (–)50 days

(C) (+)Rs. 50

(D) (+)50 days

Q.20 A simply supported, uniformly loaded, two-way slab panel is torsionally unrestrained. The effective span lengths along the short span (x) and long span (y) directions of the panel are l_x and l_y, respectively. The design moments for the reinforcements along the x and y directions are M_{ux} and M_{uy}, respectively. By using Rankine-Grashoff method, the ratio M_{ux}/M_{uy} is proportional to

(A) l_x/l_y

(B) l_y/l_x

(C) $(l_x/l_y)^2$

(D) $(l_y/l_x)^2$

Q.21 The structural design method that DOES NOT take into account the safety factors on the design loads is

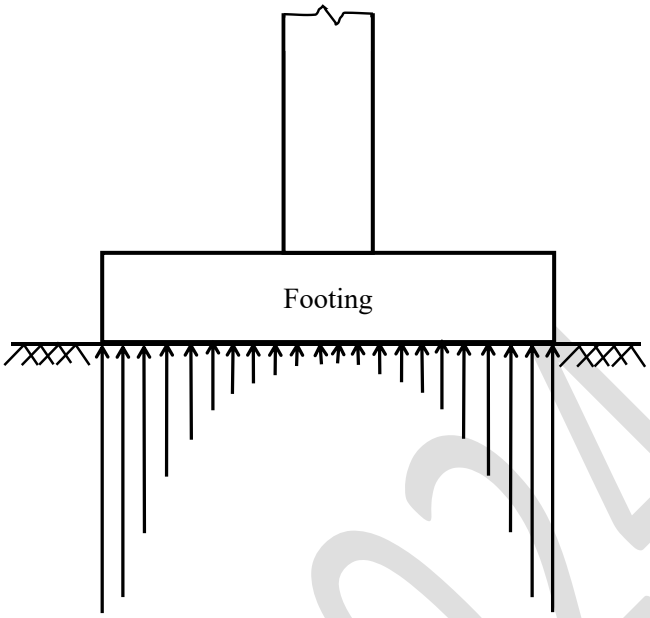
(A) working stress method.

(B) load factor method.

(C) ultimate load method.

(D) limit state method.

Q.22 The contact pressure distribution shown in the figure belongs to a



(A) rigid footing resting on a cohesionless soil.

(B) rigid footing resting on a cohesive soil.

(C) flexible footing resting on a cohesionless soil.

(D) flexible footing resting on a cohesive soil.

Q.23 Which one of the following saturated fine-grained soils can attain a negative Skempton's pore pressure coefficient (A)?

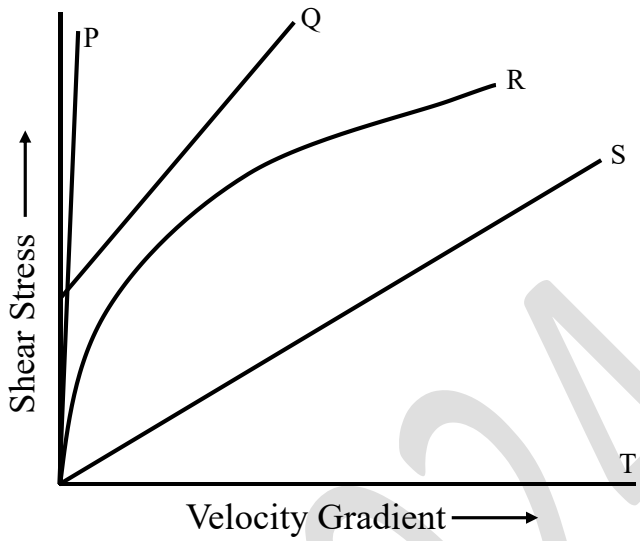
(A) Quick clays

(B) Normally-consolidated clays

(C) Lightly-consolidated clays

(D) Over-consolidated clays

Q.24 The following figure shows a plot between shear stress and velocity gradient for materials/fluids P, Q, R, S, and T.



Which one of the following options is CORRECT?

(A) P → Ideal Fluid; Q → Ideal Bingham plastic
R → Non-Newtonian fluid; S → Newtonian fluid

(B) P → Real solid; Q → Ideal Bingham plastic
S → Newtonian fluid; T → Ideal Fluid

(C) P → Ideal Fluid; Q → Ideal Bingham plastic
R → Non-Newtonian fluid; T → Real solid

(D) P → Real solid; Q → Newtonian fluid
R → Ideal Bingham plastic; T → Ideal Fluid

Q.25 What is the CORRECT match between the air pollutants and treatment techniques given in the table?

Air pollutants	**Treatment techniques**
P - NO_2	i - Flaring
Q - SO_2	ii - Cyclonic separator
R - CO	iii - Lime scrubbing
S - Particles	iv - NH_3 injection

(A) P-i, Q-ii, R-iii, S-iv

(B) P-ii, Q-i, R-iv, S-iii

(C) P-ii, Q-iii, R-iv, S-i

(D) P-iv, Q-iii, R-i, S-ii

Q.26 Which one of the following products is NOT obtained in anaerobic decomposition of glucose?

(A) CO_2

(B) CH_4

(C) H_2S

(D) H_2O

Q.27 The longitudinal sections of a runway have gradients as shown in the table.

End to end for sections of runway (m)	**Gradient** (%)
0 to 200	+1.0
200 to 600	−1.0
600 to 1200	+0.8
1200 to 1600	+0.2
1600 to 2000	−0.5

Consider the reduced level (RL) at the starting point of the runway as 100 m.

The effective gradient of the runway is

(A) 0.02%

(B) 0.35%

(C) 0.28%

(D) 0.18%

Q.28 In general, the outer edge is raised above the inner edge in horizontal curves for

(A) Highways, Railways, and Taxiways

(B) Highways and Railways only

(C) Railways and Taxiways only

(D) Highways only

Q.29 Various stresses in jointed plain concrete pavement with slab size of 3.5 m × 4.5 m are denoted as follows:

Wheel load stress at interior = S_{wl}^{i}
Wheel load stress at edge = S_{wl}^{e}
Wheel load stress at corner = S_{wl}^{c}
Warping stress at interior = S_{t}^{i}
Warping stress at edge = S_{t}^{e}
Warping stress at corner = S_{t}^{c}
Frictional stress between slab and supporting layer = S_f

The critical stress combination in the concrete slab during a summer midnight is

(A) $S_{wl}^{c} + S_{t}^{c}$

(B) $S_{wl}^{e} + S_{t}^{e} + S_f$

(C) $S_{wl}^{e} + S_{t}^{e} - S_f$

(D) $S_{wl}^{c} + S_{t}^{c} + S_f$

Q.30 For a reconnaissance survey, it is necessary to obtain vertical aerial photographs of a terrain at an average scale of 1: 13000 using a camera. If the permissible flying height is assumed as 3000 m above a datum and the average terrain elevation is 1050 m above the datum, the required focal length (in mm) of the camera is

(A) 100

(B) 150

(C) 125

(D) 200

Q.31 What is the CORRECT match between the survey instruments/parts of instruments shown in the table and the operations carried out with them?

Instruments/Parts of instruments	**Operations**
P - Bubble tube	i - Tacheometry
Q - Plumb bob	ii - Minor movements
R - Tangent screw	iii - Centering
S - Stadia cross-wire	iv - Levelling

(A) P-ii, Q-iii, R-iv, S-i

(B) P-iv, Q-iii, R-ii, S-i

(C) P-i, Q-iii, R-ii, S-iv

(D) P-iii, Q-iv, R-i, S-ii

Q.32 To finalize the direction of a survey, four surveyors set up a theodolite at a station P and performed all the temporary adjustments. From the station P, each of the surveyors observed the bearing to a tower located at station Q with the same instrument without shifting it. The bearings observed by the surveyors are $30^{o}\ 30'\ 00''$, $30^{o}\ 29'\ 40''$, $30^{o}\ 30'\ 20''$ and $30^{o}\ 31'\ 20''$. Assuming that each measurement is taken with equal precision, the most probable value of the bearing is

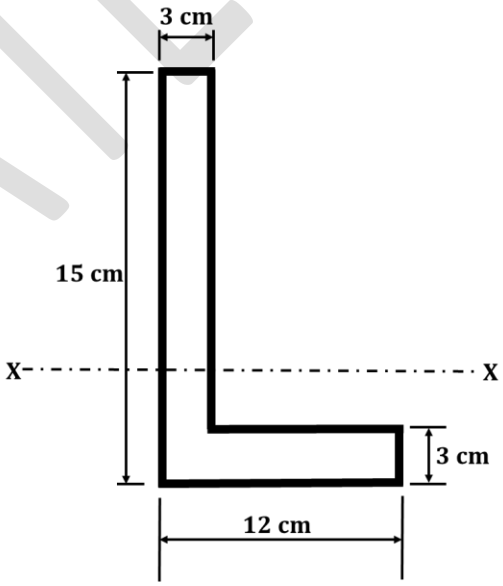
(A) $30^{o}\ 29'\ 40''$

(B) $30^{o}\ 30'\ 20''$

(C) $30^{o}\ 30'\ 00''$

(D) $30^{o}\ 31'\ 20''$

Q.33 The steel angle section shown in the figure has elastic section modulus of $150.92\ cm^3$ about the horizontal $X-X$ axis, which passes through the centroid of the section.



(Figure NOT to scale)

The shape factor of the section is _____ (*rounded off to 2 decimal places*).

Q.34 A reinforced concrete pile of 10 m length and 0.7 m diameter is embedded in a saturated pure clay with unit cohesion of 50 kPa. If the adhesion factor is 0.5, the net ultimate uplift pullout capacity (in kN) of the pile is _____ (*rounded off to the nearest integer*).

Q.35 A 2 m wide rectangular channel is carrying a discharge of 30 m^3/s at a bed slope of 1 in 300. Assuming the energy correction factor as 1.1 and acceleration due to gravity as 10 m/s^2, the critical depth of flow (in meters) is _____ (*rounded off to 2 decimal places*).

Q.36 – Q.65 Carry TWO marks Each

Q.36 In a sample of 100 heart patients, each patient has 80% chance of having a heart attack without medicine X. It is clinically known that medicine X reduces the probability of having a heart attack by 50%. Medicine X is taken by 50 of these 100 patients. The probability that a randomly selected patient, out of the 100 patients, takes medicine X and has a heart attack is

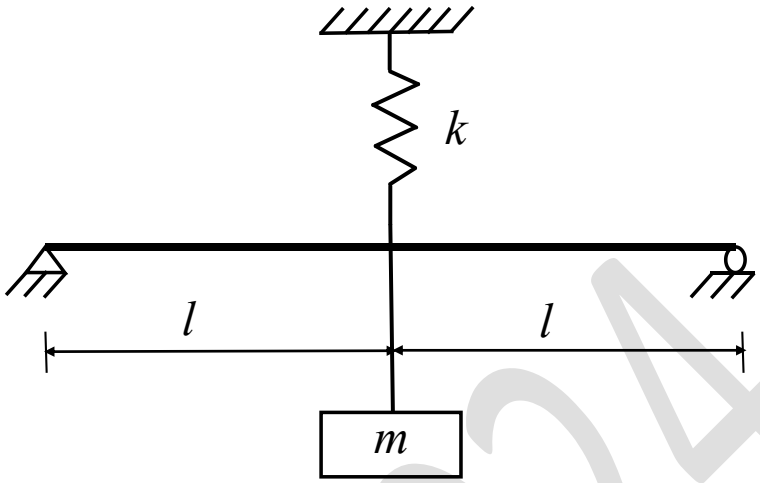
(A) 40%

(B) 60%

(C) 20%

(D) 30%

Q.37 A linearly elastic beam of length $2l$ with flexural rigidity EI has negligible mass. A massless spring with a spring constant k and a rigid block of mass m are attached to the beam as shown in the figure.



The natural frequency of this system is

(A) $\sqrt{\frac{kl^3 + 6EI}{ml^3}}$

(B) $\sqrt{\frac{kl^3 + 48EI}{ml^3}}$

(C) $\sqrt{\frac{6EIk}{(kl^3 + 6EI)m}}$

(D) $\sqrt{\frac{48EIk}{(kl^3 + 48EI)m}}$

Q.38 A critical activity in a project is estimated to take 15 days to complete at a cost of Rs. 30,000. The activity can be expedited to complete in 12 days by spending a total amount of Rs. 54,000. Consider the statements P and Q.

P: It is economically advisable to complete the activity early by crashing, if the indirect cost of the project is Rs. 8,500 per day.

Q: It is economically advisable to complete the activity early by crashing, if the indirect cost of the project is Rs. 10,000 per day.

Which one of the following options is CORRECT?

(A) Both P and Q are TRUE

(B) P is TRUE and Q is FALSE

(C) Both P and Q are FALSE

(D) P is FALSE and Q is TRUE

Q.39 A homogeneous, prismatic, linearly elastic steel bar fixed at both the ends has a slenderness ratio (l/r) of 105, where l is the bar length and r is the radius of gyration. The coefficient of thermal expansion of steel is 12×10^{-6} /°C. Consider the effective length of the steel bar as $0.5l$ and neglect the self-weight of the bar.

The differential increase in temperature (*rounded off to the nearest integer*) at which the bar buckles is

(A) 298 °C

(B) 85 °C

(C) 400 °C

(D) 250 °C

Q.40 Consider the statements P and Q related to the analysis/design of retaining walls.

P: When a rough retaining wall moves toward the backfill, the wall friction force/resistance mobilizes in upward direction along the wall.

Q: Most of the earth pressure theories calculate the earth pressure due to surcharge by neglecting the actual distribution of stresses due to surcharge.

Which one of the following options is CORRECT?

(A) Both P and Q are TRUE

(B) P is TRUE and Q is FALSE

(C) Both P and Q are FALSE

(D) P is FALSE and Q is TRUE

Q.41 A round-bottom triangular lined canal is to be laid at a slope of 1 in 1500, to carry a discharge of 25 m^3/s. The side slopes of the canal cross-section are to be kept at 1.25H : 1V. If Manning's roughness coefficient is 0.013, the flow depth (in meters) will be in the range of

(A) 2.39 to 2.42

(B) 1.94 to 1.97

(C) 2.24 to 2.27

(D) 2.61 to 2.64

Q.42 A hypothetical multimedia filter, consisting of anthracite particles (specific gravity: 1.50), silica sand (specific gravity: 2.60), and ilmenite sand (specific gravity: 4.20), is to be designed for treating water/wastewater. After backwashing, the particles should settle forming three layers: coarse anthracite particles at the top of the bed, silica sand in the middle, and small ilmenite sand particles at the bottom of the bed.

Assume
(i) Slow discrete settling (Stoke's law is applicable)
(ii) All particles are spherical
(iii) Diameter of silica sand particles is 0.20 mm

The CORRECT option fulfilling the diameter requirements for this filter media is

(A) diameter of anthracite particles is slightly less than 0.35 mm and diameter of ilmenite particles is slightly greater than 0.141 mm.

(B) diameter of anthracite particles is slightly greater than 0.35 mm and diameter of ilmenite particles is slightly less than 0.141 mm.

(C) diameter of anthracite particles is slightly less than 0.64 mm and diameter of ilmenite particles is slightly less than 0.10 mm.

(D) diameter of anthracite particles is slightly greater than 0.64 mm and diameter of ilmenite particles is slightly less than 0.10 mm.

Q.43 The consolidated data of a spot speed study for a certain stretch of a highway is given in the table.

Speed range (kmph)	**Number of observations**
0 - 10	7
10 - 20	31
20 - 30	76
30 - 40	129
40 - 50	104
50 - 60	78
60 - 70	29
70 - 80	24
80 - 90	13
90 - 100	9

The “upper speed limit” (in kmph) for the traffic sign is

(A) 50

(B) 55

(C) 65

(D) 70

Q.44 Three vectors $\vec{p}$, $\vec{q}$, and $\vec{r}$ are given as

$$\vec{p} = \hat{\imath} + \hat{\jmath} + \hat{k}$$

$$\vec{q} = \hat{\imath} + 2\hat{\jmath} + 3\hat{k}$$

$$\vec{r} = 2\hat{\imath} + 3\hat{\jmath} + 4\hat{k}$$

Which of the following is/are CORRECT?

(A) $\vec{p} \times (\vec{q} \times \vec{r}) + \vec{q} \times (\vec{r} \times \vec{p}) + \vec{r} \times (\vec{p} \times \vec{q}) = \vec{0}$

(B) $\vec{p} \times (\vec{q} \times \vec{r}) = (\vec{p} \cdot \vec{r})\,\vec{q} - (\vec{p} \cdot \vec{q})\,\vec{r}$

(C) $\vec{p} \times (\vec{q} \times \vec{r}) = (\vec{p} \times \vec{q}) \times \vec{r}$

(D) $\vec{r} \cdot (\vec{p} \times \vec{q}) = (\vec{q} \times \vec{p}) \cdot \vec{r}$

Q.45 Consider the statements P, Q , and R.

P: Compacted fine-grained soils with flocculated structure have isotropic permeability.

Q: Phreatic surface/line is the line along which the pore water pressure is always maximum.

R: The piping phenomenon occurring below the dam foundation is typically known as blowout piping.

Which of the following option(s) is/are CORRECT?

(A) Both P and R are TRUE

(B) P is FALSE and Q is TRUE

(C) P is TRUE and R is FALSE

(D) Both Q and R are FALSE

Q.46 In the context of pavement material characterization, the CORRECT statement(s) is/are

(A) The load penetration curve of CBR test may need origin correction due to the non-vertical penetrating plunger of the loading machine.

(B) The toughness and hardness of road aggregates are determined by Los Angeles abrasion test and aggregate impact test, respectively.

(C) Grading of normal (unmodified) bitumen binders is done based on viscosity test results.

(D) In compacted bituminous mix, Voids in the Mineral Aggregate (VMA) is equal to the sum of total volume of air voids (V_v) and total volume of bitumen (V_b).

Q.47 The expression for computing the effective interest rate (i_{eff}) using continuous compounding for a nominal interest rate of 5% is

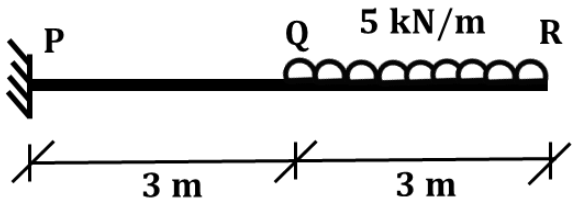
$$i_{eff} = \lim_{m \to \infty} \left(1 + \frac{0.05}{m}\right)^{m} - 1$$

The effective interest rate (in percentage) is _____ (*rounded off to 2 decimal places*).

Q.48 Consider two matrices $\mathbf{A} = \begin{bmatrix} 2 & 1 & 4 \\ 1 & 0 & 3 \end{bmatrix}$ and $\mathbf{B} = \begin{bmatrix} -1 & 0 \\ 2 & 3 \\ 1 & 4 \end{bmatrix}$.

The determinant of the matrix **AB** is _____(*in integer*).

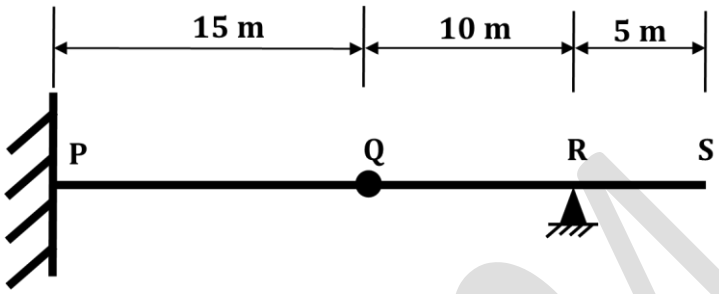
Q.49 For the 6 m long horizontal cantilever beam PQR shown in the figure, Q is the mid-point. Segment PQ of the beam has flexural rigidity $\mathrm{EI} = 2 \times 10^5\ \mathrm{kN.m^2}$ whereas the segment QR has infinite flexural rigidity. Segment QR is subjected to uniformly distributed, vertically downward load of 5 kN/m.



(Figure NOT to scale)

The magnitude of the vertical displacement (in mm) at point Q is _____ (*rounded off to 3 decimal places*).

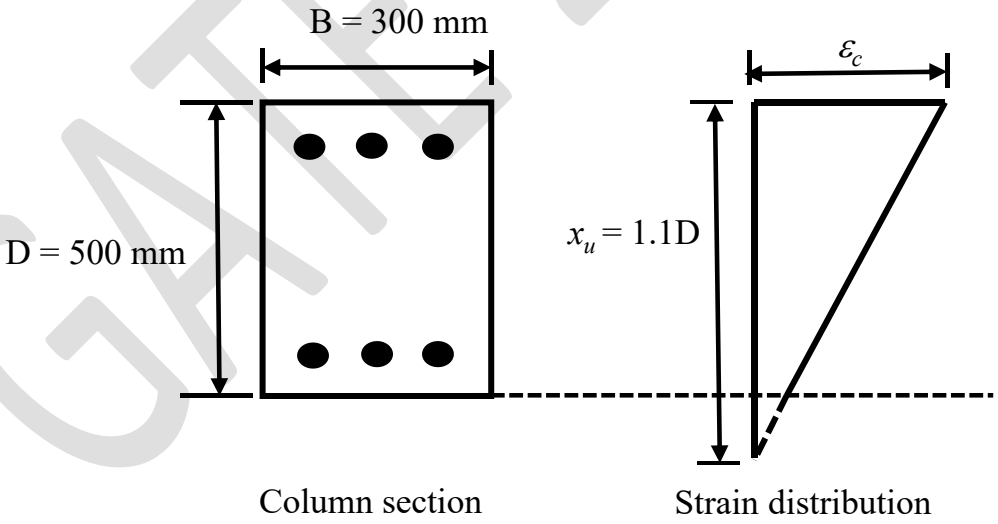
Q.50 The horizontal beam PQRS shown in the figure has a fixed support at point P, an internal hinge at point Q, and a pin support at point R. A concentrated vertically downward load (V) of 10 kN can act at any point over the entire length of the beam.



(Figure NOT to scale)

The maximum magnitude of the moment reaction (in kN.m) that can act at the support P due to V is _____ (*in integer*).

Q.51 A concrete column section of size 300 mm × 500 mm as shown in the figure is subjected to both axial compression and bending along the major axis. The depth of the neutral axis (x_u) is 1.1 times the depth of the column, as shown.



(Figure NOT to scale)

The maximum compressive strain (ε_c) at highly compressive extreme fiber in concrete, where there is no tension in the section, is _____ $\times 10^{-3}$ (*rounded off to 2 decimal places*).

Q.52 The table shows the activities and their durations and dependencies in a project.

Activity	**Duration** (Days)	**Depends on**
A	8	-
B	4	A
C	4	B
D	4	C, L
F	4	A
G	4	F
H	6	G, L
K	10	A
L	6	F, K

The total duration (in days) of the project is_____ (*in integer*).

Q.53 A homogeneous earth dam has a maximum water head difference of 15 m between the upstream and downstream sides. A flownet was drawn with the number of potential drops as 10 and the average length of the element as 3 m. Specific gravity of the soil is 2.65. For a factor of safety of 2.0 against piping failure, void ratio of the soil is _____ (*rounded off to 2 decimal places*).

Q.54 The in-situ percentage of voids of a sand deposit is 50%. The maximum and minimum densities of sand determined from the laboratory tests are 1.8 g/cm^3 and 1.3 g/cm^3, respectively. Assume the specific gravity of sand as 2.7.

The relative density index of the in-situ sand is _____ (*rounded off to 2 decimal places*).

Q.55 A drained triaxial test was conducted on a saturated sand specimen using a stress-path triaxial testing system. The specimen failed when the axial stress reached a value of 100 kN/m^2 from an initial confining pressure of 300 kN/m^2.

The angle of shearing plane (in degrees) with respect to horizontal is _____ (*rounded off to the nearest integer*).

Q.56 A storm with a recorded precipitation of 11.0 cm, as shown in the table, produced a direct run-off of 6.0 cm.

Time from start (hours)	1	2	3	4	5	6	7	8
Recorded cumulative precipitation (cm)	0.5	1.5	3.1	5.5	7.3	8.9	10.2	11.0

The Ø-index of this storm is _____ cm/hr (*rounded off to 2 decimal places*).

Q.57 A 500 m long water distribution pipeline P with diameter 1.0 m, is used to convey 0.1 m^3/s of flow. A new pipeline Q, with the same length and flow rate, is to replace P. The friction factors for P and Q are 0.04 and 0.01, respectively. The diameter of the pipeline Q (in meters) is _____ (*rounded off to 2 decimal places*).

Q.58 A 2 m × 1.5 m tank of 6 m height is provided with a 100 mm diameter orifice at the center of its base. The orifice is plugged and the tank is filled up to 5 m height. Consider the average value of discharge coefficient as 0.6 and acceleration due to gravity (g) as 10 m/s^2. After unplugging the orifice, the time (in seconds) taken for the water level to drop from 5 m to 3.5 m under free discharge condition is _____ (*rounded off to 2 decimal places*).

Q.59 A rectangular channel is 4.0 m wide and carries a discharge of 2.0 m^3/s with a depth of 0.4 m. The channel transitions to a maximum width contraction at a downstream location, without influencing the upstream flow conditions. The width (in meters) at the maximum contraction is _____ (*rounded off to 2 decimal places*).

Q.60 A circular settling tank is to be designed for primary treatment of sewage at a flow rate of 10 million liters/day. Assume a detention period of 2.0 hours and surface loading rate of 40000 liters/m^2/day. The height (in meters) of the water column in the tank is _____ (*rounded off to 2 decimal places*).

Q.61 An organic waste is represented as $C_{240}O_{200}H_{180}N_5S$.

(Atomic weights: S-32, H-1, C-12, O-16, N-14).

Assume complete conversion of S to SO_2 while burning.

SO_2 generated (in grams) per kg of this waste is _____ (*rounded off to 1 decimal place*).

Q.62 A horizontal curve of radius 1080 m (with transition curves on either side) in a Broad Gauge railway track is designed and constructed for an equilibrium speed of 70 kmph. However, a few years after construction, the Railway Authorities decided to run express trains on this track. The maximum allowable cant deficiency is 10 cm.

The maximum restricted speed (in kmph) of the express trains running on this track is _____ (*rounded off to the nearest integer*).

Q.63 A vertical summit curve on a freight corridor is formed at the intersection of two gradients, +3.0% and –5.0%.

Assume the following:
Only large-sized trucks are allowed on this corridor
Design speed = 80 kmph
Eye height of truck drivers above the road surface = 2.30 m
Height of object above the road surface for which trucks need to stop = 0.35 m
Total reaction time of the truck drivers = 2.0 s
Coefficient of longitudinal friction of the road = 0.36
Stopping sight distance gets compensated on the gradient

The design length of the summit curve (in meters) to accommodate the stopping sight distance is _____ (*rounded off to 2 decimal places*).

Q.64 A child walks on a level surface from point P to point Q at a bearing of 30^o, from point Q to point R at a bearing of 90^o and then directly returns to the starting point P at a bearing of 240^o. The straight-line paths PQ and QR are 4 m each. Assuming that all bearings are measured from the magnetic north in degrees, the straight-line path length RP (in meters) is _____ (*rounded off to the nearest integer*).

Q.65 Differential levelling is carried out from point P (BM: +200.000 m) to point R. The readings taken are given in the table.

Points	**Staff readings** (m)		**Remarks**
	Back Sight	**Fore Sight**	
P	(–)2.050		BM: +200.000 m
Q	1.050	0.950	Q is a change point
R		(–)1.655	

Reduced Level (in meters) of the point R is _____ (*rounded off to 3 decimal places*).