GATE 2024 CIVIL ENGINEERING[1]

EE25BTECH11013 - Bhargav

General Aptitude (GA)

Q.1 – Q.5 Carry ONE mark Each

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? (*GATE CE* 2024)
   a) obfuscate
   b) obliterate
   c) fracture
   d) fissure

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 (*GATE CE* 2024)

   a) 27 b) 52 c) 54 d) 26

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, (*GATE CE* 2024)
   a) $q^p = p^q$
   b) $q^p = p^{2q}$
   c) $\sqrt{q} = \sqrt{p}$
   d) $\sqrt[q]{q} = \sqrt[p]{p}$

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

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

(*GATE CE* 2024)

   a) 35 b) 40 c) 45 d) 31

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? (*GATE CE* 2024)

a) 51 b) 49 c) 50 d) 55

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. (*GATE CE* 2024)

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

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? (*GATE CE* 2024)

a) 12 b) 14 c) 10 d) 28

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).

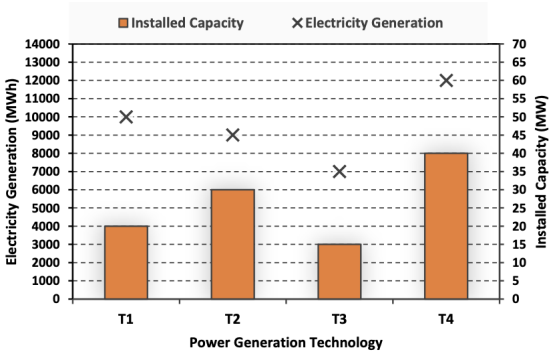

Fig. 8

The Capacity Factor of a power generation technology is:

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

Which one of the given technologies has the highest Capacity Factor? (*GATE CE* 2024)

a) T1 b) T2 c) T3 d) T4

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	

Fig. 9

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 (*GATE CE* 2024)

a) 0 b) 1 c) 2 d) 3

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 (*GATE CE* 2024)

a) 328 b) 382 c) 238 d) 283

CE – CIVIL ENGINEERING

Q.11 – Q.35 Carry ONE mark Each

11) The smallest positive root of the equation

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

lies in the range (*GATE CE* 2024)

a) $0 < x \leq 2$ b) $2 < x \leq 4$ c) $6 \leq x \leq 8$ d) $10 \leq x \leq 100$

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 (*GATE CE* 2024)

a) $u = x^2 + f(y) + g(x)$
b) $u = x^2 + xf(y) + h(y)$
c) $u = x^2 + xf(y) + g(x)$
d) $u = x^2 + f(y) + yg(x)$

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 (*GATE CE* 2024)

a) $\frac{17}{18}$ b) $\frac{11}{18}$ c) $\frac{14}{18}$ d) $\frac{1}{18}$

14) The three – dimensional state of stress at a point is given by

$$\sigma = \begin{pmatrix} 10 & 0 & 0 \\ 0 & 40 & 0 \\ 0 & 0 & 0 \end{pmatrix} \text{ MPa.} \quad (1)$$

The maximum shear stress at the point is (*GATE CE* 2024)

a) 20 MPa b) 15 MPa c) 5 MPa d) 25 MPa

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 (*GATE CE* 2024)

a) 35 b) 37 c) 38 d) 39

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? (*GATE CE* 2024)

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

17) The correct sequence of removing the Shores/Props for casting a cantilever RC beam is (*GATE CE* 2024)

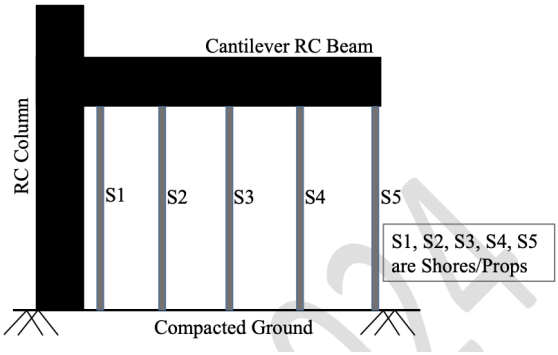

Fig. 17

a) S1 → S2 → S3 → S4 → S5
b) S5 → S4 → S3 → S2 → S1
c) S3 → S2 → S4 → S1 → S5
d) S3 → S4 → S2 → S5 → S1

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 (*GATE CE* 2024)

a) remain the same b) decrease c) increase d) become zero

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? (*GATE CE* 2024)

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

20) The number of degrees of freedom for a natural open channel flow with a mobile bed is (*GATE CE* 2024)

a) 2 b) 3 c) 4 d) 5

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 (*GATE CE* 2024)

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

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 suddenly observes a stopped vehicle at 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 $g = 9.81\ m/s^2$, the distance (in meters) required to bring the car to a safe stop lies in the range (*GATE CE* 2024)

a) 126 to 130 b) 41 to 45 c) 33 to 37 d) 75 to 79

23) As per 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 (*GATE CE* 2024)

a) 7%, 300 m b) 5%, 200 m c) 4%, 500 m d) 10%, 1000 m

24) Which one of the following statements related to bitumen is FALSE? (*GATE CE* 2024)
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 under specified test conditions.
d) Ductility test is carried out on bitumen to test its adhesive property and ability to stretch.

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 (*GATE CE* 2024)

a) 90° b) 180° c) 270° d) 360°

26) A surveyor observes a zenith angle of $93^\circ 00' 00''$ during a theodolite survey. The corresponding vertical angle is (*GATE CE* 2024)

a) $-03^{\circ}00'00''$ b) $+03^{\circ}00'00''$ c) $-87^{\circ}00'00''$ d) $+87^{\circ}00'00''$

27) Among the following statements relating the fundamental lines of a transit theodolite, which one is CORRECT? (*GATE CE* 2024)

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.

28) For the PDE

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

which of the following option(s) is/are CORRECT? (*GATE CE* 2024)

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 $y > 0$

29) The elements that DO NOT increase the strength of structural steel are (*GATE CE* 2024)

a) Carbon b) Manganese c) Sulphur d) Chlorine

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 become under – reinforced? (*GATE CE* 2024)

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.

31) The primary air pollutant(s) is/are (*GATE CE* 2024)

a) Sulphur dioxide
b) Lead
c) Ozone
d) Sulphuric acid

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

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

(3)

The value of $f(1.5)$ estimated using second-order Newton's interpolation formula is _____ (*rounded off to* 2 *decimal places*). (*GATE CE* 2024)

33) The plane frame shown 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*).

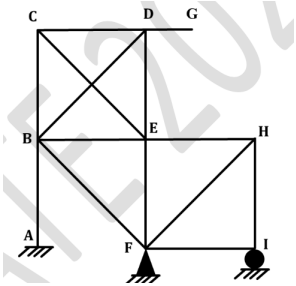

Fig. 33

(*GATE CE* 2024)

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 γ_w = 10 kN/m^3. The dry unit weight (in kN/m^3) of the compacted soil is _____ (*rounded off to* 2 *decimal places*). (*GATE CE* 2024)

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*). (*GATE CE* 2024)

Q.36 – Q.65 Carry TWO marks Each

36) What are the eigenvalues of the matrix

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 4 & 1 \\ 1 & 1 & 2 \end{pmatrix}? \tag{4}$$

(*GATE CE* 2024)

a) $1, 2, 5$ b) $1, 3, 4$ c) $-5, 1, 2$ d) $-5, -1, 2$

37) A vector field $\mathbf{p}$ and a scalar field r are given by

$$\mathbf{p} = (2x^2 - 3xy + z^2)\hat{i} + (2y^2 - 3yz + x^2)\hat{j} + (2z^2 - 3xz + x^2)\hat{k}, \tag{5}$$

$$r = 6x^2 + 4y^2 - z^2 - 9xyz - 2xy + 3xz - yz. \quad (6)$$

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 **p** is zero. Which one of the following options is CORRECT? (*GATE CE* 2024)

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

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

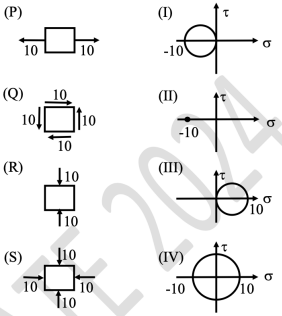

Fig. 38

(*GATE CE* 2024)

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)

39) The beam shown 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

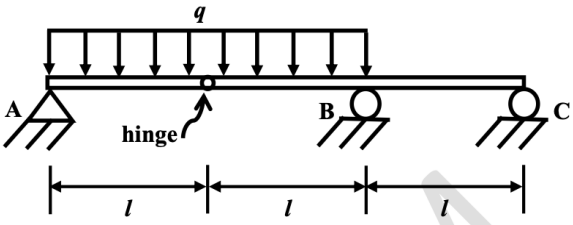

Fig. 39

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) $R_A = \frac{ql}{2},\ R_B = ql,\ R_C = \frac{ql}{2}$

40) A homogeneous shaft PQR with fixed supports at both ends is subjected to a torsional moment T at point Q. The polar moments of inertia of the portions PQ and QR are J_1 and J_2. The torsional moment reactions at the supports are T_P and T_R. If $\frac{T_P}{T_R} = 4$ and $\frac{J_1}{J_2} = 2$, the ratio $\frac{L_1}{L_2}$ is (*GATE CE* 2024)

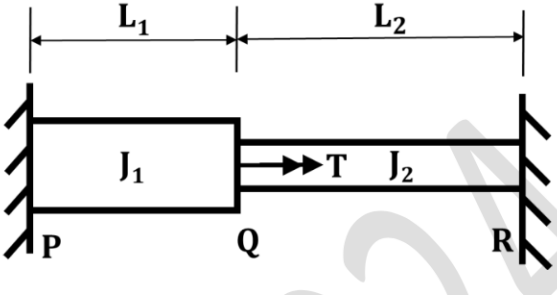

Fig. 40

a) 0.50 b) 0.25 c) 4.00 d) 2.00

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 (*GATE CE* 2024)

a) $30^\circ, 30^\circ$ b) $60^\circ, 60^\circ$ c) $30^\circ, 60^\circ$ d) $60^\circ, 30^\circ$

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

$$\mathbf{V} = 3\hat{i} + (5x)\hat{j}. \tag{7}$$

Which one of the following statements is CORRECT? (*GATE CE* 2024)

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.

43) For assessing compliance with emission standards of incineration plants: HCl limit = 50 mg/Nm^3 (at 11% O_2). Measured: HCl = 42 mg/Nm^3, O_2 = 13%. Assuming 21% O_2 in air, the correct statement is (*GATE CE* 2024)

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 $O_2 > 11\%$ and HCl emission is lesser than the standard.
d) No compliance, as $O_2 > 11\%$ in the flue gas.

44) The free mean speed is 60 km/hr on a given road. The average space headway at jam density is 8 *m*. For a linear speed-density relationship, the maximum flow (veh/hr/lane) is (*GATE CE* 2024)

a) 1875 b) 938 c) 2075 d) 1038

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 (*GATE CE* 2024)

a) 30% b) 10% c) 35% d) 40%

46) Which of the following statement(s) is/are CORRECT? (*GATE CE* 2024)
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.

47) The return period of a large earthquake for a given region is 200 years. Assuming Poisson distribution, the probability that it will be exceeded at least once in 50 years is _____ % (rounded off to nearest integer). (*GATE CE* 2024)

48) A 2×2 *m* tank of 3 *m* height has inflow, outflow and stirring. Initially half-filled. At $t = 0$, inflow = 2 L/s of 5 g/m^3 salt solution, outflow = 1 L/s well-mixed. Model:

$$\frac{dm}{dt} + \frac{m}{6000 + t} = 0.01 \tag{8}$$

where *m* is the salt mass in grams. The mass of salt in the tank at 75% capacity is _____ g (*rounded off to 2 decimal places*). (*GATE CE* 2024)

49) A plane truss with 13 joints and 22 members, supports at A (pin), L (pin) and K (roller). Loads: 10 kN downward at H and 10 kN horizontal at B. The magnitude of the reaction (*in kN*) at support L is _____ (rounded off to 1 decimal place). (*GATE CE* 2024)

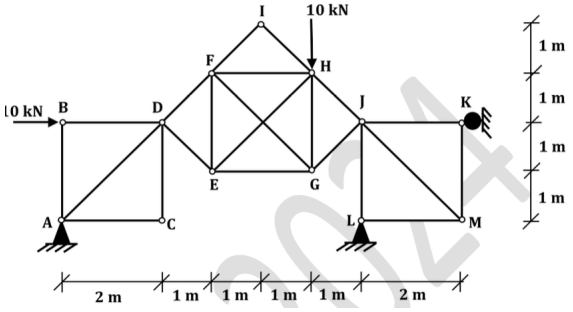

Fig. 49

50) An inverted T – shaped beam B1 is prestressed with 1000 kN force at kern point. Beam B2 is identical without prestress. The additional cracking moment (kNÂ·m) carried by B1 in comparison to B2 is _____ (*rounded off to nearest integer*). (*GATE CE* 2024)

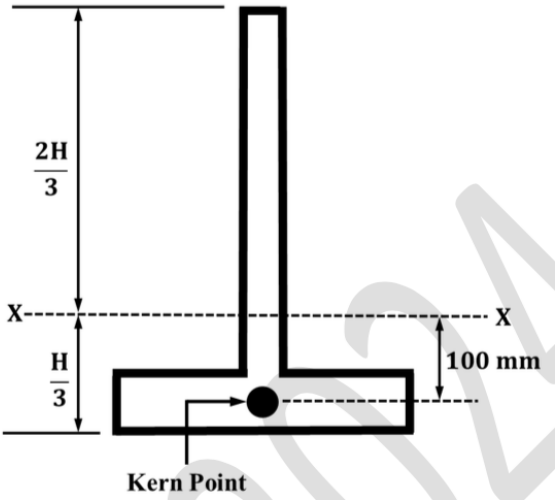

Fig. 50

51) Equipment cost = Rs. 1,00,000. Salvage value = Rs. 10,000 at 5 years. Find the difference in depreciation (Rs.) between double-declining balance and straight-line methods in Year – 2. (*GATE CE* 2024)
52) A slab panel with an effective depth of 250 mm is reinforced with 0.2 percent 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 nearest integer*). (*GATE CE* 2024)
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 percent of (S_c) will be _____ (*rounded off*). (*GATE CE* 2024)

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 (*GATE CE* 2024)

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*). (*GATE CE* 2024)

56) The ordinates of a 1-hour unit hydrograph (UH) are given below. (*GATE CE* 2024)

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). (*GATE CE* 2024)

57) A standard round bottom triangular canal has bed slope 1 in 200, Chezy's coefficient = 150. For Q = 20 m^3/s, the normal depth y (m) is _____ (rounded off to 2 decimal places). (*GATE CE* 2024)

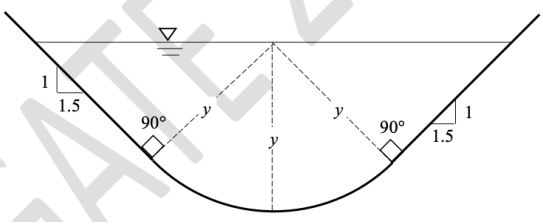

Fig. 57

58) A spillway has unit discharge 7.5 m^3/s/m. Flow depth downstream = 0.5 m. The tail water depth (m) required to form a hydraulic jump is _____ (*rounded off to 2 decimal places*). (*GATE CE* 2024)

59) A 5 m × 5 m tank of 10 m height contains water and oil, connected to an overhead reservoir. γ_w = 10 kN/m^3, specific gravity of oil = 0.8. The total force (kN) due to pressure on side PQR is _____ (*rounded off to nearest integer*). (*GATE CE* 2024)

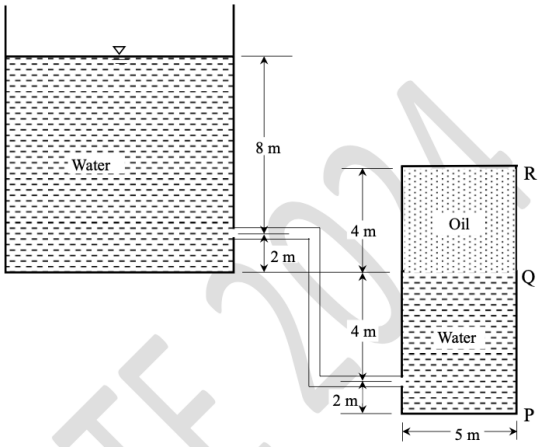

Fig. 59

60) Activated carbon removes pollutant in a batch reactor (first-order, k = 0.38/day). Time (days) required to remove 95% pollutant is _____ (*rounded off to* 1 *decimal place*). (*GATE CE* 2024)

61) A water treatment plant treats 25 MLD water with alkalinity 4.0 mg/L (as $CaCO_3$). During coagulation, 450 kg/day $Ca(HCO_3)_2$ is required. Find pure CaO required (kg/day). (*GATE CE* 2024)

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 (*inmm*) will be _____ (*rounded off to the nearest integer*). (*GATE CE* 2024)

63) Six vehicle trajectories in a time – space domain are shown. The mean speed (km/hr) of vehicles is _____ (*rounded off to nearest integer*). (*GATE CE* 2024)

[H]

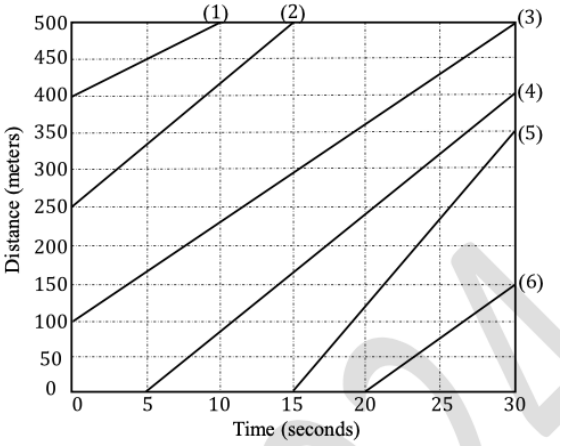

Fig. 63

64) Axle load survey: average rear axle load = 12000 kg, 800 CV/day. Pavement reconstructed after 5 years, design life 15 years. Annual growth = 4%. Standard axle load = 8160 kg. Cumulative standard axle (*msa*) = _____ (*rounded off to* 2 *decimal places*). (*GATE CE* 2024)

65) A bird is at point P at height 8 m above MSL. Flies to point Q at 3 m above MSL. Ground slope = 1 in 2. Ignoring curvature and refraction, horizontal distance (m) between P and Q is _____ (*in integer*). (*GATE CE* 2024)