

SESSION - 1

GATE 2022 (CE Set-1) Civil Engineering
GATE 2022 General Aptitude

Q.1 – Q.5 Carry ONE mark each.

Q.1	You should _____ when to say _____.
(A)	no / no
(B)	no / know
(C)	know / know
(D)	know / no

Q.2	Two straight lines pass through the origin $(x_0, y_0) = (0,0)$. One of them passes through the point $(x_1, y_1) = (1,3)$ and the other passes through the point $(x_2, y_2) = (1,2)$. What is the area enclosed between the straight lines in the interval $[0, 1]$ on the x-axis?
(A)	0.5
(B)	1.0
(C)	1.5
(D)	2.0



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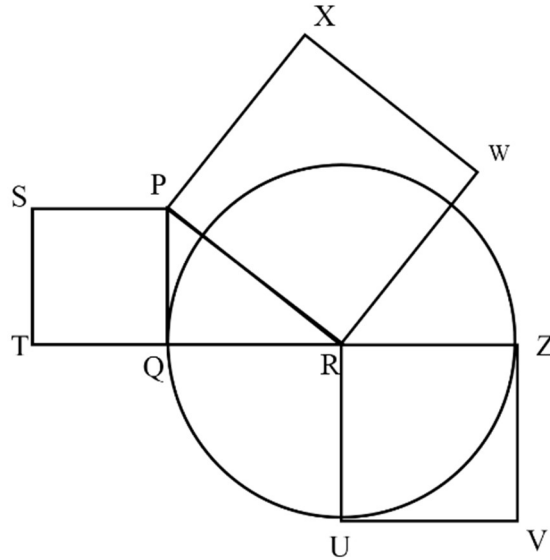
Q.3	If $p : q = 1 : 2$ $q : r = 4 : 3$ $r : s = 4 : 5$ and u is 50% more than s, what is the ratio $p : u$?
(A)	2 : 15
(B)	16 : 15
(C)	1 : 5
(D)	16 : 45

Q.4	Given the statements: • P is the sister of Q. • Q is the husband of R. • R is the mother of S. • T is the husband of P. Based on the above information, T is _____ of S.
(A)	the grandfather
(B)	an uncle
(C)	the father
(D)	a brother

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Q.5

In the following diagram, the point R is the center of the circle. The lines PQ and ZV are tangential to the circle. The relation among the areas of the squares, PXWR, RUVZ and SPQT is



(A) Area of SPQT = Area of RUVZ = Area of PXWR

(B) Area of SPQT = Area of PXWR – Area of RUVZ

(C) Area of PXWR = Area of SPQT – Area of RUVZ

(D) Area of PXWR = Area of RUVZ – Area of SPQT

Q. 6 – Q. 10 Carry TWO marks each.

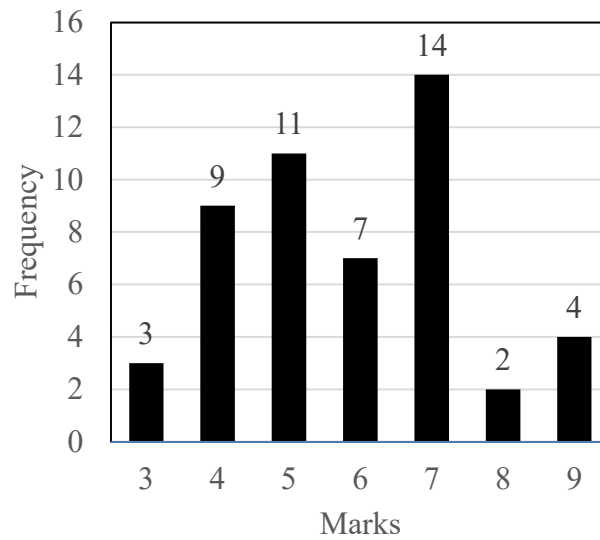
Q.6	Healthy eating is a critical component of healthy aging. When should one start eating healthy? It turns out that it is never too early. For example, babies who start eating healthy in the first year are more likely to have better overall health as they get older. Which one of the following is the CORRECT logical inference based on the information in the above passage?
(A)	Healthy eating is important for those with good health conditions, but not for others
(B)	Eating healthy can be started at any age, earlier the better
(C)	Eating healthy and better overall health are more correlated at a young age, but not older age
(D)	Healthy eating is more important for adults than kids

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Q.7	P invested ₹ 5000 per month for 6 months of a year and Q invested ₹ x per month for 8 months of the year in a partnership business. The profit is shared in proportion to the total investment made in that year. If at the end of that investment year, Q receives $\frac{4}{9}$ of the total profit, what is the value of x (in ₹)?
(A)	2500
(B)	3000
(C)	4687
(D)	8437

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Q.8



The above frequency chart shows the frequency distribution of marks obtained by a set of students in an exam.

From the data presented above, which one of the following is CORRECT?

(A) mean > mode > median

(B) mode > median > mean

(C) mode > mean > median

(D) median > mode > mean

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Q.9

In the square grid shown on the left, a person standing at P2 position is required to move to P5 position.

The only movement allowed for a step involves, “two moves along one direction followed by one move in a perpendicular direction”. The permissible directions for movement are shown as dotted arrows in the right.

For example, a person at a given position **Y** can move only to the positions marked **X** on the right.

Without occupying any of the shaded squares at the end of each step, the minimum number of steps required to go from P2 to P5 is

	1	2	3	4	5
P		😊			
Q					
R					
S					
T					

		X	←	→	X	
	X					X
				Y		
	X					X
			X	←	→	X

Example: Allowed steps for a person at **Y**

(A) 4

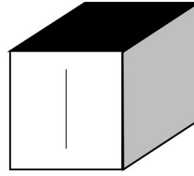
(B) 5

(C) 6

(D) 7

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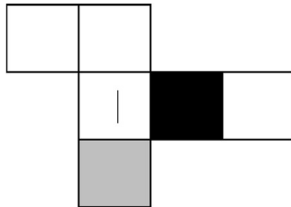
Q.10



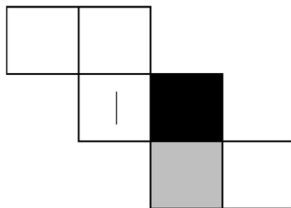
Consider a cube made by folding a single sheet of paper of appropriate shape. The interior faces of the cube are all blank. However, the exterior faces that are not visible in the above view may not be blank.

Which one of the following represents a possible unfolding of the cube?

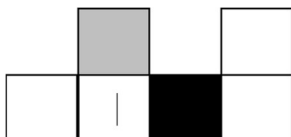
(A)



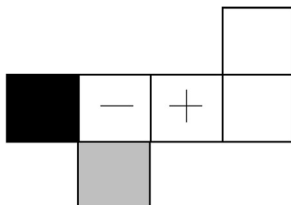
(B)



(C)



(D)



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Q.11 - 35 Carry ONE mark each.

Q.11	Consider the following expression: $z = \sin(y + it) + \cos(y - it)$ where z, y, and t are variables, and $i = \sqrt{-1}$ is a complex number. The partial differential equation derived from the above expression is
(A)	$\frac{\partial^2 z}{\partial t^2} + \frac{\partial^2 z}{\partial y^2} = 0$
(B)	$\frac{\partial^2 z}{\partial t^2} - \frac{\partial^2 z}{\partial y^2} = 0$
(C)	$\frac{\partial z}{\partial t} - i \frac{\partial z}{\partial y} = 0$
(D)	$\frac{\partial z}{\partial t} + i \frac{\partial z}{\partial y} = 0$

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Q.12	For the equation $\frac{d^3 y}{dx^3} + x \left(\frac{dy}{dx} \right)^{3/2} + x^2 y = 0$ the correct description is
(A)	an ordinary differential equation of order 3 and degree 2.
(B)	an ordinary differential equation of order 3 and degree 3.
(C)	an ordinary differential equation of order 2 and degree 3.
(D)	an ordinary differential equation of order 3 and degree 3/2.
Q.13	The hoop stress at a point on the surface of a thin cylindrical pressure vessel is computed to be 30.0 MPa. The value of maximum shear stress at this point is
(A)	7.5 MPa
(B)	15.0 MPa
(C)	30.0 MPa
(D)	22.5 MPa

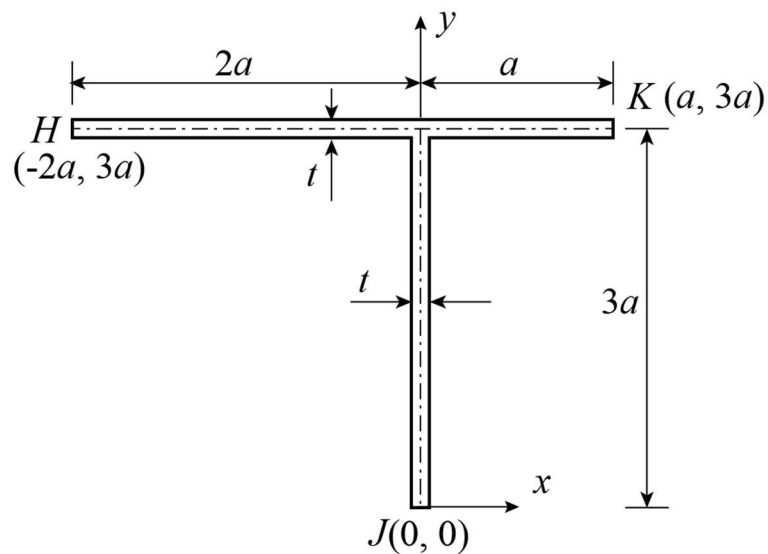
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Q.14	In the context of elastic theory of reinforced concrete, the modular ratio is defined as the ratio of
(A)	Young's modulus of elasticity of reinforcement material to Young's modulus of elasticity of concrete.
(B)	Young's modulus of elasticity of concrete to Young's modulus of elasticity of reinforcement material.
(C)	shear modulus of reinforcement material to the shear modulus of concrete.
(D)	Young's modulus of elasticity of reinforcement material to the shear modulus of concrete.
Q.15	Which of the following equations is correct for the Pozzolanic reaction?
(A)	$\text{Ca(OH)}_2 + \text{Reactive Superplasticiser} + \text{H}_2\text{O} \rightarrow \text{C-S-H}$
(B)	$\text{Ca(OH)}_2 + \text{Reactive Silicon dioxide} + \text{H}_2\text{O} \rightarrow \text{C-S-H}$
(C)	$\text{Ca(OH)}_2 + \text{Reactive Sulphates} + \text{H}_2\text{O} \rightarrow \text{C-S-H}$
(D)	$\text{Ca(OH)}_2 + \text{Reactive Sulphur} + \text{H}_2\text{O} \rightarrow \text{C-S-H}$

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Q.16

Consider the cross-section of a beam made up of thin uniform elements having thickness t ($t \ll a$) shown in the figure. The (x, y) coordinates of the points along the center-line of the cross-section are given in the figure.



The coordinates of the shear center of this cross-section are:

(A) $x = 0, y = 3a$

(B) $x = 2a, y = 2a$

(C) $x = -a, y = 2a$

(D) $x = -2a, y = a$

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Q.17	Four different soils are classified as CH, ML, SP, and SW, as per the Unified Soil Classification System. Which one of the following options correctly represents their arrangement in the decreasing order of hydraulic conductivity?
(A)	SW, SP, ML, CH
(B)	CH, ML, SP, SW
(C)	SP, SW, CH, ML
(D)	ML, SP, CH, SW
Q.18	Let σ'_v and σ'_h denote the effective vertical stress and effective horizontal stress, respectively. Which one of the following conditions must be satisfied for a soil element to reach the failure state under Rankine's passive earth pressure condition?
(A)	$\sigma'_v < \sigma'_h$
(B)	$\sigma'_v > \sigma'_h$
(C)	$\sigma'_v = \sigma'_h$
(D)	$\sigma'_v + \sigma'_h = 0$

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Q.19	With respect to fluid flow, match the following in Column X with Column Y: <table border="1"> <thead> <tr> <th>Column X</th><th>Column Y</th></tr> </thead> <tbody> <tr> <td>(P) Viscosity</td><td>(I) Mach number</td></tr> <tr> <td>(Q) Gravity</td><td>(II) Reynolds number</td></tr> <tr> <td>(R) Compressibility</td><td>(III) Euler number</td></tr> <tr> <td>(S) Pressure</td><td>(IV) Froude number</td></tr> </tbody> </table> Which one of the following combinations is correct?	Column X	Column Y	(P) Viscosity	(I) Mach number	(Q) Gravity	(II) Reynolds number	(R) Compressibility	(III) Euler number	(S) Pressure	(IV) Froude number
Column X	Column Y										
(P) Viscosity	(I) Mach number										
(Q) Gravity	(II) Reynolds number										
(R) Compressibility	(III) Euler number										
(S) Pressure	(IV) Froude number										
(A)	(P) – (II), (Q) – (IV), (R) – (I), (S) – (III)										
(B)	(P) – (III), (Q) – (IV), (R) – (I), (S) – (II)										
(C)	(P) – (IV), (Q) – (II), (R) – (I), (S) – (III)										
(D)	(P) – (II), (Q) – (IV), (R) – (III), (S) – (I)										

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Q.20	Let ψ represent soil suction head and K represent hydraulic conductivity of the soil. If the soil moisture content θ increases, which one of the following statements is TRUE ?
(A)	ψ decreases and K increases.
(B)	ψ increases and K decreases.
(C)	Both ψ and K decrease.
(D)	Both ψ and K increase.
Q.21	A rectangular channel with Gradually Varied Flow (GVF) has a changing bed slope. If the change is from a steeper slope to a steep slope, the resulting GVF profile is
(A)	S_3
(B)	S_1
(C)	S_2
(D)	either S_1 or S_2 , depending on the magnitude of the slopes

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Q.22	The total hardness in raw water is 500 milligram per liter as CaCO_3 . The total hardness of this raw water, expressed in milligram equivalent per liter, is (Consider the atomic weights of Ca, C, and O as 40 g/mol, 12 g/mol, and 16 g/mol, respectively.)
(A)	10
(B)	100
(C)	1
(D)	5
Q.23	An aerial photograph is taken from a flight at a height of 3.5 km above mean sea level, using a camera of focal length 152 mm. If the average ground elevation is 460 m above mean sea level, then the scale of the photograph is
(A)	1 : 20000
(B)	1 : 20
(C)	1 : 100000
(D)	1 : 2800

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Q.24	A line between stations P and Q laid on a slope of 1 in 5 was measured as 350 m using a 50 m tape. The tape is known to be short by 0.1 m. The corrected horizontal length (in m) of the line PQ will be
(A)	342.52
(B)	349.30
(C)	356.20
(D)	350.70
Q.25	The matrix M is defined as $\mathbf{M} = \begin{bmatrix} 1 & 3 \\ 4 & 2 \end{bmatrix}$ and has eigenvalues 5 and -2. The matrix Q is formed as $\mathbf{Q} = \mathbf{M}^3 - 4\mathbf{M}^2 - 2\mathbf{M}$ Which of the following is/are the eigenvalue(s) of matrix Q ?
(A)	15
(B)	25
(C)	-20
(D)	-30

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Q.26	For wastewater coming from a wood pulping industry, Chemical Oxygen Demand (COD) and 5-day Biochemical Oxygen Demand (BOD ₅) were determined. For this wastewater, which of the following statement(s) is/are correct?
(A)	COD > BOD ₅
(B)	COD ≠ BOD ₅
(C)	COD < BOD ₅
(D)	COD = BOD ₅
Q.27	Which of the following process(es) can be used for conversion of salt water into fresh water?
(A)	Microfiltration
(B)	Electrodialysis
(C)	Ultrafiltration
(D)	Reverse osmosis



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Q.28	A horizontal curve is to be designed in a region with limited space. Which of the following measure(s) can be used to decrease the radius of curvature?
(A)	Decrease the design speed.
(B)	Increase the superelevation.
(C)	Increase the design speed.
(D)	Restrict vehicles with higher weight from using the facility.

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Q.29	Consider the following recursive iteration scheme for different values of variable P with the initial guess $x_1 = 1$: $x_{n+1} = \frac{1}{2} \left(x_n + \frac{P}{x_n} \right), \quad n = 1, 2, 3, 4, 5$ For $P = 2$, x_5 is obtained to be 1.414, rounded-off to three decimal places. For $P = 3$, x_5 is obtained to be 1.732, rounded-off to three decimal places. If $P = 10$, the numerical value of x_5 is _____. (round off to three decimal places)
Q.30	The Fourier cosine series of a function is given by: $f(x) = \sum_{n=0}^{\infty} f_n \cos nx$ For $f(x) = \cos^4 x$, the numerical value of $(f_4 + f_5)$ is _____. (round off to three decimal places)
Q.31	An uncompacted heap of soil has a volume of 10000 m^3 and void ratio of 1. If the soil is compacted to a volume of 7500 m^3, then the corresponding void ratio of the compacted soil is _____. (round off to one decimal place)
Q.32	A concentrated vertical load of 3000 kN is applied on a horizontal ground surface. Points P and Q are at depths 1 m and 2 m below the ground, respectively, along the line of application of the load. Considering the ground to be a linearly elastic, isotropic, semi-infinite medium, the ratio of the increase in vertical stress at P to the increase in vertical stress at Q is _____. (in integer)

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Q.33	At a site, Static Cone Penetration Test was carried out. The measured point (tip) resistance q_c was 1000 kPa at a certain depth. The friction ratio (f_r) was estimated as 1 % at the same depth. The value of sleeve (side) friction (in kPa) at that depth was _____ . (in integer)
Q.34	During a particular stage of the growth of a crop, the consumptive use of water is 2.8 mm/day. The amount of water available in the soil is 50 % of the maximum depth of available water in the root zone. Consider the maximum root zone depth of the crop as 80 mm and the irrigation efficiency as 70 %. The interval between irrigation (in days) will be _____. (round off to the nearest integer)
Q.35	The bearing of a survey line is N31°17'W. Its azimuth observed from north is _____ deg. (round off to two decimal places)

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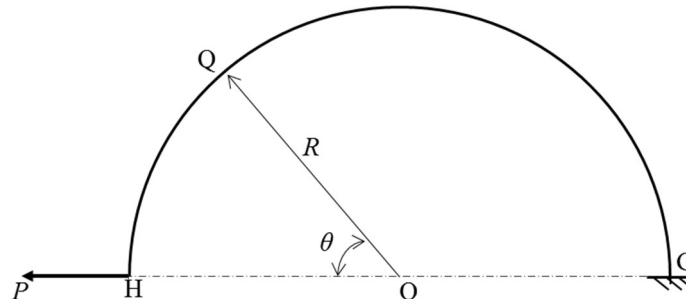
Q. 36 - 65 Carry TWO marks each.

Q.36	The Cartesian coordinates of a point P in a right-handed coordinate system are (1, 1, 1). The transformed coordinates of P due to a 45° clockwise rotation of the coordinate system about the positive x-axis are
(A)	$(1, 0, \sqrt{2})$
(B)	$(1, 0, -\sqrt{2})$
(C)	$(-1, 0, \sqrt{2})$
(D)	$(-1, 0, -\sqrt{2})$

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Q.37

A semi-circular bar of radius R m, in a vertical plane, is fixed at the end G, as shown in the figure. A horizontal load of magnitude P kN is applied at the end H. The magnitude of the axial force, shear force, and bending moment at point Q for $\theta = 45^\circ$, respectively, are



(A) $\frac{P}{\sqrt{2}}$ kN, $\frac{P}{\sqrt{2}}$ kN, and $\frac{PR}{\sqrt{2}}$ kNm

(B) $\frac{P}{\sqrt{2}}$ kN, $\frac{P}{\sqrt{2}}$ kN, and 0 kNm

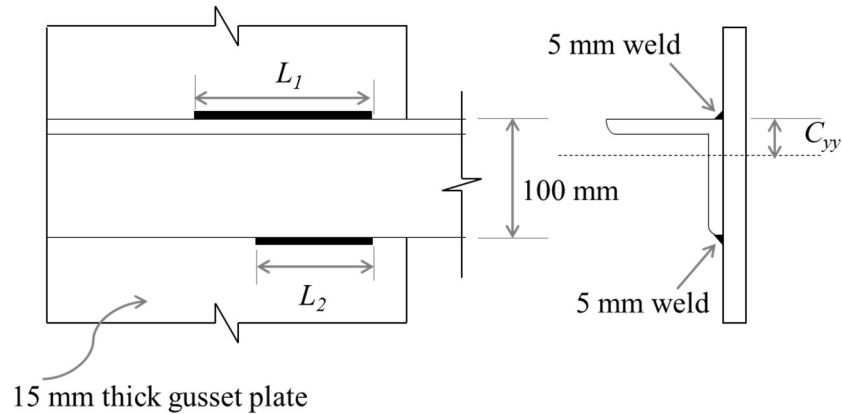
(C) 0 kN, $\frac{P}{\sqrt{2}}$ kN, and $\frac{PR}{\sqrt{2}}$ kNm

(D) $\frac{P}{\sqrt{2}}$ kN, 0 kN, and $\frac{PR}{\sqrt{2}}$ kNm

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Q.38

A weld is used for joining an angle section ISA 100 mm $\times$ 100 mm $\times$ 10 mm to a gusset plate of thickness 15 mm to transmit a tensile load. The permissible stress in the angle is 150 MPa and the permissible shear stress on the section through the throat of the fillet weld is 108 MPa. The location of the centroid of the angle is represented by C_{yy} in the figure, where $C_{yy} = 28.4$ mm. The area of cross-section of the angle is 1903 mm². Assuming the effective throat thickness of the weld to be 0.7 times the given weld size, the lengths L_1 and L_2 (rounded-off to the nearest integer) of the weld required to transmit a load equal to the full strength of the tension member are, respectively



(A) 541 mm and 214 mm

(B) 214 mm and 541 mm

(C) 380 mm and 151 mm

(D) 151 mm and 380 mm

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Q.39

The project activities are given in the following table along with the duration and dependency.

Activities	Duration (days)	Depends on
P	10	-
Q	12	-
R	5	P
S	10	Q
T	10	P, Q

Which one of the following combinations is correct?

(A)

Total duration of the project = 22 days, Critical path is $Q \rightarrow S$

(B)

Total duration of the project = 20 days, Critical path is $Q \rightarrow T$

(C)

Total duration of the project = 22 days, Critical path is $P \rightarrow T$

(D)

Total duration of the project = 20 days, Critical path is $P \rightarrow R$

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Q.40

The correct match between the physical states of the soils given in **Group I** and the governing conditions given in **Group II** is

Group I	Group II
1. normally consolidated soil	P. sensitivity > 16
2. quick clay	Q. dilation angle $= 0$
3. sand in critical state	R. liquid limit > 50
4. clay of high plasticity	S. over consolidation ratio $= 1$

(A)

1-S, 2-P, 3-Q, 4-R

(B)

1-Q, 2-S, 3-P, 4-R

(C)

1-Q, 2-P, 3-R, 4-S

(D)

1-S, 2-Q, 3-P, 4-R

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Q.41	As per Rankine's theory of earth pressure, the inclination of failure planes is $(45 + \frac{\phi}{2})^\circ$ with respect to the direction of the minor principal stress. The above statement is correct for which one of the following options?
(A)	Only the active state and not the passive state
(B)	Only the passive state and not the active state
(C)	Both active as well as passive states
(D)	Neither active nor passive state
Q.42	Henry's law constant for transferring O ₂ from air into water, at room temperature, is $1.3 \frac{\text{mmol}}{\text{liter-atm}}$. Given that the partial pressure of O ₂ in the atmosphere is 0.21 atm, the concentration of dissolved oxygen (mg/liter) in water in equilibrium with the atmosphere at room temperature is (Consider the molecular weight of O ₂ as 32 g/mol)
(A)	8.7
(B)	0.8
(C)	198.1
(D)	0.2

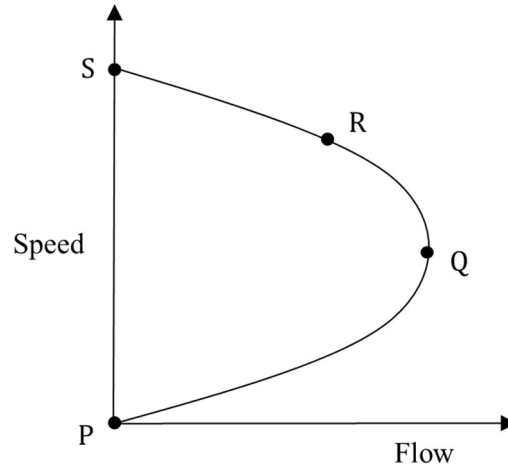
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Q.43	In a water sample, the concentrations of Ca^{2+}, Mg^{2+} and HCO_3^- are 100 mg/L, 36 mg/L and 122 mg/L, respectively. The atomic masses of various elements are: $\text{Ca} = 40$, $\text{Mg} = 24$, $\text{H} = 1$, $\text{C} = 12$, $\text{O} = 16$. The total hardness and the temporary hardness in the water sample (in mg/L as CaCO_3) will be
(A)	400 and 100, respectively.
(B)	400 and 300, respectively.
(C)	500 and 100, respectively.
(D)	800 and 200, respectively.

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Q.44

Consider the four points P, Q, R, and S shown in the Greenshields fundamental speed-flow diagram. Denote their corresponding traffic densities by k_P , k_Q , k_R , and k_S , respectively. The correct order of these densities is



(A)

$$k_P > k_Q > k_R > k_S$$

(B)

$$k_S > k_R > k_Q > k_P$$

(C)

$$k_Q > k_R > k_S > k_P$$

(D)

$$k_Q > k_R > k_P > k_S$$

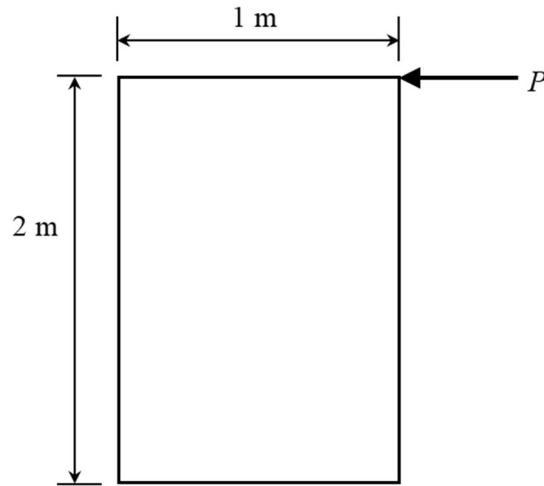
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Q.45	Let $\max\{a, b\}$ denote the maximum of two real numbers a and b . Which of the following statement(s) is/are TRUE about the function $f(x) = \max\{3 - x, x - 1\}$?
(A)	It is continuous on its domain.
(B)	It has a local minimum at $x = 2$.
(C)	It has a local maximum at $x = 2$.
(D)	It is differentiable on its domain.

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Q.46

A horizontal force of P kN is applied to a homogeneous body of weight 25 kN, as shown in the figure. The coefficient of friction between the body and the floor is 0.3. Which of the following statement(s) is/are correct?



- (A) The motion of the body will occur by overturning.
- (B) Sliding of the body never occurs.
- (C) No motion occurs for $P \leq 6$ kN.
- (D) The motion of the body will occur by sliding only.

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Q.47	In the context of cross-drainage structures, the correct statement(s) regarding the relative positions of a natural drain (stream/river) and an irrigation canal, is/are
(A)	In an aqueduct, natural drain water goes under the irrigation canal, whereas in a super-passage, natural drain water goes over the irrigation canal.
(B)	In a level crossing, natural drain water goes through the irrigation canal.
(C)	In an aqueduct, natural drain water goes over the irrigation canal, whereas in a super-passage, natural drain water goes under the irrigation canal.
(D)	In a canal syphon, natural drain water goes through the irrigation canal.

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Q.48

Consider the differential equation

$$\frac{dy}{dx} = 4(x + 2) - y$$

For the initial condition $y = 3$ at $x = 1$, the value of y at $x = 1.4$ obtained using Euler's method with a step-size of 0.2 is _____. (round off to one decimal place)

Q.49

A set of observations of independent variable (x) and the corresponding dependent variable (y) is given below.

x	5	2	4	3
y	16	10	13	12

Based on the data, the coefficient a of the linear regression model

$$y = a + bx$$

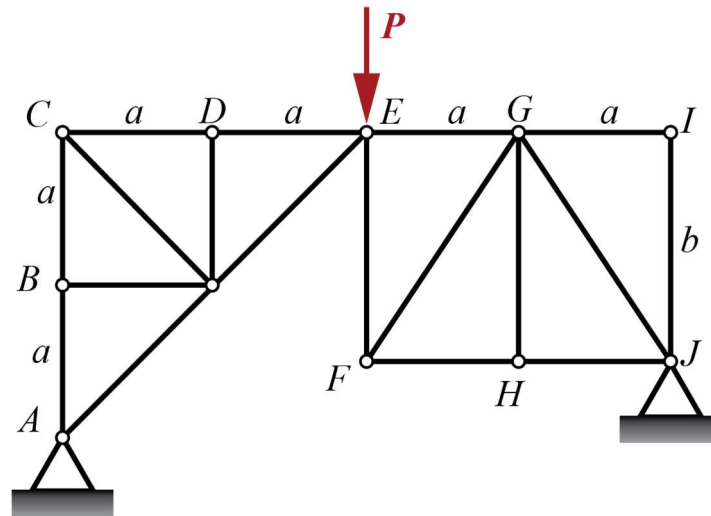
is estimated as **6.1**.

The coefficient b is _____. (round off to one decimal place)

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Q.50

The plane truss shown in the figure is subjected to an external force P . It is given that $P = 70 \text{ kN}$, $a = 2 \text{ m}$, and $b = 3 \text{ m}$.

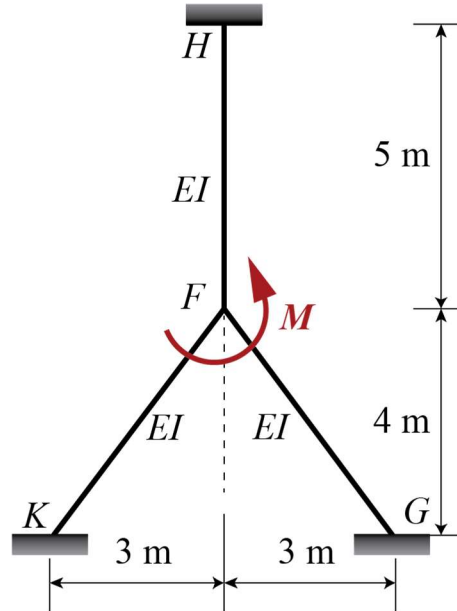


The magnitude (absolute value) of force (in kN) in member EF is _____.
(round off to the nearest integer)

GATE 2022 (CE Set-1) Civil Engineering

Q.51

Consider the linearly elastic plane frame shown in the figure. Members HF , FK and FG are welded together at joint F . Joints K , G and H are fixed supports. A counter-clockwise moment M is applied at joint F . Consider flexural rigidity $EI = 10^5 \text{ kN-m}^2$ for each member and neglect axial deformations.

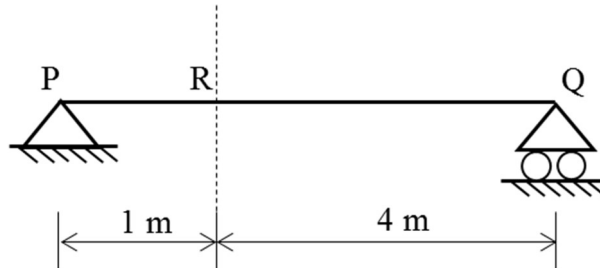


If the magnitude (absolute value) of the support moment at H is 10 kN-m , the magnitude (absolute value) of the applied moment M (in kN-m) to maintain static equilibrium is _____. (round off to the nearest integer)

GATE 2022 (CE Set-1) Civil Engineering

Q.52

Consider a simply supported beam PQ as shown in the figure. A truck having 100 kN on the front axle and 200 kN on the rear axle, moves from left to right. The spacing between the axles is 3 m. The maximum bending moment at point R is _____ kNm. (*in integer*)



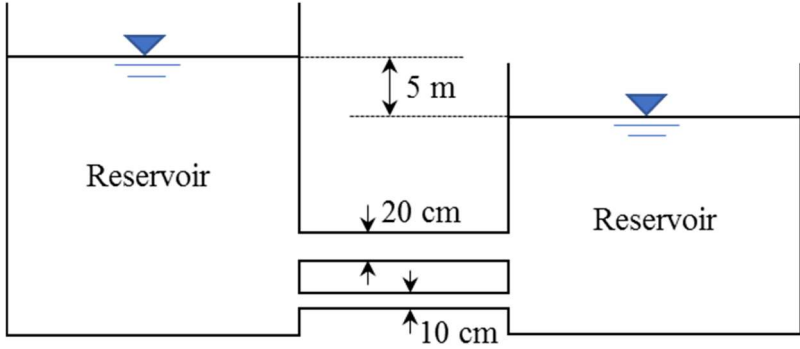
Q.53

A reinforced concrete beam with rectangular cross section (width = 300 mm, effective depth = 580 mm) is made of M30 grade concrete. It has 1% longitudinal tension reinforcement of Fe 415 grade steel. The design shear strength for this beam is 0.66 N/mm^2 . The beam has to resist a factored shear force of 440 kN. The spacing of two-legged, 10 mm diameter vertical stirrups of Fe 415 grade steel is _____ mm. (*round off to the nearest integer*)

GATE 2022 (CE Set-1) Civil Engineering

Q.54	A square concrete pile of 10 m length is driven into a deep layer of uniform homogeneous clay. Average unconfined compressive strength of the clay, determined through laboratory tests on undisturbed samples extracted from the clay layer, is 100 kPa. If the ultimate compressive load capacity of the driven pile is 632 kN, the required width of the pile is _____ mm. (<i>in integer</i>) (Bearing capacity factor $N_c = 9$; adhesion factor $\alpha = 0.7$)																		
Q.55	A raft foundation of 30 m × 25 m is proposed to be constructed at a depth of 8 m in a sand layer. A 25 m thick saturated clay layer exists 2 m below the base of the raft foundation. Below the clay layer, a dense sand layer exists at the site. A 25 mm thick undisturbed sample was collected from the mid-depth of the clay layer and tested in a laboratory oedometer under double drainage condition. It was found that the soil sample had undergone 50 % consolidation settlement in 10 minutes. The time (in days) required for 25 % consolidation settlement of the raft foundation will be _____. (<i>round off to the nearest integer</i>)																		
Q.56	A two-hour duration storm event with uniform excess rainfall of 3 cm occurred on a watershed. The ordinates of streamflow hydrograph resulting from this event are given in the table. <table><tr><td>Time (hours)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>Streamflow (m³/s)</td><td>10</td><td>16</td><td>34</td><td>40</td><td>31</td><td>25</td><td>16</td><td>10</td></tr></table> Considering a constant baseflow of 10 m³/s, the peak flow ordinate (in m³/s) of one-hour unit hydrograph for the watershed is _____. (<i>in integer</i>)	Time (hours)	0	1	2	3	4	5	6	7	Streamflow (m ³ /s)	10	16	34	40	31	25	16	10
Time (hours)	0	1	2	3	4	5	6	7											
Streamflow (m ³ /s)	10	16	34	40	31	25	16	10											

GATE 2022 (CE Set-1) Civil Engineering

Q.57	Two reservoirs are connected by two parallel pipes of equal length and of diameters 20 cm and 10 cm, as shown in the figure (<i>not drawn to scale</i>). When the difference in the water levels of the reservoirs is 5 m, the ratio of discharge in the larger diameter pipe to the discharge in the smaller diameter pipe is _____. (<i>round off to two decimal places</i>) (Consider only loss due to friction and neglect all other losses. Assume the friction factor to be the same for both the pipes) 
Q.58	Depth of water flowing in a 3 m wide rectangular channel is 2 m. The channel carries a discharge of 12 m³/s. Take $g = 9.8 \text{ m/s}^2$. The bed width (in m) at contraction, which just causes the critical flow, is _____ without changing the upstream water level. (<i>round off to two decimal places</i>)
Q.59	A wastewater sample contains two nitrogen species, namely ammonia and nitrate. Consider the atomic weight of N, H, and O as 14 g/mol, 1 g/mol, and 16 g/mol, respectively. In this wastewater, the concentration of ammonia is 34 mg NH₃/liter and that of nitrate is 6.2 mg NO₃⁻/liter. The total nitrogen concentration in this wastewater is _____ milligram nitrogen per liter. (<i>round off to one decimal place</i>)

GATE 2022 (CE Set-1) Civil Engineering

Q.60	A 2 % sewage sample (in distilled water) was incubated for 3 days at 27 °C temperature. After incubation, a dissolved oxygen depletion of 10 mg/L was recorded. The biochemical oxygen demand (BOD) rate constant at 27 °C was found to be 0.23 day⁻¹ (at base e). The ultimate BOD (in mg/L) of the sewage will be _____. (round off to the nearest integer)
Q.61	A water treatment plant has a sedimentation basin of depth 3 m, width 5 m, and length 40 m. The water inflow rate is 500 m³/h. The removal fraction of particles having a settling velocity of 1.0 m/h is _____. (round off to one decimal place) (Consider the particle density as 2650 kg/m³ and liquid density as 991 kg/m³)
Q.62	A two-phase signalized intersection is designed with a cycle time of 100 s. The amber and red times for each phase are 4 s and 50 s, respectively. If the total lost time per phase due to start-up and clearance is 2 s, the effective green time of each phase is _____ s. (in integer)
Q.63	At a traffic intersection, cars and buses arrive randomly according to independent Poisson processes at an average rate of 4 vehicles per hour and 2 vehicles per hour, respectively. The probability of observing at least 2 vehicles in 30 minutes is _____. (round off to two decimal places)

GATE 2022 (CE Set-1) Civil Engineering

Q.64

The vehicle count obtained in every **10 minute** interval of a traffic volume survey done in peak one hour is given below.

Time Interval (in minutes)	Vehicle Count
0 – 10	10
10 – 20	11
20 – 30	12
30 – 40	15
40 – 50	13
50 – 60	11

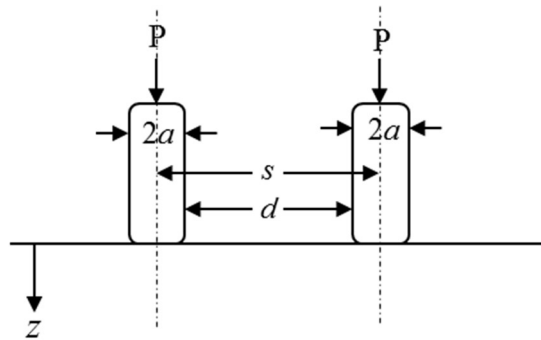
The peak hour factor (PHF) for 10 minute sub-interval is _____.
(round off to one decimal place)

GATE 2022 (CE Set-1) Civil Engineering

Q.65

For the dual-wheel carrying assembly shown in the figure, P is the load on each wheel, a is the radius of the contact area of the wheel, s is the spacing between the wheels, and d is the clear distance between the wheels. Assuming that the ground is an elastic, homogeneous, and isotropic half space, the ratio of Equivalent Single Wheel Load (ESWL) at depth $z = d/2$ to the ESWL at depth $z = 2s$ is _____. (round off to one decimal place)

(Consider the influence angle to be 45° for the linear dispersion of stress with depth)

**END OF THE QUESTION PAPER**

Q. No.	Session	Question Type	Subject Name	Key/Range	Mark
1	5	MCQ	GA	D	1
2	5	MCQ	GA	A	1
3	5	MCQ	GA	D	1
4	5	MCQ	GA	B	1
5	5	MCQ	GA	B	1
6	5	MCQ	GA	B	2
7	5	MCQ	GA	B	2
8	5	MCQ	GA	B	2
9	5	MCQ	GA	B	2
10	5	MCQ	GA	MTA	2
11	5	MCQ	CE	A	1
12	5	MCQ	CE	A	1
13	5	MCQ	CE	A OR B	1
14	5	MCQ	CE	A	1
15	5	MCQ	CE	B	1
16	5	MCQ	CE	A	1
17	5	MCQ	CE	A	1
18	5	MCQ	CE	A	1
19	5	MCQ	CE	A	1
20	5	MCQ	CE	A	1
21	5	MCQ	CE	A	1
22	5	MCQ	CE	A	1
23	5	MCQ	CE	A	1
24	5	MCQ	CE	A	1
25	5	MSQ	CE	A, C	1
26	5	MSQ	CE	A, B	1
27	5	MSQ	CE	B, D	1
28	5	MSQ	CE	A, B	1
29	5	NAT	CE	3.100 to 3.200	1
30	5	NAT	CE	0.120 to 0.130	1
31	5	NAT	CE	0.5 to 0.5	1
32	5	NAT	CE	4 to 4	1
33	5	NAT	CE	10 to 10	1
34	5	NAT	CE	MTA	1
35	5	NAT	CE	328.60 to 328.80	1
36	5	MCQ	CE	A	2
37	5	MCQ	CE	A	2
38	5	MCQ	CE	A	2
39	5	MCQ	CE	A	2
40	5	MCQ	CE	A	2
41	5	MCQ	CE	C	2
42	5	MCQ	CE	A	2
43	5	MCQ	CE	A	2
44	5	MCQ	CE	A	2



45	5	MSQ	CE	A, B	2
46	5	MSQ	CE	A, C OR A, B, C	2
47	5	MSQ	CE	A, B	2
48	5	NAT	CE	6.3 to 6.5	2
49	5	NAT	CE	1.9 to 1.9	2
50	5	NAT	CE	28 to 32	2
51	5	NAT	CE	57 to 63	2
52	5	NAT	CE	180 to 180	2
53	5	NAT	CE	100 to 102	2
54	5	NAT	CE	400 to 400	2
55	5	NAT	CE	1730 to 1740	2
56	5	NAT	CE	12 to 12	2
57	5	NAT	CE	5.60 to 5.70	2
58	5	NAT	CE	2.05 to 2.35	2
59	5	NAT	CE	29.0 to 30.0	2
60	5	NAT	CE	1000 to 1005	2
61	5	NAT	CE	0.38 to 0.42	2
62	5	NAT	CE	48 to 48	2
63	5	NAT	CE	0.78 to 0.82	2
64	5	NAT	CE	0.8 to 0.8	2
65	5	NAT	CE	0.5 to 0.5	2

SESSION - 2

GATE 2022 General Aptitude

Q.1 – Q.5 Carry ONE mark each.

Q.1	The movie was funny and I _____.
(A)	could help laughing
(B)	couldn't help laughed
(C)	couldn't help laughing
(D)	could helped laughed

Q.2	$x : y : z = \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$ What is the value of $\frac{x+z-y}{y}$?
(A)	0.75
(B)	1.25
(C)	2.25
(D)	3.25



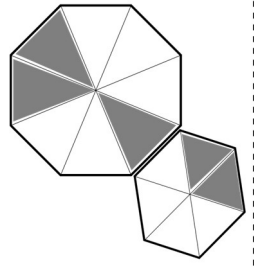
GATE 2022 (CE Set-2) Civil Engineering

Q.3	Both the numerator and the denominator of $\frac{3}{4}$ are increased by a positive integer, x, and those of $\frac{15}{17}$ are decreased by the same integer. This operation results in the same value for both the fractions. What is the value of x?
(A)	1
(B)	2
(C)	3
(D)	4

Q.4	A survey of 450 students about their subjects of interest resulted in the following outcome. • 150 students are interested in Mathematics. • 200 students are interested in Physics. • 175 students are interested in Chemistry. • 50 students are interested in Mathematics and Physics. • 60 students are interested in Physics and Chemistry. • 40 students are interested in Mathematics and Chemistry. • 30 students are interested in Mathematics, Physics and Chemistry. • Remaining students are interested in Humanities. Based on the above information, the number of students interested in Humanities is
(A)	10
(B)	30
(C)	40
(D)	45

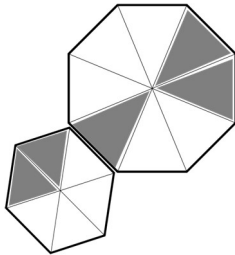
GATE 2022 (CE Set-2) Civil Engineering

Q.5

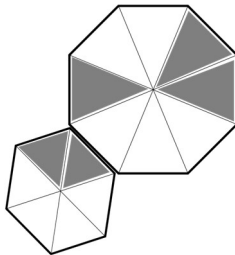


For the picture shown above, which one of the following is the correct picture representing reflection with respect to the mirror shown as the dotted line?

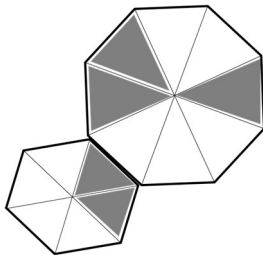
(A)



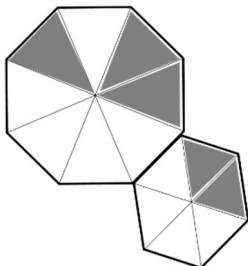
(B)



(C)



(D)



Q. 6 – Q. 10 Carry TWO marks each.

Q.6	In the last few years, several new shopping malls were opened in the city. The total number of visitors in the malls is impressive. However, the total revenue generated through sales in the shops in these malls is generally low. Which one of the following is the CORRECT logical inference based on the information in the above passage?
(A)	Fewer people are visiting the malls but spending more
(B)	More people are visiting the malls but not spending enough
(C)	More people are visiting the malls and spending more
(D)	Fewer people are visiting the malls and not spending enough

Q.7	In a partnership business the monthly investment by three friends for the first six months is in the ratio 3: 4: 5. After six months, they had to increase their monthly investments by 10%, 15% and 20%, respectively, of their initial monthly investment. The new investment ratio was kept constant for the next six months. What is the ratio of their shares in the total profit (in the same order) at the end of the year such that the share is proportional to their individual total investment over the year?
(A)	22 : 23 : 24
(B)	22 : 33 : 50
(C)	33 : 46 : 60
(D)	63 : 86 : 110

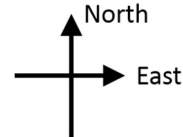
GATE 2022 (CE Set-2) Civil Engineering

Q.8	Consider the following equations of straight lines: Line L1: $2x - 3y = 5$ Line L2: $3x + 2y = 8$ Line L3: $4x - 6y = 5$ Line L4: $6x - 9y = 6$ Which one among the following is the correct statement?
(A)	L1 is parallel to L2 and L1 is perpendicular to L3
(B)	L2 is parallel to L4 and L2 is perpendicular to L1
(C)	L3 is perpendicular to L4 and L3 is parallel to L2
(D)	L4 is perpendicular to L2 and L4 is parallel to L3

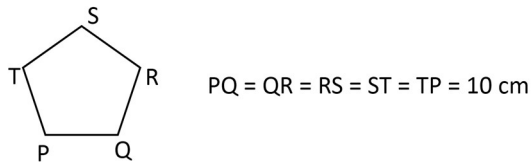
Q.9	Given below are two statements and four conclusions drawn based on the statements. Statement 1: Some soaps are clean. Statement 2: All clean objects are wet. Conclusion I: Some clean objects are soaps. Conclusion II: No clean object is a soap. Conclusion III: Some wet objects are soaps. Conclusion IV: All wet objects are soaps. Which one of the following options can be logically inferred?
(A)	Only conclusion I is correct
(B)	Either conclusion I or conclusion II is correct
(C)	Either conclusion III or conclusion IV is correct
(D)	Only conclusion I and conclusion III are correct

GATE 2022 (CE Set-2) Civil Engineering

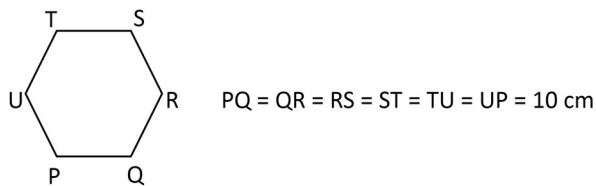
- Q.10 An ant walks in a straight line on a plane leaving behind a trace of its movement. The initial position of the ant is at point P facing east.
- The ant first turns 72° anticlockwise at P, and then does the following two steps in sequence exactly FIVE times before halting.
1. moves forward for 10 cm.
 2. turns 144° clockwise.
- The pattern made by the trace left behind by the ant is



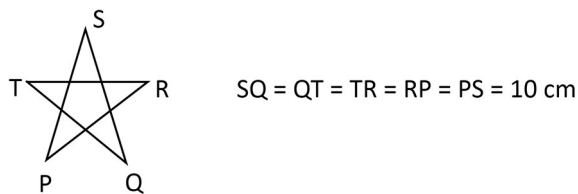
(A)



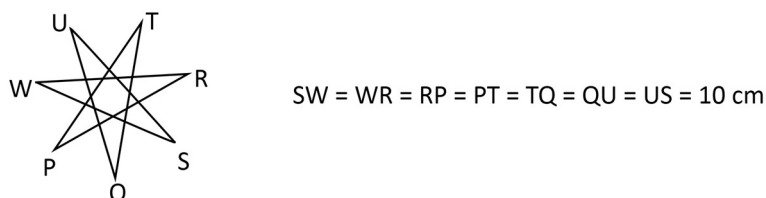
(B)



(C)



(D)



GATE 2022 (CE Set-2) Civil Engineering

Q.11 - 35 Carry ONE mark each.

Q.11	The function $f(x, y)$ satisfies the Laplace equation $\nabla^2 f(x, y) = 0$ on a circular domain of radius $r = 1$ with its center at point P with coordinates $x = 0, y = 0$. The value of this function on the circular boundary of this domain is equal to 3. The numerical value of $f(0, 0)$ is:
(A)	0
(B)	2
(C)	3
(D)	1

GATE 2022 (CE Set-2) Civil Engineering

Q.12	$\int \left(x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots \right) dx$ is equal to
(A)	$\frac{1}{1+x} + \text{Constant}$
(B)	$\frac{1}{1+x^2} + \text{Constant}$
(C)	$-\frac{1}{1-x} + \text{Constant}$
(D)	$-\frac{1}{1-x^2} + \text{Constant}$
Q.13	For a linear elastic and isotropic material, the correct relationship among Young's modulus of elasticity (E), Poisson's ratio (ν), and shear modulus (G) is
(A)	$G = \frac{E}{2(1+\nu)}$
(B)	$G = \frac{E}{(1+2\nu)}$
(C)	$E = \frac{G}{2(1+\nu)}$
(D)	$E = \frac{G}{(1+2\nu)}$

GATE 2022 (CE Set-2) Civil Engineering

Q.14	Read the following statements relating to flexure of reinforced concrete beams: I. In <i>over-reinforced</i> sections, the failure strain in concrete reaches earlier than the yield strain in steel. II. In <i>under-reinforced</i> sections, steel reaches yielding at a load lower than the load at which the concrete reaches failure strain. III. <i>Over-reinforced</i> beams are recommended in practice as compared to the <i>under-reinforced</i> beams. IV. In <i>balanced</i> sections, the concrete reaches failure strain earlier than the yield strain in tensile steel. Each of the above statements is either True or False. Which one of the following combinations is correct?
(A)	I (True), II (True), III (False), IV (False)
(B)	I (True), II (True), III (False), IV (True)
(C)	I (False), II (False), III (True), IV (False)
(D)	I (False), II (True), III (True), IV (False)

GATE 2022 (CE Set-2) Civil Engineering

Q.15

Match all the possible combinations between **Column X (Cement compounds)** and **Column Y (Cement properties)**:

Column X	Column Y
(i) C_3S	(P) Early age strength
(ii) C_2S	(Q) Later age strength
(iii) C_3A	(R) Flash setting
	(S) Highest heat of hydration
	(T) Lowest heat of hydration

Which one of the following combinations is correct?

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

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

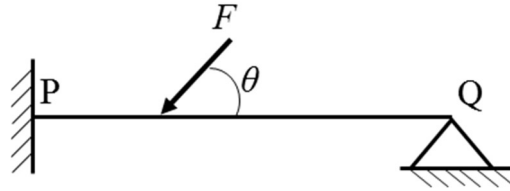
(C) (i) - (P), (ii) - (Q) and (R), (iii) - (T)

(D) (i) - (T), (ii) - (S), (iii) - (P) and (Q)

GATE 2022 (CE Set-2) Civil Engineering

Q.16

Consider a beam PQ fixed at P, hinged at Q, and subjected to a load F as shown in figure (*not drawn to scale*). The static and kinematic degrees of indeterminacy, respectively, are



(A)

2 and 1

(B)

2 and 0

(C)

1 and 2

(D)

2 and 2

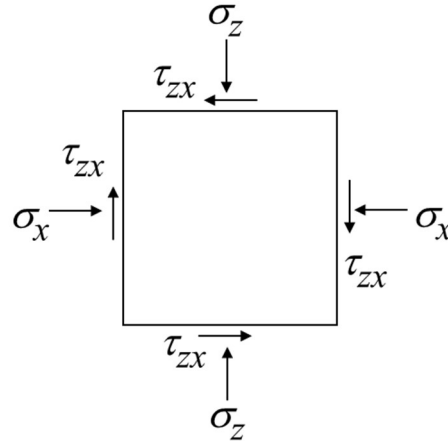
GATE 2022 (CE Set-2) Civil Engineering

Q.17	Read the following statements: (P) While designing a shallow footing in sandy soil, monsoon season is considered for critical design in terms of bearing capacity. (Q) For slope stability of an earthen dam, sudden drawdown is never a critical condition. (R) In a sandy sea beach, quicksand condition can arise only if the critical hydraulic gradient exceeds the existing hydraulic gradient. (S) The active earth thrust on a rigid retaining wall supporting homogeneous cohesionless backfill will reduce with the lowering of water table in the backfill. Which one of the following combinations is correct?
(A)	(P)-True, (Q)-False, (R)-False, (S)-False
(B)	(P)-False, (Q)-True, (R)-True, (S)-True
(C)	(P)-True, (Q)-False, (R)-True, (S)-True
(D)	(P)-False, (Q)-True, (R)-False, (S)-False

GATE 2022 (CE Set-2) Civil Engineering

Q.18

Stresses acting on an infinitesimal soil element are shown in the figure (with $\sigma_z > \sigma_x$). The major and minor principal stresses are σ_1 and σ_3 , respectively. Considering the compressive stresses as positive, which one of the following expressions correctly represents the angle between the major principal stress plane and the horizontal plane?



(A)

$$\tan^{-1} \left(\frac{\tau_{zx}}{\sigma_1 - \sigma_x} \right)$$

(B)

$$\tan^{-1} \left(\frac{\tau_{zx}}{\sigma_3 - \sigma_x} \right)$$

(C)

$$\tan^{-1} \left(\frac{\tau_{zx}}{\sigma_1 + \sigma_x} \right)$$

(D)

$$\tan^{-1} \left(\frac{\tau_{zx}}{\sigma_1 + \sigma_3} \right)$$

GATE 2022 (CE Set-2) Civil Engineering

Q.19

Match **Column X** with **Column Y**:

Column X	Column Y
(P) Horton equation	(I) Design of alluvial channel
(Q) Penman method	(II) Maximum flood discharge
(R) Chezy's formula	(III) Evapotranspiration
(S) Lacey's theory	(IV) Infiltration
(T) Dicken's formula	(V) Flow velocity

Which one of the following combinations is correct?

(A) (P)-(IV), (Q)-(III), (R)-(V), (S)-(I), (T)-(II)

(B) (P)-(III), (Q)-(IV), (R)-(V), (S)-(I), (T)-(II)

(C) (P)-(IV), (Q)-(III), (R)-(II), (S)-(I), (T)-(V)

(D) (P)-(III), (Q)-(IV), (R)-(I), (S)-(V), (T)-(II)

GATE 2022 (CE Set-2) Civil Engineering

Q.20	In a certain month, the reference crop evapotranspiration at a location is 6 mm/day. If the crop coefficient and soil coefficient are 1.2 and 0.8, respectively, the actual evapotranspiration in mm/day is
(A)	5.76
(B)	7.20
(C)	6.80
(D)	8.00
Q.21	The dimension of dynamic viscosity is:
(A)	$M L^{-1} T^{-1}$
(B)	$M L^{-1} T^{-2}$
(C)	$M L^{-2} T^{-2}$
(D)	$M L^0 T^{-1}$

GATE 2022 (CE Set-2) Civil Engineering

Q.22	A process equipment emits 5 kg/h of volatile organic compounds (VOCs). If a hood placed over the process equipment captures 95% of the VOCs, then the fugitive emission in kg/h is
(A)	0.25
(B)	4.75
(C)	2.50
(D)	0.48

GATE 2022 (CE Set-2) Civil Engineering

Q.23

Match the following attributes of a city with the appropriate scale of measurements.

Attribute	Scale of measurement
(P) Average temperature ($^{\circ}\text{C}$) of a city	(I) Interval
(Q) Name of a city	(II) Ordinal
(R) Population density of a city	(III) Nominal
(S) Ranking of a city based on ease of business	(IV) Ratio

Which one of the following combinations is correct?

- (A) (P)-(I), (Q)-(III), (R)-(IV), (S)-(II)
- (B) (P)-(II), (Q)-(I), (R)-(IV), (S)-(III)
- (C) (P)-(II), (Q)-(III), (R)-(IV), (S)-(I)
- (D) (P)-(I), (Q)-(II), (R)-(III), (S)-(IV)

GATE 2022 (CE Set-2) Civil Engineering

Q.24	If the magnetic bearing of the Sun at a place at noon is S 2° E , the magnetic declination (in degrees) at that place is
(A)	2° E
(B)	2° W
(C)	4° E
(D)	4° W
Q.25	P and Q are two square matrices of the same order. Which of the following statement(s) is/are correct?
(A)	If P and Q are invertible, then $[\mathbf{PQ}]^{-1} = \mathbf{Q}^{-1}\mathbf{P}^{-1}$.
(B)	If P and Q are invertible, then $[\mathbf{QP}]^{-1} = \mathbf{P}^{-1}\mathbf{Q}^{-1}$.
(C)	If P and Q are invertible, then $[\mathbf{PQ}]^{-1} = \mathbf{P}^{-1}\mathbf{Q}^{-1}$.
(D)	If P and Q are not invertible, then $[\mathbf{PQ}]^{-1} = \mathbf{Q}^{-1}\mathbf{P}^{-1}$.

GATE 2022 (CE Set-2) Civil Engineering

Q.26	In a solid waste handling facility, the moisture contents (MC) of food waste, paper waste, and glass waste were found to be MC_f , MC_p , and MC_g , respectively. Similarly, the energy contents (EC) of plastic waste, food waste, and glass waste were found to be EC_{pp} , EC_f , and EC_g , respectively. Which of the following statement(s) is/are correct?
(A)	$MC_f > MC_p > MC_g$
(B)	$EC_{pp} > EC_f > EC_g$
(C)	$MC_f < MC_p < MC_g$
(D)	$EC_{pp} < EC_f < EC_g$
Q.27	To design an optimum municipal solid waste collection route, which of the following is/are NOT desired:
(A)	Collection vehicle should not travel twice down the same street in a day.
(B)	Waste collection on congested roads should not occur during rush hours in morning or evening.
(C)	Collection should occur in the uphill direction.
(D)	The last collection point on a route should be as close as possible to the waste disposal facility.

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Q.28	For a traffic stream, v is the space mean speed, k is the density, q is the flow, v_f is the free flow speed, and k_j is the jam density. Assume that the speed decreases linearly with density. Which of the following relation(s) is/are correct?
(A)	$q = k_j k - \left(\frac{k_j}{v_f} \right) k^2$
(B)	$q = v_f k - \left(\frac{v_f}{k_j} \right) k^2$
(C)	$q = v_f v - \left(\frac{v_f}{k_j} \right) v^2$
(D)	$q = k_j v - \left(\frac{k_j}{v_f} \right) v^2$
Q.29	The error in measuring the radius of a 5 cm circular rod was 0.2%. If the cross-sectional area of the rod was calculated using this measurement, then the resulting absolute percentage error in the computed area is _____. (round off to two decimal places)
Q.30	The components of pure shear strain in a sheared material are given in the matrix form: $\boldsymbol{\epsilon} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ Here, $\text{Trace}(\boldsymbol{\epsilon}) = 0$. Given, $P = \text{Trace}(\boldsymbol{\epsilon}^8)$ and $Q = \text{Trace}(\boldsymbol{\epsilon}^{11})$. The numerical value of $(P + Q)$ is _____. (in integer)

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Q.31	The inside diameter of a sampler tube is 50 mm. The inside diameter of the cutting edge is kept such that the Inside Clearance Ratio (ICR) is 1.0 % to minimize the friction on the sample as the sampler tube enters into the soil. The inside diameter (in mm) of the cutting edge is _____. (round off to two decimal places)
Q.32	A concentrically loaded isolated square footing of size 2 m × 2 m carries a concentrated vertical load of 1000 kN. Considering Boussinesq's theory of stress distribution, the maximum depth (in m) of the pressure bulb corresponding to 10 % of the vertical load intensity will be _____. (round off to two decimal places)
Q.33	In a triaxial unconsolidated undrained (UU) test on a saturated clay sample, the cell pressure was 100 kPa. If the deviatoric stress at failure was 150 kPa, then the undrained shear strength of the soil is _____ kPa. (in integer)
Q.34	A flood control structure having an expected life of n years is designed by considering a flood of return period T years. When $T = n$, and $n \rightarrow \infty$, the structure's hydrologic risk of failure in percentage is _____. (round off to one decimal place)
Q.35	The base length of the runway at the mean sea level (MSL) is 1500 m. If the runway is located at an altitude of 300 m above the MSL, the actual length (in m) of the runway to be provided is _____. (round off to the nearest integer)

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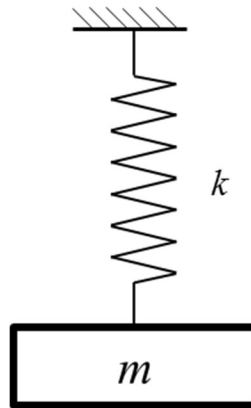
Q. 36 - 65 Carry TWO marks each.

Q.36	Consider the polynomial $f(x) = x^3 - 6x^2 + 11x - 6$ on the domain S given by $1 \leq x \leq 3$. The first and second derivatives are $f'(x)$ and $f''(x)$. Consider the following statements: I. The given polynomial is zero at the boundary points $x = 1$ and $x = 3$. II. There exists one local maxima of $f(x)$ within the domain S. III. The second derivative $f''(x) > 0$ throughout the domain S. IV. There exists one local minima of $f(x)$ within the domain S. The correct option is:
(A)	Only statements I, II and III are correct.
(B)	Only statements I, II and IV are correct.
(C)	Only statements I and IV are correct.
(D)	Only statements II and IV are correct.

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Q.37

An undamped spring-mass system with mass m and spring stiffness k is shown in the figure. The natural frequency and natural period of this system are ω rad/s and T s, respectively. If the stiffness of the spring is doubled and the mass is halved, then the natural frequency and the natural period of the modified system, respectively, are



(A)

2ω rad/s and $T/2$ s

(B)

$\omega/2$ rad/s and $2T$ s

(C)

4ω rad/s and $T/4$ s

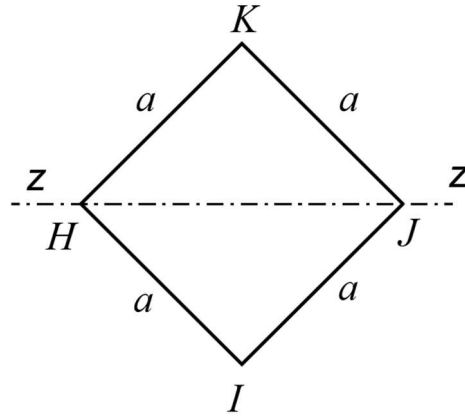
(D)

ω rad/s and T s

GATE 2022 (CE Set-2) Civil Engineering

Q.38

For the square steel beam cross-section shown in the figure, the shape factor about $Z - Z$ axis is S and the plastic moment capacity is M_P . Consider yield stress $f_y = 250 \text{ MPa}$ and $a = 100 \text{ mm}$.



The values of S and M_P (rounded-off to one decimal place) are

- | | |
|-----|-------------------------------------|
| (A) | $S = 2.0, M_P = 58.9 \text{ kN-m}$ |
| (B) | $S = 2.0, M_P = 100.2 \text{ kN-m}$ |
| (C) | $S = 1.5, M_P = 58.9 \text{ kN-m}$ |
| (D) | $S = 1.5, M_P = 100.2 \text{ kN-m}$ |

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Q.39	A post-tensioned concrete member of span 15 m and cross-section of 450 mm × 450 mm is prestressed with three steel tendons, each of cross-sectional area 200 mm ² . The tendons are tensioned one after another to a stress of 1500 MPa. All the tendons are straight and located at 125 mm from the bottom of the member. Assume the prestress to be the same in all tendons and the modular ratio to be 6. The average loss of prestress, due to elastic deformation of concrete, considering all three tendons is
(A)	14.16 MPa
(B)	7.08 MPa
(C)	28.32 MPa
(D)	42.48 MPa

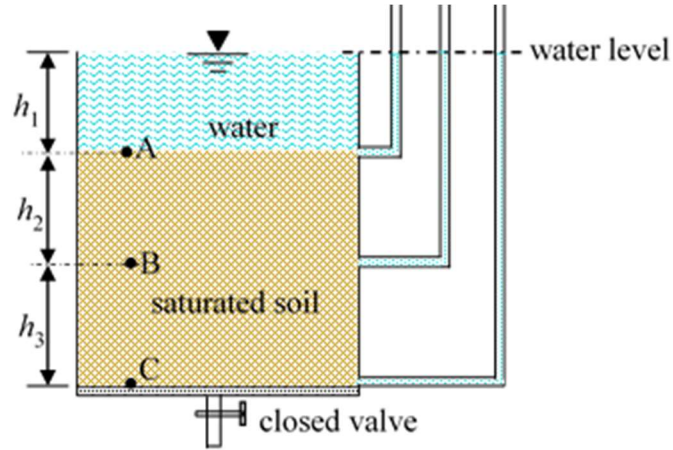
GATE 2022 (CE Set-2) Civil Engineering

Q.40	Match the following in Column X with Column Y: <table border="1"> <thead> <tr> <th>Column X</th><th>Column Y</th></tr> </thead> <tbody> <tr> <td>(P) In a triaxial compression test, with increase of axial strain in loose sand under drained shear condition, the volumetric strain</td><td>(I) decreases.</td></tr> <tr> <td>(Q) In a triaxial compression test, with increase of axial strain in loose sand under undrained shear condition, the excess pore water pressure</td><td>(II) increases.</td></tr> <tr> <td>(R) In a triaxial compression test, the pore pressure parameter "B" for a saturated soil</td><td>(III) remains same.</td></tr> <tr> <td>(S) For shallow strip footing in pure saturated clay, Terzaghi's bearing capacity factor (N_q) due to surcharge</td><td>(IV) is always 0.0.</td></tr> <tr> <td></td><td>(V) is always 1.0.</td></tr> <tr> <td></td><td>(VI) is always 0.5.</td></tr> </tbody> </table> Which one of the following combinations is correct?	Column X	Column Y	(P) In a triaxial compression test, with increase of axial strain in loose sand under drained shear condition, the volumetric strain	(I) decreases.	(Q) In a triaxial compression test, with increase of axial strain in loose sand under undrained shear condition, the excess pore water pressure	(II) increases.	(R) In a triaxial compression test, the pore pressure parameter " B " for a saturated soil	(III) remains same.	(S) For shallow strip footing in pure saturated clay, Terzaghi's bearing capacity factor (N_q) due to surcharge	(IV) is always 0.0.		(V) is always 1.0.		(VI) is always 0.5.
Column X	Column Y														
(P) In a triaxial compression test, with increase of axial strain in loose sand under drained shear condition, the volumetric strain	(I) decreases.														
(Q) In a triaxial compression test, with increase of axial strain in loose sand under undrained shear condition, the excess pore water pressure	(II) increases.														
(R) In a triaxial compression test, the pore pressure parameter " B " for a saturated soil	(III) remains same.														
(S) For shallow strip footing in pure saturated clay, Terzaghi's bearing capacity factor (N_q) due to surcharge	(IV) is always 0.0.														
	(V) is always 1.0.														
	(VI) is always 0.5.														
(A)	(P)-(I), (Q)-(II), (R)-(V), (S)-(V)														
(B)	(P)-(II), (Q)-(I), (R)-(IV), (S)-(V)														
(C)	(P)-(I), (Q)-(III), (R)-(VI), (S)-(IV)														
(D)	(P)-(I), (Q)-(II), (R)-(V), (S)-(VI)														

GATE 2022 (CE Set-2) Civil Engineering

Q.41

A soil sample is underlying a water column of height h_1 , as shown in the figure. The vertical effective stresses at points A, B, and C are σ'_A , σ'_B , and σ'_C , respectively. Let γ_{sat} and γ' be the saturated and submerged unit weights of the soil sample, respectively, and γ_w be the unit weight of water. Which one of the following expressions correctly represents the sum $(\sigma'_A + \sigma'_B + \sigma'_C)$?



(A)

$$(2h_2 + h_3)\gamma'$$

(B)

$$(h_1 + h_2 + h_3)\gamma'$$

(C)

$$(h_2 + h_3)(\gamma_{\text{sat}} - \gamma_w)$$

(D)

$$(h_1 + h_2 + h_3)\gamma_{\text{sat}}$$

GATE 2022 (CE Set-2) Civil Engineering

Q.42	A 100 mg of HNO_3 (strong acid) is added to water, bringing the final volume to 1.0 liter. Consider the atomic weights of H, N, and O, as 1 g/mol, 14 g/mol, and 16 g/mol, respectively. The final pH of this water is (Ignore the dissociation of water.)
(A)	2.8
(B)	6.5
(C)	3.8
(D)	8.5
Q.43	In a city, the chemical formula of biodegradable fraction of municipal solid waste (MSW) is $\text{C}_{100}\text{H}_{250}\text{O}_{80}\text{N}$. The waste has to be treated by forced-aeration composting process for which air requirement has to be estimated. Assume oxygen in air (by weight) = 23 %, and density of air = 1.3 kg/m³. Atomic mass: C = 12, H = 1, O = 16, N = 14. C and H are oxidized completely whereas N is converted only into NH_3 during oxidation. For oxidative degradation of 1 tonne of the waste, the required theoretical volume of air (in m³/tonne) will be (<i>round off to the nearest integer</i>)
(A)	4749
(B)	8025
(C)	1418
(D)	1092

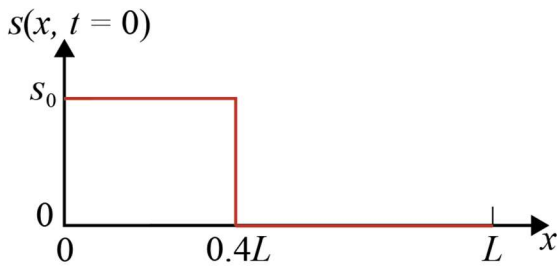
GATE 2022 (CE Set-2) Civil Engineering

Q.44	A single-lane highway has a traffic density of 40 vehicles/km. If the time-mean speed and space-mean speed are 40 kmph and 30 kmph, respectively, the average headway (in seconds) between the vehicles is
(A)	3.00
(B)	2.25
(C)	8.33×10^{-4}
(D)	6.25×10^{-4}
Q.45	Let $\mathbf{y}$ be a non-zero vector of size 2022×1 . Which of the following statement(s) is/are TRUE ?
(A)	$\mathbf{y}\mathbf{y}^T$ is a symmetric matrix.
(B)	$\mathbf{y}^T \mathbf{y}$ is an eigenvalue of $\mathbf{y}\mathbf{y}^T$.
(C)	$\mathbf{y}\mathbf{y}^T$ has a rank of 2022.
(D)	$\mathbf{y}\mathbf{y}^T$ is invertible.

GATE 2022 (CE Set-2) Civil Engineering

Q.46	Which of the following statement(s) is/are correct?
(A)	If a linearly elastic structure is subjected to a set of loads, the partial derivative of the total strain energy with respect to the deflection at any point is equal to the load applied at that point.
(B)	If a linearly elastic structure is subjected to a set of loads, the partial derivative of the total strain energy with respect to the load at any point is equal to the deflection at that point.
(C)	If a structure is acted upon by two force system P_a and P_b , in equilibrium separately, the external virtual work done by a system of forces P_b during the deformations caused by another system of forces P_a is equal to the external virtual work done by the P_a system during the deformation caused by the P_b system.
(D)	The shear force in a conjugate beam loaded by the M/EI diagram of the real beam is equal to the corresponding deflection of the real beam.
Q.47	Water is flowing in a horizontal, frictionless, rectangular channel. A smooth hump is built on the channel floor at a section and its height is gradually increased to reach choked condition in the channel. The depth of water at this section is y_2 and that at its upstream section is y_1 . The correct statement(s) for the choked and unchoked conditions in the channel is/are
(A)	In choked condition, y_1 decreases if the flow is supercritical and increases if the flow is subcritical.
(B)	In choked condition, y_2 is equal to the critical depth if the flow is supercritical or subcritical.
(C)	In unchoked condition, y_1 remains unaffected when the flow is supercritical or subcritical.
(D)	In choked condition, y_1 increases if the flow is supercritical and decreases if the flow is subcritical.

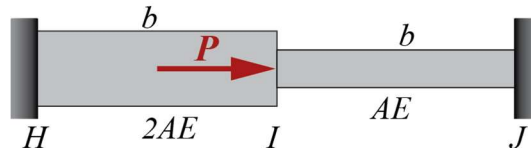
GATE 2022 (CE Set-2) Civil Engineering

Q.48	The concentration $S(x, t)$ of pollutants in a one-dimensional reservoir at position x and time t satisfies the diffusion equation $\frac{\partial s(x, t)}{\partial t} = D \frac{\partial^2 s(x, t)}{\partial x^2}$ on the domain $0 \leq x \leq L$, where D is the diffusion coefficient of the pollutants. The initial condition $s(x, 0)$ is defined by the step-function shown in the figure.  The boundary conditions of the problem are given by $\frac{\partial s(x, t)}{\partial x} = 0$ at the boundary points $x = 0$ and $x = L$ at all times. Consider $D = 0.1 \text{ m}^2/\text{s}$, $s_0 = 5 \text{ } \mu\text{mol}/\text{m}$, and $L = 10 \text{ m}$. The steady-state concentration $\tilde{s}\left(\frac{L}{2}\right) = s\left(\frac{L}{2}, \infty\right)$ at the center $x = \frac{L}{2}$ of the reservoir (in $\mu\text{mol}/\text{m}$) is _____. (in integer)
Q.49	A pair of six-faced dice is rolled thrice. The probability that the sum of the outcomes in each roll equals 4 in exactly two of the three attempts is _____. (round off to three decimal places)

GATE 2022 (CE Set-2) Civil Engineering

Q.50

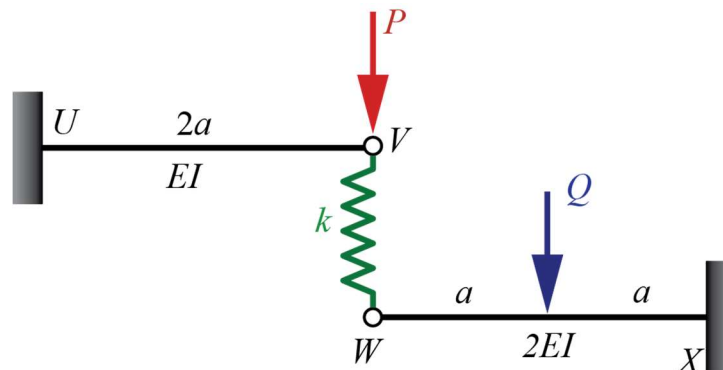
Consider two linearly elastic rods HI and IJ , each of length b , as shown in the figure. The rods are co-linear, and confined between two fixed supports at H and J . Both the rods are initially stress free. The coefficient of linear thermal expansion is α for both the rods. The temperature of the rod IJ is raised by ΔT , whereas the temperature of rod HI remains unchanged. An external horizontal force P is now applied at node I . It is given that $\alpha = 10^{-6} \text{ }^\circ\text{C}^{-1}$, $\Delta T = 50 \text{ }^\circ\text{C}$, $b = 2 \text{ m}$, $AE = 10^6 \text{ N}$. The axial rigidities of the rods HI and IJ are $2AE$ and AE , respectively.



To make the axial force in rod HI equal to zero, the value of the external force P (in N) is _____. (round off to the nearest integer)

Q.51

The linearly elastic planar structure shown in the figure is acted upon by two vertical concentrated forces. The horizontal beams UV and WX are connected with the help of the vertical linear spring with spring constant $k = 20 \text{ kN/m}$. The fixed supports are provided at U and X . It is given that flexural rigidity $EI = 10^5 \text{ kN-m}^2$, $P = 100 \text{ kN}$, and $a = 5 \text{ m}$. Force Q is applied at the center of beam WX such that the force in the spring VW becomes zero.

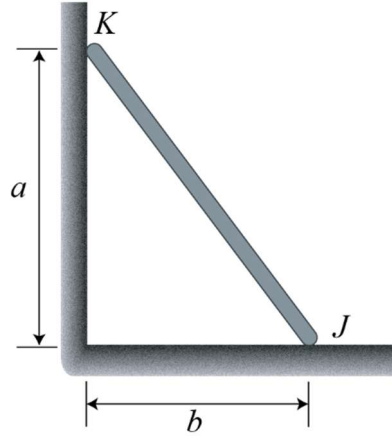


The magnitude of force Q (in kN) is _____. (round off to the nearest integer)

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Q.52

A uniform rod KJ of weight w shown in the figure rests against a frictionless vertical wall at the point K and a rough horizontal surface at point J . It is given that $w = 10 \text{ kN}$, $a = 4 \text{ m}$ and $b = 3 \text{ m}$.



The minimum coefficient of static friction that is required at the point J to hold the rod in equilibrium is _____. (round off to three decimal places)

Q.53

The activities of a project are given in the following table along with their durations and dependency.

Activities	Duration (days)	Depends on
A	10	-
B	12	-
C	5	A
D	14	B
E	10	B, C

The total float of the activity E (in **days**) is _____. (in integer)

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Q.54

A group of total **16** piles are arranged in a square grid format. The center-to-center spacing (s) between adjacent piles is **3 m**. The diameter (d) and length of embedment of each pile are **1 m** and **20 m**, respectively. The design capacity of each pile is **1000 kN** in the vertical downward direction. The pile group efficiency (η_g) is given by

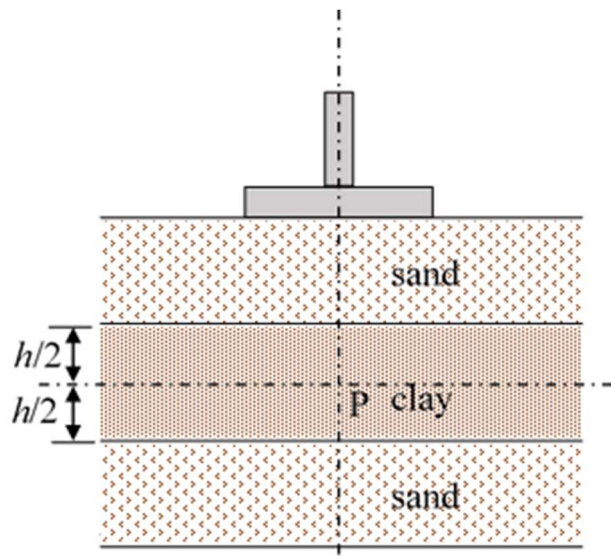
$$\eta_g = 1 - \frac{\theta}{90} \left[\frac{(n-1)m + (m-1)n}{mn} \right]$$

where m and n are number of rows and columns in the plan grid of pile arrangement, and $\theta = \tan^{-1} \left(\frac{d}{s} \right)$.

The design value of the pile group capacity (in **kN**) in the vertical downward direction is _____. (round off to the nearest integer)

Q.55

A saturated compressible clay layer of thickness h is sandwiched between two sand layers, as shown in the figure. Initially, the total vertical stress and pore water pressure at point P, which is located at the mid-depth of the clay layer, were 150 kPa and 25 kPa, respectively. Construction of a building caused an additional total vertical stress of 100 kPa at P. When the vertical effective stress at P is 175 kPa, the percentage of consolidation in the clay layer at P is _____. (in integer)



GATE 2022 (CE Set-2) Civil Engineering

Q.56	A hydraulic jump takes place in a 6 m wide rectangular channel at a point where the upstream depth is 0.5 m (just before the jump). If the discharge in the channel is $30 \text{ m}^3/\text{s}$ and the energy loss in the jump is 1.6 m, then the Froude number computed at the end of the jump is _____. (round off to two decimal places) (Consider the acceleration due to gravity as 10 m/s^2.)
Q.57	A pump with an efficiency of 80% is used to draw groundwater from a well for irrigating a flat field of area 108 hectares. The base period and delta for paddy crop on this field are 120 days and 144 cm, respectively. Water application efficiency in the field is 80%. The lowest level of water in the well is 10 m below the ground. The minimum required horse power (h.p.) of the pump is _____. (round off to two decimal places) (Consider 1 h.p. = 746 W; unit weight of water = 9810 N/m^3)
Q.58	Two discrete spherical particles (P and Q) of equal mass density are independently released in water. Particle P and particle Q have diameters of 0.5 mm and 1.0 mm, respectively. Assume Stokes' law is valid. The drag force on particle Q will be _____ times the drag force on particle P. (round off to the nearest integer)
Q.59	At a municipal waste handling facility, 30 metric ton mixture of food waste, yard waste, and paper waste was available. The moisture content of this mixture was found to be 10%. The ideal moisture content for composting this mixture is 50%. The amount of water to be added to this mixture to bring its moisture content to the ideal condition is _____ metric ton. (in integer)

GATE 2022 (CE Set-2) Civil Engineering

Q.60	A sewage treatment plant receives sewage at a flow rate of 5000 m³/day. The total suspended solids (TSS) concentration in the sewage at the inlet of primary clarifier is 200 mg/L. After the primary treatment, the TSS concentration in sewage is reduced by 60 %. The sludge from the primary clarifier contains 2 % solids concentration. Subsequently, the sludge is subjected to gravity thickening process to achieve a solids concentration of 6 %. Assume that the density of sludge, before and after thickening, is 1000 kg/m³. The daily volume of the thickened sludge (in m³/day) will be _____. (round off to the nearest integer)			
Q.61	A sample of air analyzed at 25 °C and 1 atm pressure is reported to contain 0.04 ppm of SO₂. Atomic mass of S = 32, O = 16. The equivalent SO₂ concentration (in µg/m³) will be _____. (round off to the nearest integer)			
Q.62	A parabolic vertical crest curve connects two road segments with grades +1.0% and −2.0%. If a 200 m stopping sight distance is needed for a driver at a height of 1.2 m to avoid an obstacle of height 0.15 m, then the minimum curve length should be _____ m. (round off to the nearest integer)			
Q.63	Assuming that traffic on a highway obeys the Greenshields model, the speed of a shockwave between two traffic streams (P) and (Q) as shown in the schematic is _____ kmph. (in integer) Direction of traffic → <table><tr><td style="border-bottom: 1px solid black; padding: 5px 10px; text-align: center;">(P) Flow = 1200 vehicles/hour Speed = 60 kmph</td><td style="border-left: 1px dashed black; border-right: 1px dashed black; padding: 0 10px;"></td><td style="border-bottom: 1px solid black; padding: 5px 10px; text-align: center;">(Q) Flow = 1800 vehicles/hour Speed = 30 kmph</td></tr></table>	(P) Flow = 1200 vehicles/hour Speed = 60 kmph		(Q) Flow = 1800 vehicles/hour Speed = 30 kmph
(P) Flow = 1200 vehicles/hour Speed = 60 kmph		(Q) Flow = 1800 vehicles/hour Speed = 30 kmph		

GATE 2022 (CE Set-2) Civil Engineering

Q.64	It is given that an aggregate mix has 260 grams of coarse aggregates and 240 grams of fine aggregates. The specific gravities of the coarse and fine aggregates are 2.6 and 2.4, respectively. The bulk specific gravity of the mix is 2.3. The percentage air voids in the mix is _____. (round off to the nearest integer)
Q.65	The lane configuration with lane volumes in vehicles per hour of a four-arm signalized intersection is shown in the figure. There are only two phases: the first phase is for the East-West and the West-East through movements, and the second phase is for the North-South and the South-North through movements. There are no turning movements. Assume that the saturation flow is 1800 vehicles per hour per lane for each lane and the total lost time for the first and the second phases together is 9 seconds. The optimum cycle length (in seconds), as per the Webster's method, is _____. (round off to the nearest integer)



Q. No.	Session	Question Type	Subject Name	Key/Range	Mark
1	6	MCQ	GA	C	1
2	6	MCQ	GA	B	1
3	6	MCQ	GA	C	1
4	6	MCQ	GA	D	1
5	6	MCQ	GA	A	1
6	6	MCQ	GA	B	2
7	6	MCQ	GA	D	2
8	6	MCQ	GA	D	2
9	6	MCQ	GA	D	2
10	6	MCQ	GA	C	2
11	6	MCQ	CE	C	1
12	6	MCQ	CE	MTA	1
13	6	MCQ	CE	A	1
14	6	MCQ	CE	A	1
15	6	MCQ	CE	A	1
16	6	MCQ	CE	A	1
17	6	MCQ	CE	A	1
18	6	MCQ	CE	A	1
19	6	MCQ	CE	A	1
20	6	MCQ	CE	A	1
21	6	MCQ	CE	A	1
22	6	MCQ	CE	A	1
23	6	MCQ	CE	A	1
24	6	MCQ	CE	A	1
25	6	MSQ	CE	A, B	1
26	6	MSQ	CE	A, B	1
27	6	MSQ	CE	C	1
28	6	MSQ	CE	B, D	1
29	6	NAT	CE	0.39 to 0.41	1
30	6	NAT	CE	32 to 32	1
31	6	NAT	CE	49.49 to 49.52	1
32	6	NAT	CE	4.35 to 4.39	1
33	6	NAT	CE	75 to 75	1
34	6	NAT	CE	63.0 to 63.5	1
35	6	NAT	CE	1602 to 1606	1
36	6	MCQ	CE	B	2
37	6	MCQ	CE	A	2
38	6	MCQ	CE	A	2
39	6	MCQ	CE	A	2
40	6	MCQ	CE	A	2
41	6	MCQ	CE	A	2
42	6	MCQ	CE	A	2
43	6	MCQ	CE	A	2
44	6	MCQ	CE	A	2



45	6	MSQ	CE	A, B	2
46	6	MSQ	CE	A, B, C	2
47	6	MSQ	CE	A, B, C	2
48	6	NAT	CE	2 to 2	2
49	6	NAT	CE	0.018 to 0.020	2
50	6	NAT	CE	47 to 53	2
51	6	NAT	CE	620 to 660	2
52	6	NAT	CE	0.350 to 0.400	2
53	6	NAT	CE	1 to 1	2
54	6	NAT	CE	11000 to 11200	2
55	6	NAT	CE	50 to 50	2
56	6	NAT	CE	0.20 to 0.41	2
57	6	NAT	CE	30.00 to 32.00	2
58	6	NAT	CE	8 to 8	2
59	6	NAT	CE	24 to 24	2
60	6	NAT	CE	10 to 10	2
61	6	NAT	CE	102 to 108	2
62	6	NAT	CE	270 to 275	2
63	6	NAT	CE	15 to 15	2
64	6	NAT	CE	8 to 8	2
65	6	NAT	CE	37 to 37	2