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GATE - 2021

Questions with Detailed Solutions

CIVIL ENGINEERING

(Forenoon Session)

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GATE - 2021

CIVIL ENGINEERING

Questions with Detailed Solutions

06/02/21

Forenoon Session

SUBJECTWISE WEIGHTAGE

S. No.	NAME OF THE SUBJECT	Number of Questions
01	Engineering Mechanics	1
02	Strength of Material	4
03	Structural Analysis	3
04	Construction Materials	1
05	Construction Planning & Management	3
06	Reinforced Cement Concrete	1
07	Design of Steel Structures	1
08	Geotechnical Engineering	8
09	Fluid Mechanics & Hydraulic Machines	4
10	Hydrology	2
11	Irrigation Engineering	1
12	Environmental Engineering	8
13	Transportation Engineering	6
14	Geomatics Engineering (Surveying)	3
15	Engineering Mathematics	9
16	Verbal Ability	2
17	Numerical Ability	8
Total No. of Questions		**65**

Section : General Aptitude

01. Humans have the ability to construct worlds entirely in their minds, which don't exist in the physical world. So far as we know, no other species possesses this ability. This skill is so important that we have different words to refer to its different flavors, such as imagination, invention and innovation.

(a) The terms imagination, invention and innovation refer to unrelated skills.
(b) No species possess the ability to construct worlds in their minds.
(c) Imagination, invention and innovation are unrelated to the ability to construct mental worlds.
(d) We do not know of any species other than humans who possess the ability to construct mental worlds.

01. Ans: (d)

Sol: Only humans have the ability to construct world s entirely in their minds and no other species has this.

02. Statement: Either P marries Q or X marries Y
Among the options below, the logical NEGATION of the above statement is:
(a) P does not marry Q and X marries Y.
(b) X does not marry Y and P marries Q.
(c) Neither P marries Q nor X marries Y.
(d) P marries Q and X marries Y.

02. Ans: (c)

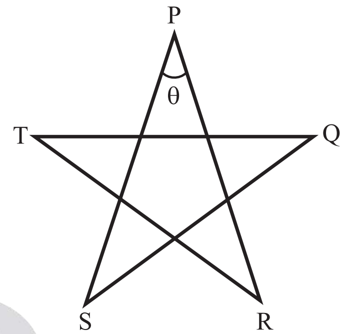
Sol:

03. Getting to the top is________ than staying on top.
(a) easier (b) easiest
(c) more easy (d) much easy

03. Ans: (a)

Sol: Comparative degree : easier

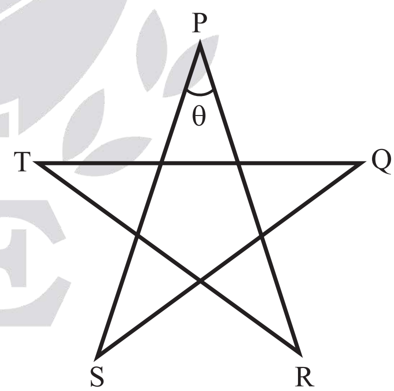
04.



Five line segments of equal lengths, PR. PS. QS. QT and RT are used to form a star as shown in the figure above.
The value of θ, in degrees, is_____
(a) 45 (b) 72
(c) 108 (d) 36

04. Ans: (d)

Sol:



Sum of the angles = 180°

Each angle = $\frac{180}{5} = 36°$

05. Four persons P, Q. R and S are to be seated in a row, all facing the same direction, but not necessarily in the same order. P and R cannot sit adjacent to each other. S should be seated to the right of Q. The number of distinct seating arrangements possible is:
(a) 4 (b) 6 (c) 2 (d) 8

05. Ans: (b)

Sol: P and R can not adjacent .... 'S' is seated right of Q.

(i) P Q S R

After interchanging 'P' and 'R' we get one more chance.

R Q S P

(i) Q __ S __ (here two chances)

(ii)__ Q__ S (here two chances)

06. A function, λ, is defined by

$$\lambda(p,q)=\begin{cases}(p-q)^2, \text{ if } & p\ge q,\\ p+q, \text{ if } & p<q\end{cases}$$

The value of the expression $\dfrac{\lambda(-(-3+2),(-2+3))}{(-(-2+1))}$ is:

(a) 0 (b) 16 (c) $\frac{16}{3}$ (d) -1

06. Ans: (a)

Sol:

$$\lambda(p,q)=\begin{cases}(p-q)^2, \text{ if } p\ge q\\ (p+q), \text{ if } p\quad q\end{cases}$$

$$\frac{\lambda(-(-3+2),(-2+3))}{(-(-2+1))}=\frac{\lambda(1,1)}{1}$$

$$=\frac{(1-1)^2}{1}=0$$

07. In a company, 35% of the employees drink coffee, 40% of the employees drink tea and 10% of the employees drink both tea and coffee. What % of employees drink neither tea nor coffee?

(a) 35 (b) 15 (c) 40 (d) 25

07. Ans: (a)

Sol:

n[coffee] = 35%

n[Tea] = 40%

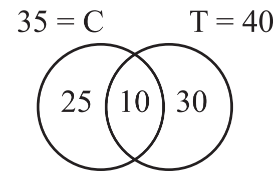
n[c∩t] = 10%

n[c∪T] = 35 + 40-10 = 65%

100 – 65% = 35%

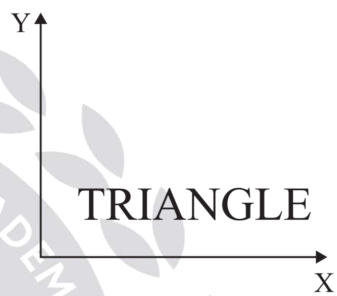
Neither tea or coffee

or



= 100–65% = 35%

08.



The mirror image of the above text about the X-axis is

1. 

2. 

3. 

4. 

08. Ans: (a)

09. ⊕ and ⊙ are two operators on numbers p and q such that

$$p\oplus q=\frac{p^2+q^2}{pq} \text{ and } p\odot q=\frac{p^2}{q};$$

If x⊕y=2⊙2, then x=

(a) 2y (b) $\frac{3y}{2}$ (c) y (d) $\frac{y}{2}$

09. Ans: (c)

Sol:

$$P\oplus q=\frac{P+q}{pq} \qquad p\odot q=\frac{\gamma}{q}$$

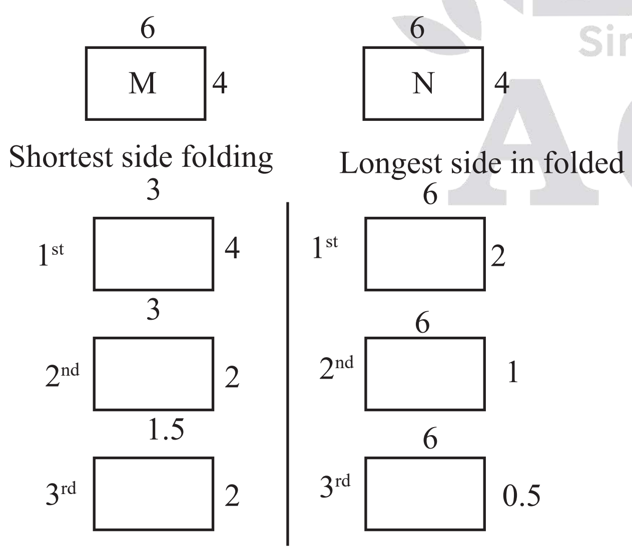
$x \oplus y = 2 \odot 2$

$\dfrac{x^2+y^2}{xy} = \dfrac{2^2}{2}$

$x^2 + y^2 = 2xy$
$x^2 + y^2 - 2xy = 0$
$(x-y)^2 = 0$
$x - y = 0$
$x = y$

10. Consider two rectangular sheets, Sheet M and Sheet N of dimensions 6 cm x 4 cm each.
Folding operation 1: The sheet is folded into half by joining the short edges of the current shape.
Folding operation 2: The sheet is folded into half by joining the long edges of the current shape.
Folding operation 1 is carried out on Sheet M three times.
Folding operation 2 is carried out on Sheet N three times.
The ratio of perimeters of the final folded shape of Sheet N to the final folded shape of Sheet M is
(a) 5 : 13 (b) 13 : 7
(c) 3 : 2 (d) 7 : 5

10. Ans: (b)



Perimater = 2 (2+1.5) = 7 Perimater = 2 (6+0.5) = 13

But requirement is N : M

13 : 7

Section : Civil Engineering

01. Vehicular arrival at an isolated intersection follows the Poisson distribution. The mean vehicular arrival rate is 2 vehicle per minute. The probability (round off to two decimal places) that at least 2 vehicles will arrive in any given 1-minute interval is________

01. Ans: (0.59)

Sol:

$\lambda = 2$ veh/minute

Let x = Number of vehicles arrive in a minute

$P(x \geq 2) = 1 - P(x < 2)$
$= 1 - \{ p(x=0) + p(x=1)\}$

$= 1 - \left\{\dfrac{\lambda^0 e^{-\lambda}}{0!} + \dfrac{\lambda^1 e^{-\lambda}}{1!}\right\}$

$= 1 - \{e^{-2} + 2e^{-2}\}$
$= 1.3e^{-2}$
$= 0.593$

02. Spot speeds of vehicles observed at a point on a highway are 40, 55, 60, 65 and 80 km/h. The space-mean speed (in km/h, round off to two decimal places) of the observed vehicles is____

Ans: (56.99)

Sol:

Space mean speed (v_s) = Harmonic mean of all spot speeds

$$\frac{1}{V} = \frac{1}{40} + \frac{1}{55} + \frac{1}{60} + \frac{1}{65} + \frac{1}{80}$$

$V = 11.39$ kmph
$V_s = (n)(V)$
$= (5)(11.39)$
$= 56.99$ km/hr

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Estimation & Costing (Hindi & English)	Structural Analysis	Strength of Materials	Surveying (Geomatics)
Irrigation Engineering	Hydrology	Environmental Engg.	RCC & PSC
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03. Which one of the following is correct?

(a) The partially treated effluent from a food processing industry, containing high concentration of biodegradable organics, is being discharged into a flowing river at a point P. If the rate of degradation of the organics is higher than the rate of aeration, then dissolved oxygen of the river water will be lowest at point P.

(b) For an effluent sample of a sewage treatment plant, the ratio $BOD_{5\text{-day, }20°C}$ upon ultimate BOD is more than 1.

(c) A young lake characterized by low nutrient content and low plant productivity is called eutrophic lake.

(d) The most important type of species involved in the degradation of organic matter in the case of activated sludge process based wastewater treatment is *chemoheterotrophs.*

03. Ans: (d)

Sol: *chemoheterotrophs* are organisms that obtain energy by oxidation. Chemoheterotrophs can be either autotrophic (or) heterotropic. But in ASP heterotrophs only involved in biodegradation of organics.

04. Consider the limit:

$$\lim_{x\to 1}\left(\frac{1}{\ln x}-\frac{1}{x-1}\right)$$

*The limit (correct up to one decimal place) is*____

Ans: (0.5)

Sol:

Let $\ell = \lim_{x\to 1}\left(\frac{1}{\ell nx}-\frac{1}{x-1}\right) \qquad (\infty - \infty \text{ form})$

Then

$$\ell = \lim_{x\to 1}\left[\frac{(x-1)-\ell nx}{(x-1)\ell nx}\right]\left(\frac{0}{0}\text{ form}\right)$$

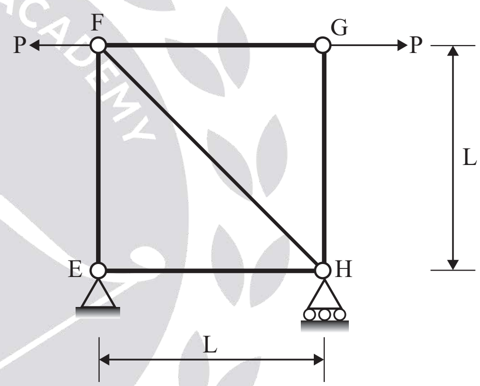
$$\Rightarrow \ell = \lim_{x\to 1}\left[\frac{1-\frac{1}{x}}{(x-1)\frac{1}{x}+\ell nx}\right]\left(\frac{0}{0}\text{ form}\right)$$

$$\Rightarrow \ell = \lim_{x\to 1}\left[\frac{0+\frac{1}{x^2}}{(x-1)\left(\frac{-1}{x^2}\right)+(1)\left(\frac{1}{x}\right)+\frac{1}{x}}\right]$$

$$\Rightarrow \ell = \frac{+1}{0+1+1}=\frac{1}{2}$$

$\therefore l = +0.5$

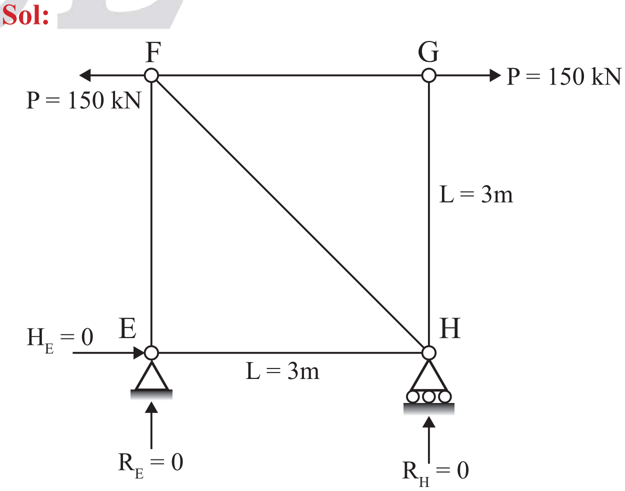
05 A truss EFGH is shown in the figure, in which all the members have the same axial rigidity R. In the figure, P is the magnitude of external horizontal forces acting at joints F and G.



IF R - 500×10³ kN, P= 150 kN and L - 3 m, the magnitude of the horizontal displacement of joint G *(in mm, round off to one decimal place)* is_____

05. Ans: (0.9)

Sol:



Taking moment about 'E'

$\Sigma M_E = 0$ ↺ -ve ↻ - ve

$-R_H + P \times L - P \times L = 0$

$R_H = 0$

$R_E = 0$

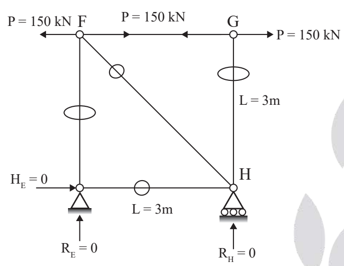
Horizontal displacement of joint 'G'

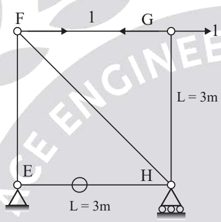
$$\delta_{HG} = \Sigma \frac{PKL}{AE}$$

where,

P = forces in all the members due to real loads

K = forces in all the members due to virtual unit load applied at joint 'G' in horizontal direction.





Sign conventions: -

Tension : +ve

Compression : -ve

Horizontal displacement of joint 'G'

$$\delta_{HG} = \Sigma \frac{PKL}{AE}$$

Axial rigidity (AE) = R = 500×10^3 kN

$$\delta_{HG} = \frac{P_{FG} K_{FG} L_{FG}}{R} + ...$$

$$= \frac{(+150)(+1)(3000)}{500 \times 10^3}$$

= 0.9 mm

06. Which of the following is NOT a correct statement?

(a) The first reading from a level station is a 'Fore Sight'.

(b) Contours of different elevations may intersect each other in case of an overhanging cliff.

(c) Basic principle of surveying is to work from whole to parts.

(d) Planimeter is used for measuring ' area'

06. Ans:(a)

Sol: The first reading from a level station is a back sight.

07. An unlined canal under regime conditions along with a silt factor of 1 has a width of flow 71.25 m. Assuming the unlined canal as a wide channel, the corresponding average depth of flow (in m. round off to two decimal places) in the canal will be____

07. Ans: (2.92)

Sol: As it is assumed as a wide channel

P = B = 71.25 m

For a regime channel $P = 4.75\sqrt{Q}$

$71.25 = 4.75\sqrt{Q}$

$Q = 225\ m^3/s$

$$V = \left(\frac{Qf^2}{140}\right)^{1/6} = 1.08\ m$$

$$A = \frac{Q}{V} = \frac{225}{1.08} = 208.33\ m^2$$

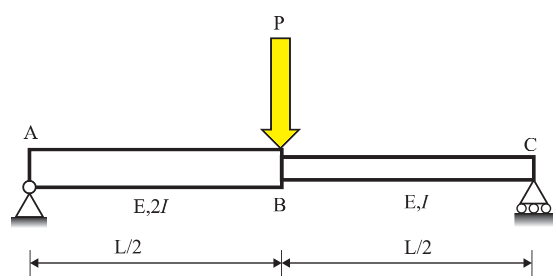
Treating it as a very wide channel,

A = BD

208.33 = 71.25D

D = 2.92 m

08. Employ stiffness matrix approach for the simply supported beam as shown in the figure to calculate unknown displacements/rotations. Take length. L = 8 m; modulus of elasticity, E = 3×10^4 N/mm^2 ; moment of inertia, $I = 225\times10^6$ mm^4.



The mid-span deflection of the beam (in mm, round off to integer) under

P= 100 kN in downward direction will be___

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		1^{st} & 17^{th} May 2021		
		1^{st} & 17^{th} June 2021		

GATE + PSUs - 2022 (FLEXIBLE BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Flexible Batches	Daily 6 to 8 Hours	**5^{th}, 20^{th} July 2021**	3 to 4 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		4^{th}, 18^{th} August 2021		

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Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 6 to 8 Hours	**2^{nd} & 17^{th} April 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
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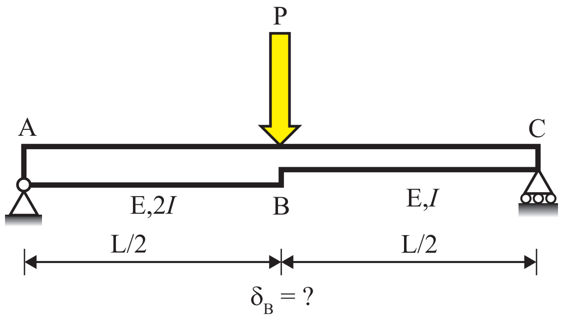
Batch Type	Timings	Batch Date	Duration	Venue & Streams
Spark	Daily 6 to 8 Hours	**17^{th} May 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1^{st} & 17^{th} June 2021		

08. Ans:(119)

Sol:



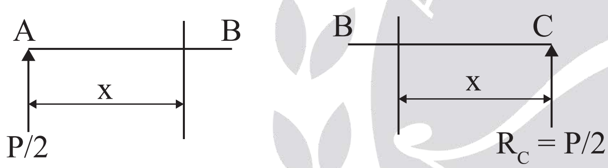
Given

P = 100 kN, E = 3 × 10⁴ , I = 225 × 10⁶ mm⁴

L = 8 m

As deflection to be find out at mid span (point load location) strain energy method is the easiest to find.

$U_{AC} = U_{AB} + U_{BC}$



$$U_{AB} = \int_0^{L/2} \frac{\left[\frac{P}{2}x\right]^2}{4EI}dx \qquad U_{BC} = \int_0^{L/2} \frac{\left[\frac{P}{2}x\right]^2}{2EI}$$

$$U_{AC} = \frac{1}{16EI}\int_0^{L/2}(Px)^2dx + \frac{1}{8EI}\int_0^{L/2}(Px)^2dx = \frac{3}{16EI}\int_0^{L/2}(Px)^2dx$$

$$\delta_B = \frac{\partial U}{\partial p} = \frac{3}{16EI} = \int_0^{L/2} 2Px^2dx = \frac{3P}{8EI}\left[\frac{\left(\frac{L}{2}\right)^3}{3}\right]$$

$$= \frac{PL^3}{64EI}$$

$$\delta_B = \frac{100\times10^3\times(8000)^3}{64\times3\times10^4\times225\times10^6} = 118.5 \text{ mm}$$

$\simeq 119$ mm

09. The rank of matrix

$$\begin{bmatrix}1&2&2&3\\3&4&2&5\\5&6&2&7\\7&8&2&9\end{bmatrix} \text{ is}$$

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

09. Ans: (a)

Sol: Let $A = \begin{bmatrix}1&2&2&3\\3&4&2&5\\5&6&2&7\\7&8&2&9\end{bmatrix}$

$R_2 \to R_2 \to 3R_1$; $R_3 \to R_3 \to 5R_1$; $R_4 \to R_4 \to 7R_1$

Then $A \sim \begin{bmatrix}1&2&2&3\\0&-2&-4&-4\\0&-4&-8&-8\\0&-6&-12&-12\end{bmatrix}$

$R_3 \to R_3 \to 2R_2$; $R_4 \to R_4 \to 3R_2$

$$\Rightarrow A \sim \begin{bmatrix}1&2&2&3\\0&-2&-4&-4\\0&0&0&0\\0&0&0&0\end{bmatrix}$$

$\therefore \rho\,(A_4 \times 4) = 2$

10. The shape of the most commonly designed highway vertical curve is

(a) spiral

(b) circular (single radius)

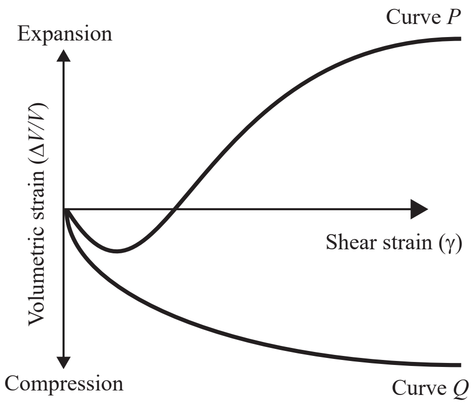
(c) parabolic

(d) circular (multiple radii)

10. Ans: (c)

Sol: The ideal vertical curve is a 2° parabola

11. Based on drained triaxial shear tests on sands and clays, the representative variations of volumetric strain $\left(\frac{\Delta V}{V}\right)$ with the shear strain (γ) is shown in the figure.



Choose the CORRECT option regarding the representative behaviour exhibited by Curve P and Curve Q.

(a) Curve P represents loose sand and normally consolidated clay, while Curve 'Q' represents dense sand and overconsolidated clay

(b) Curve P represents loose sand and overconsolidated clay, while Curve 'Q' represents dense sand and normally consolidated clay

(c) Curve P represents dense sand and overconsolidated clay, while Curve 'Q' represents loose sand and normally consolidated clay

(d) Curve P represents dense sand and normally consolidated clay, while Curve 'Q' represents loose sand and overconsolidated clay.

11. Ans: (c)

Sol:

For dense sand and OC clay, volumetric strain initially decreases and then increases with the increase in shear strain.

For loose sand and NC clay, volumetric strain decreases with the increase in shear strain.

12. A highway designed for 80 km/h speed has a horizontal curve section with radius 250 m. If the design lateral friction is assumed to develop fully, the required super elevation is

(a) 0.07 (b) 0.05
(c) 0.02 (d) 0.09

12. Ans:(b)

Sol: V = 80 kmph; R = 250 m ; f = 0.15 (as per IRC)

Equation of super elevation with friction

$$e + f = \frac{V^2}{127R}$$

$$e + 0.15 = \frac{80^2}{127(250)}$$

$e + 0.15 = 0.202$

$e = 0.051$

≈ 0.05

13. A small project has 12 activities - N, P, Q, R, S, T, U, V, W, X, Y, and Z. The relationship among these activities and the duration of these activities are given in the Table.

Activity	Duration (in weeks)	Depends upon
N	2	-
P	5	N
Q	3	N
R	4	P
S	5	Q
T	8	R
U	7	R,S
V	2	U
W	3	U
X	5	T,V
Y	1	W
Z	3	X,Y

The total float of the activity "V" (in weeks, in integer) is ________

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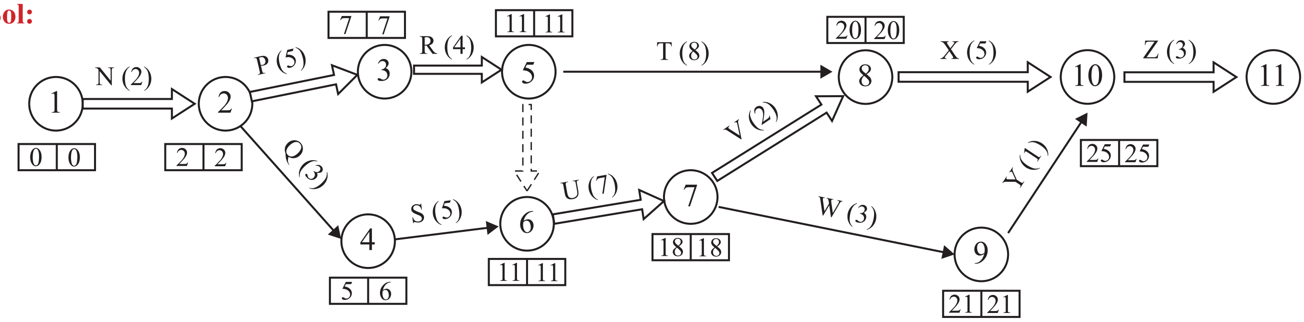
13. Ans: 0

Sol:



Total float = $(L_j - E_i) - d_{ij}$

Total float of "V" = (20 − 18) − 2 = 0

Note: 'V' is a critical activity, hence total float of "V" =0

14. A partially-saturated soil sample has natural moisture content of 25% and bulk unit weight of 18.5 kN/m³. The specific gravity of soil solids is 2.65 and unit weight of water is 9.81 kN/m³. The unit weight of the soil sample on full saturation is

(a) 20.12 kN/m³ (b) 18.50 kN/m³ (c) 21.12 kN/m³ (d) 19.03 kN/m³

14. Ans:(d)

Sol:

Given,

$w = 25\%$

$\gamma = 18.5$ kN/m³

$G_s = 2.65$

$\gamma_w = 9.81$ kN/m³

$e.S = W.G_s$

$e.S = 0.25 \times 2.65 = 0.6625$

$$\gamma = \frac{\gamma_w\{G + e.S\}}{1+e}$$

$$18.5 = 9.81\left[\frac{2.65 + 0.6625}{1+e}\right]$$

$e = 0.7565$

$$\therefore \gamma_{sat} = \frac{\gamma_w\{G_s + e\}}{1+e}$$

$$= \frac{9.81\{2.65 + 0.7565\}}{1 + 0.7565}$$

$\gamma_{sat} = 19.025$ kN/m³

Say 19.03 kN/m³

15. A baghouse filter has to treat 12 m³/s of waste gas continuously. The baghouse is to be divided into 5 sections of equal cloth area such that one section can be shut down for cleaning and/ or repairing, while the other 4 sections continue to operate. An air-to-cloth ratio of 6.0 m³ /min-m² cloth will provide sufficient treatment to the gas. The individual bags are of 32 cm in diameter and 5 m in length. The total number of bags (in integer) required in the baghouse is____

15. Ans: (30)

Sol:

$Q = 12$ m³/sec

Number of sections in used = 5-1 = 4

Flow velocity of air through cloth bag

$$= \frac{\text{Air}}{\text{Cloth}} = 6\ m^3/\min - m^2 = 6\ m/\min$$

Dia of bag = 32 cm = 0.32 m

Length of bag = 5m

Number of bags required n = ?

Total area of clothe filter required

$= \frac{Q}{v} = \frac{12}{\frac{6}{60}} = \frac{12 \times 60}{6} = 120\ m^2$

Surface area of each bag = $\pi D \times L = \pi \times 0.32 \times 5$

$= 5.026\ m^2$

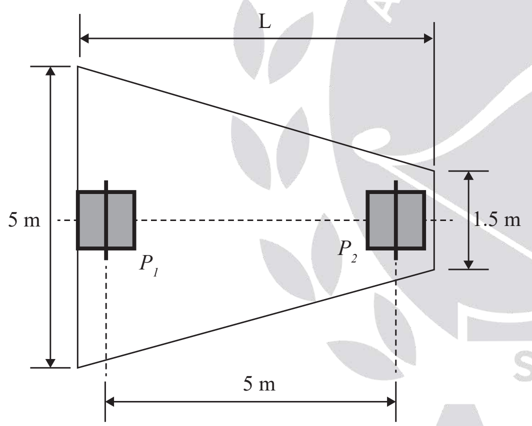
Number of bags required

$= \frac{\text{Total area of filter}}{\text{area of each bag}} = \frac{120}{5.026} = 23.87 \simeq 24$

No. of bags per each section = $\frac{24}{4}$ = 6 bags

Total no. of bags required in 5 sections = 6 ×5 = 30 days

16. A combined trapezoidal footing of length L supports two identical square columns (P_1 and P_2) of size 0.5 m ×0.5 m, as shown in the figure. The columns P_1 and P_2 carry loads of 2000 kN and 1500 kN, respectively.

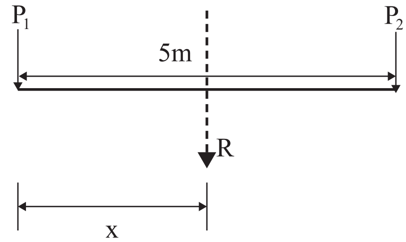


If the stress beneath the footing is uniform, the length of the combined footing L (in m, round off to two decimal places) is

16. Ans: (5.83)

Sol:

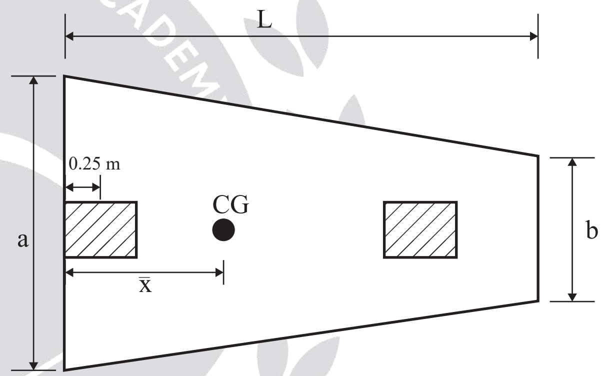
To have uniform stress below the footing the condition to be satisfied is that the resultant load should pass through the C.G of the footing.



Let the resultant load (R) passes at a distance, x as shown in the figure.

$x = \frac{P_1 \times 0 + P_2 \times 5}{P_1 + P_2}$ (taking moments about centre of column, P_1)

$= \frac{2000 \times 0 + 1500 \times 5}{2000 + 1500} = 2.143$ m



Let $\bar{x}$ be the C.G distance of the footing from left outer face as shown

$\bar{x} = \left[\frac{a+2b}{a+b}\right]\frac{L}{3}$ (C.G distance formula for trapezodial shape)

$= \left(\frac{5 + 2 \times 1.5}{5 + 1.5}\right)\frac{L}{3}$

Equating: $\bar{x} = x + 0.25$

$\left(\frac{5 + 2 \times 1.5}{5 + 1.5}\right)\frac{L}{3} = 2.143 + 0.25$

L = 5.833 m

say 5.83 m

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Batch Type	Timings	Batch Date	Duration	Venue
Morning, Evening Batches	**6am to 8am** & **6pm to 8:30pm**	20th March 2021	8 to 10 Months	Abids, Dilsukhnagar, Kukatpally.

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 @ DELHI

Batch Type	Timings	Batch Date	Duration	Venue
Regular Batches	Daily 5 to 6 Hours	5th March 2021 7th April 2021 15th May 2021 5th June 2021	6 to 7 Months	ACE campus Saket

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 @ PUNE

Batch Type	Timings	Batch Date	Duration	Venue
Regular / Weekend Batches	Daily 5 to 6 Hours	20th March 2021	6 to 7 Months	Pune Classroom

GATE + PSUs – 2022 & 2023 @ VIZAG

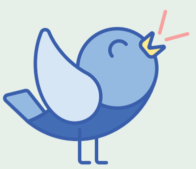
Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vizag Classroom

GATE + PSUs – 2022 & 2023 @ VIJAYAWADA

Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vijayawada Classroom

GATE + PSUs – 2022 @ TIRUPATI

Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	20th March 2021	6 to 7 Months	Tirupati Classroom



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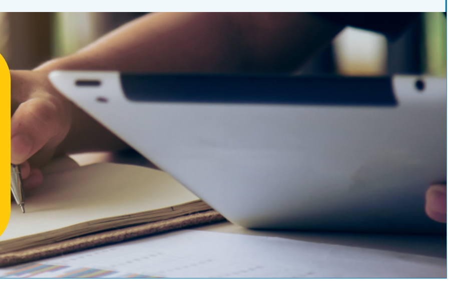
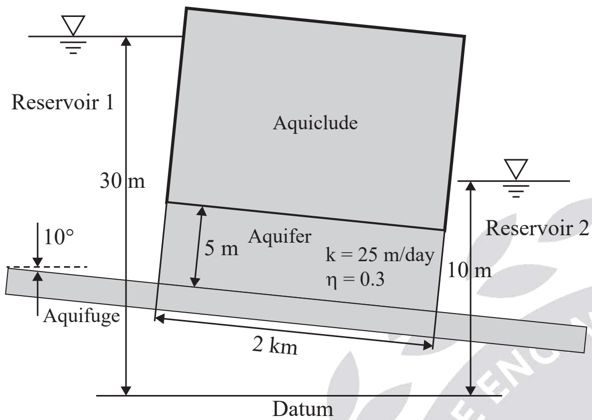


17. Two reservoirs are connected through a homogeneous and isotropic aquifer having hydraulic conductivity (K) of 25 m/day and effective porosity (η) of 0.3 as shown in the figure (not to scale). Ground water is flowing in the aquifer at the steady state.



If water in Reservoir 1 is contaminated then the time (in days, round off to one decimal place) taken by the contaminated water to reach to Reservoir 2 will be

17. Ans: (2400)

Sol: k = 25 m/day n = 0.3

L = 2000 m h_f = 20 m

$$v = ki = 25 \times \frac{20}{2000} = 0.25$$

$$v_s = \frac{v}{n} = \frac{0.25}{0.3} = 0.8333 \text{ m/day}$$

$$v_s = \frac{\text{DIST}}{\text{TIME}}$$

$$0.8333 = \frac{2000}{T}$$

T = 2400 days

18. The values of abscissa (x) and ordinate (y) of a curve are as follows:

x	y
2.0	5.00
2.5	7.25
3.0	10.00
3.5	13.25
4.0	17.00

By Simpson's 1/3rd rule, the area under the curve (round off to two decimal places)

18. Ans: (20.67)

Sol:

Let $x_o = 2$, $x_1 = 2.5$, $x_2 = 3$, $x_3 = 3.5$, $x_4 = 4$

$y_o = 5$; $y_1 = 7.25$, $y_2 = 10$, $y_3 = 13.25$ and $y_4 = 17$.

Then h = 0.5

The formula of simpson's 1/3rd rule to the

$$\Rightarrow \int_2^4 f(x)\,dx \simeq \int_2^4 f(x)dx = \left(\frac{0.5}{3}\right)[(5+17)+2(10)+4(7.25+13.25)]$$

$$\Rightarrow \int_2^4 f(x)\,dx \simeq \int_2^4 p(x)dx = \left(\frac{0.5}{3}\right)[22+20+4(20.5)]$$

$$\therefore \int_2^4 f(x)\,dx \simeq \int_2^4 p(x)dx = \frac{62}{3} = 20.67$$

19. A tube-well of 20 cm diameter fully penetrates a horizontal, homogeneous and isotropic confined aquifer of infinite horizontal extent. The aquifer is of 30 m uniform thickness. A steady pumping at the rate of 40 litres/s from the well for a long time results in a steady drawdown of 4 m at the well face. The subsurface flow to the well due to pumping is steady, horizontal and Darcian and the radius of influence of the well is 245 m. The hydraulic conductivity of the aquifer (in m/day, round off to integer) is_______

19. Ans: (36)

Sol:

d_w = 20 cm, r_w = 10 cm, confined aquifer

B = 30 m, Q = 40 litres/sec, S_w = 4 m

R = 245 m, k = ? m/day

$$Q = \frac{40 \times 10^{-3}}{\left(\frac{1}{24} \times 3600\right)} = 3456\ m^3/day$$

$$Q = \frac{2\pi T S_w}{\ell n\left[\frac{R}{r_w}\right]}$$

$$3456 = \frac{2\pi T \times 4}{\ell n\left[\frac{245}{0.1}\right]}$$

$T = 1073.11\ m^2$ / day

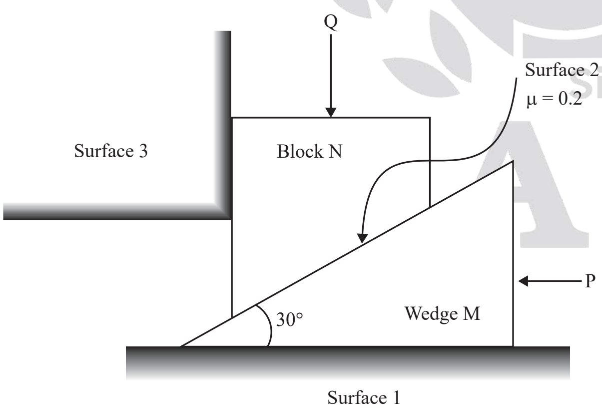
$T = kB$

$1073.11 = k \times 30$

$k = 35.77$ m/day

$k = 36$ m/day

20. A wedge M and a block N are subjected to forces P and Q as shown in the figure. If force P is sufficiently large, then the block N can be raised. The weights of the wedge and the block are negligible compared to the forces P and Q. The coefficient of friction (μ) along the inclined surface between the wedge and the block is 0.2. All other surfaces are frictionless. The wedge angle is 30°.



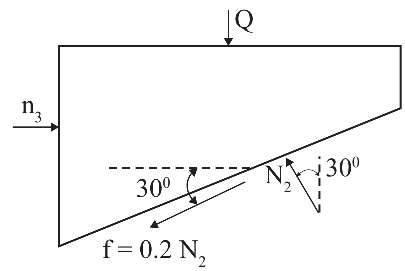
The limiting force P, in terms of Q, required for impending motion of block N to just move it in the upward direction is given as P=αQ. The value of the coefficient ' α ' (round off to one decimal place) is

(a) 2.0 (b) 0.5

(c) 0.6 (d) 0.9

20. Ans: (d)

Sol: 1. FBD of Block N

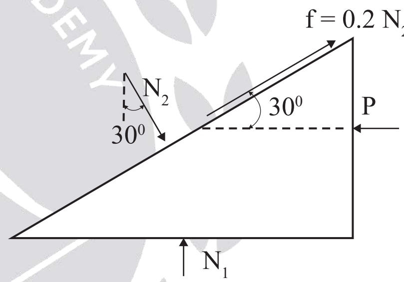


$$\sum F_y = 0$$

$N_2 \cos 30 = Q + 0.2\ N_2 \times \sin 30$

$\therefore N_2 = Q \times 1.3054$ - (1)

1. FBD of Wedge M:



$\sum F_y = 0$

$P = N_2 \sin 30 + 0.2 N_2 \cos 30$

$P = N_2 \times 0.6732$

From equation (1)

$P = Q \times 1.3054 \times 0.6732$

$P = 0.8788 \times Q = \alpha \times Q$

$\alpha \simeq 0.9$

21. A secondary clarifier handles a total flow of 9600 m^3 /d from the aeration tank of a conventional activated-sludge treatment system. The concentration of solids in the flow from the aeration tank is 3000 mg/L. The clarifier is required to thicken the solids to 12000 mg/L, and hence it is to be designed for a solid flux of 3.2 kg/m^2.h . The surface area of the designed clarifier for thickening (in m^2, in integer) is

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21. Ans: (375)

Sol:

$Q = 9600\ m^3/day = 9.6$ MLD

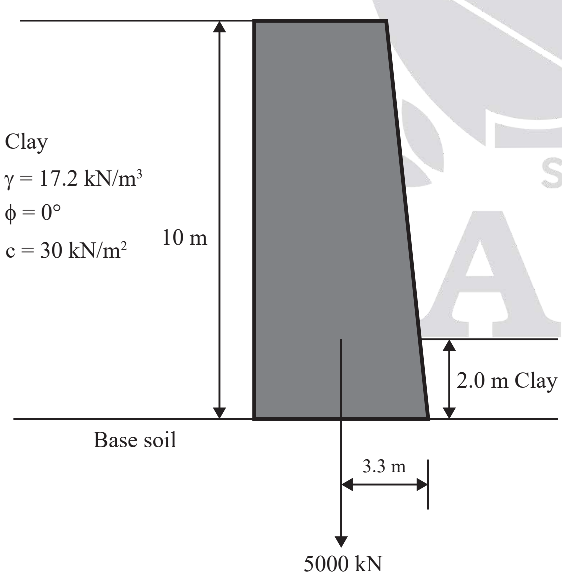
Concentration of solids $C_{Solids} = 3000$ mg/L

Solids flux = $3.2\ kg/m^2.h$

Surface area of clarifier = $\dfrac{\text{Total solids}}{\text{Solids flux rate}}$

$$= \frac{9.6 \times \frac{3000}{24}}{3.2} \frac{kg/hr}{kg/m^2 - hr} = 375\ m^2$$

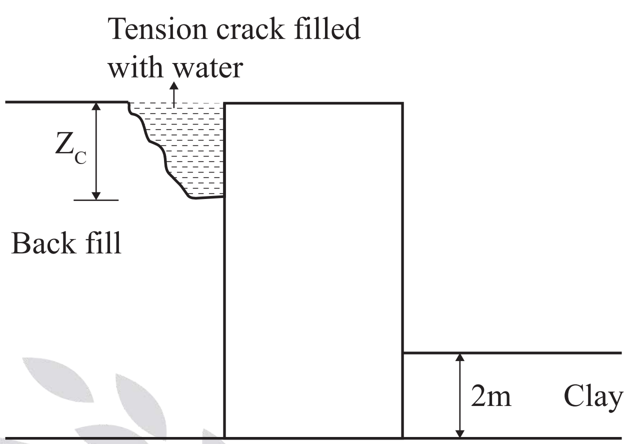
22. A retaining wall of height 10 m with clay backfill is shown in the figure (not to scale). Weight of the retaining wall is 5000 kN per m acting at 3.3 m from the toe of the retaining wall. The interface friction angle between base of the retaining wall and the base soil is 20. The depth of clay in front of the retaining wall is 2.0 m. The properties of the clay backfill and the clay placed in front of the retaining wall are the same. Assume that the tension crack is filled with water. Use Rankine's earth pressure theory. Take unit weight of water, $\gamma_w = 9.81\ kN/m^3$.______



The factor of safety (rounded off to two decimal places) against sliding failure of the retaining wall after ignoring the passive earth pressure will be ______

22. Ans: (4.29)

Sol:



Depth of tension crack, $z_c = \dfrac{2C}{\gamma}$ if $\phi = 0$

$$= \frac{2 \times 30}{17.2} = 3.488\ m$$

Tension crack develops only in the back fill (clay)

The tension crack will not develop in the clay which is infront of the wall.

The total active thrust on the wall, due to the backfill, and the water in the tension crack

$$F_a = k_a . \frac{\gamma H^2}{2} - 2C\sqrt{k_a}.H + \frac{2C^2}{\gamma} + \frac{\gamma_w z_c^2}{2}$$

$k_a = 1$ since $\phi = 0$

$$F_a = 1 \times \frac{17.2 \times 10^2}{2} - 2 \times 30\sqrt{1} \times 10 + \frac{2 \times 30^2}{17.2} + \frac{9.81 \times 3.488^2}{2}$$

$= 424.326$ kN

Factor of safety against sliding neglecting passive earth pressure on front side, F_s

$$F_s = \frac{\mu.W}{F_a}$$

μ = coefficient of friction at base

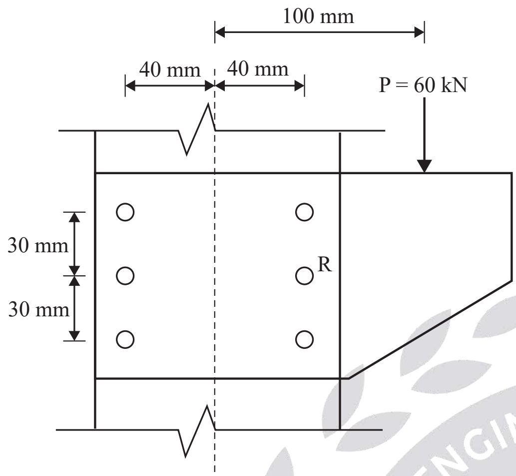
$= \tan\delta$

$$F_s = \frac{\tan\delta.W}{F_a}$$

$$= \frac{\tan 20^\circ \times 5000}{424.326} = 4.2888$$

say 4.29

23. A column is subjected to a total load (P) of 60 kN supported through a bracket connection, as shown in the figure (not to scale).



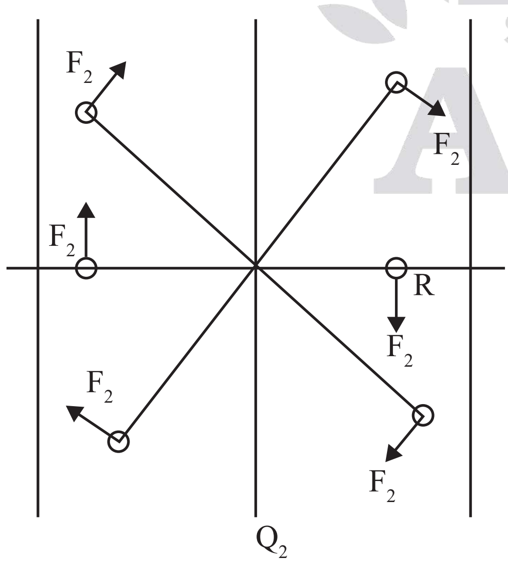
The resultant force in bolt R (in kN, round off to one decimal place) is ________

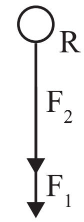
23. Ans: (28.18)

Sol: $F_1 = \frac{P}{n} = \frac{60}{6} = 10\text{ kN}$

Shear force due to twisting moment

$$F_2 = \frac{60 \times 100 \times 40}{4(50)^2 + 2(40)^2} = 18.18\text{kN}$$





Resultant force in bolt R

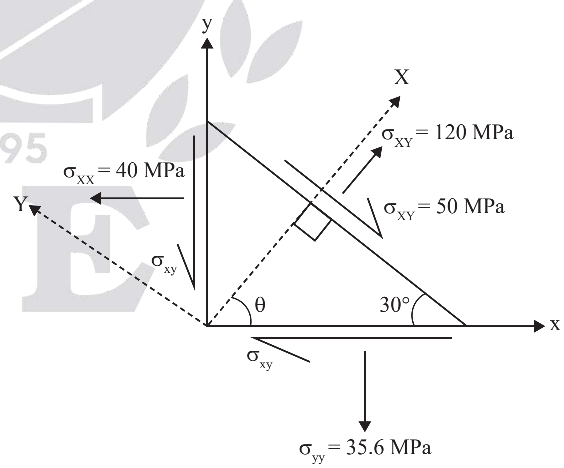
$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$R = \sqrt{(10)^2 + (18.8)^2 + 2 \times 10 \times 18.18\cos 0^\circ}$$

$(\theta = 0^\circ)$

$R = 28.18\text{ kN} \simeq 28.2\text{ kN}$

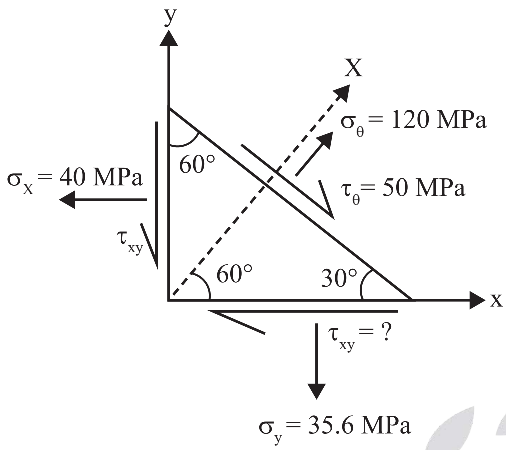
24. The state of stress in a deformable body is shown in the figure. Consider transformation of the stress from the x-y coordinate system to the X-Y coordinate system. The angle θ, locating the X-axis is assumed to be positive when measured from the x-axis in counter -clock wise direction.



The absolute magnitude of the shear stress component σ_{xy} (in MPa, round off to one decimal place) in x-y coordinate system is ______

24. Ans: (96.2)

Sol:



We know

$$\sigma_\theta = \left[\frac{\sigma_x + \sigma_y}{2}\right] + \left[\frac{\sigma_x - \sigma_y}{2}\right]\cos 2\theta + \tau_{xy}\sin 2\theta$$

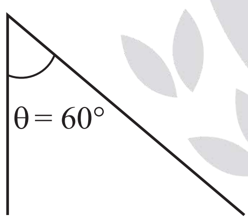
Given

$\sigma_\theta = 120$ MPa

$\sigma_x = 40$, $\quad\sigma_y = 35.6$

$\tau_{xy} = ?$, $\quad\theta = 60°$

(Always from vertical plane)



$$120 = \left[\frac{40 + 35.6}{2}\right] + \left[\frac{40 - 35.6}{2}\right]\cos 120 + \tau_{xy}\sin 120°$$

$\tau_{xy} = 96.18$ MPa

$\simeq 96.2$

25. The shape of the cumulative distribution function of Gaussian distribution is

(a) Straight line at 45 degree angle

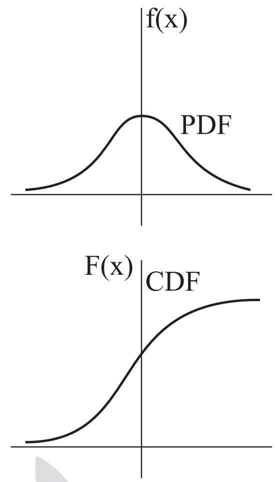
(b) Bell -shaped

(c) S-shaped

(d) Horizontal line

25. Ans: (c)

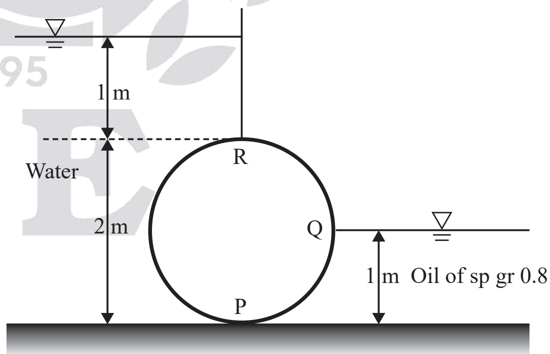
Sol:



$$\text{PDF}: f(x) = \frac{1}{\sigma\sqrt{2\pi}}e^{-(x-\mu)^2/(2\sigma^2)}$$

$$\text{CDF}: F(x) = \frac{1}{2}\left[1 + \text{erf}\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\right]$$

26. A cylinder (2.0 m diameter, 3.0 m long and 25 kN weight) is acted upon by water on one side and oil (specific gravity = 0.8) on other side as shown in the figure.

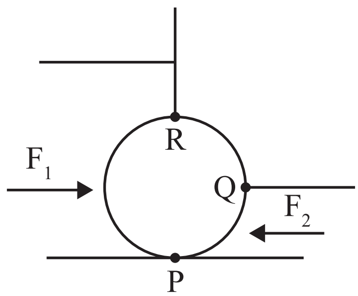


The absolute ratio of the net magnitude of vertical forces to the net magnitude of horizontal forces (round off to two decimal places) is _____

26. Ans: (0.61)

Sol:

Horizontal force:



$F_1 = \gamma.(A\bar{h})_p$

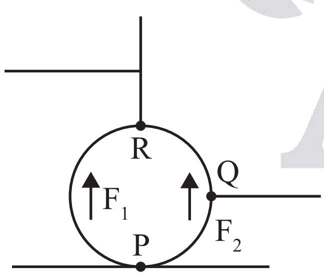
$= \gamma_w.[(2\times 3)(2)]$
$= 12\ \gamma_w$

$F_2 = \gamma(A\bar{h})_P$

$= 0.8\gamma_w\left[(1\times 3)\times\frac{1}{2}\right] \quad = 1.2\ \gamma_w$

$\therefore \Sigma F_x = 12\gamma_w - 1.2\gamma_w \Rightarrow \Sigma F_x = 10.8\gamma_w$

Vertical force:



$F_1 = \gamma_w.\forall$

$= \gamma_w\left(\frac{\pi}{8}\times 2^2\times 3\right)$

$= \frac{3\pi}{2}\gamma_w$

$F_2 = \gamma_o.V$

$= 0.8\gamma_w\left(\frac{\pi}{4}\times 1^2\times 3\right)$

$0.6\pi\ \gamma_w$

$\Sigma F_V = F_1 + F_2 = 2.1\pi\gamma_w$

$= 6.594\ \gamma_w$

$\frac{\Sigma F_V}{\Sigma F_x} = \frac{6.594\ \gamma_w}{10.8\ \gamma_w} = 0.61$

Another Solution

26. Ans: 0.38

Sol:

1. $\vec{F}_{H_{NE.T}} = \vec{F}_{H_{water}} - \vec{F}_{H_{oil}}$

$F_{H_{Net}} = \rho_{water}.g.\bar{h}_{water}.A_{projected\ cylinder} - \rho_{oil}.g.\bar{h}_{oil}.A_{project\ half\ cylinder}$

$\vec{F}_{H_{net}} = 1000\times 9.81\times\left(1+\frac{2}{2}\right)(2\times 3) - 800\times 9.81\times\left(\frac{1}{2}\right)(1\times 3)$

$\vec{F}_{Not} = 117720 - 11772$

$|\vec{F}_{H_{Net}}| = 105948\ N = 105.948\ kN \qquad \text{--- (1)}$

2.

$F_V\uparrow = F_{V_{water}}^{\uparrow} + F_{V\,oil}$

$= [\text{weight of water displaced by cylinder}]$

$+ [\text{weight of oil displaced by cylinder}]$

$F_{V_{liquids}} = W_{water}\uparrow + W_{oil}\uparrow$

$F_{V_{liquids}} = \rho.g.\ V_{water} + \rho_{oil}\,g.V_{oil}$

$= \rho_w.g.\frac{\pi R^2.L}{2} + \rho_{oil}\,g.\frac{\pi R^2.L}{4}$

$F_{V_{liquids}} = 1000\times 9.81\times\frac{\pi(1)^2(3)}{2} + 800\times 9.81\times\frac{\pi(1)^2}{4}\times 3$

$= 46228.536 + 18491.414$

$Fv_{liquid} = 64719.95N \cong 64.72$ kN $\uparrow$

$|F_{V_{Not}}|_{liquids} = (F_V)_{liquids} \uparrow - W_{cylinder} \downarrow$

$|Fv_{liquids}| = 64.72 \uparrow - 25 \downarrow$

$\therefore\ |F_{V_{Not}}| = 39.72$ kN $\uparrow$ ------ (2)

$\frac{F_{V_{Net}}}{F_{H_{Net}}} = \frac{39.720(kN)}{105.948(kN)}$

$= 0.3749 \cong 0.375$

$=0.38$

27. A water sample is analyzed for coliform organisms by the multiple tube fermentation method. The results of confirmed test are as follows:

Sample size (mL)	Number of positive results out of 5 tubes	Number of negative results out of 5 tubes
0.01	5	0
0.001	3	2
0.0001	1	4

The most probable number (MPN) of coliform organisms for the above results is to be obtained using the following MPN Index.

MPN Index for Various Combinations of Positive Results when Five Tubes used per Dilution of 10.0 mL, 1.0 mL and 0.1 mL	
Combination of positive tubes	**MPN Index per 100 mL**
0-2-4	11
1-3-5	19
4-2-0	22
5-3-1	110

The MPN of coliform organisms per 100 mL is

(a) 110000 (b) 1100000

(c) 1100 (d) 110

27. Ans: (a)

Sol:

MPN against 5-3-1 for (10-1-0.1) sample = 110

MPN against 5-3-1 for sample (0.01-0.001 - 0.0001)

$= 110 \times 1000$

$= 110000$

28. If water is flowing at the same depth in most hydraulically efficient triangular and rectangular channel sections then the ratio of hydraulic radius of triangular section to that of rectangular section is

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

28. Ans: (a)

Sol: Hydraulically efficient triangle, $R_1 = \frac{y_1}{2\sqrt{2}}$

Hydraulically efficient rectangle, $R_2 = \frac{y_2}{2}$

Given $y_1 = y_2$

$$\frac{R_1}{R_2} = \frac{y_1}{2\sqrt{2}} \times \frac{2}{y_2} = \frac{1}{\sqrt{2}}$$

ESE – 2021 Prelims

Online Test Series

Starts from: 1st July 2020

No. of Tests : 44

+

Free 30 Practice Tests of ESE – 2020 Online Test Series

Total Tests : 74

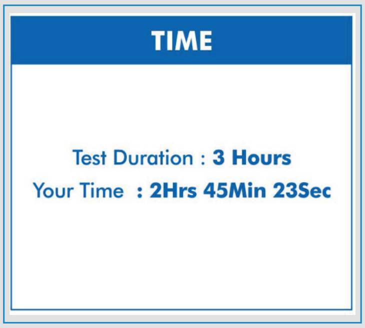
Note: GATE 2020 & ESE 2020 (Prelims) Online Test Series are available now.

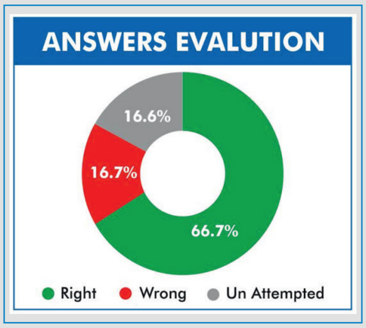
MPSC PRELIMS 2020 | SSC-JE (Paper-II) MAINS 2019
KPSC (Asst. Engineer) | AAI

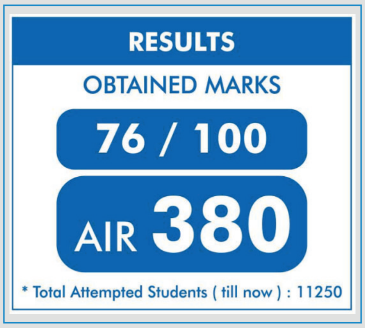
TEST SERIES HIGHLIGHTS

- Detailed Solutions are Available.
- Video Solutions are Available for Difficult Questions.
- All India rank will be given for each test.
- Comparison with all India toppers of ACE student.

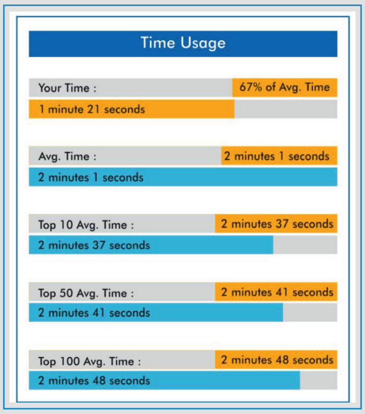
TEST WISE STATISTICS:

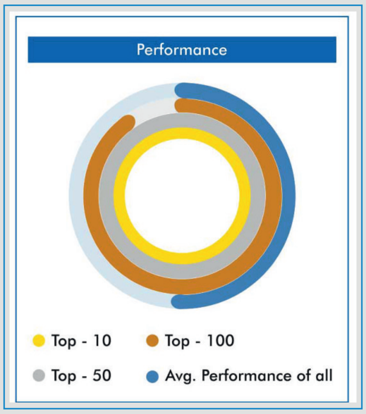


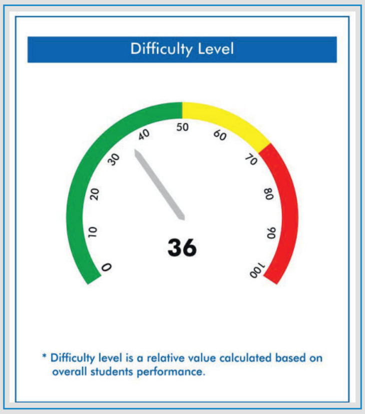




QUESTION WISE STATISTICS:







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29. Ammonia nitrogen is present in a given wastewater sample as the ammonium ion (NH_4^+) and ammonia (NH_3) . If pH is the only deciding factor for the proportion of these two constituents, which of the following is a correct statement?

(a) At pH 7.0, (NH_4^+) and NH_3 will be found in equal measures,

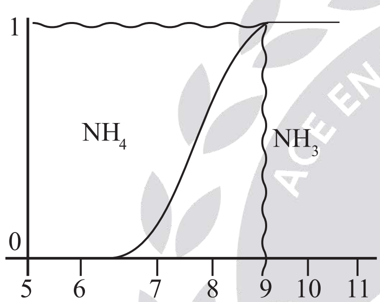
(b) At pH below 9.25, NH_3 will be predominant

(c) At pH 7.0, (NH_4^+) will be predominant.

(d) At pH above 9.25, only (NH_4^+) will be present.

29. Ans: (b)

Sol:



30. A 50 mL sample of industrial wastewater is taken into a silica crucible. The empty weight of the crucible is 54.352g. The crucible with the sample is dried in a hot air oven at 104°C till a constant weight of 55.129 g. Thereafter, the crucible with the dried sample is fired at 600°C for 1 h in a muffle furnance, and the weight of the crucible along with residue is determined as 54.783 g. The concentration of total volatile solids is ____

(a) 1700 mg/L (b) 8620 mg/L

(c) 6920 mg/L (d) 15540 mg/L

30. Ans: (c)

Sol: V = 50 ml

$W_1 = 54.352$ gm

$W_2 = 55.129$ gm

$W_3 = 54.783$ gm

Total volatile solids $= \dfrac{W_2 - W_3}{V}$

$= \dfrac{(55.129 - 54.783)}{50} \times 10^6$ mg/lit

= 6920 mg/*l*

31. The direct and indirect costs estimated by a contractor for bidding a project is ₹160000 and ₹20000 respectively. If the mark up applied is 10% of the bid price, the quoted price (in ₹) of the contractor is

(a) 182000 (b) 196000

(c) 198000 (d) 200000

31. Ans: (d)

Sol:

Direct costs → ₹1,60,000

Indirect costs → ₹20,000

Mark up applied is 10% of the Bidprice

Bid price = Direct cost + Indirect cost + Markup

Bid price = direct cost + indirect cost + $\dfrac{10}{100}$ × Bid price

Bid price $\left(1 - \dfrac{10}{100}\right) = DC + IC$

$BP = \dfrac{(1,60,000 + 20,000)}{0.9}$

$= \dfrac{1,80,000}{0.9} = ₹\ 2,00,000$

32. The longitudinal section of a runway provides the following data:

End to -end runway (m)	Gradient (%)
0 to 300	+1.2
300 to 600	– 0.7
600 to 1100	+ 0.6
1100 to 1400	– 0.8
1400 to 1700	–1.0

The effective gradient of the runway (in %, round off to two decimal places) is________

32. Ans: (0.32)

Sol:

Longitudinal section of runway is tabulated as given below

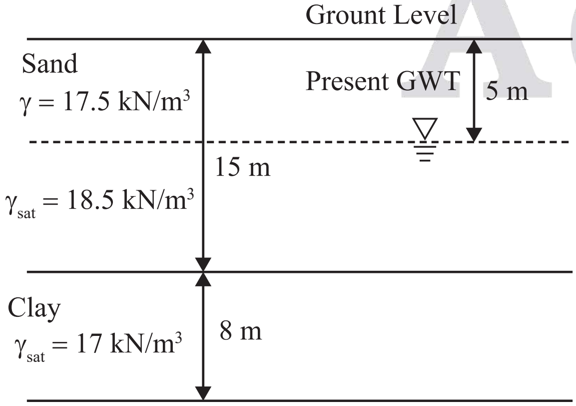
Station	Length (m)	Elevation (m)	RL (m)
A	0	-	100m (assume)
B	300	+3.6	103.6
C	300	-2.1	101.5
D	500	+3	104.5
E	300	-2.4	102.1
F	300	-3	99.1

Effective gradient

$$= \left[\frac{\text{Elevation of highest point(D)} - \text{Elevation of lowest point(F)}}{\text{Total length}}\right] \times 100$$

$$= \frac{104.5 - 99.1}{1700} \times 100 = 0.317 \simeq 0.32\%$$

33. The soil profile at a construction site is shown in the figure (not to scale). Ground water table (GWT) is at 5 m below the ground level at present. An old well data shows that the ground water table was as low as 10 m below the ground level in the past. Take unit weight of water, $\gamma_w = 9.81$ kN/m.



The over consolidation ratio (OCR) (round off to two decimal places) at the mid-point of the clay layer is______

33. Ans: 1.22

Sol:

When the W.T was at 10 m depth in the past, the effective stress at mid point of clay, σ^1

$$\sigma' = 10\gamma + 5\gamma_1' + 4\gamma_2'$$

$$= 10 \times 17.5 + 5[18.5 - 9.81] + 4(17 - 9.81)$$

$= 175 + 43.45 + 28.76 = 247.21$ kN/m^2

When WT is 5 m depth, the σ^1 at mid point of clay,

$$\sigma' = 5\gamma + 10\gamma_1' + 4\gamma_2'$$

$= 5 \times 17.5 + 10\ (18.5 - 9.81) + 4(17-9.81)$

$= 87.5 + 86.9 + 28.76$

$= 203.16$

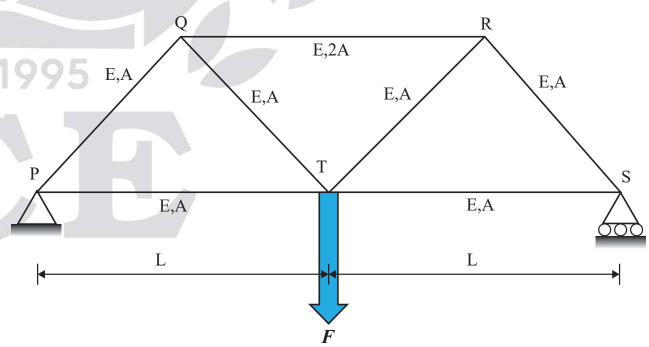
σ_c' = preconsolidation stress

= maximum effective stress to which soil is consolidated

σ' = present stress

$$\text{OCR} = \frac{\sigma_c'}{\sigma'} = \frac{247.21}{203.16} = 1.22$$

34. Refer the truss as shown in the figure (not to scale).



If load, F= $10\sqrt{3}$ kN, moment of inertia, I = 8.33 $\times 10^6$ mm^4, area of cross- section, A = 10^4 mm^2, and length, L = 2 m for all the members of the truss, the compressive stress (in kN/m^2 , in integer) carried by the member Q-R is

Hearty Congratulations to our

ESE - 2019 TOP RANKERS

ELECTRICAL ENGINEERING

ELECTRONICS & TELECOMMUNICATION ENGINEERING

MECHANICAL ENGINEERING

CIVIL ENGINEERING

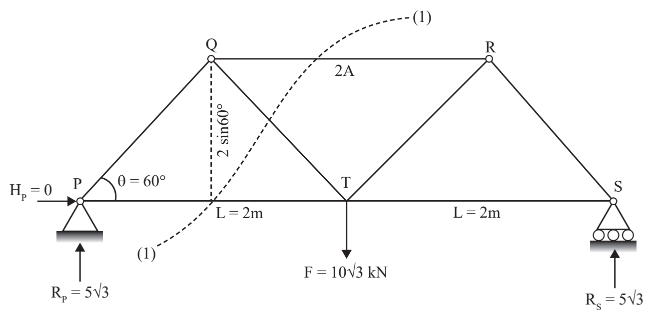
and many more...

Total Selections in Top 10 | 33

EE : 9	E&T : 8	ME : 9	CE : 7

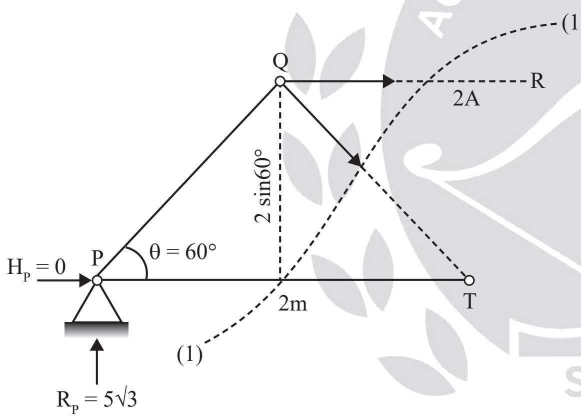
34. Ans: (500)

Sol:



Compressive stress carried by the member 'QR'

$$= \frac{\text{Compressive force}}{\text{Area}}$$



$\Sigma M_T = 0$ -ve +ve

$$F_{QR} \times 2\sin 60^\circ + 5\sqrt{3} \times 2 = 0$$

$$F_{QR} = \frac{-5\sqrt{3}}{\sin 60^\circ} = -10 \text{ kN}$$

$F_{QR} = 10$ kN (compression)

Compressive stress $= \frac{10}{2A} = \frac{5}{A}$

$$\frac{5}{10^4 \times 10^{-6}} = 500 \text{ kN/m}^2 \text{ (compression)}$$

35. The cohesion (c), angle of internal friction (ϕ) and unit weight (γ) of a soil are 15 kPa, 20° and 17.5 kN/m³, respectively. The maximum depth of unsupported excavation in the soil (in m, round off to two decimal places) is______________

35. Ans: 4.9

Sol: Given

$C = 15$ kPa

$\phi = 20°$

$\gamma = 17.5$ kN/m³

$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 20^\circ}{1+\sin 20^\circ} = 0.49$$

$$H_c = \frac{4C}{\gamma\sqrt{k_a}}$$

$$H_c = \frac{4 \times 15}{17.5 \times \sqrt{0.49}}$$

$H_c = 4.897$

$H_c = 4.9$ m

36. In an Oedometer apparatus, a specimen of fully saturated clay has been consolidated under a vertical pressure of 50 kN/m² and is presently at equilibrium. The effective stress and pore water pressure immediately on increasing the vertical stress to 150 kN/m², respectively are

(a) 0 and 150 kN/m²

(b) 100 kN/m² and 50 kN/m²

(c) 150 kN/m² and 0

(d) 50 kN/m² and 100 kN/m²

36. Ans: (d)

Sol:

At the end of initial consolidation, $\sigma' = 50$ kN/m²

$\bar{u} = 0$

Given increase in vertical stress,

$\Delta\sigma = 150 - 50 = 100$ kN/m²

All the increased vertical stress is initially taken by pore water.

$\therefore$ The increase in pore water pressure,

$\Delta\bar{u} = 100$

Increase in effective stress, $\Delta\sigma' = 0$

$\therefore$ Immediately after increasing the load, the $\sigma' = 50$ and $\bar{u} = 100$

$\sigma' = 50 + \Delta\sigma' = 50 + 0 = 50 \text{ kN/m}^2$

$u = 0 + \Delta\bar{u} = 0 + 100 = 100 \text{ kN/m}^2$

37. The volume determined from $\iiint_V 8xyz\,dV$ for $V = [2,3]\times[1,2]\times[0,1]$ will be (in integer)______________

37. Ans: (15)

Sol:

Volume $= 8\int_{x=2}^{3}\int_{y=1}^{2}\int_{z=0}^{1} xyz\,dx\,dy\,dx$

$\Rightarrow V = 8\left(\frac{x^2}{2}\right)_2^3 . \left(\frac{y^2}{2}\right)_1^2 \left(\frac{z^2}{2}\right)_0^1$

$\Rightarrow V = 8\left(\frac{9-4}{2}\right)\left[\frac{4-1}{2}\right]\left[\frac{1-0}{2}\right]$

$\therefore V = (5)(3)(1) = 15$

38. A signalized intersection operates in two phases. The lost time is 3 seconds per phases. The maximum ratios of approach flow to saturation flow for the two phases are 0.37 and 0.40. The optimum cycle length using the Webster's method (in seconds, round off to one decimal place) is_____

38. Ans: 60.9

Sol:

Two phase signal (n = 2)

Lost time, $l = 3$ sec /phase

Total lost time per cycle = L = 3 × 2 = 6 sec

$y_1 = \frac{q_1}{s_1} = 0.37$; $y_2 = \frac{q_2}{s_2} = 0.4$

$y = y_1 + y_2 = 0.37 + 0.4 = 0.77$

optimum cycle time as per webster is

$$C_o = \frac{1.5L+5}{1-y} = \frac{1.5\times 6+5}{1-0.77}$$

$= 60.869 \simeq 60.9$ sec

39. Which of the following is/are correct statement(s)?

(a) If the whole circle bearing of a line is 270°, its reduced bearing is 90° NW.

(b) The boundary of water of a calm water pond will represent contour line.

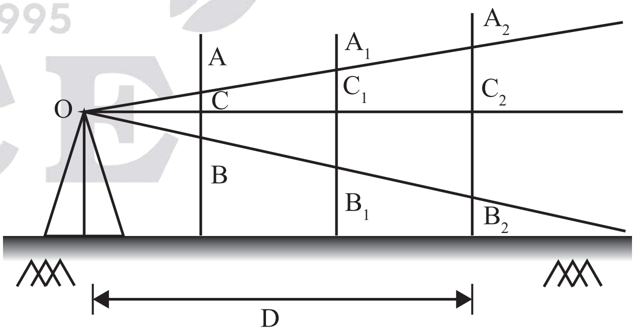
(c) In the case of fixed hair stadia tachometry, the staff intercept will be larger, when the staff is held nearer to the observation point.

(d) Back Bearing of a line is equal to Fore Bearing ± 180°

39. Ans: (a), (b) and (d)

Sol:

The principle of fixed hair tacheometry is that distances are proportional to staff intercept.



As distance increase, staff intercept also increases.

40. Contractor X is developing his bidding strategy against Contractor Y. The ratio of Y's bid price to X's cost for the 30 previous bids in which Contractor X has competed against Contractor Y is given in the Table

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GATE - 2020 TOP RANKERS

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PAVAN KUMAR REDDY A	AIR – 1
D SURENDRA KUMAR	AIR – 3
K MUKHESH	AIR – 4
GHANENDRA SINGH	AIR – 6
KV PAVAN KUMAR REDDY	AIR – 7
VELURU APARANJINI	AIR – 9
JYOTSNA PRIYA RAGU	AIR – 10
NISHANT DHULL	AIR – 10

EE

ABHASH RAI	AIR – 1
RUPAM RAJ	AIR – 2
ALIN ANTO	AIR – 4
AYUSH RAJ	AIR – 4
NEERAJ KUSHWAHA	AIR – 6
JATIN TIWARI	AIR – 8
HIMANSHU KUMAR	AIR – 9
NIKHIL KUMAR	AIR – 9
YUVRAJ SINGH RATHORE	AIR – 9

CE

AJAY SINGHAL	AIR – 1
SUMIT DEWDA	AIR – 1
ASHISH CHOUDHARY	AIR – 3
ADITYA SHARMA	AIR – 4
TARUN GUPTA	AIR – 8
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SATISH RAI	AIR – 10

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AKSHAY KUTE	AIR – 6
V. V. ATCHUTA SRAVAN KUMAR	AIR – 6
AVINASH VERMA	AIR – 9
VIVEK KUMAR KASHYAP	AIR – 9
NIKHIL GAIKWAD	AIR – 4 (XE)
APURVA KRISHNA YADAV	AIR – 7 (XE)
SHASHI BHUSHAN	AIR – 7 (XE)
SANKET BHATT	AIR – 10 (XE)

CS

HITESH POPLY	AIR – 1
HIMANSHU JAIN	AIR – 3
AVINASH KRISHNA	AIR – 5
ARAVIND G	AIR – 6
PHANI MADHUSUDHAN	AIR – 7
ASHISH KUMAR	AIR – 8
KARAN GUPTA	AIR – 9

IN

KRISHNA SINGH RAJPUT	AIR – 1
SHAKTI PATHAK	AIR – 3
SIDDHARTHA SINHA ROY	AIR – 5
AKASH CHOTIA	AIR – 6
SUSHANTHIKA J	AIR – 7
RIYA ARON	AIR – 10

PI

SURYANSH GARG	AIR – 1
MOHIT JEENA	AIR – 2
PRAVEEN KUMAR	AIR – 2
ROHIT AGARWAL	AIR – 4
ANKIT YADAV	AIR – 6
GOWTHAM GUDIMELLA	AIR – 6
SUBHANSHU RANJAN TIWARI	AIR – 8
GANESH ADIGAUR	AIR – 9
DEEPESH SHARMA	AIR – 10

and many more...

Total Selections in Top 10 58

EE : 9	EC : 9	ME:7	CE : 7	CS : 7	IN : 6	PI : 9	XE : 4

Ratio of Y's bid price to X's cost	Number of bids
1.02	6
1.04	12
1.06	3
1.10	6
1.12	3

Based on the bidding behaviour of the Contractor Y. The probability of winning against Contractor Y at a mark up of 8% for the next project is

(a) more than 50% but less than 100%

(b) 0%

(c) more than 0% but less than 50%

(d) 100%

40. Ans: (c)

Sol:

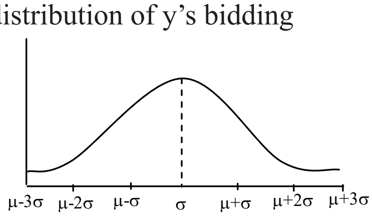
Ratio of Y's bid price to X's cost	Number of bids
1.02	6
1.04	12
1.06	3
1.10	6
1.12	3

$$\text{Mean} = \frac{1.02\times 6 + 1.04\times 12 + 1.06\times 3 + 1.10\times 6 + 1.12\times 3}{30}$$

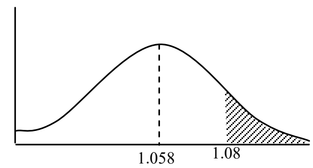
$= 1.058$

Mean = 1.058

Normal distribution of y's bidding



with markup of 8% i.e = 1.08



shaded portion is probability of X contractor winning contract over y which is less than 50%

(OR)

$$SD(\sigma) = \frac{6(1.02-1.058)^2 + (1.04-1.058)^2\times 12 + 3\times(1.06-1.058)^2 + 6\times(1.10-1.058)^2 + 3\times(1.12-1.058)^2}{30}$$

$= 0.034$

Markup is 8%

$$Z = \frac{T-\text{mean}}{SD} = \frac{1.08-1.058}{0.034} = 0.647$$

$Z = 0.647$

By general under standing of normal distribution table.

Corresponding to $z = 0.647$ and 8% mark up we get probability of

$0.2668 = 26.68\%$

Which is more than 0% but less than 50%

41. The solution of the second -order differential equation $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + y = 0$ with boundary conditions $y(0) = 1$ and $y(1) = 3$ is

(a) $e^{-x} - \left[3e\sin\left(\frac{\pi x}{2}\right) - 1\right]xe^{-x}$

(b) $e^{-x} + (3e-1)xe^{-x}$

(c) $e^{-x} - (3e-1)xe^{-x}$

(d) $e^{-x} + \left[3e\sin\left(\frac{\pi x}{2}\right) - 1\right]xe^{-x}$

41. Ans: (b)

Sol:

Given $f(D)\,y = 0$ - (1)

Where $f(D) = D^2 + 2D + 1$, $D = \frac{d}{dx}$

with $y(0) = 1$ - (2)

and $y(1) = 3$ - (3)

Consider auxiliary equation $f(m) = 0$

$\Rightarrow m^2 + 2m + 1 = 0$

$\Rightarrow m = -1, -1$

$y = (C_1 + C_2 x) e^{-x} = C_1 e^{-x} + C_2 xe^{-x}$ - (4) is a general solution of (1)

Using (1), (4) between

$1 = C_1$ - (5)

using (3) and (5), (4) becomes

$3 = e^{-1} + C_2 e^{-1}$

$C_2 = 3e-1$ - (6)

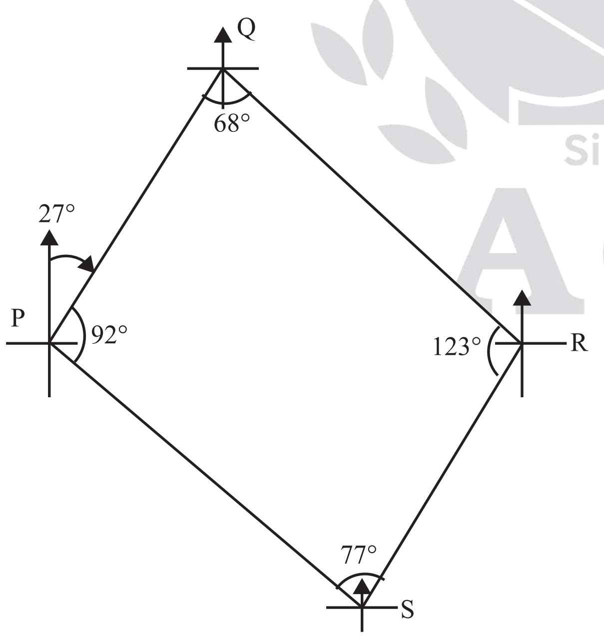
From (4) with (5) and (6) is

$y = e^{-x} + (3e-1) xe^{-x}$

42. Traversing is carried out for a closed traverse PQRS, The internal angles at vertices P, Q, R, and S are measured as 92°, 68°, 123° and 77° respectively. If fore bearing of line PQ is 27°, fore bearing of line RS (in degrees, in integer)is_______

42. Ans: (196)

Sol:



From figure;

$FB_{QR} = BB_{PQ} - \angle Q$

$= (27° + 180°) - 68°$

$= 139°$

$FB_{RS} = BB_{QR} - \angle R$

$= (139° + 180°) - 123°$

$FB_{RS} = 196°$

43. Gypsum is typically added in cement to

(a) increase workability

(b) prevent quick setting

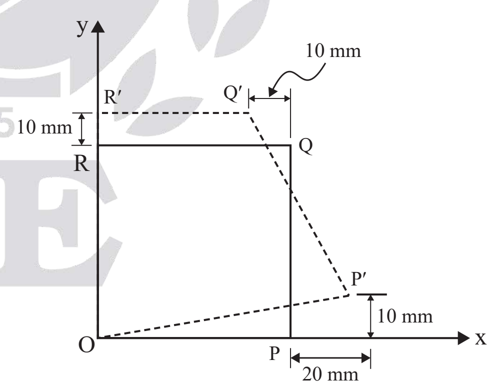
(c) enhance hardening

(d) decrease heat of hydration

43. Ans: (b)

Sol: The Gypsum is added to cement at the end of grinding clinker it is added to prevent quick setting.

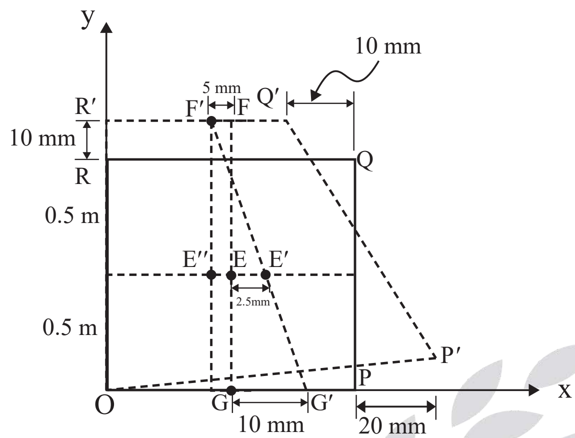
44. A square plate O-P-Q-R of a linear elastic material with sides 1.0 m is loaded in a state of plane stress. Under a given stress condition, the plate deforms to a new configuration O-P'-Q-R' as shown in the figure (not to scale). Under the given deformation, the edges of the plate remain straight.



The horizontal displacement of the point (0.5 m, 0.5 m) in the plate O-P-Q-R (in mm. round off to one decimal place) is

44. Ans: (2.5)

Sol: Assuming linear variations



'F' is mid point of QR and 'G' is mid point of OP
'E' is the centroid of plate
Only horizontal displacements are considered
From geometry E'E" = 7.5 mm
The displacement of E is EE′= E′E″ – EE″

$= 7.5 - 5$

$= 2.5$ mm

∴ The horizontal displacement of mid point is 2.5 mm right wards

45. On a road. the speed - density relationship of a traffic stream is given by u =70-0.7k (where speed, u, is in km/h and density, k, is in veh/km). At the capacity condition, the average time headway will be

(a) 2.1 s (b) 0.5 s (c) 1.6 s (d) 1.0 s

45. Ans: (a)

Sol: Linear speed density equation is given by

$u = 70 - 0.7\,k$

for maximum speed, $k = 0 \Rightarrow u_{max} = 70$ kmph

for maximum density, $u = 0 \Rightarrow 0 = 70 - 0.7\,(k_{max})$

$$k_{max} = \frac{70}{0.7}$$

$$\text{Capacity,}\quad q_{max} = \frac{k_{max}}{2}\cdot\frac{u_{max}}{2}$$

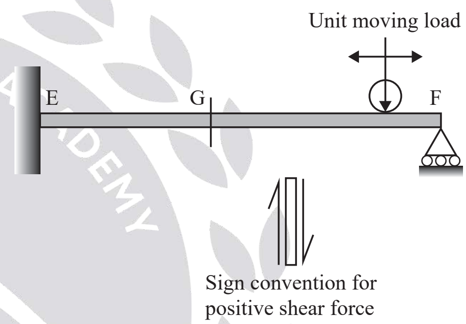
$$= \frac{70}{0.7\times 2}\times\frac{70}{2}$$

$= 1750$ veh/hr

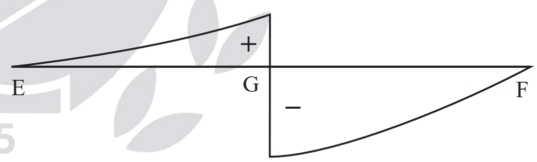
$$\text{Time head way,}\ H_t = \frac{3600}{q_{max}} = \frac{3600}{1750}$$

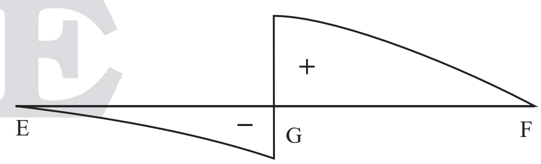
$= 2.06 \simeq 2.1$ sec/veh

46. A propped cantilever beam EF is subjected to a unit moving load as shown in the figure (not to scale). The sign convention for positive shear force at the left and right sides of my section is also shown



The CORRECT qualitative nature of the influence line diagram for shear force at G

1.


2.


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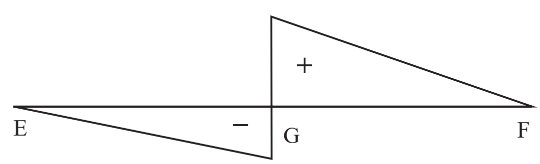

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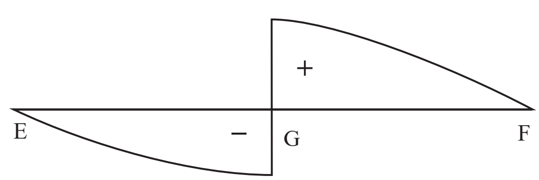
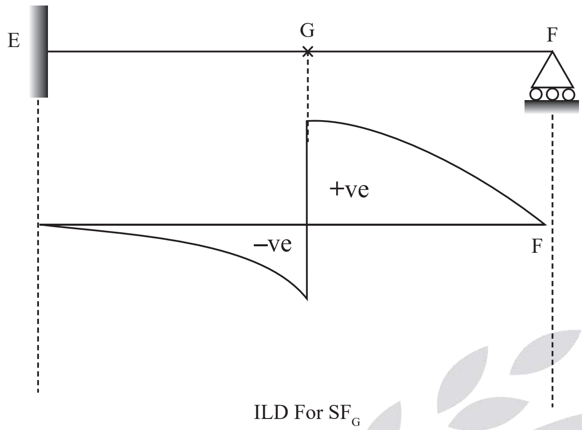


46. Ans: (b)

Sol:



ILD For SF_G

47. A fluid flowing steadily in a circular pipe of radius R has a velocity that is everywhere parallel to the axis (centerline) of the pipe. The velocity distribution along the radial direction is $V_r = U\left(1-\frac{r^2}{R^2}\right)$, where *r* is the radial distance as measured from the pipe axis and U is the maximum velocity at r = 0. The average velocity of the fluid in the pipe is

(a) $\frac{U}{4}$ (b) $\frac{U}{2}$ (c) $\frac{U}{3}$ (d) $\left(\frac{5}{6}\right)U$

47. Ans: (b)

Sol:

Given: $V_r = U\left(1-\frac{r^2}{R^2}\right)$

$$\overline{V} = ?$$

$$\overline{V} = \frac{Q}{A}$$

$$Q = \int V_r dA = \int_0^R U\left(1-\frac{r^2}{R^2}\right)2\pi r.dr$$

$$Q = \frac{2\pi U}{R^2}\left(\frac{R^2.r^2}{2}-\frac{r^4}{4}\right)\Bigg|_0^R = \frac{\pi}{2}U.R^2$$

$$A = \pi R^2$$

$$\Rightarrow \overline{V} = \frac{\frac{\pi}{2}UR^2}{\pi R^2}$$

$$\overline{V} = \frac{U}{2}$$

48. The liquid forms of particulate air pollutants are

(a) fly ash and fumes (b) dust and mist

(c) mist and spray (d) smoke and spray

48. Ans: (c)

Sol:

Mist & spray are liquid particulates in air.

49. The value of $\int_0^1 e^x dx$ using the trapezoidal rule with four equal subintervals is

(a) 2.192 (b) 718

(c) 1.727 (d) 2.718

49. Ans: (c)

Sol:

Let $\int_a^b f(x)dx = \int_0^1 e^x dx$ & n = 4

Then a = 0, b = 1, f(x) = e^x and $h = \frac{b-a}{n} = \frac{1-0}{4} = 0.25$

x	0	0.25	0.50	0.75	1
y = f(x) = e^x	1	1.284	1.649	2.117	2.718

The formula of trapezoidal rule to the given data is given by

$$\int_a^b f(x)dx \simeq \int_a^b f(x)dx = \frac{h}{2}\left[(y_0+y_n)+2(y_1+y_2+y_3)\right]$$

$$\Rightarrow \int_0^1 e^x dx \simeq \int_0^1 p(x)dx = \frac{(0.25)}{2}\left[(1+2.718)+2(1.284+1.640+2.117)\right]$$

$$\Rightarrow \int_0^1 e^x dx \simeq \int_0^1 p(x)dx = \frac{(0.25)}{2}\left[(3.718)+2(5.03)\right]$$

$$\therefore \int_0^1 e^x dx \simeq \int_0^1 p(x)dx = \left(\frac{0.25}{2}\right)\left[(3.2.8+10.1)\right] = 1.727$$

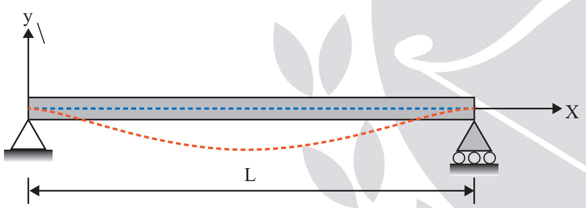
50. Which one of the following statements is correct?
    (a) Combustion is an exothermic process, which takes place in the absence of oxygen.
    (b) Pyrolysis is an exothermic process, which takes place in the absence of oxygen.
    (c) Combustion is an endothermic process, which takes place in the abundance of oxygen.
    (d) Pyrolysis is an endothermic process, which takes place in the absence of oxygen.

50. Ans: (d)

Sol: Pyrolosis occur in the absence of O_2 and it is endothermic

Combustion exothermic occur in the presence of air.

51. The equation of deformation is derived to be $y = x^2 - xL$ for a beam shown in the figure.



The curvature of the beam at the mid-span (in units, in integer) will be ______

51. Ans: 2

Sol:

$y = x^2 - xL$

slope, $\frac{dy}{dx} = 2x - L$

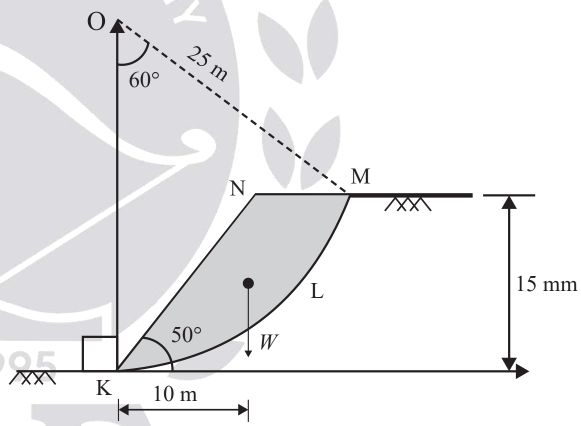
curvature, $\frac{d^2y}{dx^2} = 2$

@ mid span $\left(x = \frac{L}{2}\right)$

Curvature $= \frac{d^2y}{dx^2} = 2m$

(The beam has constant curvature throughout the beam)

52. An unsupported slope of height 15 m is shown in the figure (not to scale), in which the slope face makes an angle 50° with the horizontal. The slope material comprises purely cohesive soil having undrained cohesion 75 kPa. A trial slip circle KLM, with a radius 25 m, passes through the crest and toe of the slope and it subtends an angle 60° at its center O. The weight of the active soil mass (W, bounded by KLMN) is 2500 kN/m, which is acting at a horizontal distance of 10 m from the toe of the slope. Consider the water table to be present at a very large depth from the ground surface.



Considering the trial slip circle KLM, the factor of safety against the failure of slope under undrained condition (round off to two decimal places) is_____

52. Ans: (1.96)

Sol:

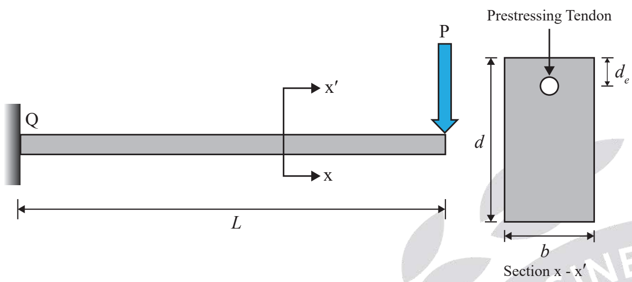
$F = \frac{C.\hat{L}\,R}{W.x}$

$\hat{L}$ = length of arc = $R.\theta^\circ \frac{\pi}{180}$

$= 25 \times 60^\circ \times \frac{\pi}{180} = 26.18$ m

$F = \frac{75 \times 26.18 \times 25}{2500 \times 10} = 1.96$

53. A prismatic cantilever prestressed concrete beam of span length, L = 1.5 m has one straight tendon placed in the cross-section as shown in the following figure (not to scale). The total prestressing force of 50 kN in the tendon is applied at d_c = 50 mm from the top in the cross-section of width. b = 200 mm and depth, d = 300 mm.



If the concentrated load, P = 5 kN, the resultant stress (in MPa, *in integer*) experienced at point 'Q' will be

53. Ans: (1)

Sol: Given Data

L = 1.5 m

P_o = 50 kN

d_c = 50 mm

b = 200 mm

d = 300 mm

P = 5 kN

Moment at Q = PL = 5 × 1.5 = 7.5 kN.m

Eccentricity $e = \frac{d}{2} - d_c = \frac{300}{2} - 50 = 10$ mm

Self weight of the beam $W_D = \gamma bD$

= 24 × 0.2 × 0.3

= 1.44 kN/m

Moment due to self weight $M_D = \frac{W_D L^2}{2}$

$= \frac{1.44 \times 1.5^2}{2}$

= 1.62 kNm

Total moment $M = M_D + M_L = 1.62 + 7.5$

= 9.12 kN-m

Resultant Stress at Q

$= -\frac{P_o}{A} - \frac{Pe}{Z} + \frac{M}{Z}$ (considering the compression as -ve)

$$= \frac{50\times10^3}{200\times300} - \frac{50\times10^3\times100}{\frac{1}{6}\times200\times300^2} + \frac{9.12\times10^6}{\frac{1}{6}\times200\times300^2}$$

= -0.83 - 1.67 + 3.04

= 0.54 N/mm²

≅ 1 N/mm²

54. If $P = \begin{bmatrix}1 & 2\\3 & 4\end{bmatrix}$ and $Q = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix}$ then $Q^T P^T$

(a) $\begin{bmatrix}1 & 2\\3 & 4\end{bmatrix}$ (b) $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$

(c) $\begin{bmatrix}2 & 1\\4 & 3\end{bmatrix}$ (d) $\begin{bmatrix}2 & 4\\1 & 3\end{bmatrix}$

54. Ans: (d)

Sol:

Consider $Q^T P^T = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix}\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$ (OR) $Q^T P^T = (PT)^T$

$\therefore Q^T P^T = \begin{bmatrix}2 & 4\\1 & 3\end{bmatrix}$

55. 'Kinematic viscosity' is dimensionally represented as

(a) $\frac{M}{LT}$ (b) $\frac{T^2}{L}$

(c) $\frac{M}{L^2T}$ (d) $\frac{L^2}{T}$

55. Ans: (d)

Sol: Kinematic Viscosity

$$\nu = \frac{\mu}{\rho} = \frac{kg/m.s}{kg/m^3} = m^2/s$$

$$[\nu] = \frac{m^2}{s} = \frac{L^2}{T}$$