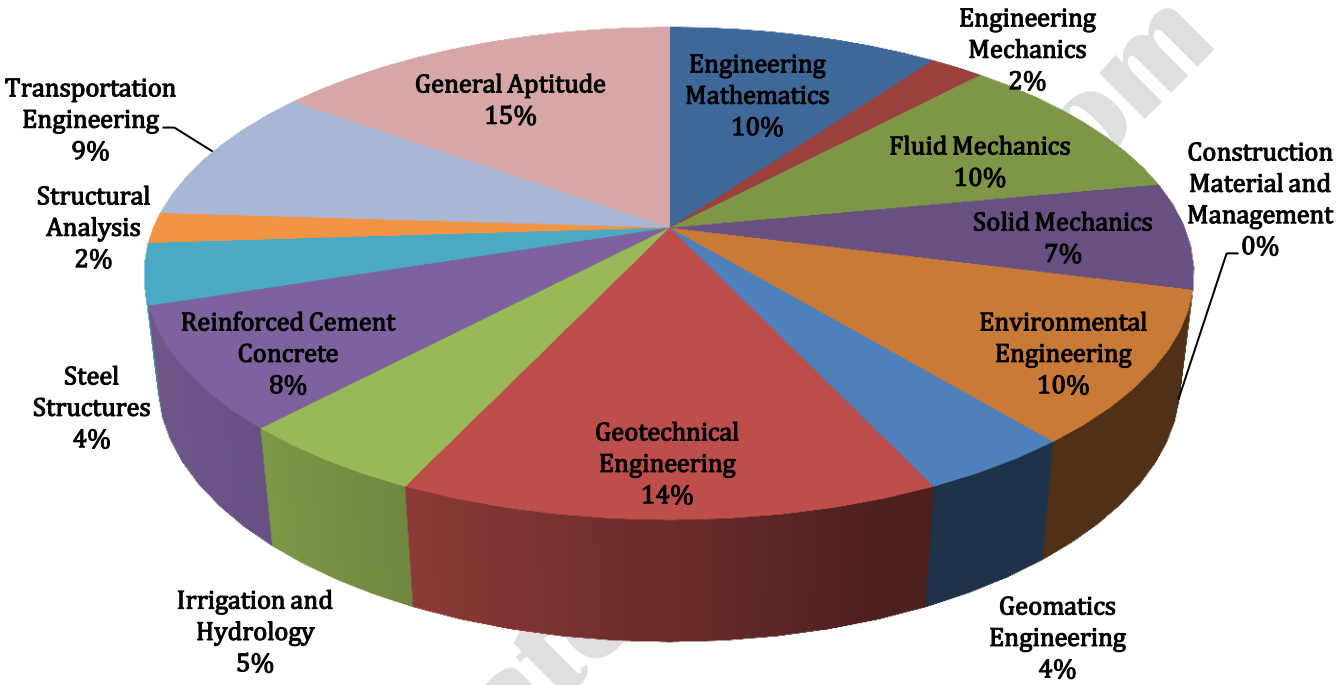
ANALYSIS OF GATE 2018

Civil Engineering



CE ANALYSIS-2018_11-Feb_Morning

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 4 2 Marks: 3	Matrix Methods; Maxima and Minima	Tough	10
Engineering Mechanics	1 Marks: 0 2 Marks: 1	Trusses and Frames	Medium	2
Fluid Mechanics	1 Marks: 4 2 Marks: 3	Fluid Properties; Fluid Statics; Boundary Layer; Flow through pipes; Hydraulic Machines; Open Channel Flow	Tough/Easy	10
Solid Mechanics	1 Marks: 1 2 Marks: 3	Simple Stress and Stain; Shear Force and Bending Moment; Stresses in Beams Deflection of Beams;	Medium	7
Construction Material and Management	1 Marks:0 2 Marks: 0	-	-	-
Environmental Engineering	1 Marks: 2 2 Marks: 4	Solid Waste Management; Air Pollution; BOD; Rapid Sand Filter	Medium	10
Geomatics Engineering	1 Marks: 0 2 Marks: 2	Theodolite and Traversing; Leveling;	Easy	4
Geotechnical Engineering	1 Marks: 4 2 Marks: 5	Soil Classification; Effective Stress; Consolidation; Permeability and Seepage; Shear Strength; Foundation Engineering (Shallow and Deep)	Medium	14
Irrigation and Hydrology	1 Marks: 1 2 Marks: 2	Irrigation; Hydrology	Medium/Easy	5
Reinforced Cement Concrete	1 Marks: 4 2 Marks: 2	Limit State of Collapse; Shear; Compression Concrete Technology	Medium	8
Steel Structures	1 Marks: 2 2 Marks: 1	Welding Connection & Plastic Analysis	Medium	4
Structural Analysis	1 Marks: 0 2 Marks: 1	Deflection Of Truss; Slope And Deflection Of Structure	Medium	2
Transportation Engineering	1 Marks: 3 2 Marks: 3	Traffic Engineering; Highway Material; Geometric Design; Airport Engineering	Medium/Easy	9
General Aptitude	1 Marks: 5 2 Marks: 5	Equations, Geometry, Vocabulary, Functions	Tough	15
Total	**65**			**100**
Faculty Feedback	Majority of the question were concept based. General Aptitude And Mathematics is tough. Core Subject Questions were 50% Medium, 30% tough and 20% easy.			

GATE 2018 Examination

Civil Engineering

Test Date: 11/02/2018

Test Time: 9:00 AM 12:00 PM

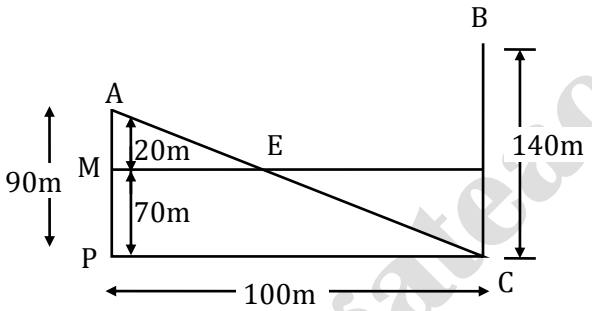
Subject Name: Civil Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. Tower A = 90 m tall, Tower B is 140 m tall. They are 100 m apart. A horizontal skywalk connects the floors at 70 m in both the towers. If a taut rope connects the top of Tower A to the bottom of Tower B, at what distance (in meter) from Tower A will the rope intersect the skywalk?

[Ans. *] Marks to all *



$\Delta AME = \Delta APC$

$$\frac{AM}{AP} = \frac{ME}{PC}$$

$$\frac{20}{90} = \frac{ME}{100}$$

2. It is no surprise that every society has had codes of behavior; however the nature of these codes is often _____?

The word that best fills the blank in the above sentence is

(A) Unpredictable (B) Simple

(C) Expected (D) Strict

[Ans. A*]

Unpredictable - Contrary word required

3. The temperature T in a room varies as a function of the outside temperature T_0 and the number of persons in the room p, according to the relation $T = k(\theta p + T_0)$ where θ and k are constants. What would be the value of θ gives the following data?

T_o	p	T
25	2	32.4
30	5	42

(A) 0.8
(B) 1.0
(C) 2.0
(D) 10.0

[Ans. B]

$32.4 = K(2\theta + 25) \ldots\ldots (i)$

$42 = K(5\theta + 30) \ldots\ldots (ii)$

$\theta = 1$

4. The driver applied the _____ as soon as she approached the hotel where she wanted to take a _____?

The words that best fill the blanks in the above sentence are

(A) Brake, Break
(B) Break, Break
(C) Brake, Brake
(D) Break, Brake

[Ans. A*]

Brake is a device which is used for stopping or moving a vehicle.

Break refers to a pause in work or during an activity.

5. Hema's age is 5 years more than twice of Hari's age. Suresh's age is 13 years less than 10 times Hari's age. If Suresh is 3 times as old as Hema, how old is Hema?

(A) 14
(B) 17
(C) 18
(D) 19

[Ans. D*]

Hema $= 2$ Hari $+ 5$

Suresh $= 10$ Hari $- 13 = 3$ Hema

Solving equations.

Hari = 7

Hema = 19

Suresh = 57

Q.6 - Q.10 Carry Two Mark each.

6. Each of the letters arranged as below represents a unique integer from 1 to 9. The letters are positioned in the figure such that $(A \times B \times C)$, $(B \times G \times E)$ and $(D \times E \times F)$ are equal. Which integer among the following choices cannot be represented by the represented by the letters A, B, C, D, F, or G?

A		D
B	G	E
C		F

(A) 4
(B) 5
(C) 6
(D) 9

[Ans. B*]

$A \times B \times C = B \times G \times E = D \times E \times F = 72$

$8 \times 9 \times 1 = 9 \times 2 \times 4 = 3 \times 4 \times 6 = 72$

Any of A, B, C, D, E, F, G cannot be 5.

7. Consider a sequence of numbers $a_1, a_2, a_3, \ldots \ldots a_n$, where $a_n = \frac{1}{n} - \frac{1}{n+2}$, for each integer $n > 0$. What is the sum of the first 50 terms?

(A) $\left(1+\frac{1}{2}\right)-\frac{1}{50}$ (B) $\left(1+\frac{1}{2}\right)+\frac{1}{50}$

(C) $\left(1+\frac{1}{2}\right)-\left(\frac{1}{51}+\frac{1}{52}\right)$ (D) $1-\left(\frac{1}{51}+\frac{1}{52}\right)$

[Ans. C*]

Sum of series will be

$\left(1-\frac{1}{3}\right)+\left(\frac{1}{2}-\frac{1}{4}\right)+\left(\frac{1}{3}-\frac{1}{5}\right)\ldots\ldots\left(\frac{1}{48}-\frac{1}{50}\right)+\left(\frac{1}{49}-\frac{1}{51}\right)+\left(\frac{1}{50}-\frac{1}{52}\right)$

All like terms will cancel out and we will be left with

$\left(1+\frac{1}{2}\right)-\left(\frac{1}{51}+\frac{1}{52}\right)$

8. A fruit seller sold a basket of fruits at 12.5% loss. Had he sold it for Rs.108 more, he would have made a 10% gain. What is the loss in Rupees incurred by the fruit seller?

(A) 48 (B) 52

(C) 60 (D) 108

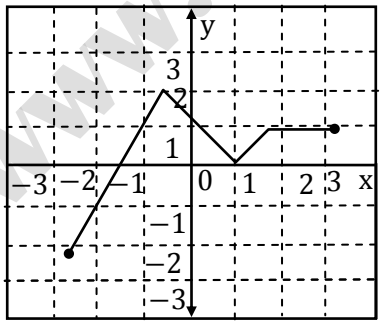
[Ans. C*]

$12.5\%\, x + 10\%\, x = 108$

$x = \frac{108}{22.5}$

So los $108 \times \frac{12.5}{22.5} = 60$

9. Which of the following function(s) is an accurate description of the graph for the range(s) indicated?



(i) $y = 2x + 4$ for $-3 \le x \le -1$

(ii) $y = |x - 1|$ for $-1 \le x \le 2$

(iii) $y = \big||x| - 1\big|$ for $-1 \le x \le 2$

(iv) $y = 1$ for $2 \le x \le 3$

(A) (i), (ii) and (iii) only.
(B) (i), (ii) and (iv) only.
(C) (i) and (iv) only.
(D) (ii) and (iv) only.

[Ans. B*]

Put value and verify

(i) $y = 2x + 4$ is true in $-3 \leq x \leq -1$

On putting $x = -3, y = -2$ and $x = -2, y = 0$ and $x = -1, y = 2$

(ii) $y = |x - 1|$ is also true $(x = -1, y = 2), (x = 0, y = 1)$ and (x=1,y=0)

(iv) $y = 1$ in $(2 \leq x \leq 3)$ always true

(i), (ii) and (iv) are true

10. The price of a wire made of a super alloy material is proportional to the square of its length. The price of 10 m length wire is Rs.1600. What would be the total price (in Rs.) of two wires of lengths 4m and 6m?

(A) 768
(B) 832
(C) 1440
(D) 1600

[Ans. B*]

$C \propto W^2$

$C = kW^2$

$C = k(10)^2 = 100 = 1600 \Rightarrow k = 16$

$C_1 = k(4)^2 = 36\,k$

$C_2 = k(6)^2 = 36\,k$

Now total cost $= 52\,k = 52 \times 16 = 832$

Technical

Q.1 - Q.25 Carry One Mark each.

1. For the given orthogonal matrix Q,

$$Q = \begin{bmatrix} \frac{3}{7} & \frac{2}{7} & \frac{6}{7} \\ -\frac{6}{7} & \frac{3}{7} & \frac{2}{7} \\ \frac{2}{7} & \frac{6}{7} & -\frac{3}{7} \end{bmatrix}$$

The inverse is =?

(A) $\begin{bmatrix} \frac{3}{7} & \frac{2}{7} & \frac{6}{7} \\ -\frac{6}{7} & \frac{3}{7} & \frac{2}{7} \\ \frac{2}{7} & \frac{6}{7} & -\frac{3}{7} \end{bmatrix}$

(B) $\begin{bmatrix} -\frac{3}{7} & -\frac{2}{7} & -\frac{6}{7} \\ \frac{6}{7} & -\frac{3}{7} & -\frac{2}{7} \\ -\frac{2}{7} & \frac{6}{7} & \frac{3}{7} \end{bmatrix}$

(C) $\begin{bmatrix} \frac{3}{7} & -\frac{6}{7} & \frac{2}{7} \\ \frac{2}{7} & -\frac{3}{7} & \frac{6}{7} \\ \frac{6}{7} & \frac{2}{7} & -\frac{3}{7} \end{bmatrix}$

(C) $\begin{bmatrix} -\frac{3}{7} & \frac{6}{7} & -\frac{2}{7} \\ -\frac{2}{7} & -\frac{3}{7} & -\frac{6}{7} \\ -\frac{6}{7} & -\frac{2}{7} & \frac{3}{7} \end{bmatrix}$

[Ans. C*]

$$|Q| = \frac{3}{7}\left(-\frac{9}{49} - \frac{12}{49}\right) - \frac{2}{7}\left(\frac{18}{49} - \frac{4}{49}\right) + \frac{6}{7}\left(-\frac{36}{49} - \frac{6}{49}\right) = -1$$

$$\text{Adj } Q = \begin{bmatrix} -\frac{21}{49} & \frac{42}{49} & -\frac{14}{49} \\ -\frac{14}{49} & -\frac{21}{49} & -\frac{42}{49} \\ -\frac{42}{49} & -\frac{14}{49} & \frac{21}{42} \end{bmatrix}$$

$$Q^{-1} = \frac{\text{Adj}Q}{|Q|}\begin{bmatrix} \frac{3}{7} & -\frac{6}{7} & \frac{2}{7} \\ \frac{2}{7} & \frac{3}{7} & \frac{6}{7} \\ \frac{6}{7} & \frac{2}{7} & -\frac{3}{7} \end{bmatrix}$$

$\because$ Q is orthogonal $Q^{-1} = Q^T$

2. There are 20,000 vehicles operating in a city with an average annual travel of 12,000 km per vehicle. The NO_x emission rate is 2.0 g/km per vehicle. The total annual release of NO_x will be.

(A) 4,80,000 kg
(B) 4,800 kg
(C) 480 kg
(D) 48 kg

[Ans. A]

Vehicles→20000

Distance→12000 km/vehicles

No_x Produced→2g/km
Total $No_x = 2000 \times 12000 \times 2 \times 10^{-3}$(kg)
$= 4,80,000$ kg

3. Bernoulli's vehicles operating for
(A) Viscous and compressible fluid flow
(B) Inviscid and compressible fluid flow
(C) Inviscid and incompressible fluid flow
(D) Viscous and incompressible fluid flow
[Ans. C]

4. For routing of flood in a given channel using the Muskingum method, two of the routing coefficients are estimated as $C_0 = -0.25$ and $C_1 = -0.55$. the value of the third coefficient C_2 would be_____
[Ans. *]Range: 0.70 to 0.70
Given
$C_0 = -0.25$
$C_1 = 0.55$
C_2 =?
We know by Mushin gum method
$C_0 + C_1 + C_2 = 1$
$-0.25 + 0.55 + C_2 = 1$
$C_2 = 1 - 0.55 + 0.25$
$C_2 = 0.7$

5. The Le Chatelier apparatus is used to determine.
(A) Compressive strength of cement
(B) Fineness of cement
(C) Setting time cement
(D) Soundness of cement
[Ans. D]
Le Chatelier Apparatus is used to find the soundness of cement

6. The width of a square footing is equal to the diameter of a circular footing are equal. If both the footings are placed on the surface of sandy soil, the ratio of the ultimate bearing capacity of circular footing to square footing will be.
(A) 4/3
(B) 1
(C) 3/4
(D) 2/3
[Ans. C]
$q_u = 0.4\ BqN_q$(For square footing)
$q_u = 0.3\ DqN_q$(For circularfooting)
$\because B = D$ (Given)
$= \frac{3}{4}$

7. In a shrinkage limit test the volume and mass of a dry soil per found to be 50 cm^3 and 88 g, respectively. The specific gravity of the soil solids is2.71 and the density of water is 1 g/cc. The shrinkage limit (in %, up to two decimal places) is_____

[Ans. *] Range: 19.50 to 20.50

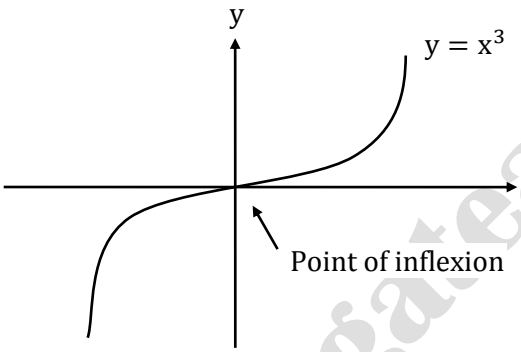
$$w_{sh} = \frac{1}{G_M} - \frac{1}{G}$$

$$= \frac{1}{\frac{M}{V\rho_w}} - \frac{1}{G}$$

$$= \frac{50 \times 1}{88} - \frac{1}{2.71} = 19.92\ \%$$

8. At the point x=0, the function $f(x) = x^3$ has
   (A) Local maximum
   (B) Local minimum
   (C) Both local maximum and minimum
   (D) Neither local maximum and local minimum

[Ans. D*]



$f(x) = x^3$ at $x = 0 =$

At x=0, the function $y = x^3$ has neither minima not maxima

9. A core cutter of 130 mm height has inner and outer diameters of 100 mm and 106 mm, respectively. The area ratio of the core cutter (in % up to two decimal places) is_____

[Ans. *] Range: 12.30 to 12.40

$$\text{Area ratio} = \frac{D_2^2 - D_1^2}{D_1^2} \times 100$$

$$= \frac{106^2 - 100^2}{100^2} = 12.36\%$$

10. A bitumen sample has graded as VG30 as per IS : IS 73-2013, the '30' in the grade means that
    (A) Penetration of bitumen at 25°C is in between 20 - 40.
    (B) Viscosity of bitumen at 60°C is in between 2400 – 3600 Poise.
    (C) Ductility bitumen at 27°C is more than 30 cm.
    (D) Elastic recovery of bitumen at 15°C is more than 30%.

[Ans. B]

11. The percent reduction in the bearing capacity of a strip footing resting on sand under footing condition (water level at the base of the footing) when compared to the situation where the water level is at a depth much greater than the width of footing, is approximately

(A) 0 (B) 25

(C) 50 (D) 100

[Ans. B]

For strip footing

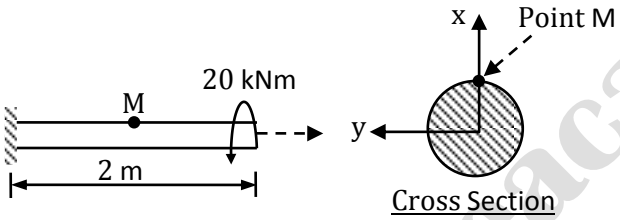
$q_u = 0.5\ B\gamma N_\gamma$ (for sandy soil)

When water level rises to base of the footing

$\gamma_{sub} = \frac{1}{2}\gamma_{sat}$

Therefore bearing capacity gets reduced by approximately 50%.

12. A solid circular beam with radius of 0.25 m and length of 2 m is subjected to a twisting moment of 20 kNm about the z-axis at the free end, which is the only load acting as shown in the figure. The shear stress component T_{xy} at Point 'M' in the cross-section of the beam at a distance of 1 m from the fixed end is



(A) 0.0 MPa (B) 0.51 MPa

(C) 0.815 MPa (D) 2.0 MPa

[Ans. A*]

The only non-zero stresses are $\tau_{\theta z} = \tau_{z\theta} = \tau$, if θ is 90° then $\theta = y$

Hence $\tau_{zy} = \tau_{yz} = \tau_{max} = 16T\pi d^3 = 0.815$ MPa

But in rest of the planes shear stresses are zero, hence $\tau_{xy} = \tau_{yx} = 0$

13. A city generates 40×10^6 kg of municipal solid waste (MSW) per year, out of which only 10% is recovered/recycled and the rest goes to landfill. The landfill has a single lift of 3 m height and is compacted to a density of 550 kg/m^3. If 80% of the land fill is assumed to be MSW, the landfill area (in m^2,up to one decimal place) required would be _____

[Ans. *] Range: 27271 to 27274

Total waste $= 40 \times 10^6$kg

10% recycled

90% landfill

$0.90 \times 40 \times 10^6 = 36 \times 10^6$kg

Density $= 550$ kg/M^3

Volume of MSW $= \frac{36 \times 10^6}{550} = 65454$ m^3

Area occupied by MSW $= \frac{65454}{3} = 21818\ m^2$
Area occupied by MSW $= 80\%$ of landfill area
$\frac{21818}{0.80} =$ Area of landfill
Total area of landfill $= 27272.72\ m^2$

14. A steel column of ISHB 350 @ 72.4 kg/m is subjected to a factored axial compressive load of 2000 kN. The load is transferred to a concrete pedestal of grade M20 through square base plate. Consider bearing strength of the concrete is $0.45f_{ck}$. Where f_{ck} is the characteristic strength of concrete. Using limit state method and neglecting the self-weight of base plate and steel column, the length of a side of the base plate to be provided is.
(A) 39 cm (B) 42 cm
(C) 45 cm (D) 48 cm
[Ans. D]
Factored load, $P_u = 2000$ kN
Bearing strength $= 0.45\ f_{ck}$
Grade of concrete $=$ M20
Area of base plate $= \frac{2000 \times 10^3}{0.45 \times 20}$
Side of base plate $= 471.4$ mm $= 47.1$ cm

15. Which of the following matrices is singular?
(A) $\begin{bmatrix} 2 & 5 \\ 1 & 3 \end{bmatrix}$ (B) $\begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$
(C) $\begin{bmatrix} 2 & 4 \\ 3 & 6 \end{bmatrix}$ (D) $\begin{bmatrix} 4 & 3 \\ 6 & 2 \end{bmatrix}$
[Ans. C*]
Option (A): $|A| = 6 - 5 = 1$
Option (B): $|A| = 9 - 4 = 5$
Option (C): $|A| = 12 - 12 = 0$
Option (D): $|A| = 8 - 18 = -10$
Hence matrix (C) is singular.

16. Two rectangular under-reinforced concrete beam sections X and Y are similar in all Aspects expect that the longitudinal compression reinforcement in section Y is 10% more. What one of the following is the correct statement?
(A) Section X has less flexural strength and is less ductile than section Y
(B) Section X has less flexural strength but is more ductile than section Y
(C) Sections X and Y have equal flexural strength but different ductility
(D) Section X and Y have equal flexural strength and ductility
[Ans. A*]
Since compression steel of section Y is more than section X therefore, flexural resistance and ductility of section Y both will be more than section X.

17. A 10 m wide rectangular channel carries a discharge of 20 m^3/sec under critical condition using $g = 9.81 m/s^2$.Specific energy (in m, up to two decimal places) is_____

[Ans. *] Range: 1.10 to 1.20

$E_c = \frac{3}{2}y_c$ [Specific energy for critical condition]

$$y_c = \left(\frac{q^2}{g}\right)^{\frac{1}{3}} ; q = \frac{20}{10} = 2\ m^3/s/m$$

$$\therefore E_c = \frac{3}{2}\left(\frac{2^2}{9.81}\right)^{\frac{1}{3}} = 1.11$$

18. A column at height 'h' with rectangular cross-section of a × 2a has buckling load of P. If the cross-section change to 0.5a × 3a and height change of 1.5 h, the buckling load of the redesigned column will be

(A) $\frac{P}{12}$ (B) $\frac{P}{4}$

(C) $\frac{P}{2}$ (D) $\frac{3P}{4}$

[Ans. A*]

$$P_{cr} \propto \left(\frac{\pi^2 EI}{L^2}\right)$$

$$\Rightarrow \left(\frac{P_1}{P_2}\right) = \left(\frac{I_1}{I_2}\right) \times \left(\frac{L_2^2}{L_1^2}\right)$$

$$\left(\frac{P}{P_2}\right) = \frac{(2a)(a)^3}{(3a)(0.5a)^3} \times (1.5)^2$$

$$= \frac{2 \times 2^3 \times 3^2}{3 \times 2^2} = 12$$

$$P_2 = \frac{P}{12}$$

19. The frequency distribution of the compressive strength of 20 concrete cube specimens is given in the table.

F(MPa)	Number of specimens with compressive strength equal to f
23	4
28	2
22.5	5
31	5
29	4

If μ is the mean strength of the specimens and σ is the standard deviation, the number of specimens (out of 20) with compressive strength less than μ-3 σ is_____

[Ans. *] Range: 0 to 0

Mean strength

$$\mu = \frac{(23 \times 4) + (2 \times 28) + (5 \times 22.5) + (5 \times 31) + 4 \times 29}{20}$$

$\mu = 26.575\ N/mm^2$

Standard deviation

$$\sigma = \sqrt{\frac{(x-\mu)^2}{N-1}}$$

$$\sigma = \sqrt{\frac{\begin{matrix}(23-26.575)^2\times 4+(28-26.575)^2\times 2+\\+(22.5-26.575)^2\times 5+(31-26.575)^2\times 5+\\+(29-26.575)^2\times 4\end{matrix}}{(20-1)}}$$

$= 3.7\ n/mm^2$

$\because \mu - 3\sigma = 26.575 - 3\times 3.7$

$= 15.48\ N/mm^2$

No any specimen has strength less than $15.48\ N/mm^2$

20. A 1:50 model of a spillway is to be tested in laboratory. The discharge in prototype Spillway $= 1000 m^2/sec$.The corresponding discharge (in m^3/s, up to two decimal places) to be maintained in the model, neglecting variation in acceleration due to gravity, is_____

[Ans. *] Range: 0.05 to 0.06

Froude law is valid

$Q_r = L_r^{2.5}$

$$\frac{Q_m}{Q_p} = \left(\frac{1}{50}\right)^{2.5}$$

$$\frac{Q_m}{1000} = \left(\frac{1}{50}\right)^{2.5}$$

$Q_m = 0.0566\ m^3/s$

$Q_m \approx 0.06\ m^3/s$

21. The deformation in concrete due to sustained loading is

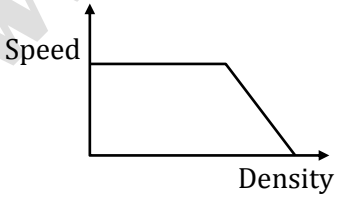
(A) Creep (B) Hydration

(C) Segregation (D) Shrinkage

[Ans. A]

Creep is inelastic deformation with time due to sustained loading.

22. The speed-density relationship for a road section is show in the figure.



The shape of the flow-density relationship is

(A) Piecewise linear (B) Parabolic

(C) Initially linear then parabolic (D) Initially parabolic then linear.

[Ans. C]

23. In a fillet weld, the direct shear stress and bending tensile stress are 50 MPa and 150 MPa, respectively. As per IS 800:2007, the equivalent stress (in MPa, up to two decimal places) will be_____

[Ans. *] Range: 173.10 to 173.30

Equivalent stress or Resultant stress

$= f_r = \sqrt{q^2 + 3\tau^2}$

$= \sqrt{150^2 + 3 \times (50)^2} = 173.2$ MPa

24. A well-designed signalized intersection is one in which the

(A) Crossing conflicts are increased

(B) Total delay is minimized

(C) Cycle time is equal to the sum of red and green times in all phases

(D) Cycle time is equal to the sum of red and yellow times in all phases

[Ans. B]

25. A flow field is given by $u = y^2, v = -xy, w = 0$.Value of the z-component of angular velocity (in radians per unit time, up to two decimal places) at the point $(0, -1,1)$ is_____

[Ans. *] Range: 1.50 to 1.50*

$$\omega_z = \frac{1}{2}\left[\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right]$$

$$= \frac{1}{2}\left[\frac{\partial}{\partial x} - (-xy) - \frac{\partial}{\partial y}(y)^2\right]$$

$$= \frac{1}{2}[-y - 2y]$$

$$= -\frac{3y}{2}$$

At point $(0, -1,1)$; $\omega_z = -\frac{3}{2} \times -1 = 1.50$ rad/s

Q.26 - Q.55 Carry Two Mark each.

26. The value of the integral $\int_0^{\pi} x \cos^2 x \, dx$ is ?

(A) $\pi^2/8$ (B) $\pi^2/4$

(C) $\pi^2/2$ (D) π^2

[Ans. B*]

The value of $\int_0^{\pi} \cos^2 x \, dx$

$$= \int_0^{\pi} \left(\frac{x}{2} + \frac{x \cos 2x}{2}\right) dx$$

$$= \frac{x^2}{4} + \frac{1}{2}\left[\left\{0 + \frac{1}{4}\right\} - \left(0 + \frac{1}{4}\right)\right]$$

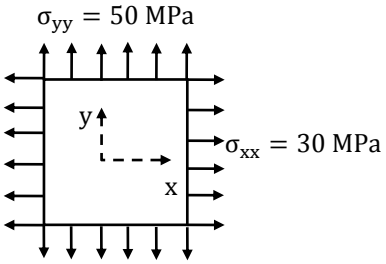
$$= \frac{\pi^2}{4} + \frac{1}{2}\left(\frac{1}{4} - \frac{1}{4}\right) = \frac{\pi^2}{4}$$

27. An RCC short column (with lateral ties) of rectangular cross-section of 250 mm × 350 mm is reinforced with four numbers of 16 mm diameter longitudinal bars. The grade of steel

and concrete are Fe415 and M20 respectively. Neglect eccentricity effect. Considering limit state of collapse in compression (IS 456 : 2000), the axial load carrying capacity of the column (in kN, up to one decimal place), is_____

[Ans. *] Range: 815.0 to 830.0

28. A plate in equilibrium is subjected to uniform stress along its edges with magnitude $\sigma_{zz} = 30$ MPa and $\sigma_{zz} = 50$ MPa as shown in the figure.



The Young's modulus of the material is 2×10^{11} N/m^2 and the Poisson's ratio is 0.3. If σ_{zz} is negligibly small assumed to be zero, then the strain ϵ_{zz} is.

(A) -120×10^{-6} (B) -60×10^{-6}

(C) 0 (D) 120×10^{-6}

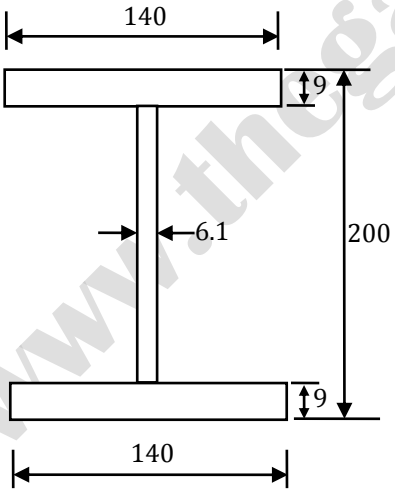
[Ans. A*]

$\sigma_{xx} = 30$ MPa, $\sigma_{yy} = 50$ MPa, $\sigma_{zz} = 0$

$$\epsilon_{zz} = \frac{\sigma_{zz}}{E} - \mu\frac{\sigma_{xx}}{E} - \mu\frac{\sigma_{yy}}{E} = -\frac{\mu}{E}(\sigma_{xx} + \sigma_{yy})$$

$$= -\frac{0.3}{2 \times 10^5}(30 + 50) = -120 \times 10^{-6}$$

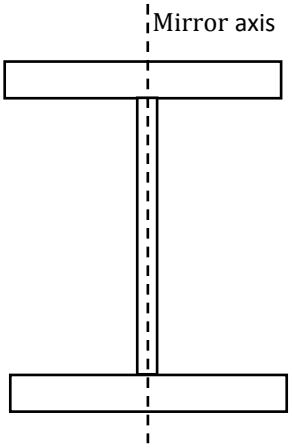
29. The dimensions of a symmetrical welded I-section are shown in figure.



(All dimensions are in mm)

The plastic section modulus about the weaker axis (in cm^3,up to one decimal place) is_____

[Ans. *] Range: 88.0 to 92.0



$$Z_p = \frac{A}{2}(\overline{x_1} + \overline{x_2})$$
$$= \left[\frac{140 \times 9}{2}(35 + 35)\right] \times 2$$
$$+ \left[\frac{(200 - 18) \times 6.1}{2}\right]\left(\frac{3.05}{2} + \frac{3.05}{2}\right)$$
$$= (89.9 \times 10^3)\text{mm}^3 = 89.9\ \text{cm}^3$$

30. A waste activated sludge (WAS) is to be blended with green waste (GW). The carbon (C) and nitrogen (N) contents, per kg of WAS and GW on dry basis are given in the table.

Parameter	WAS	GW
Carbon(g)	54	360
Nitrogen (g)	10	6

The ratio WAS to GW require (up to two decimal places) to achieve a blended C:N ratio of 20:1 on dry basis is_____

[Ans. *] Range: 1.60 to 1.70

Let the WAS content =x
Let the GW content=y
The mixing of two waste leads to the resultant C/N ratio as 20:1
⇒ Carbon content in mix
$54x + 360y = 20$ ---------- (1)
Nitrogen content in mix
$10x + 6x = 1$---------- (2)
Showing equation (1) & (2)
$x = 0.073;\ y = 0.073$
$\Rightarrow \text{Ratio} = \frac{0.073}{0.044} = 1.65$

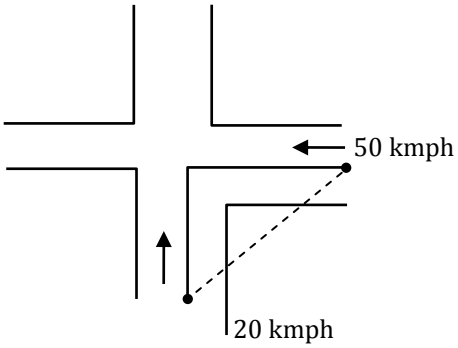
31. A priority intersection has a single-lane one-way traffic road crossing an undivided two-lane two-way traffic road. The traffic stream speed on the single-lane road is 20 kmph and the speed on the two-lane road is 50 kmph. The perception-reaction time is 2.5 s, coefficient of longitudinal friction is 0.38 and acceleration due to gravity is 9.81 m/s^2. A clear sight

triangle along the two-lane road and the single-lane road, respectively will be of the sight triangle along the two-lane road and the single-lane road, respectively will be.

(A) 50 m and 20 m (B) 61 m and 18 m

(C) 111 m and 15 m (D) 122 m and 36 m

[Ans. C]



Sides of triangle is nothing but SSD

$$SSD_1 = \left(\frac{50}{3.6}\right) \times 2.5 + \left(\frac{50}{3.6}\right)^2 \times 2 \times 9.81 \times 0.38$$

$$SSD_1 = 60.59 \approx 61 \text{ M}$$

$$SSD_2 = \left(\frac{20}{3.6}\right) \times 2.5 + \left(\frac{20}{3.6}\right)^2 \times 2 \times 9.81 \times 0.38 = 18 \text{ M}$$

But as per IRC: 66

For sight triangle at priority intersection minor road=15m

major road = Design speed × 8 sec.

$= 50 \times 0.278 \times 8 = 111\text{m}$

32. A square area (on surface of the earth) with side 100 m and uniform height, appears as 1 cm^2 on vertical aerial photograph. The topographic map shows that contour of 650 m passes through the area. If focal length of camera is 150 mm, height from which the aerial photograph was taken, is

(A) 800M (B) 1500M

(C) 2150M (D) 3150M

[Ans. C*]

$A = 100 \times 100\ m^2$

Area on photo , $a = 1cm^2$

Scale 1cm=100m

f=150 mm

h=650 m

$$\text{Scale} = \frac{1}{100} = \frac{1}{100 \times 10^2} = \frac{1}{1000} = \frac{f}{H - h}$$

$$= \frac{1}{10000} = \frac{150 \times 10^{-3}}{H - 650} = 2150 \text{ m}$$

33. A conventional drained tri-axial compression test was conducted on a normally consolidated clay sample under an effective confining pressure of 200 kPa. The deviator stress at failure was found to be 400 kPa. An identical specimen of the same clay sample is isotropically consolidated to a confining pressure of 200 kPa and subjected to standard undrained tri-axial compression test. If the deviator stress at failure is 150 kPa, the pore pressure developed (in kPa, up to one decimal place) is_____

[Ans. *] Range: 124 to 126

For first specimen @ Drained Condition

$\overline{\sigma_3} = 200$ kPa, $\sigma_d = 400$ kPa, $\overline{\sigma_1} = 600$ kPa

For second specimen @ Undrained Condition

$\overline{\sigma_3} = 200$ kPa, $\sigma_d = 150$ kPa, $\overline{\sigma_1} = 350$ kPa

For First specimen,

$\because \overline{\sigma_1} = \overline{\sigma_3}\tan^2\left(45 + \frac{0}{2}\right) + 2C\tan\left(45 + \frac{\emptyset}{2}\right)$

$\because$ for drain candition $c = 0$

$\overline{\sigma_1} = \overline{\sigma_3}\tan^2\left(45 + \frac{\emptyset}{2}\right)$

$600 = 200\tan^2\left(45 + \frac{\emptyset}{2}\right)$

$\emptyset = 30°$

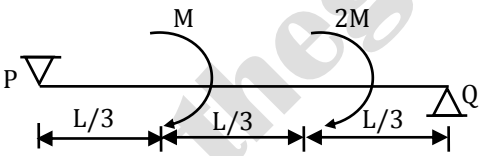
For second specimen,

In undrained condition pore pressure will be developed.

$(350\text{-}4) - (200 - 4)\tan^2\left(45 + \frac{30}{2}\right)$

$u = 125$ kPa

34. The figure shows a simply supported beam PQ of uniform flexural rigidity EI carrying two moments M and 2M.



(A) 0

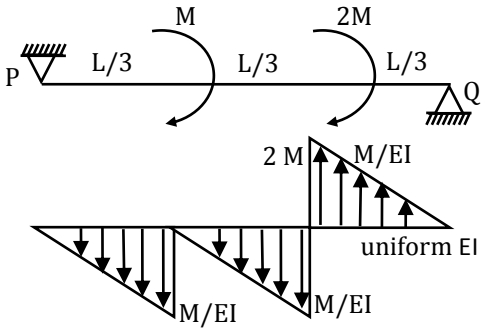
(B) $\frac{ML}{(9EI)}$

(C) $\frac{ML}{(6EI)}$

(D) $\frac{ML}{(3EI)}$

[Ans. C]

Apply conjugate beam Meth



$\therefore R_1 + R_2 = \frac{1}{2} \times \frac{L}{3} \times \frac{M}{EI} = \frac{ML}{6EI}$

Taking moment about Q= 0

$\sum M_Q = 0$

$\Rightarrow R_P \times L = \frac{1}{2} \times \frac{L}{3} . \frac{M}{EI} \left(\frac{2L}{3} + \frac{L}{9} \right) + \left\{ \frac{1}{2} \times \frac{L}{3} \times \frac{M}{EI} \left(\frac{L}{3} + \frac{L}{9} \right) \right\} - \left\{ \frac{1}{2} \times \frac{L}{3} \times \frac{M}{EI} \times \frac{2L}{9} \right\} = 0$

$\Rightarrow R_P = \frac{ML}{6EI}$

35. A rapid sand filter comprising a number of filter beds is required to produce 99 MLD of potable water. Consider water loss during backwashing as 5% rate of filtration as 6.0 m/h and length to width ratio of filter bed as 1.35. The width of each filter bed is to be kept equal to 5.2 m. One additional filter bed is to be provided to take care of break-down, repair and maintenance. The total number of filter beds required will be

(A) 19 (B) 20

(C) 21 **(D)** 22

[Ans. C]

$Q = 99$ MLD

$\because$ 5% required for backwash

$\Rightarrow Q' = 99 \times 1.05 = 103.95$ MLD

$= 103.95 \times 10^3 \text{ m}^3/\text{day}$

$\text{ROF} = 6\text{m/hr}\ Q = \frac{103.95 \times 10^3}{24} \text{m}^3/\text{hr} = 4331.25 \text{ m}^3/\text{hr}$

$\text{Area} = \frac{Q}{\text{ROF}} = \frac{4331.25}{6} = 721 \text{ m}^2$

$\frac{L}{B} = 1.35 \Rightarrow B = 5.2 \text{ m} \Rightarrow L = 7.02 \text{ m}$

Area of 1 filter $= 7.02 \times 5.2 = 36.50 \text{ m}^2$

$N = \frac{721}{36.5} = 19.75 = 20 + 1 = 21$ filter

36. The solution (up to three decimal places) at x=1 of the differential equation $\frac{d^2y}{dx^3} + 2.\frac{dy}{dx} + y = 0$ subject to boundary condition $y(0) = 1$ and $\frac{dy}{dx}(0) = -1$ is _____?

[Ans. *] Range: 0.36 to 0.37*

$(D^2 + 2D + 1)y = 0 (\because \text{Roots are } -1, -1)$
$CF = (C_1 + C_2 x)e^{-x}$
$y = C_1 e^{-x} + C_2 x e^{-x} \ldots . (i)$
$y(0) = 1; 1 = C_1 \ldots \ldots (ii)$
$y = C_1 e^{-x} + C_2 (e^{-x} - x e^{-x})$
$y'^{(0)} = -1; -1 = -C_1 + C_2 \ldots \ldots . (iii)$
From equation (ii) and (iii)
$C_1 = 1, C_2 = 0$
$y = e^{-x}$
$\text{At } x = 1, y = e^{-1} = \frac{1}{e} = 0.368$

37. Given the following data: design life n = 15 years, lane distribution factor D =0.75, annual rate of growth of commercial vehicles r =6%, vehicle damage factor F = 4 and initial traffic in the year of completion of construction =3000 commercial vehicles per day (CVPD). As per IRC:37-2012, the design traffic in terms of cumulative number of standard axles (in million standard axles, up to two decimal places) is_____

[Ans. *]Range: 75.00 to 78.00

$N = 365\,[(1 + r)^n - 1] \times A \times D \times \frac{F}{r}$
$N = \frac{365[(1 + 0.06)^{15} - 1] \times 3000}{0.06} \times 0.75 \times 4$
$N = 76461561$
$N = 76.46 \text{ msa}$

38. A 0.5×0.5 m square concrete pile is to be driven in a homogeneous clayey soil having undrained shear strength, $c_u = 50$ kPa and unit weight, $y = 180\,\text{kN/m}^3$. The design capacity of the pile is 500 kN. The adhesion factor α is given as 0.75. The length of the pile required for the above design load with a factor of safety of 2.0 is

(A) 5.2 m (B) 5.8 m
(C) 11.8 m (D) 12.5 m

[Ans. C]

Considering factor of safety = 2
$q_u = 500 \times 2 = 1000 \text{ kN}$
$\because q_u = 9CA_b + \alpha \bar{C} A_s$
$1000 = 9 \times 50 \times (0.5) + 0.75 \times 50 \times 4 \times 0.25 \times 2$
$L = 11.83 \text{ m}$

39. The infiltration rate f in a basin under ponding condition is given by $f = 30 + 10e^{-2t}$ where, f is in mm/h and t is time in hour. Total depth of infiltration (in mm, up to one decimal place) during the last 20 minutes of a storm of 30 minutes furcation is_____

[Ans. *] Range: 11.0 to 12.0

Infiltration rate $f(t) = 30 + 10e^{-2t}$

During the last 20 minutes i.e. Total Infiltration depth; in time 10 nub to 30min i.e. 0.166 hour to 0.5 hour.

$$= \int_{0.166}^{0.5} (30 + 10e^{-2t})dt$$

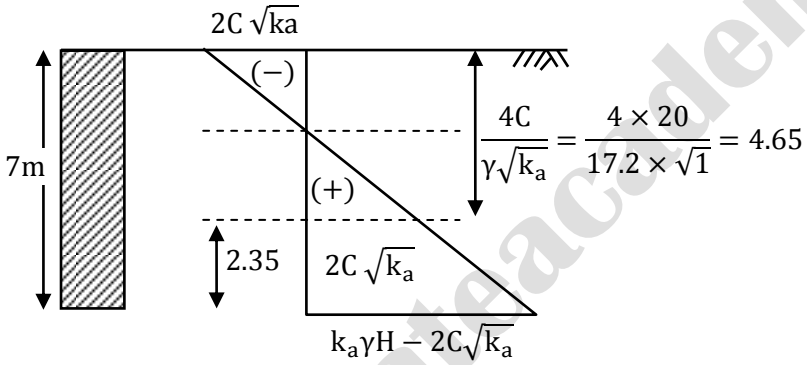
$$= 30t + \frac{10e^{-2t}}{-2}$$

$$= (30t + 5e^{-2t})_{0.166}^{0.5} = 11.76 \text{ mm}$$

40. A rigid smooth retaining wall of height 7 m with vertical back face retains saturated clay as backfill. The saturated unit weight and undrained cohesion of the backfill are 17.2 kN/m^3 and 20 KPa, respectively. The difference in the active laeral forces on the wall (in kN per meter length of wall, up to two decimal places), before and after the occurrence of tension cracks is_____

[Ans. *] Range: 46.00 to 49.00

Before the Tension Crack:

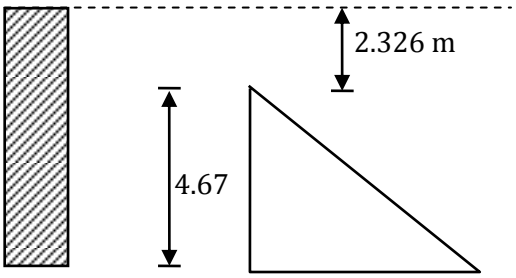


Lateral active force $= \frac{1}{2} \times (k_a\gamma H - 2c\sqrt{k_a} + 2c\sqrt{k_a}) \times 2.35$

$$= \frac{1}{2} \times k_a\gamma H \times 2.35$$

$$= \frac{1}{2} \times 1 \times 17.2 \times 7 \times 2.35 = 141.47 \text{ kN/m}$$

After the Tension Crack:



$$k_a\gamma H - 2C\sqrt{k_a} = 80.4$$

$$\text{Lateral active force} = \frac{1}{2} \times 80.40 \times 46.74$$
$$= 187.895 \text{ kN/m}$$
$$\text{Difference} = 46.43 \text{ kN/m}$$

41. Calculate the carbonate hardness of the following water sample

Ion	Concentration mg/L	Atomic Weight
Ca^{2+}	60	40
mg^{2+}	30	24.31
Hco_3^-	400	61

The carbonate hardness (expressed as mg/L of C_aCO_3, up to one decimal place) for the water sample is_____

[Ans. *]Range: 272 to 274

$$\text{Total hardness} = \frac{[Ca^{2+}]}{\text{Eq. wt of Ca}} \text{equation wt of } CaCO_3 + \frac{[Mg^{2t}]}{\text{Eq wt of Mg}} \times \text{Eq wt of } CaCo_3$$
$$= \frac{60}{20} \times 50 + \frac{30}{12.155} \times 50 = 273.40 \text{ mg/L}$$
$$\text{AIR} = \frac{[MCO_3^-]}{\text{Eq wt of } HCO_3^-} \times \text{ Eq wt of } CaCO_3$$
$$= \frac{400}{61} \times 50 = 327 \text{ mg/L}$$
$$\text{C. H} = (\text{TH, Alkalinity})_{\text{MIN}} = 273 \text{ mg/L}$$

42. Aircraft approaches the threshold of a runway strip at a speed of 200 Km/h. The pilot decelerates the aircraft at rate of 1.637 m/s^2 and takes 18 sec to exit runway strip. If the deceleration after exiting the runway is 1 m/s^2, then the distance(in m, up to one decimal place) of gate position from location of exit on runway is _____

[Ans. *] Range: 311.0 to 319.0

Initial speed =200 km/hr=55.5 m/s

Final speed at exit =V

$V = u + at$

$V = 55.5 - 1.697 \times 18$

$V = 25\frac{m}{s} \rightarrow$ at exit of runway

Distance travelled till stopping

$V^2 - u^2 = 2as$

$\Rightarrow V = 0$

$O^2 - 25^2 = 2 \times (-1) \times S$

$= 312.5$ m

43. The following details refer to a closed traverse:

Line	Consecutive coordinate			
	North	South	East	West
PQ	-	437	173	-
QR	101	-	558	-
RS	419	-	-	96
SP	-	83	-	634

The length and direction (whole circle bearing) of closure, respectively are

(A) 1 m and 90° (B) 2 m and 90°

(C) 1 m and 270° (D) 2 m and 270°

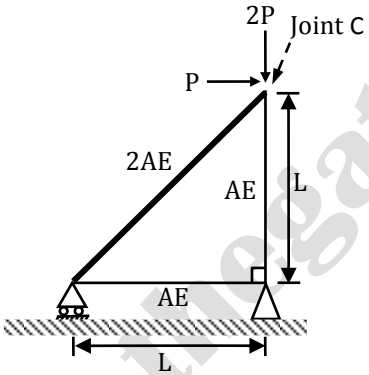
[Ans. A*]

$\sum L = 101 + 419 - 437 - 83 = 0$

$\sum D = 174 + 558 - 96 - 634 = 1$

Therefore departure of lcosure is 1m and WCB is 90°

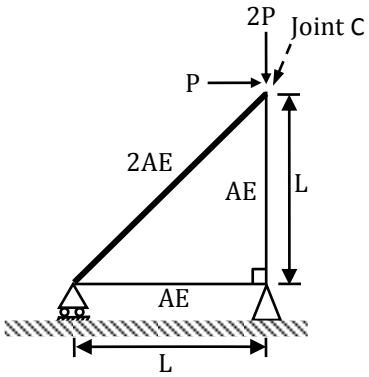
44. Consider the deformable pin-jointed truss with loading, geometry and section properties as shown in the figure.



Given that $E = 2 \times \frac{10^{11}N}{m^2}$, $A = 10$ mm^2, $L = 1$ m and $P = 1$ kN. The horizontal displacement of Joint C (in mm, up to one decimal place) is_____

[Ans. *] Range: 2.60 to 2.80

When load is given like this, (in above figure), find the force in each member due member due to real force.

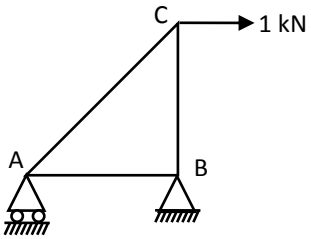


$\because F_{AB} = P$ (C)

$F_{BC} = 3P$ (C)

$F_{AC} = \sqrt{2}P$ (T)

Now, apply an imaginary unit load at C in the horizontal direction.



$F_{AB} = 1$ kN (C)

$F_{BC} = 1$ kN (C)

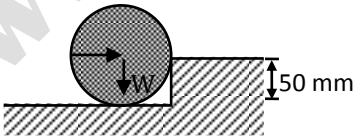
$F_{AC} = \sqrt{2}$ kN (T)

Member	Real load (P)	p	L	AE	$\frac{P.b.L}{AE}$
AB	$-P$	-1	L	AE	PL/AE
BC	$-3P$	-1	L	AE	3PL/AE
CA	$\sqrt{2}P$	$\sqrt{2}$	$\sqrt{2}$L	2AE	$2\sqrt{2}$PL/AE

$$\sum = \frac{5.414\ PL}{AE}$$

$$\partial_c = \frac{5.414 \times 1000 \times 1000}{10 \times 2 \times 10^5} = 2.7 \text{ mm}$$

45. A cylinder of radius 250 mm and weight, W=10 kN is rolled up an obstacle of height 50 mm by applying a horizontal force P at its centre as shown in the figure.



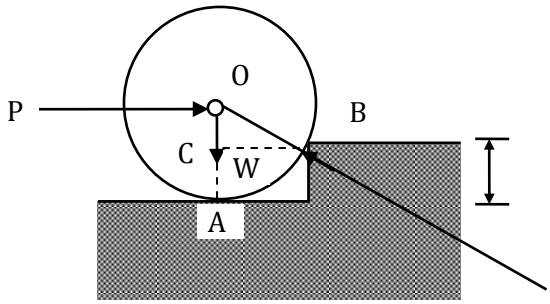
All interfaces are assumed frictionless. The minimum value of P is

(A) 405 kN (B) 5.0 kN

(C) 6.0 kN (D) 7.5 kN

[Ans. D*]

$\sum \overrightarrow{M_B} = 0$



$P \times OC - W \times BC = 0$

In ΔOCB

$OC^2 + CB^2 = OB^2$

$CB = \sqrt{250^2 - 200^2} = 150$

$$P = \frac{10 \times 10^3 \times 150}{200} = 2.5 \times 3 \text{ kN} = 7.5 \text{ kN}$$

46. Variation of water depth (y) in gradually varied channel flow is given by first order differential equation

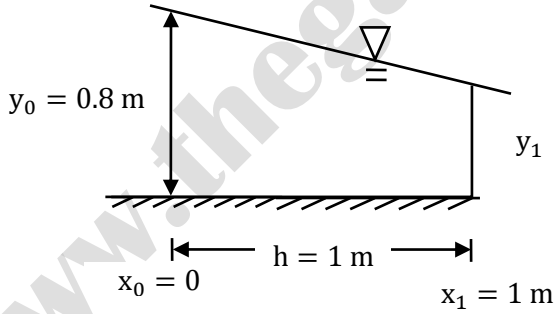
$$\frac{dy}{dx} = \frac{1 - e^{\frac{10}{3}\ln(y)}}{250 - 45\, e^{-3\ln(y)}}$$

Given initial conditions, y(x=0), 0.8 m. The depth (in m, up to three decimal places) of flow at downstream section at x=1m from one calculation step of single step Euler method is

_____

[Ans.*] Range: 0.78 to 0.80

$$\frac{dy}{dx} = \frac{1 - e^{\frac{10}{3}\ln(y)}}{250 - 45\, e^{-3\ln(y)}}$$



$y_1 = y_0 + hf(x_0, y_0)$

$$y_1 = 0.8 + 1\left[\frac{1 - e^{\frac{10}{3}\ln 0.8}}{250 - 45\, e^{-3\ln 0.8}}\right]$$

$$= 0. + 1\left[\frac{-1.1.39}{162.109}\right]8$$

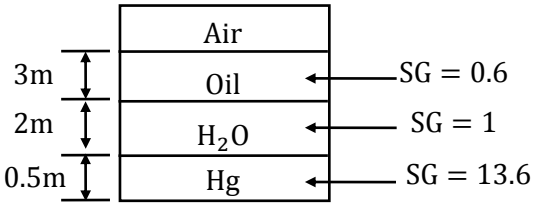
$= 0.793$ m

47. A closed tank contains 0.5 m thick layer of mercury (Special gravity=13.6) at the bottom. A 20 m thick layer of water lies above the mercury layer. A 3.0 m thick layer of oil (Special gravity=0.6) lies above the water layer. The space above the oil layer contains air under pressure. The gauge pressure at the bottom of tank is 196.2 kN/m^2 . The density of water is 1000 $kg.m^3$ and the acceleration due to gravity is 9.81 m/s^2.The value of pressure in the air space is

(A) 92.214 N/m^2 (B) 95.644 N/m^2

(C) 98.922 N/m^2 (D) 99.321 N/m^2

[Ans. A*]



P_{air} is in gauge pressure

$P_{air}$is in gauge pressure

$P_{air} + (0.6 \times 10^3)(9.81)(3) + (10^3)(9.81)(3) + (10^3)(9.81)(0.5) = 196.2 \times 10^3$

$P_{air} = 92.214\ kN/m^2$

48. The solution at x=1, t=1 of the partial differential equation , $\frac{\partial^2 u}{\partial x^2} = 25\frac{\partial^2 u}{dt^2}$ subjected to initial condition of u(0) =3x, $\frac{\partial u}{\partial t}(0) = 3$ is _____

(A) 1 (B) 2

(C) 4 (D) 6

[Ans. D*]

$$\frac{c^2\,\partial^2 u}{\partial x^2} = \frac{\partial^2 u}{\partial t^2}$$

$u(x,0) = f(x)$

$u_t(x,0) = g(x)$

$$\frac{\partial^2 u}{\partial x^2} = 25\frac{\partial^2 u}{\partial t^2}$$

$f(x) = 3x$

$g(x) = 3$

$c^2 = \frac{1}{25}$

D'Alemberts'formula,

$$u(x,t) = \frac{1}{2}[f(x+Ct) + f(x-Ct)] + \frac{1}{2C}\int_{x-Ct}^{x+Ct} g(y)\ dy$$

$$= \frac{1}{2}[6x] + \frac{3}{2}(5)\left[x + \frac{t}{5} - x + \frac{t}{5}\right]$$

$u(x,t) = 3x + 3t$

At $x = 1, t = 1$

$u(x,t) = 6$

49. Rainfall depth over a watershed is monitored through six numbers of well distributed rain gauges. Gauged data are given below

Rain gauge Number	1	2	3	4	5	6
Rainfall depth (mm)	470	465	435	525	480	610
Area of Thiessen Polygon (10^4 m^2)	95	100	98	80	85	92

The Thiessen mean value (in mm, up to one decimal place) of the rainfall is_____

[Ans. *] Range: 478.5 to 479.5

By Thiessen Polygon method,

Mean value of rainfall is given as:

$$P_{avg} = \frac{\sum_{i=1}^{6} Pi\ Ai}{\sum_{i=1}^{6} Ai}$$

$$P_{avg} = \frac{470 \times 95 + 465 \times 100 + 435 \times 98 + 525 \times 80 + 480 \times 85 + 510 \times 92}{95 + 100 + 98 + 80 + 85 + 92}$$

$$= 479.09 \text{ mm}$$

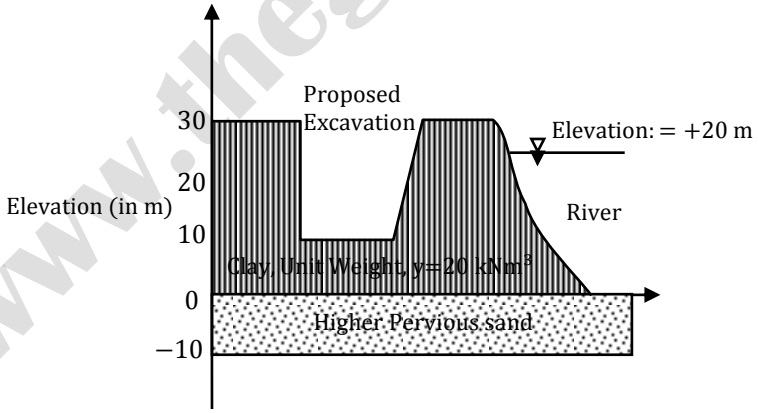
50. The void ratio of a soil 0.55 at an effective normal stress of 140 kPa. The compression index is equal to 0.25, in order to reduce the void ratio to 0.4 an increase in the magnitude of effective normal stress (in kPa, up to one decimal place) should be _____?

[Ans. *] Range: 416.0 to 420.0

$$C_C = \frac{\Delta e}{\log_{10}\left(\frac{\sigma_1}{\sigma_2}\right)};\ \ 0.25 = \frac{0.55 - 0.40}{\log_{10}\left(\frac{\sigma_2}{140}\right)}$$

$$\log_{10}(\sigma_2) - \log_{10}(140) = \frac{0.15}{0.25};\ \sigma_2 = 555.35 \text{ kPa};\ \Delta\sigma = 417.4 \text{ kPa}$$

51. At a construction site, a contractor plans to make an excavation as shown in the figure.



The water level in the adjacent river is at an elevation of +20.0 kN/m^3. The factor of sagety (up to two decimal places) against sand boiling for the proposed excavation is_____

[Ans. *] Range: 1.00 to 1.03

$$\text{Factor of safety} = \frac{h \times \gamma_{sat}}{z \times \gamma_w} = \frac{10 \times 20}{20 \times 10} = 1$$

52. A RCC beam of rectangular cross section has factored shear of 200 kN at it's critical section. Its width b is 250 mm and effective depth d is 350 mm. Assume design shear strength t_c of concrete as 0.62 N/ mm^2 and maximum allowable shear stress $t_{c,max}$ in concrete as 2.8 N/ mm^2. If two legged 10 mm dimeter vertical stirrups of Fe250 grade steel are used, then the required spacing (in cm, up to one decimal place) as per limit state method will be_____

[Ans. *] Range: 7.0 to 9.0

$V_{us} = (\tau_v - \tau_c)bd$

$= \left(\frac{200 \times 10^3}{250 \times 350} - 0.62\right) \times 250 \times 350$

$V_{us} = 145750$ N

$\because = V_{us} = \frac{0.87\, f_y A_{syd}}{S_v}$

$S_v = \frac{0.87 \times 250 \times 2 \times 78.5 \times 350}{145750}$

$S_v = 82$ mm

$S_v = 8.2$ cm

53. In a laboratory, a flow expression is performed over a hydraulic structure. Measured value of discharge and velocity are 0.05 M^3/s and 0.25 M/s, respectively. If the full scale structure (30 times bigger) is subjected to a discharge of 270 m^3/s, then time scale (model to full scale) value (up to two decimal place)is_____

[Ans. *] Range: 0.15 to 0.25*

$(Fr)_m = (Fr)_p$

$\left(\frac{V}{\sqrt{Lg}}\right)_m = \left(\frac{V}{\sqrt{Lg}}\right)_p$

$V_r = \sqrt{L_r}$

or $\frac{L_r}{T_r} = \sqrt{L_r}$

$T_r = \sqrt{L_r}$

$T_r = \sqrt{\frac{1}{30}} = 0.1826$

54. The ultimate BOD (L_0) of a wastewater smple is estimated as 87% of COD. The COD of this wastewater is 300mg/L. Considering first order BOD reaction rate constant k (use natural log)=0.23 per day and temperature coefficient θ=1.047, the BOD value (in mg/L, up to one decimal place) after three days of incubation at 27°C for this wastewater will be_____

[Ans. *] Range: 154.0 to 161.0

$L_o = 0.87$ COD $= 0.87 \times 300 = 261$ mg/L

$k = 0.23\ day^{-1}$

$k_{27} = 0.23 \times (1.047)^{T-20} = 0.23 \times (1.047)^{27-20}$

$k_{27^{\circ}C} = 0.317\ day^{-1}$
$BOD_3 = L_o\left(1 - e^{-k\times 3}\right) = 261(1 - e^{-0.317\times 3}) = 160\ mg/L$

55. A cantilever beam of length 2m with square section of side length 0.1 m is loaded vertically at free end. The vertical displacement at the free end is 5 mm. The beam is made of steel with Young's modulus of $2 \times 10^{11}\ N/m^2$ .The maximum bending stress at the fixed end of the cantilever is

(A) 20.0 MPa (B) 37.5 MPa
(C) 60 MPa (D) 75 MPa

[Ans. B]

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

$$\Rightarrow 5 \times 10^{-3} = \frac{P \times (2)^3}{3 \times (2 \times 10^{11}) \times \frac{1}{12} \times 0.1 \times (0.1)^3}$$

$P = .3125\ N = 3.125\ kN$

$\therefore$ Moment $M_{max} = 3.125 \times 2 = 6.25\ kN - m$

$$\text{Now, } \frac{M}{I} = \frac{\sigma}{y} \Rightarrow \sigma = \frac{M}{1}.y$$

$$= \frac{6.25}{Z} = \frac{6.25}{\frac{(0.1)^3}{6}}\ kN = 37.5\ N/mm^2$$

$= 37.5$ MPa