Real Test

Civil Engineering

Q1 At the end of 2019, a chemist bought 40 boxes of cough lozenges. Henceforth, every year he added y% of the boxes at the beginning of the year and sold z% of the boxes at the end of the year where y > 0 and z > 0. If the chemist had 40 boxes at the end of the year 2024, after making the sales of the year, which of the following is true?

(A) y = z
(B) y < z
(C) $y = \frac{z}{2}$
(D) y > z

Q2 What is the time when the hour hand and the minute hand of a clock coincide between 5:00 PM and 6:00 PM?

(A) $5:32\frac{8}{11}$
(B) $5:26\frac{4}{11}$
(C) $5:22\frac{8}{11}$
(D) $5:27\frac{3}{11}$

Q3 In a certain code, 'GOLDSMITH' is written as 'ISJLTCMNH'. How would 'VEGETABLE' be written in that code?

(A) FKCZUDHDW
(B) DMABSJHDU
(C) ELBATEGEV
(D) EVEGATLEB

Q4 Six friends — K, L, M, N, O, and P — are seated around a circular table. The following information is known about their seating positions:
M and N are seated directly opposite each other.
O is seated next to both N and P.
K is seated second to the right of M.
With this arrangement, who is seated directly opposite L?

(A) N
(B) P
(C) O
(D) K

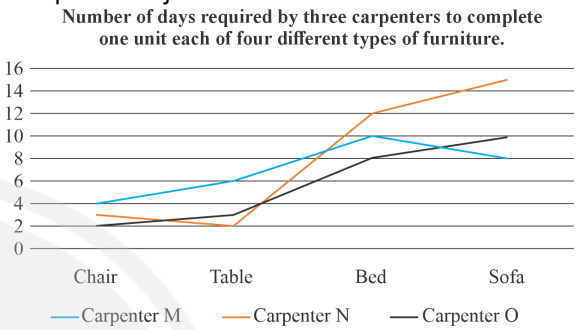
Q5 Select the correct word to complete the analogy:
Whisper : Shout :: Suggest : _____.

(A) Ignore
(B) Command
(C) Describe
(D) Propose

Q6 A hostel stocked enough food to feed 150 boys for 45 days. After 10 days, 25 boys left. How many more days will the remaining food last for the boys who are still there?

(A) 16 days
(B) 36 days
(C) 42 days
(D) 45 days

Q7 The graph shows the individual work rates of carpenters M, N, and O. If they all work together to build a table, how long will it take them to complete the job?



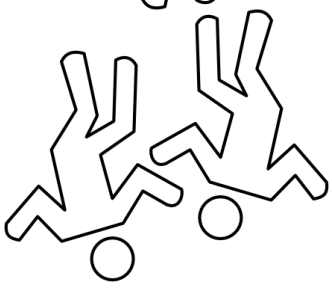
(A) 1 day
(B) 2 day
(C) 3 day
(D) 4 day

Q8 A couple had five married sons, and each of these had four children. The number of members in the family is?

(A) 40
(B) 16
(C) 25
(D) 32

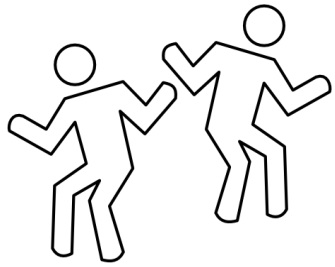
Q9 Choose the alternative that closely resembles the water reflection of the image below

(A)

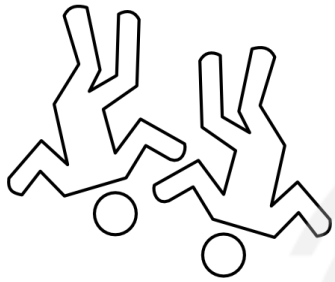


(B)

(C)



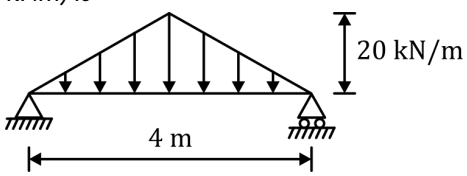
(D)



Q10 Read the passage and answer the questions:
The rapid advancement of technology has revolutionized many aspects of human life. While it brings convenience and efficiency, it also poses new challenges like data privacy concerns and increased dependency on devices.
Which of the following can be inferred from the passage?
(A) Technology has only positive effects on human life.
(B) Dependency on devices can be problematic.
(C) Data privacy is no longer an issue today.
(D) Technology advancement has slowed down in recent years.

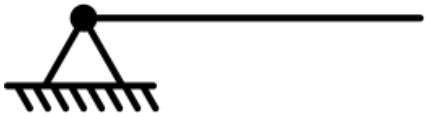
Q11 Minimum grade of concrete & maximum water cement ratio for RCC water tank will be
(A) M30 & 0.45 (B) M20 & 0.25
(C) M25 & 0.30 (D) M40 & 0.50

Q12 The maximum bending moment developed (in kNm) is



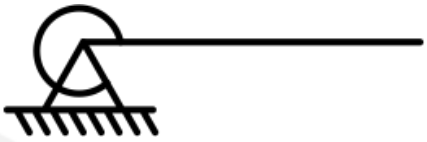
(A) 26.67 (B) 40
(C) 160 (D) 53.33

Q13 Which one is a torsion spring joint?
(A)

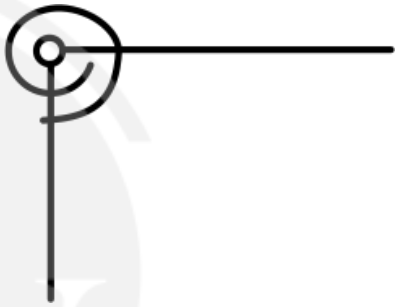


(B)

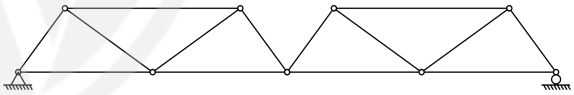
(C)



(D)



Q14 What is the additional number of members required to make this structure stable?



(A) 1
(B) 2
(C) 3
(D) None of the above

Q15 Addition of air-entraining agents to concrete increases all of the following except
(A) workability
(B) strength of concrete
(C) durability
(D) resistance to freezing & thawing

Q16 The fineness modulus
(A) is a numerical index of fineness.
(B) gives some idea of the mean size of particles present in the entire body of aggregate.
(C) is a sum of cumulative percentages retained on the set of sepecified sieves divided by

100.

(D) is regarded as weighted average size of sieve on which material is retained.

Q17 A shaft of diameter 25 mm and length 0.5 m fits inside a bearing of diameter 25.5 mm. The annular gap is filled with oil of viscosity 100 poise. The shaft is pulled out of the bearing at a constant speed of 3 m/s. Assuming the velocity profile in the oil is linear, the power required is closest to:

(A) 1.41 kW (B) 14.14 kW

(C) 141.4 kW (D) 0.141 kW

Q18 The areal extent of an unconfined aquifer is 200 ha, porosity 40% and specific retention is 0.15. During a drought the water table drops by 450 cm. The volume of water lost would be _____ Million m^3 (upto 2 decimal places).

Q19 Let $f(x) = x^3 - 3x + 1$. Let c be a point in the open interval (0,2) that satisfies the mean value theorem for f on the interval [0,2].

Which of the following statement is correct?

(A) $f'(c) = \frac{f(2)-f(0)}{2-0}$ and $c = 1$

(B) There exists exactly one $c \in (0, 2)$ such that $f'(c) = \frac{f(2)-f(0)}{2-0}$.

(C) The mean value theorem does not apply because f'(x) is not constant on (0,2).

(D) There are two distinct value of $c \in (0, 2)$ that satisfy the mean value theorem for this function.

Q20 Consider the periodic function $f(x) = |x|^2$ defined on the internal $-\pi \le x \le \pi$. The Fourier series representation of f(x) is given by:

$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos(nx)dx$ Where the Fourier coefficients are given by

$a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} |x|^2 dx$ and

$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} |x|^2 \cos(nx)dx$

The value of the first non-zero cosine coefficient a_2 is___(Enter in integer)

Q21 Let A be a 5 × 5 matrix with rank 3 and trace 10. If $\lambda = 0$ is an eigen value with algebraic multiplicity 2, what is the sum of the other three eigen values _____?

Q22 For a CBR% of 8% for 5 mm Penetration, load stress (in kg/cm^2) is

(A) 164.4 (B) 5.6

(C) 8.4 (D) 109.6

Q23 For a horizontal curve of radius 50m on a gradient of 1 in 16, find the compensated gradient.

(A) 1 in 21 (B) 1 in 25

(C) 1 in 27 (D) 1 in 16

Q24 Which of the following statement about using welded connection is/are correct?

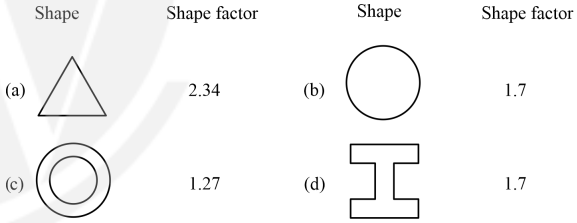
(A) Welded joints are better for impact and vibration as compared to bolted joints

(B) Welding leads to rapid construction and saves time in the project.

(C) Welding leads to rigid connection of the joints.

(D) Welding does not need skilled manpower and specialized equipments.

Q25 Which of the following is incorrectly matched?



(A) a (B) b

(C) c (D) d

Q26 During a daily routine observation 8.4 litres of water was added to bring the water surface in evaporation pan to a stipulated level & the yearly raingauge measured 0.36 cm of rainfall. The pan evaporation recorded for the day if the diameter of the pan is 1.2 m, would be ____ mm.

(A) 7.79 (B) 3.83

(C) 11.03 (D) 7.07

Q27 Which of the following statements are incorrect?

(1) Silt extractors are provided in the upstream side of the river adjacent to head regulator.

(2) Syphon Aqueduct is provided to carry canal over a natural drain when the canal bed is below

the HFL of the drain.
(3) Semi Modular outlet is also known as Rigid Module.
(4) Non Modular outlet is also known as Flexible Module.
(A) 1 & 2 only
(B) 2, 3 & 4 only
(C) 1, 3 & 4 only
(D) 3 & 4 only

Q28 Following data is with respect to Laecy's silt theory:
(i) Discharge = 20 m^3/s
(ii) Silt factor = 1.0
(iii) Side slopes = 0.5 H : 1 V
The bed width of the channel would be about _____ m.
(upto one decimal place)

Q29 The length, width and height of an embankment were measured with a 30 m chain and the volume of embankment was calculated to be 524.6 cu.m. Later it was found that the chain used to measure the dimension of the embankment was 12 cm too short. The true volume of the embankment is given by

Q30 Diurnal variation of magnetic declination at a place will depends upon:
(A) geographical position of the place
(B) the time of the day
(C) Season of the year
(D) the year of the cycle of secular variation

Q31 The population of Indore in the year 2017 was recorded as 95450. If the average percent increase in the population per decade is 28%, The population of Indore in the year 2037 estimated using Geometrical increase method will be:
(A) 122176 (B) 156386
(C) 116432 (D) 134789

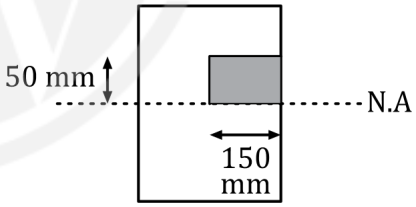
Q32 A soil sample has the following properties:
Dry density of soil (γ_d) = 20 kN/m^3
Porosity (n) = 30%
Find the value of water content when the sample is 60 percent saturated.
(A) 0.48 (B) 0.64
(C) 0.09 (D) 0.76

Q33 A point load of magnitude 400 kN is applied at a point A on the ground surface. The coordinates of point A are (4m, 7m, 0). Determine the vertical stress ___(in kN/m^2) at point B (4m, 7m, –8m)
(Use Boussinesq's equation and report your answer in the nearest integer)

Q34 A plate load test is conducted on a cohesionless soil using a plate of size 0.6 m × 0.6 m. The settlement of the plate is 25 mm. What will be the settlement of footing square shape having 3 m size on the same soil at same load intensity.
(A) 125 mm (B) 33.33 mm
(C) 46.5 mm (D) 14.8 mm

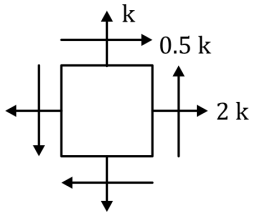
Q35 Liquid limit and plastic limit of a soil sample are 26% and 21%, respectively. Then classify the soil as per the ISSC system.
(A) CL (B) ML
(C) CL – ML (D) OL

Q36 For a rectangular section of width, 200 mm, and depth 300 mm subjected to bending moment of 60 kNm, find the force (in kN) carried by shaded part



(A) 50 kN (B) 6.67 kN
(C) 25 kN (D) 40 kN

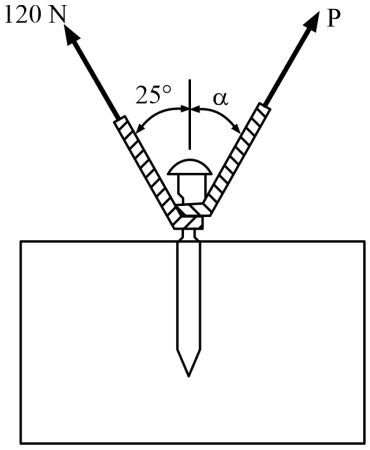
Q37 For plane stress condition shown, find value of k if resultant stress on plane of maximum shear is 99.5 MPa.



(A) 60 MPa (B) 80 MPa
(C) 40 MPa (D) 50 MPa

Q38

A stake is being pulled out of the ground by means of two ropes as shown below. Knowing that $\alpha = 30°$, determine the magnitude of the force P (in Newton, upto the one decimal place) so that the resultant force exerted on the stake is vertical.

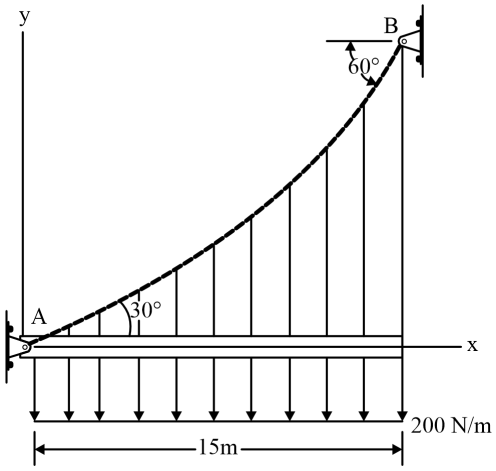


Q39 The doubly reinforced beam having effective depth 600 mm, width 350 mm and effective cover 60 mm is provided with 6-25 mm ϕ bar at bottom and 4-20 mm ϕ bar at top. Beam will come into category of?
(Fe415 steel & M20 concrete)
(A) Under reinforced
(B) Over reinforced
(C) Balanced
(D) None

Q40 A slab having total depth of 300 mm IS provided with 0.25% of main reinforcement using 10 mm diameter steel bars. The uniform centre to centre spacing (in mm) will be _____(round to nearest integer)

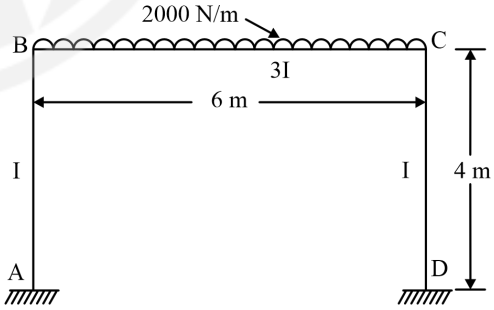
Q41 The cable AB is subjected to a uniform loading of 200 N/m. If the weight of the cable is neglected and the slope angles at points A and B are 30° and 60°, respectively, determine the maximum tension developed in the cable. Use the given equation

$$y = \frac{1}{F_H}\left(100x^2 + C_1x + C_2\right)$$



Where ,
y = dip at different distance x , F_H = Horizontal support reaction
C_1 & C_2 are constant
Which of the following is the correct maximum tension T_{max} developed in the cable?
(A) 3.50 kN (B) 4.50 kN
(C) 5.20 kN (D) 6.50 kN

Q42 Given the portal frame ABCD with ends 'A' and 'D' fixed, and a uniformly distributed load of 2000 N/m over segment BC, analyze the frame using the slope deflection method as shown. The fixed-end moments for segment BC due to given loading are M_{BC} = –6000 Nm and M_{CB} =+6000 Nm. Which of the following is the correct rotation θ_B at joint B?

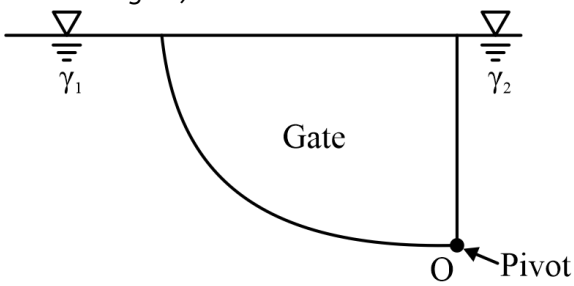


(A) $\frac{2000}{EI}$ (B) $\frac{3000}{EI}$
(C) $\frac{1000}{EI}$ (D) $\frac{5000}{EI}$

Q43 Direct cost for a construction is estimated by the contractor as Rs 50 Lakh and for the same project indirect cost was estimated to be Rs.10 Lakh. If markup price is to 10% of total cost, then quoted price (in Lakhs) for the contractor is _____. (Round off to the nearest integer.)

Q44

A two dimensional gate having cross-section of a quarter cylinder is pivoted at the bottom O and is in static equilibrium when subjected to different fluids of specific weight γ_1 and γ_2 (as shown in figure).



Assume the gate to be weightless. The ratio of γ_1 and γ_2 is _____.

Q45 An equilateral triangular Plate of side 'a' is submerged inside water with one of the vertices at free surface. The force acting on the plate upto its centroid from the free surface is:
ϱ = density of water
(A) $(2/27)\varrho ga^3$ (B) $(4/27)\varrho ga^3$
(C) $(1/27)\varrho ga^3$ (D) $(2/27)\varrho ga^4$

Q46 For the information given for peak hour at a point on road, find 10-min peak hour factor.

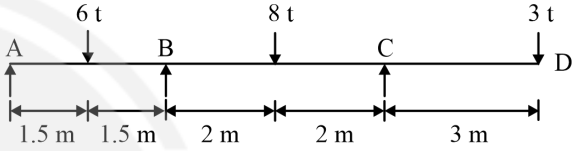
Time	Vehicle Count
6:00-6:05	5
6:05-6:10	8
6:10-6:15	3
6:15-6:20	7
6:20-6:25	4
6:25-6:30	9
6:30-6:35	2
6:35-6:40	5
6:40-6:45	4
6:45-6:50	8
6:50-6:55	6
6:55-7:00	7

(A) 0.872 (B) 0.809
(C) 0.944 (D) 0.921

Q47 Relationship between Speed and density $V = 90 - 0.9K$.
Find the time headway when density is 40 veh/km.
(A) 1.65 s (B) 2.15 s
(C) 1.85 s (D) 1.35 s

Q48 For a two lane dual carriageway highway to be constructed in 8 months, traffic in both directions on survey day is 3600 cvpd. If vehicle damage factor was estimated to be 2.75, rate of annual growth 7.5% and design life 15 years, find design traffic (in msa)
[Round to next multiple of 5]

Q49 A simply supported beam of steel carries the load as shown in figure below. Find the value of required plastic moment capacity (Mp) (in t-m) of the beam if it is known that the beam fails in one of the independent beam mechanism. (Round off the answer to two decimal places).



Q50 A rectangular channel is 3 m wide and carries a flow of 2.7 m^3/s at a depth of 0.9 m. A contraction of the channel width is proposed at a certain section. The smallest allowable contracted width that will not affect the upstream flow conditions is _____ m.

Q51 A rectangular channel of width 15.0 m carries uniform flow at a normal depth of 0.6 m. The channel slope is 0.005 and Manning's roughness coefficient is 0.014
(A) The discharge per unit width is approximately 0.45 m^3/s per meter width
(B) The critical depth is approximately 0.7535 m
(C) The critical slope corresponding to critical depth is approximately 0.0024
(D) The depth alternate to 0.6 m is approximately 0.963 m

Q52 A six-hour storm with successive two-hour rainfalls of 30mm, 40mm and 30mm occurred over an area of 450 ha. Infiltration during this storm is represented by Horton's exponential model $f(t) = 5 + 27.183e^{-0.5t}$, where f(t) is in mm/hour, and t in hours. Assuming all other losses to be negligible other than infiltration, the

resulting runoff from this storm would be ____ ha-m (upto one decimal place).

Q53 Following are the tacheometric survey observations:

Instrument at P	Staff at	Distance	Vertical Angle	Cross hair Readings
	A	80	2°30'	1.325, 2.122
	B	140	1°36'	0.985, 2.382

The tacheometric constants (K, C) for the above observations are:

(A) 100, 0.3 (B) 100, 0.4

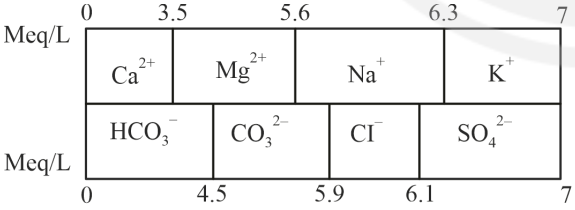
(C) 99.67, 0.76 (D) 100, 0.26

Q54 A neighborhood covering approximately 40 hectares includes 400 individual houses and 8 hectares of apartment complexes accommodating 400 residents. If each house has an average of 5 residents and the daily waste generation rate is 1.0 kg per person, estimate the number of trips required per collection day (assuming waste is collected twice a week) by a compactor truck with a capacity of 4.5 tonnes.

(A) 1 trip (B) 2 trip

(C) 3 trip (D) 4 trip

Q55 For a sample of water with the ionic composition shown below. The Carbonate and Non-Carbonate hardness concentration (in mg/L) as $CaCO_3$ respectively are



(A) 285 & 10 (B) 10 & 280

(C) 280 & 0 (D) 0 & 280

Q56 In the assessment of water quality, which of the following statements correctly describe the Most Probable Number (MPN) method for a water sample?

(A) The microorganisms estimated are gram-negative in nature

(B) The method is based on the assumption of a Poisson distribution

(C) It provides the exact count of microorganisms in the sample

(D) It involves the estimation of pathogenic viruses.

Q57 A water treatment plant is designed to treat 100 MLD of water. A pilot study has shown that a filtration rate of 12 $m^3/m^2/hr$ is suitable for the treatment process. Each filter unit has dimensions of 6m × 10m. One filter unit is to be kept out of service for backwashing. If the backwashing is done at 40 $m^3/m^2/hr$ for 25 minutes, and the water is washed for the first 5 min of each filter run. the net production in MLD of each filter unit is_____

Q58 Let the vector field $\vec{F}$ (x,y,z) = (yz,xz,xy), consider the surface S which is the part of the plane x + y + z =1 in first octant and let $\vec{n}$ be the unit normal vector pointing away from the origin. Which of the following statement is/are correct?

(A) The surface integral $\iint_S \vec{F} \cdot \vec{n}\, ds$ gives the total flux through the tetrahedron formed by x = 0, y = 0, z = 0 and x + y + z =1

(B) The divergence if $\vec{F}$ is constant and is zero.

(C) The flux of $\vec{F}$ through S is necessarily zero as divergence of F is zero.

(D) The surface integral of $\vec{F}$ over the entire closed boundary S_{total} (all four faces of tetrahedron) equal the volume integral $\iiint_v \left(\nabla \cdot \vec{F}\right) dv$ where v is tetrahedron bounded by x = 0, y = 0, z = 0 and x + y + z = 1.

Q59 Let $\vec{F}$ (x,y,z)=(z^2,x^2,y^2) and let c be the boundary of the triangle cut from the plane x + y + z =1 in the first octant, oriented counterclockwise when viewed from above. Which of the following options is/are correct.

(A) The circulation $\oint_c \vec{F} \cdot \vec{d}r = 0$

(B) The curl of $\vec{F}$ is (2y, 2z, 2x).

(C)

By stokes theorem of $\oint_c \vec{F} \cdot \vec{d}\, r = \iint_s \left(\vec{\nabla} \times \vec{F}\right) ds$, Where s is the triangular plane x + y + z =1

(D) The surface integral $\iint_s \left(\vec{\nabla} \times \vec{F}\right) ds$ equal the volume of tetrahedron bounded by S and the coordinate planes.

Q60 The Laplace transform of the function: $f(t) = 3\,\delta(t-2) + 4\,e^{-4t}\cos 3t$ is:

(A) $3e^{-2s} + \frac{4(s+4)}{(s+4)^2+9}$

(B) $3e^{2s} + \frac{s-4}{(s-4)^2+9}$

(C) $3e^{-2s} + \frac{s-4}{(s+4)^2+9}$

(D) $3e^{2s} + \frac{s+4}{(s-4)^2+9}$

Q61 Consider the following initial value problem: $\frac{d^2y}{dt^2} + 4y = 3\sin t,\ y(0) = 1,\ y'(0) = 0$

Solve the differential equation using Laplace transform and find $y(\pi)$?

Q62 Let A be a singular 3×3 matrix with eigen vectors $\begin{bmatrix}1\\0\\1\end{bmatrix}$ and $\begin{bmatrix}0\\1\\1\end{bmatrix}$ for $\lambda = 1$ and $\lambda = -1$, respectively. If $b = \begin{bmatrix}2\\1\\3\end{bmatrix}$, the system $Ax = b$:

(A) Has a unique solution

(B) Has infinitely many solutions

(C) Is inconsistent

(D) Depends on third eigen vector

Q63 A soil specimen of thickness 8 m has water table 1m below the ground surface. The soil above water table is saturated due to capillarity. If the water table is lowered by drainage to a depth of 2 m. The change in effective stress at a point (A) at the depth of 3 m will be_____. Assume that soil above w.t. always remains saturated due to capillary action (take G_s = 2.65, e = 0.70)

(A) 19.62 kN/m^2

(B) 18.7 kN/m^2

(C) 9.20 kN/m^2

(D) 9.81 kN/m^2

Q64 Stability analysis by the method of slices for 1:1 slope gave the following results:

Sum of tangential forces = 190 kN/m

Sum of normal forces = 400 kN/m

Sum of Neutral forces = 80 kN/m

Length of failure surface = 20 m

Effective cohesion = 16 kN/m^2

Effective angle of internal friction = 20

The factor of safety with respect to the shear strength is-

(A) 3.2 (B) 2.3

(C) 2.9 (D) 3.6

Q65 A rectangular footing 1.5 m × 2.5 m carries a column load of 400 kN at ground level. The ground strata is made up of cohesionless soil having poison's ratio of 0.3 and young's modulus of 16 MN/m^2. The immediate elastic settlement of footing (in mm, rounded off to 2 decimal place) is_____.

The strata is 8 m thick and influence factor = 0.78.

Answer Key

Q1 (D)
Q2 (D)
Q3 (A)
Q4 (C)
Q5 (B)
Q6 (C)
Q7 (A)
Q8 (D)
Q9 (D)
Q10 (B)
Q11 (A)
Q12 (A)
Q13 (D)
Q14 (A)
Q15 (B)
Q16 (A, B, C, D)
Q17 (B)
Q18 2.2~2.3
Q19 (B)
Q20 1~1
Q21 10~10
Q22 (C)
Q23 (A)
Q24 (A, B, C)
Q25 (D)
Q26 (C)
Q27 (C)
Q28 17~19
Q29 517~520
Q30 (A, B, C, D)
Q31 (B)
Q32 (C)
Q33 3~3
Q34 (C)
Q35 (C)
Q36 (C)
Q37 (A)
Q38 101~102
Q39 (A)
Q40 105~105
Q41 (C)
Q42 (B)
Q43 66~66
Q44 0.31~0.34
Q45 (A)
Q46 (B)
Q47 (A)
Q48 40~40
Q49 8.5~9.5
Q50 1.68~1.72
Q51 (B, C, D)
Q52 14.5~15
Q53 (B)
Q54 (B)
Q55 (C)
Q56 (A, B)
Q57 14.5~17.3
Q58 (B, D)
Q59 (B, C)
Q60 (A)
Q61 1~1
Q62 (B)
Q63 (D)
Q64 (B)

Q65 7.08~7.12

Hints & Solutions

Q1 Text Solution:

For net zero change after first y% ↑ and then z% ↓, Only possible for y > z

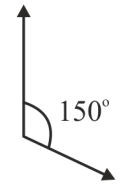
For ex.

Let Initial value = 100 after 25 % increase, new value = 125

Then after 20% decrease, final value = 125×.80 = 100

Q2 Text Solution:

5 PM



Time taken by the minute hand to coincide with the hour hand

$= \frac{\text{Angle to be covered by minute hand}}{\text{relative speed of minute hand}}$

$= \frac{150}{5.5} = \frac{300}{11} = 27\frac{3}{11}$ minutes

Time at the minute and hour hands coincide

$= 5\text{pm} + 27\frac{3}{11}$ minutes$= 5 : 27\frac{3}{11}\ pm$

Q3 Text Solution:

Given:

GOLDSMITH → ISJLTCMNH

Pattern is

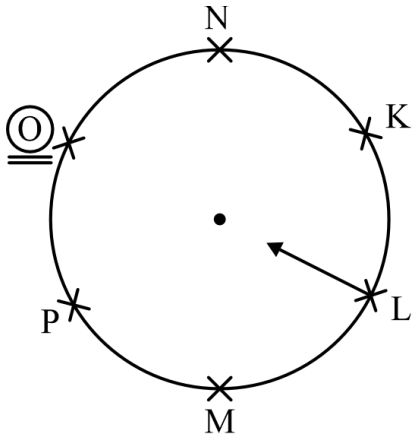
$\text{GOLDSMITH} \xrightarrow{\text{reverse}} \text{HTIMSDLOG} \xrightarrow{+1,-1,\ldots}$

ISJLTCMNH

$\text{VEGETABLE} \xrightarrow{\text{reverse}} \text{ELBATEGEV} \xrightarrow{+1,-1,\ldots}$

FKCZUDHDW

Q4 Text Solution:



Q5 Text Solution:

The analogy follows a scale of intensity or forcefulness:

- Whisper (soft/spoken quietly) is to Shout (loud/spoken forcefully)
- Similarly, Suggest (offer an idea gently) is to Command (order authoritatively

Q6 Text Solution:

Initially

Boys	Days
150	45

After 10 days

150	35
(150-25) 125	?

days = $35 \times \frac{150}{125}$= 42 days

Q7 Text Solution:

Carpenter 'M' 1 day's work to build a table$= \frac{1}{6}$

Carpenter 'N' 1 day's work to build a table $= \frac{1}{2}$

Carpenter 'O' 1 day's work to build a table $= \frac{1}{3}$

All working together, i.e., M&N&,O 1 day's work to build a table

$= \frac{1}{6} + \frac{1}{2} + \frac{1}{3}$

$= \frac{1+3+2}{6} = \frac{6}{6} = 1$

Time taken by working together to complete the job = 1 day

Q8 Text Solution:

Coupe → 2

Sons → 5

Son's wives → 5

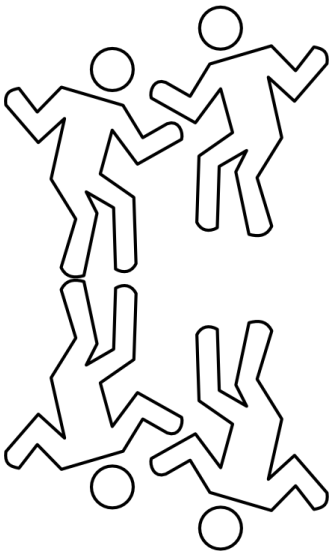
Children → 5 × 4 = 20

Total family members = 32

Q9 Text Solution:

In water reflection

- The **top becomes the bottom**, and vice versa.
- The **left-right orientation stays the same**.
- The **limbs** that were raised will now appear **lower**, and those that were lower will appear **raised** in the reflection.



Q10 Text Solution:
The passage explicitly states that technology **"poses new challenges like data privacy concerns and increased dependency on devices."** This directly supports the inference that dependency on devices can be problematic.

Q11 Text Solution:
Minimum grade of concrete & maximum water cement ratio for RCC water tank will be M30 & 0.45

Q12 Text Solution:
$M_{max} = \frac{\omega L^2}{12}$
$\omega = 20KN/m$
l = 4 m
$M_{max} = \frac{20 \times 4^2}{12}$
$M_{max} = 26.67KNm$

Q13 Text Solution:
Figure in option D represents torsion spring joint.

Q14 Text Solution:
Total no. of joints j = 9
Minimum no. of member required to make this truss internally stable
$m_{req} = 2j - 3 = 2 \times 9 - 3 = 15$
$m_{provided} = 14$
Additional no. of member required = $m_{required} - m_{provided}$
= 15 - 14 = 1

Q15 Text Solution:
→ Air- entraining admixtures result in improved properties of plastic concrete like workability, easier placing and finishing, increased durability, better resistance to frost action and reduction in bleeding and seggregation. The capillaries are also interrupted by relatively large non-interconnecting air voids in air-entrained concrete.
→ Air-entrainment, while improving durability and plasticity, may have an adverse effect on the amount of entrained air. The decrease in strength is usually proportional to the around of entrained air.

Q16 Text Solution:
The fineness modulus is a numerical index of fineness, giving some idea of the mean size of the particles present in the entire body of the aggregate. The determination of the fineness modulus consists in dividing a sample of aggregate into fractions of different sizes by sieving through a set of standard test sieves. Each fraction contains particles between definite limits. The limits being the opening sizes of standard test sieves. The material retained on each sieve after sieving represents the fraction of aggregate coarser than the sieve in question but finer than the sieve above. The sum of the cumulative percentages retained on the sieves divided by 100 give the fineness modulus. The sieves that are to be used for the sieve analysis of the aggregate (coarse, fine or all-in-aggregate) for concrete as per IS: 2386 (Part-I)-1963, are 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm and 150 µm.
The fineness modulus can be regarded as a weighted average size of a sieve on which material is retained, and the sieves being counted from the finest. For example, a fineness modulus of 6.0 can be interpreted to mean that the sixth sieve, i.e., 4.75 mm is the average size. The value of fineness modulus is higher for coarser aggregate. **For the aggregates commonly used, the fineness modulus of fine aggregate varies between 2.0 and 3.5, for coarse aggregate it varies between 5.5 and 8.0, and from 3.5 to 6.5 for all-in-aggregate.**
The object of finding fineness modulus is to grade the given aggregate for the most

economical mix for the required strength and workability with minimum quantity of cement. If the test aggregate gives higher fineness modulus, the mix will be harsh and if, on the other hand, gives a lower fineness modulus it will produce an uneconomical mix. For workability, a coarser aggregate requires less water-cement ratio. The fineness modulus is also important for measuring the slight variations in the aggregate from the same source.

Q17 Text Solution:

$y = \frac{25.5-25}{2} = 0.25\ m,$

μ = 100 poise = 10 N-s/m^2.

Power = F × V

$$Power = \frac{\mu VA}{y} \times V$$

$$Power = \frac{10\times3\times\pi\times25\times10^{-3}\times0.5\times3}{0.25\times10^{-3}}$$

Power = 14.137 kW

Q18 Text Solution:

$S_y + S_r = n$

$S_y = 0.25$

$$S_y = \frac{V_{wy}}{A \times Z}$$

$$0.25 = \frac{V_{wy}}{200 \times 4.5 \times 10^4}$$

$V_{wy} = 2.25 \times 10^6\ m^3$

$V_{wy} = 2.25\ Mm^3$.

Q19 Text Solution:

we have to apply the MVT which state that if 'f' is continuous on [a,b] and differentiable on (a,b) then there exists at least one cÎ (a, b) such that.

$f'(c) = \frac{f(b)-f(a)}{b-a}$.

here,

- f(x) =x^3 – 3x +1
- a = 0 , b = 2
- f is a polynomial → continuous & differentiable every where.

So MVT applies:

f(0) =1 , f(2) = 8 – 6 + 1 = 3

$\Rightarrow \frac{f(2)-f(0)}{2-0} = \frac{3-1}{2} = 1$

Now compute f'(x) = 3x^2 – 3

put f'(x) =1

$3x^2 - 3 = 1 \Rightarrow 3x^2 = 4 \Rightarrow x^2 = \frac{4}{3} \Rightarrow x = \pm\frac{2}{\sqrt{3}}$

only one +ve root $x = \frac{2}{\sqrt{3}} \approx 1.1547 \in (0, 2)$

So, exactly one value cÎ (0,2) satisfiy MVT.

option 'B' is correct.

Q20 Text Solution:

Given: f(x) = |x|^2

$a_2 = \frac{1}{\pi}\int_{-\pi}^{\pi}|x|^2 \cos 2x.\, dx$

∵ |x| and cos2x both are even function so their product will also be even function.

$\Rightarrow a_2 = \frac{2}{\pi}\int_0^{\pi} x^2 \cos 2x dx$

$\{|x| = x \text{ for } x > 0\}$

$= \frac{2}{\pi}\left[x^2 \frac{\sin 2x}{2} - \int 2x.\frac{\sin 2x}{2}dx\right]_0^{\pi}$

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

$\left[\frac{x^2 \sin 2x}{2} - \left[x.\frac{(-\cos 2x)}{2} - \int \frac{(-\cos 2x)}{2}dx\right]\right]_0^{\pi}$

$= \frac{2}{\pi}\left[\frac{x^2 \sin 2x}{2} + \frac{x\cos 2x}{2} - \frac{\sin 2x}{4}\right]_0^{\pi}$

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

$\left[\left(\frac{\pi^2 \sin 2\pi}{2} + \frac{\pi\cos 2\pi}{2} - \frac{\sin 2\pi}{4}\right) - \left(0 + 0 - 0\right)\right]$

$= \frac{2}{\pi}\left[0 + \frac{\pi}{2} \times 1 - 0\right] = \frac{2}{\pi} \times \frac{\pi}{2} = 1$

Q21 Text Solution:

As we know, sum of all eigen values is equal to trace of matrix.

Sum of eigen values = 10

Given that the two eigen values are 0.

So, sum of remaining three = 10 – 0 = 10

Q22 Text Solution:

CBR% (5 mm Penetration) = $\frac{\text{Stress}\times100}{105}$

Stress (in kg/cm^2) = 0.08×105

$= 8.4\ \text{kg/cm}^2$

Q23 Text Solution:

Initial Gradient = $\frac{1}{16}$ × 100 = 6.25%

Grade Compensation = $\left(\frac{30+R}{R}, \frac{75}{R}\right)\%$ min

= $(1.6, 1.5)\%$

= 1.5%

Final Gradient = 6.25 – 1.5 = 4.75%

= 1 in 21

Q24 Text Solution:

Welding needs skilled manpower and specialized equipments.

Q25 Text Solution:

Shape factor of I-section as in option (d) is incorrect. It should lie between 1.12 to 1.14

Q26 Text Solution:

$$Z = \frac{8.4\times10^{-3}}{\left(\frac{\pi\times1.2^2}{4}\right)} = 7.43\times10^{-3}\text{m} = 7.43\text{mm}$$

E_P = P + Z = 3.6 + 7.43 = 11.03 mm

Q27 Text Solution:

Modular Outlet → Rigid Module

Semi Modular Outlet → Flexible Module.

Q28 Text Solution:

$$\text{V} = \left(\frac{\text{Qf}^2}{140}\right)^{1/6} = \left(\frac{20\times1^2}{140}\right)^{1/6} = 0.723\ \text{m/s}$$

$$\text{P} = 4.75\sqrt{\text{Q}} = 4.75\sqrt{20} = 21.24\ \text{m}$$

Q = AV

20 = A × 0.723

A = 27.66 m^2

A = (B + xD) D

27.66 = (21.24 – 1.736D) D

27.66 = 21.24D – 1.736 D^2

$$1.736\text{D}^2 - 21.24\text{D} + 27.66 = 0$$

$$P = B + 2D\sqrt{1+x^2}$$

$$21.24 = B + 2D\sqrt{1+0.5^2}$$

$$B = 21.24 - 2.236D$$

$$D = y = 1.48\ m$$

$$B = 21.24 - 2.236\times1.48$$

$$B = 17.93\ m$$

Q29 Text Solution:

True volume = $\left(\frac{l'}{l}\right)^3$ × measured volume

Actual length of the chain used = 30 – 0.12 = 29.88 m

True volume =

$$\left(\frac{29.88}{30}\right)^3 \times 524.6 = 518.33\ \text{cu. m}$$

Q30 Text Solution:

Variation of Magnetic Declination

The declination at any place keeps on changing from time to time. These variations nay be classified as follows:

1. Secular variation: The magnetic meridian swings like a pendulum. It swings in one direction for about 100 - 150 years, gradually comes to rest, and then swings in other direction. This is known as secular variation. The causes of the secular variation are not well understood.

2. Annual variation: It is the change in the declination at a place over a period of 1 year. It is caused because of the rotation of earth about sun. It is found that the annual variation is about 1 - 2 min.

3. Diurnal variation: It is the change in the declination at a place in 24 hr. It is due to the rotation of earth about its own axis. The amount of variation is from a fraction of a minute to over 12 and is due to the following:

(a) geographical position of the place (lesser near equator and increases towards the poles).

(b) the time of the day (more in day).

(c) season of the year (more in summers).

(d) the year of the cycle of secular variation.

4. Irregular variation: The variation caused due to magnetic disturbances or storms are listed under irregular variation. In general, the value may be of the order of 1°.

Q31 Text Solution:

Given P_{2017} = 95450

% increase in population per decade = 28%

$P_{2037} = P_{2017}$ [1 + r (in decimal)]^N

{where N = no. of decades}

P_{2037} = 95450 $[1 + 0.28]^2$

= 156386

Q32 Text Solution:

Given, γ_d = 20 kN/m^3, n = 0.30, S = 0.60

To find water content:

$$e = \frac{n}{1-n} = \frac{3}{7}$$

We know that $wG_s = eS$ ... (i)

$$\gamma_d = \frac{G_s\gamma_w}{1+e} \Rightarrow G_s = \frac{20\times\frac{10}{7}}{9.81} = 2.91$$

Putting the value of e and G_s in equation (i)

$$\Rightarrow w = \frac{\frac{3}{7}\times0.60}{2.91} = 0.088 \approx 0.09$$

Q33 Text Solution:

Given: Load applied (Q) = 400 kN

According to Boussinesq Equation,

$$\sigma_P = \frac{3}{2\pi}\frac{Q\cos\theta}{R^2}$$

$$\because R = \sqrt{x^2+y^2+z^2}$$

$$\Rightarrow \sqrt{0^2+0^2+8^2} = 8\ \text{m}$$

$$\cos\theta = \frac{Z}{R} = \frac{8}{8} = 1$$

Hence,

$\sigma_R = \sigma_z = \frac{3Q}{2\pi z^2} = \frac{3\times400}{2\pi\times8^2} = 2.98\frac{kN}{m^2} \approx 3\frac{kN}{m^2}$

Q34 Text Solution:

B_p = 0.6 m, B_f = 3 m, S_p = 25 mm, S_f = ?

$$S_f = S_p\left[\frac{B_f}{B_p}\frac{(B_p+0.3)}{(B_f+0.3)}\right]^2 \text{ for cohesionless soil}$$

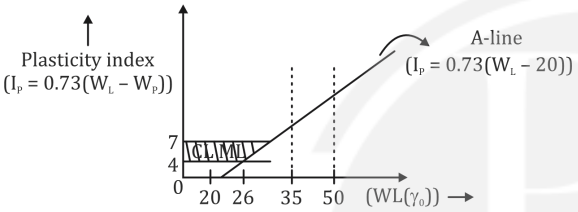
$$= 25\left[\frac{3}{0.6}\frac{(0.6+0.3)}{(3+0.3)}\right]^2 = 46.5 \text{ mm}$$

Q35 Text Solution:

Given, W_L = 26%, W_P = 21%

IP (plasticity index) = $W_L - W_P$ = 26 – 21 = 5%

For A-line, IP = 0.73 (W_L – 20) = 0.73 (26 – 20) = 4.38%

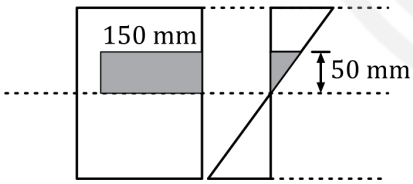


If I_P is between 4 and 7, and W_L & I_P falls closer to A-line,dual symbols are used.

Here, W_L < 35, so the soil is of low compressibility and 4 < I_P < 7

So, the soil is classified as CL – ML.

Q36 Text Solution:



Bending stress at y = 50 mm

$\sigma_b = \frac{My}{I} = \frac{60\times10^6\times50\times12}{200\times300^3} = 6.67 \text{ N/mm}^2$

$\frac{20}{3}$ N/mm^2

Force in shaded part

= Area of stress diagram × 150 mm

$= \frac{1}{2}\times\frac{20}{3}\times\frac{50\times150}{10^3}$kN

= 25 kN

Q37 Text Solution:

$\sigma_x = 2K$

$\sigma_y = K,\ \tau_{xy} = 0.5K$

Major Principal Stress

$\sigma_1 = \frac{\sigma_x+\sigma_y}{2} + \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + (\tau_{xy})^2}$

$\Rightarrow \sigma_1 = \frac{(2K+K)}{2} + \sqrt{\left(\frac{2K-K}{2}\right)^2 + (0.5K)^2}$

= 1.5K + 0.707K = 2.207K

Minor Principal Stress

$\sigma_2 = 1.5K - 0.707K = 0.793K$

Resultant stress on plane of maximum shear stress $= \frac{(\sigma_1^2+\sigma_2^2)^{1/2}}{2}$

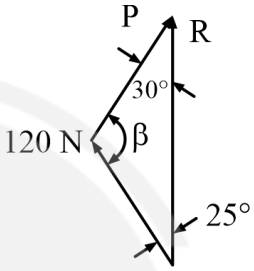
$= \left(\frac{(2.207K)^2+(0.793K)^2}{2}\right)^{1/2}$

= 1.658 K

= 1.658 K = 99.5

= K = 60 N/mm^2

Q38 Text Solution:



Using the triangle rule and the law of sines:

$\frac{120\ N}{\sin\ 30^\circ} = \frac{P}{\sin\ 25^\circ}$

P = 101.4 N

Q39 Text Solution:

X_u

$= \frac{0.87\times415\times\left(6\times\frac{\pi}{4}\times25^2\right)-(0.87\times415-0.45\times20)4\times\frac{\pi}{4}\times20^2}{0.36\times20\times350}$

= 246.42 mm

X_{ulim} = 0.48 × 600 = 288 mm

$X_u < X_{ulim}$

Q40 Text Solution:

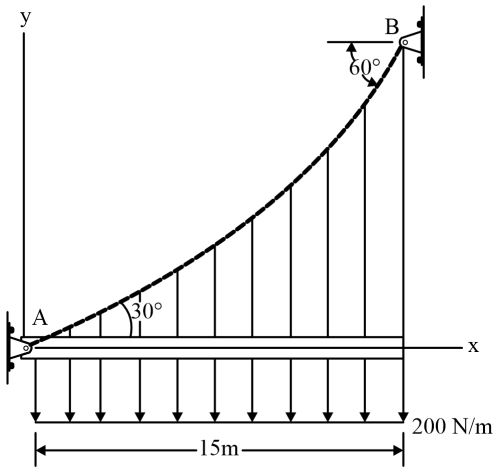
$$(Ast) = \frac{0.25}{100}Bd = \frac{0.25}{100}\times(1000)(300) =$$

=7500 mm square

$$Spacing = \frac{1000}{Ast}\times\frac{\pi}{4}\times\phi^2 = 1000\times\frac{\pi}{4}\times10^2$$

=105 mm

Q41 Text Solution:



At x = 0, y = 0, using given equation

$$y = \frac{1}{F_H}\left(100x^2 + C_1x + C_2\right)$$

$$0 = \frac{1}{F_H}\left(0 + 0 + C_2\right) \Rightarrow C_2 = 0$$

At x = 0, $\frac{dy}{dx} = \tan 30^\circ$

$$\frac{dy}{dx} = \frac{1}{F_H}\left(200x + C_1\right) = \tan 30^\circ$$

$$\frac{C_1}{F_H} = \frac{1}{\sqrt{3}}$$

$$\boxed{C_1 = \frac{F_H}{\sqrt{3}}}$$

At x = 15 m, $\frac{dy}{dx} = 60^\circ$

$$\frac{dy}{dx} = \frac{1}{F_H}\left(200 \times 15 + C_1\right) = \tan 60^\circ$$

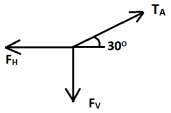
$$\boxed{3000 + C_1 = F_H\sqrt{3}}$$

$$3000 + \frac{F_H}{\sqrt{3}} = F_H\sqrt{3}$$

$$1.1547F_H = 3000$$

$$\boxed{F_H = 2598.07N}$$

At A,



$$\Sigma F_x = 0$$

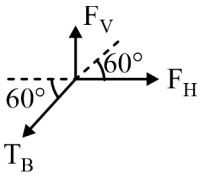
$$T_A \cos 30^\circ = F_H$$

$$T_A = \frac{F_H}{\cos 30^\circ}$$

$$T_A = \frac{2598.07}{\cos 30^\circ}$$

$$\boxed{T_A = 3000N}$$

At B,



$$\Sigma F_x = 0$$

$$F_H - T_B \cos 60^\circ = 0$$

$$F_H = T_B \cos 60^\circ$$

$$\boxed{F_B = \frac{2591.07}{\cos 60^\circ} = 5196.14\ N}$$

$$\boxed{T_{max} = T_B = 5196.14\ N = 5.2\ kN}$$

Q42 Text Solution:

Unknown values → θ_B, θ_C

Known values → $\theta_A = \theta_D = 0$

Fixed end moments (due to given loading)

$$\overline{M}_{AB} = \overline{M}_{BA} = 0, \overline{M}_{AB} = -6000\ \text{Nm},$$

$$\overline{M}_{CB} = +6000\ \text{Nm}$$

Slope deflection equation

$$M_{AB} = \overline{M}_{AB} + \frac{2\,EI}{L}\left(2\theta_A + \theta_B - \frac{3\Delta}{L}\right)$$

$$M_{AB} = \frac{2\,EI}{4}\left(\theta_B\right) = \frac{EI\theta_B}{2}$$

$$M_{BA} = \overline{M}_{BA} + \frac{2\,EI}{L}\left(2\theta_B + \theta_A - \frac{3\Delta}{L}\right)$$

$$M_{BA} = \frac{2\,EI}{4}\left(2\theta_B\right) = EI\theta_B$$

$$M_{BC} = \frac{2E(3I)}{6}\left(2\theta_B + \theta_C - \frac{3\Delta}{L}\right) - 6000$$

$$= EI\left(2\theta_B + \theta_C\right) - 6000$$

$$M_{CB} = 6000 + \frac{2E(3I)}{6}\left(2\theta_C + \theta_B - \frac{3\Delta}{L}\right)$$

$$= 6000 + EI\left(2\theta_C + \theta_B\right)$$

As the portal frame is symmetrical and loaded symmetrically, rotations

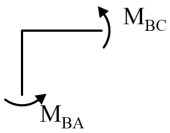
$\theta_B = -\theta_C, \Delta = 0$ (there is no sway)

$$M_{BC} = EI\left(\theta_B\right) - 6000$$

$$M_{CB} = 6000 - EI\theta_B$$

At joint B,

$\Sigma M_B = 0$



$$\sum M_B = 0, -M_{BC} - M_{BA} = 0$$

$$M_{BC} + M_{BA} = 0$$

$$EI\left(\theta_B\right) - 6000 + EI\theta_B = 0$$

$$\boxed{\theta_B = \frac{3000}{EI}}$$

Q43 Text Solution:

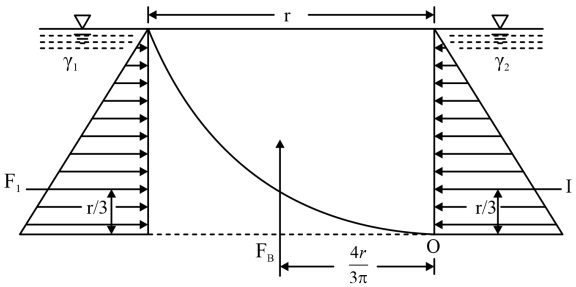
Total project cost = 50 + 10 = 60 Lakhs

∵Quoted price = Total project cost + Markup price

∴Quoted price = Total project cost + 10% of Total project cost

or, Quoted price = 1.1 × Total project cost
= 1.1 × 60
= 66 Lakhs

Q44 Text Solution:



Hydrostatic force, $F_1 = \frac{1}{2}\gamma_1 r^2$

and $F_2 = \frac{1}{2}\gamma_2 r^2$

Both are acting at a distance $\frac{r}{3}$ above the pivot.

Buoyant force, $F_B = \frac{\pi r^2}{4} \times 1$
$\cdot \gamma_1$ acting at a distance of $\frac{4r}{3\pi}$ from O

For static equilibrium:

$$(F_2 - F_1) \times \frac{r}{3} = F_B \times \frac{4r}{3\pi}$$

$$\Rightarrow \quad \left(\frac{1}{2}\gamma_2 r^2 - \frac{1}{2}\gamma_1 r^2\right)\frac{r}{3} = \frac{\pi r^2}{4}\gamma_1 \times \frac{4r}{3\pi}$$

$$\Rightarrow \quad \frac{1}{2}(\gamma_2 - \gamma_1) = \gamma_1$$

$$\Rightarrow \quad \frac{\gamma_1}{\gamma_2} = \frac{1}{3} = 0.33$$

Q45 Text Solution:

Side of equilateral triangle = a

Height of triangle (h) = $\left(\frac{a}{2}\right)$ tan60 = $\frac{\sqrt{3}a}{2}$

Centroid of triangle from free surface = $\frac{2h}{3}$

Horizontal Force(F) = $\rho g \overline{h}\, A_v$

Where;

A_v = Projected area on vertical plane = (1/2)(2/3)(a)(2/3)h = (2/9)ah

$\overline{h}$ = Centroid of the concerned area(A_v) = (2/3)(2h/3) = 4h/9

Now, F = ρg(4h/9)(2ah/9) = (8/81) ρgah^2

Put, h = $\frac{\sqrt{3}a}{2}$

F = (2/27)ρga^3

Q46 Text Solution:

Peak hour Volume
(q_p) = 5 + 8 + 3 + 7 + 4 + 9 + 2 + 5 + 6 + 8 + 4 + 7 = 68

Maximum 10 min Volume
= 14 (For 6:45-6:55)

$$PHF_{10} = \frac{q_p}{6[q_{10}]_{max}} = \frac{68}{6\times 14} = 0.809$$

Q47 Text Solution:

$$q = VK = 90K - 0.9K^2$$
$$q = 90 \times 40 - 0.9 \times 40^2$$
$$= 3600 - 1440 = 2160 \text{ Veh/hr}$$
$$q = \frac{3600}{H_t}$$
$$H_t = \frac{3600}{2160} = 1.67 \text{ sec}$$

Q48 Text Solution:

P= 1800 cvpd (each direction)

η = 15 years

x = 8 months = $\frac{2}{3}$ years

F = 2.75

D = 0.75 (Two lane dual carriageway)

r = 7.5% = 0.075

A = P $(1+r)^x$ = 1800 $(1.075)^{2/3}$
= 1888.91

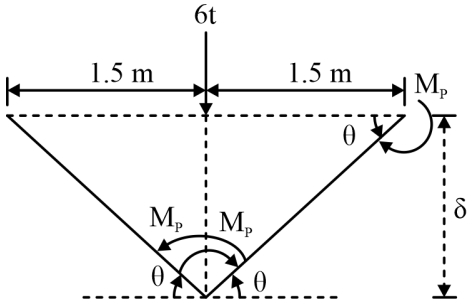
$$N_{des} = 365A\left(\frac{(1+r)^n - 1}{r}\right)\frac{DF}{10^6}\, msa$$

= 365 × 1888.91 × $\left(\frac{(1.075)^{15}-1}{0.075}\right) \times \frac{2.75\times 0.75}{10^6}$

= 37.14 msa

Q49 Text Solution:

I. Mechanism, span AB



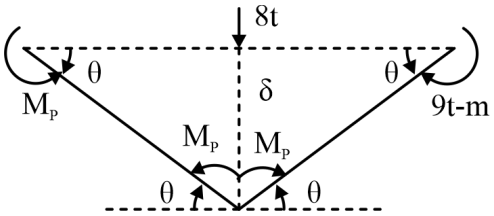
$$6t \times \delta = 3M_p\theta$$

But, $\theta = \frac{\delta}{1.5}$

$$\therefore 6t \times \delta = 3M_p \times \frac{\delta}{1.5}$$

$$\Rightarrow M_p = 3t\text{-m}$$

II. Mechanism, span BC



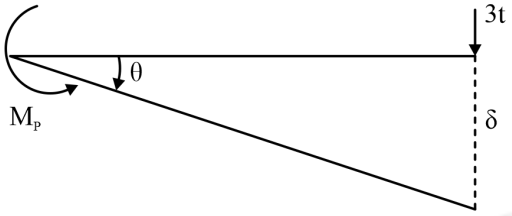
$3M_p \times \theta + 9\ t - m \times \theta = 8 \times \delta$

$\Rightarrow 3M_p \times \frac{\delta}{2} + 9\ \text{t-m} \times \frac{\delta}{2} = 8 \times \delta$

$\Rightarrow 3M_p + 9\ \text{t-m} = 16t\text{-m}$

$\Rightarrow M_p = \frac{7}{3}t\text{-m} = 2.33t\text{-m}$

III. Mechanism, span CD



$\Rightarrow 3 \times \delta = M_p \times \theta$

$\Rightarrow 3 \times \delta = M_p \times \frac{\delta}{3}$

$\Rightarrow M_p = 9\ \text{t-m}$

Required plastic moment capacity = Maximum of mechanism I, II and IV = 9 tm

Q50 Text Solution:

$q = \frac{Q}{B_1} = \frac{2.7}{3} = 0.9\text{m}^3/\text{s/m}$

Upstream conditions,

$V_1 = \frac{q_1}{y_1} = \frac{0.9}{0.9} = 1.0\text{m/s}$

and, $F_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{1.0}{\sqrt{9.81 \times 0.9}} = 0.337 < 1$

and, $E_1 = y_1 + \frac{V_1^2}{2g} = 0.9 + \frac{(1.0)^2}{2 \times 9.81}$

$= 0.950\text{m}$

At the minimum contraction, critical depth will occur at the contracted section

$E_1 = E_2 = E_C = 0.950$ m

y_{c2} = critical depth at section 2 = $\frac{2}{3}E_C$

$y_{c2} = \frac{0.950 \times 2}{3} = 0.633$ m

$y_{c2} = \left(\frac{q_2^2}{g}\right)^{1/3} = 0.633\ m$

$q_2 = 1.577\ \text{m}^3/\text{s/m}$

As $q_2 = \frac{Q}{B_2}$

$B_2 = \frac{Q}{q_2} = \frac{2.7}{1.577} = 1.712\text{m}$

Q51 Text Solution:

$1)\ V = \frac{1}{n}(R)^{2/3}(S)^{1/2}$

$V = \frac{1}{0.014} \times (0.556)^{2/3}(0.005)^{1/2}$

$V = 3.415\text{m/s}$

$q = V \times y$

$= 3.415 \times 0.6$

$q = 2.049\text{m}^3/\text{s/m}$

$2)\ y_c = \left(\frac{q^2}{g}\right)^{1/3}$

$y_c = \left(\frac{(2.097)^2}{9.81}\right)^{1/3}$

$y_c = 0.7535$ m

$q = V_c \times y_c$

$2.097 = \frac{1}{0.014} \times \left(0.684\right) \times (S_c)^{1/2} \times 0.7535$

$S_c = 0.0024$

$R_c = \frac{15 \times 0.7535}{15 + 2 \times 0.7535}$

$R_c = 0.684$

3) $E_1 = E_2$

$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g}$

$\Rightarrow 0.6 + \frac{(3.415)^2}{2 \times 9.81} = y_2 + \frac{(2.097)^2}{2 \times 9.81 \times (y_2)^2}$

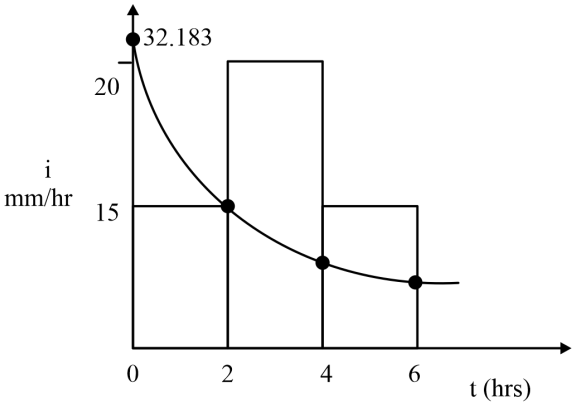
$y_2 = 0.963$ meter

Q52 Text Solution:

$P_1 = 30$ mm → $t_1 = 2$ hrs, $i_1 = 15$ mm/hr

P_2 = 40 mm → t_2 = 2 hrs, i_2 = 20 mm/hr

P_3 = 30 mm → t_3 = 2 hrs, i_3 = 15 mm/hr



$f(0) = 5 + 27.183e^{-0.5 \times 0} = 32.183$

$f(2) = 5 + 27.183e^{-0.5 \times 2} = 15$

f(4) = 8.68

f(6) = 6.35

P = 30 + 40 + 30 = 100 mm

$F = 30 + \int_2^6 \left(5 + 27.183e^{-0.5t}\right) dt$

$F = 30 + \left[5t - 54.366e^{-0.5t}\right]_2^6$

F = 30 + [30 – 2.71 – 10 + 20] = 67.29 mm

R = P – F = 32.71 mm

R.V = C·A × R = 450 × (32.71 × 10^{-3}) = 14.72 ha-m.

Q53 Text Solution:

For an inclined line of sight with the staff vertical, the horizontal distance is given by:

$D = Ks\cos^2\theta + C\cos\theta$

80 = K × (2.122 – 1.325) × $\cos^2$(2°30') + C cos(2°30')

$\Rightarrow \boxed{80 = K \times (0.7955) + 0.999C}$ ...(1)

140 = K × (2.382 – 0.985)$\cos^2$(1°36') + C × cos(1°36')

$\Rightarrow \boxed{140 = 1.3959K + 0.9996C}$ ...(2)

On solving equation (1) and (2), we get

K = 100 and C = 0.4

Note: 1°36' = 1° + $\left(\frac{36}{60}\right)^\circ = 1.6^\circ$ [on gate calculator]

Q54 Text Solution:

For given data:

Total population = 400 × 5 + 400 = 2400

Total waste generation per week = 2400 × 1 × 7 =16800 kg

Waste to be picked up per collection day,

= $\frac{16800}{2} = 8400$ kg **(As two pickups per week)**

As truck capacity is 4.5 tonnes

Number of trips per collection day = $\frac{8400}{4.5 \times 1000} = 1.87 = 2$ trips

Q55 Text Solution:

Carbonate Hardness = (4.5+1.1) × 50

= 280 mg/L as $CaCO_3$

Non-carbonate Hardness = 0 mg/L

Q56 Text Solution:

The microorganisms estimated are gram-negative in nature and B. The method is based on the assumption of a Poisson distribution

A. True: The MPN method is commonly used to estimate coliform bacteria, which are gram-negative.

B. True: The method relies on statistical probability, assuming a Poisson distribution of microorganisms in the sample.

C. False: MPN provides an estimate, not an exact count of microorganisms.

D. False: The MPN method does not detect viruses; it is specific to bacteria, primarily coliforms.

Q57 Text Solution:

For one Filter unit in one day

Volume of water Filtered = ROF × DOF × (SA) of Each Filter

= 12 × 23.5 × 60

= 16920 m^3

Volume of filtered water used in Backwashing = ROB × DOB × (SA) of Each Filter

$= 40 \times \frac{25}{60} \times 60$

= 1000 m^3

Net Volume of Water Filtered by a single filter = 16920 – 1000

= 15920 m^3/day

= 15.92 MLD

Q58 Text Solution:

Option (a) is incorrect, since in the given expression of surface integral $\iint_s \vec{F} \cdot \vec{n}\, ds$,

s is only the surface corresponding to the plane $x + y + z = 1$ of the tetrahedron.

It does not include other faces of closed tetrahedron so $\iint_s \vec{F} \cdot \vec{n}\, ds$ does not give

total flux through the tetrahedron formed by $x=0,\ y=0,\ z=0\ \&\ x+y+z=1.$

Now,

$\vec{F}\ (x,y,z)=(yz,xz,xy)$

$\nabla.\ \vec{F}\ =\frac{\partial}{\partial x}(yz)+\frac{\partial}{\partial y}(xz)+\frac{\partial}{\partial z}(xy)=0=0+0+0$

divergence of $\vec{F}$ is constant and is zero, so option (b) is correct.

Option (c) is incorrect as flux through 's' may or may not be zero. The zero divergence in a closed volume will always imply net flux in that volume to be zero, but it won't imply that net flux through any of the face of that volume is zero.

Opiton (d) is correct as it is mathematical expression for Gauss divergence theorem.

Q59 Text Solution:

$$\left(\vec{\nabla}\times\vec{F}\right)=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\ \frac{\partial}{\partial x}&\frac{\partial}{\partial y}&\frac{\partial}{\partial z}\\ z^2&x^2&y^2\end{vmatrix}$$

$=\hat{i}\,(2y)-\hat{j}\,(0-2z)+\hat{k}\,(2x-0)$

$=(2y)\hat{i}+(2z)\hat{j}+(2x)\hat{k}$

option 'b' is correct.

By stokes theorem:

$$\oint_{c}\vec{F}\cdot d\vec{r}=\iint_{s}\left(\nabla\times\vec{F}\right)d\vec{s}$$

$\vec{\nabla}\times\vec{F}\ =(2y,2z,2x)$

surface S is part of the plane x+y+z =1.

The triangle in first octant has vertices A = (1,0,0), B =(0,1,0) C =(0,0,1)

The triangle lies on a plane with unit normal $\hat{n}=\frac{1}{\sqrt{3}}(1,1,1).$

$\left(\vec{\nabla}\times\vec{F}\right)\cdot\hat{n}=\frac{1}{\sqrt{3}}\left(2y+2z+2x\right)$

$=\frac{2}{\sqrt{3}}\left(x+y+z\right)=\frac{2}{\sqrt{3}}$

$\iint\left(\vec{\nabla}\times\vec{F}\right)\cdot\hat{n}\ ds=\frac{2}{\sqrt{3}}\times Area\ S$

$.....\left(1\right)$

Triangle A(1,0,0) , B =(0,1,0), C (0,0,1)

Area $=\frac{1}{2}$

$\left|\overrightarrow{AB}\times\overrightarrow{AC}\right|=\left|\left(-\hat{i}+\hat{j}\right)\times\left(-\hat{i}+\hat{k}\right)\right|$

$$\overrightarrow{AB}\times\overrightarrow{AC}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\ -1&1&0\\ -1&0&1\end{vmatrix}$$

$=\hat{i}\,(1)-\hat{j}\,(-1)+\hat{k}\,(-(-1))$

$\frac{1}{2}\left|\overrightarrow{AB}\times\overrightarrow{AC}\right|=\frac{1}{2}\times\sqrt{3}=\frac{\sqrt{3}}{2}.....(2)$

From (1) & (2)

$\iint\left(\vec{\nabla}\times\vec{F}\right).\hat{n}\ ds=\frac{2}{\sqrt{3}}\times\frac{\sqrt{3}}{2}=1$

$\Rightarrow\oint\vec{F}\cdot\vec{dr}=1$

option 'a' is incorrect & option 'c' is correct

option 'd' is incorrect as surface integral doesnt give volume.

option 'b' & 'c' are correct.

Q60 Text Solution:

Laplace transform of the Dirac Delta function:

$\mathrm{L}(\delta(\mathrm{t}-\mathrm{a}))=\mathrm{e}^{-\mathrm{as}}$

$\Rightarrow\mathrm{L}\left[3\delta\left(\mathrm{t}-2\right)\right]=3\mathrm{e}^{-2\mathrm{s}}$

$\mathrm{L}\left[\mathrm{e}^{\mathrm{at}}\cos\ \mathrm{bt}\right]=\frac{\mathrm{s}-\mathrm{a}}{(\mathrm{s}-\mathrm{a})^2+\mathrm{b}^2}$

$\Rightarrow\mathrm{L}\left[\mathrm{e}^{-4\mathrm{t}}\cos\left(3\mathrm{t}\right)\right]=\frac{\mathrm{s}-(-4)}{(\mathrm{s}-(-4))^2+3^2}$

$=\frac{\mathrm{s}+4}{(\mathrm{s}+4)^2+9}$

$\Rightarrow\mathrm{L}\left[\mathrm{f}\left(\mathrm{t}\right)\right]=3\mathrm{e}^{-2\mathrm{s}}+\frac{4(\mathrm{s}+4)}{(\mathrm{s}+4)^2+9}$

option 'a' is correct

Q61 Text Solution:

$y''+4y=3\sin t$

$L[y'']+4L[y]=L[3\sin t]$

$\mathrm{s}^2\mathrm{Y}\left(\mathrm{s}\right)-\mathrm{sy}\left(0\right)-y'\left(0\right)+4Y\left(\mathrm{s}\right)=\frac{3}{s^2+1}$

A.T.Q: $y(0)=1\ \&\ y'(0)=0$

$\left(\mathrm{s}^2+4\right)Y\left(\mathrm{s}\right)=\mathrm{s}+\frac{3}{\mathrm{s}^2+1}$

$Y\left(\mathrm{s}\right)=\frac{\mathrm{s}}{\mathrm{s}^2+4}+\frac{3}{(\mathrm{s}^2+1)(\mathrm{s}^2+4)}$

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

Applying inverse Laplace:

$\mathrm{y}\left(\mathrm{t}\right)=\mathrm{L}^{-1}\left(\frac{\mathrm{s}}{\mathrm{s}^2+4}\right)-\mathrm{L}^{-1}\left(\frac{1}{\mathrm{s}^2+4}\right)$

$+\mathrm{L}^{-1}\left(\frac{1}{\mathrm{s}^2+1}\right)$

$=\cos 2\mathrm{t}-\frac{1}{2}\sin 2\mathrm{t}+\sin\mathrm{t}$

$\Rightarrow\ y(\pi) = \cos 2\pi - \frac{1}{2}\sin 2\pi + \sin\pi = 1$

Q62 Text Solution:

$$b = \begin{bmatrix}2\\1\\3\end{bmatrix}, \lambda_1 = \begin{bmatrix}1\\0\\1\end{bmatrix}, \lambda_2 = \begin{bmatrix}0\\1\\1\end{bmatrix}$$

$$b = 2\begin{bmatrix}1\\0\\1\end{bmatrix} + 1\begin{bmatrix}0\\1\\1\end{bmatrix} = \begin{bmatrix}2\\1\\3\end{bmatrix}$$

b lies in column space of A, which means the system is consistent (i.e. either the system has unique solution or infinitely many solutions)

Now,

$\because$ A is singular $\Rightarrow$ det(A) = 0

$\Rightarrow \rho(A) < 3$ ...(1)

By rank-nullity theorem:

$\rho(A)$ + Nullity(A) = n

$\because$ 3 × 3 matrix Þ n = 3

Nullity(A) = n – $\rho(A)$ = 3 – $\rho(A)$

$\Rightarrow$From equation(1), Nullity ≥ 2

$\because b \in col(A)$ and Nullity > 0

We will get infinitely many solutions

Concept summary

condition	Solution type
$b \notin col(A)$	No solution (Inconsistent)
$b \in col(A)$, Nullity = 0	Unique solution
$b \in col(A)$, Nullity > 0	Infinitely many solution

So, option (b) is correct

Q63 Text Solution:

Given: G = 2.65, e = 0.70

$\gamma_{sat} = \frac{G_s\gamma_w + e\gamma_w}{1+e} = 19.33\ \text{kN/m}^2$

Effective stress at point A before W.T. get lowered.

$\bar{\sigma}_A, = \gamma_{sat} \times 3 - \gamma_w \times 2$

= 19.33 × 3 – 9.81 × 2 = 38.37 kN/m^2

Effective stress at point A after W.T get lowered.

$\bar{\sigma}_{A2} = \gamma_{sat} \times 3 - \gamma_w \times 1$

$= 19.33 \times 3 - 9.81 \times 1 = 48.18\ \text{kN/m}^2$

Change in effective stress $(\Delta\bar{\sigma}) = \bar{\sigma}_{A2} - \bar{\sigma}_{A1}$

= 48.18 – 38.27 = 9.81 kN/m^2.

Hence, the correct option is (d)

Q64 Text Solution:

Using Swedish circle method,

$$F = \frac{c\widehat{L} + \left(\Sigma N - \Sigma U\right)\tan\phi}{\Sigma T}$$

Here,

C = 16 kN/m

$\phi = 20^\circ$

ΣN = 400 kN

ΣT = 190 kN

ΣU = 80 kN

$\widehat{L} = 20\ \text{m}$

$\Rightarrow F = \frac{16\times 20 + (400-80)\tan 20^\circ}{190}$

$\Rightarrow F = 2.297 \approx 2.30$

Q65 Text Solution:

$$S_i = \frac{q_n B(1-\mu^2)I_f}{E_s}$$

$$= \frac{\left(\frac{400}{1.5\times 2.5}\right)\times 1.5\times\left(1-0.3^2\right)\times 0.78\ \text{m}}{16\times 10^3}$$

$= 7.098\ \text{mm} \simeq 7.10\ \text{mm}$