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GATE 2017

Civil Engineering

Questions with Detailed Solutions

FORENOON SESSION

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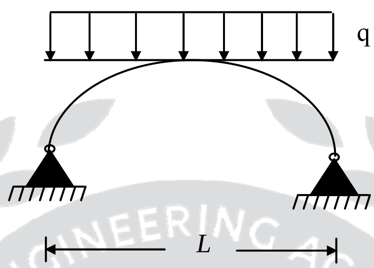
Section: Civil Engineering

01. The figure shows a two –hinged parabolic arch of span *L* subjected to a uniformly distributed load of intensity *q* per unit length.

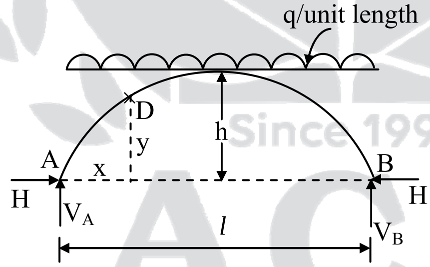


The maximum bending moment in the arch is equal to

(A) $\frac{qL^2}{8}$ (B) $\frac{qL^2}{12}$ (C) Zero (D) $\frac{qL^2}{10}$

01. Ans: (C)

Sol



For a 2-hinged parabolic arch

$$V_A = V_B = \frac{q\ell}{2} \text{ and } H = \frac{q\ell^2}{8h}$$

Taking any point D; $y = \frac{4h}{\ell^2}x(\ell - x)$

$$M_D = V_A x - H \times y - q\frac{x^2}{2} = \frac{q\ell}{2}x - \frac{q\ell^2}{8h} \times \frac{4h}{\ell^2}x(\ell - x) - \frac{qx^2}{2} = 0$$

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02. A strip footing is resting on the ground surface of a pure clay bed having an undrained cohesion C_u. The ultimate bearing capacity of the footing is equal to

(A) $2\pi C_u$ (B) πC_u (C) $(\pi+1)\ C_u$ (D) $(\pi+2)C_u$

02. Ans: (D)

Sol: For pure clays, the ultimate bearing capacity of strip footing resting on the ground surface, $q_n = CN_C$

$N_C = 5.7$, as per Terzaghi

$N_C = 5.14$ as per Meyerhof Hansen, skempton vesic and I.S. code bearing capacity theories.

In the present case $q_u = 5.14\ C$

(or) $q_u = (\pi + 2)\ C$

03. The reaction rate involving reactants A and B is given by $-k[A]^{\alpha}[B]^{\beta}$. Which one of the following statements is valid for the reaction to be a first –order reaction?

(A) $\alpha = 0$ and $\beta = 0$ (B) $\alpha = 1$ and $\beta = 0$

(C) $\alpha = 1$ and $\beta = 1$ (D) $\alpha = 1$ and $\beta = 2$

03. Ans: (B)

Sol: Since it is 1st order reaction the sum of the powers must be 1. (i.e $\alpha + \beta=1$)

04. $\underset{x\to 0}{\text{Lim}}\left(\dfrac{\tan x}{x^2 - x}\right)$ is equal to ________

04. Ans: –1

Sol:

$$\lim_{x\to 0}\left(\frac{\tan x}{x^2 - x}\right) \qquad \left(\frac{0}{0}\text{form}\right)$$

Applying L Hospital rule

$$= \lim_{x\to 0}\left(\frac{\sec^2 x}{2x - 1}\right) = \frac{\sec^2 0}{-1} = -1$$

05. An elastic bar of length L, uniform cross sectional area A, coefficient of thermal expansion α, and Young's modulus E is is fixed at the two ends. The temperature of the bar is increased by T, resulting in an axial stress σ. Keeping all other parameters unchanged, if the length of the bar is doubled, the axial stress would be

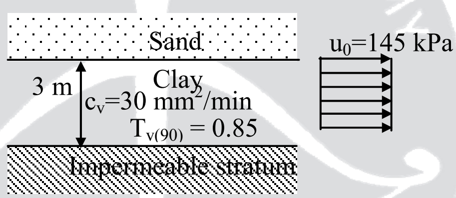
(A) σ (B) 2σ (C) 0.5σ (D) $0.25\ \alpha\sigma$

05. Ans: (A)

Sol: Temperature stress, $\sigma = (\alpha t)E$

Temperature stress is independent of length. If length is doubled the stress due to temperature remains unchanged.

06. A 3 m thick clay layer is subjected to an initial uniform pore pressure of 145 kPa as shown in the figure.



For the given ground conditions, the time (in days, rounded to the nearest integer) required for 90% consolidation would be___

06. Ans: 1771

Sol: For the given clay, drainage path, d = H (single drainage)

$$= 3\text{ m} = 3000\text{ mm}$$

$$c_v = 3\text{ mm}^2/\text{min}$$

$$T_{V(90)} = 0.85$$

$$T_V = \frac{c_v.t}{d^2}$$

$$0.85 = \frac{3\times t}{(3000)^2}$$

$$\therefore\ t = 2.55\times 10^6\text{ min} = 1770.83\text{ days}$$

Say 1771 days

07. Which one of the following is NOT present in the acid rain?

(A) HNO_3 (B) H_2SO_4 (C) H_2CO_3 (D) CH_3COOH

07. Ans: (D)

Sol:

Acid rains are mainly caused by HNO_3, H_2SO_4, H_2CO_3 but not by CH_3 COOH as it is a weak acid.

08. The accuracy of an Electronic Distance Measuring Instrument (EDMI) is specified as ± (*a* mm + *b* ppm). Which one of the following statements is correct?

(A) Both *a* and *b* remain constant, irrespective of the distance begin measured

(B) *a* remains constant and *b* varies in proportion to the distance being measured.

(C) *a* varies in proportion to the distance being measured and *b* remains constant.

(D) Both *a* and *b* vary in proportion to the distance being measured.

08. **Ans: (B)**

Sol: Inorder to increase the accuracy of geodetic measurements, the effect of instrument errors is reduced by a suitable procedure of the measurements and measurement configuration or calculation corrections can be applied on the measured values. Constant corrections or corrections depending on measured distance can be used to correct distance measurement by the EDM's of the total stations base lines are used to determine the distance meters errors. The standard deviation of the measured distance.

$\sigma = A + B .D$

Where A is 'mm' includes phase solution of EMD maximum amplitude of short periodic error or phase distance meters, maximum effect of non linear distance errors and accuracy or an additive constant. (ppm)

'B' in 'PPM' includes the range of the typical frequency drift of the main oscillator within the specified temperature range and the maximum error which may be caused by the limited step interval of the 'ppm dial'.

D = Distance measured by EDMI

09. A simply supported beam is subjected to a uniformly distributed load. Which one of the following statements is true?

(A) Maximum or minimum shear force occurs where the curvature is zero

(B) Maximum or minimum bending moment occurs where the shear force is zero

(C) Maximum or minimum bending moment occurs where the curvature is zero

(D) Maximum bending moment and maximum shear force occur at the same section.

09. Ans: (B)

10. For a steady incompressible laminar flow between two infinite parallel stationary plates, the shear stress variation is

(A) linear with zero value at the plates (B) linear with zero value at the center

(C) quadratic with zero value at the plates (D) quadratic with zero value at the center

10. Ans: (B)

11. A runway is being constructed in a new airport as per the International Civil Aviation Organization (ICAO) recommendations. The elevation and the airport reference temperature of this airport are 535 m above the mean sea level and 22.65°C, respectively. Consider the effective gradient of runway as 1%. The length of runway required for a design-aircraft under the standard conditions is 2000 m. Within the framework of applying sequential corrections as per the ICAO recommendations, the length of runway corrected for the temperature is

(A) 2223 m (B) 2250 m (C) 2500 m (D) 2750 m

11. Ans: (C)

Sol: Elevation of airport = 535 m

Airport reference temperature,

ART = 22.65°C

Effective gradient = 1%

Standard length of runway = 2000 m

Correction for elevation:

300 m – 7%

$$535\text{ m} \rightarrow ? = \frac{7\times 535}{300} = 12.48\%$$

Length after elevation correction

= 2000 × 1.1248 = 2249.6 m

Temperature correction:

ART = 22.65°C

Standard airport temperature, SAT at

msl = 15°C

Temperature gradient 1000 m elevation

= 6.5°C reduction

For 535 m elevation reduction of temperature $= \frac{6.5\times 535}{1000} = 3.48^\circ\text{C}$

∴ SAT at airport site = 15 – 3.48 = 11.52°C

For 1°C difference of ART and SAT = 1% increase in length is recommended by ICAO

For (22.65 – 11.52) = 11.13°C of difference

Increase in length of runway is 11.13%

∴ Final length of runway after temperature correction = 2249.6 × 1.113 = 2499.98 m ≃ 2500 m

12. The matrix P is the inverse of a matrix Q. If I denotes the identity matrix, which one of the following options is correct?

(A) PQ = I but QP ≠ I (B) QP = I but PQ ≠ I

(C) PQ = I and QP = I (D) PQ –QP = I

12. Ans: (C)

Sol: $Q^{-1} = P$ …………….(1)

Premultiplying both sides of (1) by Q

$$QQ^{-1} = QP$$

$$I = QP$$

Post multiplying both sides of (1) by Q

$$Q^{-1}Q = PQ$$

$$I = PQ$$

∴ Option (C) is correct.

13. A uniformly distributed line load of 500 kN/m is acting on the ground surface. Based on Boussinesq's theory, the ratio of vertical stress at a depth 2 m to that at 4 m, right below the line of loading, is

(A) 0.25 (B) 0.5 (C) 2.0 (D) 4.0

13. Ans: (c)

Sol: Extending Boussinesq's equation for point load, the vertical stress directly below the line load,

$$\sigma_z = \frac{2q'}{\pi z}$$

$$\therefore \sigma_z \, \alpha \, \frac{1}{z}$$

$$\frac{\sigma_z \text{at 2m depth}}{\sigma_z \text{at 4m depth}} = \left[\frac{4}{2}\right] = 2$$

14. Consider the following partial differential equation:

$$3\frac{\partial^2\phi}{\partial x^2}+B\frac{\partial^2\phi}{\partial x\partial y}+3\frac{\partial^2\phi}{\partial y^2}+4\phi=0$$

For this equation to be classified as parabolic, the value of B^2 must be __________

14. Ans: 36

Sol:

$$3\frac{\partial^2\phi}{\partial x^2}+B\frac{\partial^2\phi}{\partial x\partial y}+3\frac{\partial^2\phi}{\partial y^2}+4\phi=0$$

Here A = 3, C = 3

The above PDE is said to be parabolic

If $B^2 - 4AC = 0$

$B^2 - 36 = 0$

$B^2 = 36$

15. The number of spectral bands in the Enhanced Thematic Mapper sensor on the remote sensing satellite Landsat-7 is

(A) 64 (B) 10 (C) 8 (D) 15

15. Ans: (C)

Sol: The landsat enhanced thematic mapper plus (ETM +) sensor is carried on Land sat-7 and images consist of 8 spectral bands with a spatial resolution of 30 m for bands 1 to 7. The resolution for band 8. (Panchromatic is 15 m).

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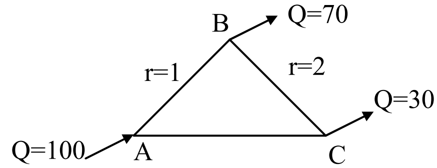
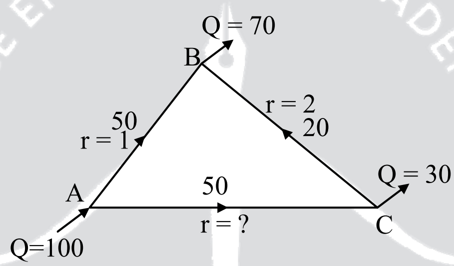
16. A triangular pipe network is shown in the figure.



The head loss in each pipe is given by $h_f = rQ^{1.8}$, with the variables expressed in a consistent set of units. The value of r for the pipe AB is 1 and for the pipe BC is 2. If the discharge supplied at the point A(i.e. 100) is equally divided between the pipes AB and AC, the value of r (up to two decimal places) for the pipe AC should be ____

16. Ans: 0.62

Sol:



$h_f = rQ^{1.8}$

$\sum h_f = 0$

$+ 1(50)^{1.8} - 2(20)^{1.8} - r\,(50)^{1.8} = 0$

$r = 0.62$

17. A soil sample is subjected to a hydrostatic pressure, σ. The Mohr circle for any point in the soil sample would be

(A) a circle of radius σ and center at the origin

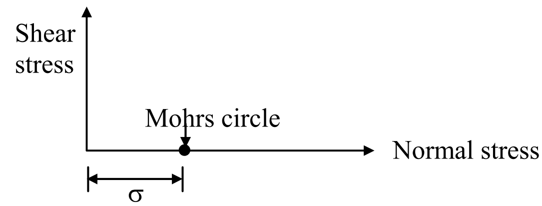
(B) a circle of radius σ and center at a distance σ from the origin

(C) a point at a distance σ from the origin

(D) a circle of diameter σ and center at the origin

17. Ans: (C)

Sol: For hydrostatic pressure ($\sigma_1 = \sigma_2 = \sigma_3$), the Mohr's circle will be a point at a distance σ from the origin



18. The number of parameters in the univariate exponential and Gaussian distributions, respectively, are

(A) 2 and 2 (B) 1 and 2 (C) 2 and 1 (D) 1 and 1

18. Ans: (B)

19. The wastewater from a city, containing a high concentration of biodegradable organics, is being steadily discharged into a flowing river at a location S. If the rate of aeration of the river water is lower than the rate of degradation of the organics, then the dissolved oxygen of the river water

(A) is lowest at the location S.

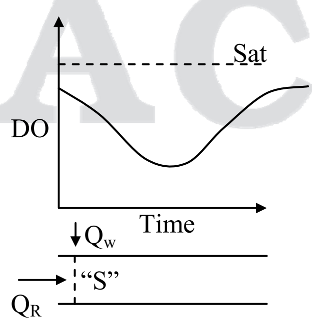
(B) is lowest at a point upstream of the location S

(C) remains constant all along the length of the river

(D) is lowest at a point downstream of the location S.

19. Ans: (D)

Sol:



Distance = velocity × time

DO is lowest point downstream of the location 'S'.

20. Group I lists the type of gain or loss of strength in soils. Group II lists the property or process responsible for the loss or gain of strength in soils.

Group I

P. Regain of strength with time

Q. Loss of strength due to cyclic loading

R. Loss of strength due to upward seepage

S. Loss of strength due to remolding

Group –II

1. Boiling 2. Liquefaction
3. Thixotropy 4. Sensitivity

The correct match between Group I and Group II is

(A) P-4, Q-1, R-2, S-3 (B) P-3, Q-1, R-2, S-4
(C) P-3,Q-2,R-1,S-4 (D) P-4, Q-2, R-1, S-3

20. Ans: (C)

Sol: P –3, Q–2, R–1, S–4

21. Let x be a continuous variable defined over the interval (–∞, ∞), and f(x) = $e^{-x-e^{-x}}$

The integral g (x) =∫f(x) dx is equal to

(A) e^{e-x} (B) $e^{-e^{-x}}$ (C) $e^{-e^{x}}$ (D) e^{-x}

21. Ans: (B)

Sol: $f(x) = e^{-x-e^{-x}}$

$g(x) = \int f(x)\,dx$

$= \int e^{-x-e^{-x}} dx$ put $e^{-x} = t$

$= \int e^{-x} e^{-e^{-x}} dx$ $-e^{-x}dx = dt$

$\int e^{-t}(-dt)$ $e^{-x}dx = -dt$

$= e^{-t}$

$= e^{-e^{-x}}$

22. Vehicles arriving at an intersection from one of the approach roads follows the Poisson distribution. The mean rate of arrival is 900 vehicles per hour. If a gap is defined as the time difference between two successive vehicle arrivals (with vehicles assumed to be points), the probability (up to four decimal places) that the gap is greater than 8 seconds is ________

22. Ans: 0.1353

Sol: Time, T = 8 sec

Mean rate of arrival,

q = 900 veh/hr

$$= \frac{900}{60 \times 60} = 0.25 \text{ veh/sec}$$

Probability that the gap is greater than 8 sec

$P(t \geq T = 8 \text{ sec}) = e^{-qt}$

$= e^{-(0.25 \times 8)}$

$= 0.1353$

23. A super-elevation *e* is provided on a circular horizontal curve such that a vehicle can be stopped on the curve without sliding. Assuming a design speed *v* and maximum coefficient of side friction f_{max}, which one of the following criteria should be satisfied?

(A) $e \leq f_{max}$

(B) $e > f_{max}$

(C) no limit on e can be set

(D) $e = \frac{1-(f_{max})^2}{f_{max}}$

23. Ans: (A)

Sol: For a stopped vehicle to avoid sliding inwards $e \leq f_{max}$

24. The ordinates of a 2-hour unit hydrograph for a catchment are given as

Time(h)	0	1	2	3	4
Ordinate (m^3/s)	0	5	12	25	41

The ordinate (in m^3/s) of a 4-hour unit hydrograph for this catchement at the time of 3 h would be_______

24. Ans: 15

Sol:

Time	2hr UHG Ord.	2hr delayed 2hr UHG ord	4hr DRH ord	4hr UHG ord= 4hr DRH/2
0	0	-		
1	5	-		
2	12	0		
3	25	5	30	15

Ord of 4hr UHG at 3rd hr time interval

$= 15\ m^3/sec$

25. According to IS 456- 2000, which one of the following statements about the depth of neutral axis $x_{u,\,bal}$ for a balanced reinforced concrete section is correct?

(A) $x_{u,\,bal}$ depends on the grade of concrete only

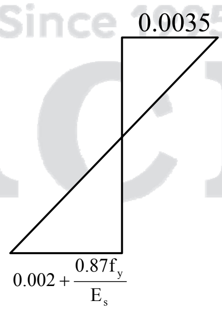
(B) $x_{u,\,bal}$ depends on the grade of steel only

(C) $x_{u,\,bal}$ depends on both the grade of concrete and grade of steel.

(D) $x_{u,\,bal}$ does not depend on the grade of concrete and grade of steel.

25. Ans: (B)

Sol:



Strain Diagram

Max depth of N.A,

$$x_{u\,bal} = \left[\frac{0.0035}{0.0055 + \frac{0.87f_y}{E_s}}\right]d$$

Where $f_y \rightarrow$ yield stress of steel

$E_s \rightarrow$ modulus of elasticity of steel

$$\left(E_s = 2\times10^5 \frac{N}{mm^2}\right)$$

From the above formula $x_{u\,max}$ depends on only grade of steel

$$x_{u\,bal} = 0.53d \rightarrow \text{Fe-250}$$
$$x_{u\,bal} = 0.48d \rightarrow \text{Fe-415}$$
$$x_{u\,bal} = 0.46d \rightarrow \text{Fe-500}$$

26. Group –I contains three broad classes of irrigation supply canal outlets. Group II presents hydraulic performance attributes.

Group I	Group II
P. Non-modular outlet	1. Outelet discharge depends on the water levels in both the supply canal as well as the receiving water course.
Q. Semi-modular outlet	2. Outlet discharge is fixed and is independent of the water levels in both the supply canal as well as the receiving water course
R. Modular outlet	3. Outlet discharge depends only on the water level in the supply canal

The correct match of the items in Group I with the items in Group II is

(A) P – 1 ; Q – 2; R – 3
(B) P – 3; Q – 1; R – 2
(C) P – 2; Q – 3; R – 1
(D) P – 1; Q – 3; R – 2

26. Ans: (D)

Sol: Modular outlet $Q_{module} = f\left[\Delta Q^{o}_{Parent}\right]$

$= f\left[\Delta Q^{o}_{daughter}\right]$

Semi-modular

$Q_{module} = f\,[\Delta\, Q_{parent}]$

$= f[\Delta Q^{o}{}_{daughter}]$

Non modular

$Q_{module} = f[\Delta\, Q_{parent}]$

$= f[\Delta\, Q_{daughter}]$

27. A pre-tensioned rectangular concrete beam 150 mm wide and 300 mm depth is prestressed with three straight tendons, each having a cross-sectional area of 50 mm^2, to an initial stress of 1200 N/mm^2. The tendons are located at 100 mm from the soffit of the beam. If the modular ratio is 6, the loss of prestressing force (in kN, up to one decimal place) due to the elastic deformation of concrete only is ______

27. Ans: 4.8

Sol: Given:

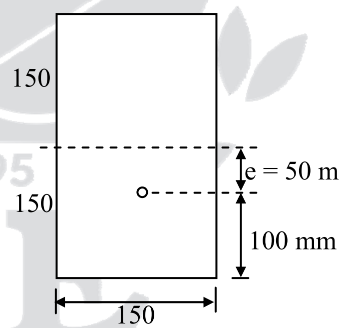
$b = 150$ mm

$D = 300$ mm

$A_s = 3 – 50$ mm^2

$\sigma_o = 1200$ N/mm^2

$m = 6$



ΔP = ? Loss of prestressing force

Loss of prestress due to elastic deformation in pretensioning

$\Delta\sigma = mf_c$

$$f_c = \frac{P}{A} + \frac{Pe}{I}.e$$

$$P = \sigma_o A_s = 1200 \times 50 \times 3 = 180 \text{ kN}$$

$$f_c = \frac{P}{A} + \frac{Pe}{I}.e$$

$$= \frac{180\times10^3}{150\times300} + \frac{180\times10^3\times50}{\frac{150\times300^3}{12}}\times50$$

$$= 4 + 1.3 = 5.3 \text{ N/mm}^2$$

$$\Delta\sigma = 6 \times 5.3 = 31.8 \text{ N/mm}^2$$

$$\Delta P = 4.8 \text{ kN}$$

28. The wastewater having an organic concentration of 54 mg/*l* is flowing at a steady rate of 0.8 m^3/day through a detention tank of dimensions 2 m × 4 m × 2 m. If the contents of the tank are well mixed and the decay constant is 0.1 Per day, the outlet concentration (in mg/*l*, up to one decimal place) is ________

Ans: 0.54

Sol: $\frac{dC}{dt} \propto C$

$$\frac{dC}{dt} = -kC$$

$$\int_{\ell_o}^{\ell t}\frac{dC}{C} = \int_{o}^{t} -kdt$$

$$\text{Log}_{10}\left[\frac{C_t}{C_o}\right] = -kE$$

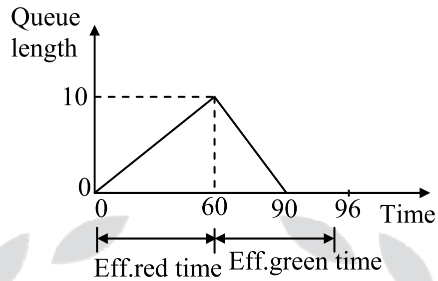
$$\frac{C_t}{C_o} = 10^{-kf}$$

$$C_t = C_o\ 10^{-kt} = C_o\ 10^{-k\times\frac{V}{Q}}$$

$$C_t = 5410^{-0.1\times\frac{(2\times4\times2)}{0.8}}$$

$C_t = 0.54$ mg/*l*

29. The queue length (in number of vehicles) versus time (in seconds) plot for an approach to a signalized intersection with the cycle length of 96 seconds is shown in the figure (not drawn to scale)



At time t = 0, the light has just turned red. The effective green time is 36 seconds, during which vehicles discharge at the saturation flow rate, s (in vph). Vehicles arrive at a uniform rate, v (in vph), throughout the cycle. Which one of the following statements is TRUE?

(A) v = 600 vph, and for this cycle, the average stopped delay per vehicle = 30 seconds

(B) s = 1800 vph, and for this cycle, the average stopped delay per vehicle = 28.125 seocnds

(C) v = 600 vph, and for this cycle, the average stopped delay per vehicle = 45 seconds

(D) s = 1200 vph, and for this cycle, the average stopped delay per vehicle = 28.125 seconds

29. Ans: (A)

Sol:

$$\text{Average delay} = \frac{\text{Red time}}{2} = \frac{60}{2} = 30\text{ sec}$$

30. A particle of mass 2 kg is travelling at a velocity of 1.5 m/s. A force $f(t) = 3t^2$(in N) is applied to it in the direction of motion for a duration of 2 seconds, where t denotes time in seconds. The velocity (in m/s, up to one decimal place) of the particle immediately after the removal of the force is _______

30. Ans: 5.5

Sol: m = 2kg; velocity = 1.5 m/s = Initial

$f(t) = 3t^2$

$$f(t) = m\frac{dv}{dt} \Rightarrow f(t)dt = mdV$$

$$\int_0^2 3t^2 dt = m\int_{1.5}^{V} dV$$

$$\left[\frac{3t^3}{3}\right]_0^2 = m[V]_{1.5}^{V} \Rightarrow 2^3 = 2\times[\,V-1.5]$$

$$\Rightarrow 8 = 2V - 3$$

$$V = \frac{8+3}{2} = 5.5\,m/s$$

31. A consolidated undrained $(\overline{CU})$ triaxial compression test is conducted on a normally consolidated clay at a confining pressure of 100kPa. The deviator stress at failure is 80 kPa, and the pore –water pressure measured at failure is 50 kPa. The effective angle of internal friction (in degrees, up to one decimal place) of the soil is______

31. Ans: 26.4

Sol: For NC clay in an CU test, both C_u & $C' = 0$

Given σ_3 = 100 kPa, σ_d = 80 kPa, u = 50 kPa

To find ϕ'

$$\sigma'_1 = \sigma'_3 \tan^2\left(45 + \frac{\phi'}{2}\right) \qquad (\because C' = 0)$$

$$(\sigma_1 - u) = (\sigma_3 - u)\tan^2\left(45 + \frac{\phi'}{2}\right)$$

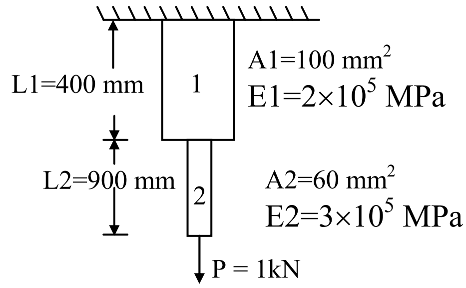
$$(100 + 80 - 50) = (100 - 50)\tan^2\left(45 + \frac{\phi'}{2}\right)$$

$$130 = 50\tan^2\left(45 + \frac{\phi'}{2}\right)$$

$\therefore \phi' = 26.39°$

Say 26.4°

32. Consider the stepped bar made with a linear elastic material and subjected to an axial load of 1 kN, as shown in the figure



Segments 1 and 2 have cross-sectional area of 100 mm^2 and 600 mm^2, Young's modulus of 2×10^5 MPa and 3×10^5 MPa, and length of 400 mm and 900 mm, respectively. The strain energy (in N-mm, up to one decimal place) in the bar due to the axial load is______

32. Ans:35

Sol:

$$U = U_1 + U_2 = \frac{P_1^2\ell_1}{2A_1E_1} + \frac{P_2^2\ell_2}{2A_2E_2}$$

$$= \frac{(1000)^2(400)}{(2)(100)(2\times10^5)} + \frac{(1000)^2(900)}{2(60)(3\times10^5)}$$

$= 10 + 25 = 35$ N-mm

33. An effective rainfall of 2-hour duration produced a flood hydrograph peak of 200 m^3/s. The flood hydrograph has a base flow of 20 m^3/s. If the spatial average rainfall in the watershed for the duration of storm is 2 cm and the average loss rate is 0.4 cm/hour, the peak of 2-hour unit hydrograph (in m^3/s-cm, up to one decimal place) is_______

33. Ans: 150

Sol: Peak ord of 2 hr FHG = 200 m^3/sec

Base flow = 20 m^3/sec

Peak ord of 2hr DRH = [peak ord of 2hr FHG]–Base flow

= 200 – 20 = 180 m^3/sec

P_e = 2 cm

$t_e = 2hr$

ϕ-Index = 0.4 cm/hr

$$\phi - \text{index} = \frac{P_e - R}{t_e}$$

$$0.4 = \frac{2 - R}{2}$$

$$R = 1.2 \text{ cm}$$

$$\text{Peak ord of 2 hr UHG} = \frac{\text{Peak ord of 2hr DRH}}{R}$$

$$= \frac{180}{1.2} = 150 \text{ m}^3/\text{sec}$$

34. The spherical grit particles, having a radius of 0.01 mm and specific gravity of 3.0 need to be separated in a settling chamber. It is given that

- $g = 9.81 \text{ m/s}^2$
- The density of the liquid in the settling chamber = 1000 kg/m^3
- the kinematic viscosity of the liquid in the settling chamber = 10^{-6} m^2/s

Assuming laminar conditions, the settilling velocity (in mm/s, up to one decimal place) is___

34. Ans: 0.436

Sol:

$d = 0.01 \text{ mm} = 0.01 \times 10^{-3} \text{ m}$

$S = 3$

$g = 9.81 \text{ m/s}^2$

$\rho_w = 1000 \text{ kg/m}^3$

$\nu = 10^{-6} \text{ m}^2/\text{sec}$

$$v_S = \frac{g[S-1]d^2}{18\nu} = \frac{9.81[3-1](0.02\times10^{-3})^2}{18\times10^{-6}}$$

$= 4.36 \times 10^{-4}$ m/sec

$= 0.436$ mm/sec

35. The radius of a horizontal circular curve on a highway is 120 m. The design speed is 60 km/hour, and the design coefficient of lateral friction between the tyre and the road surface is 0.15. The estimated value of superelevation required (if full lateral friction is assumed to develop), and the value of coefficient of friction needed (if no superelevation is provided) will, respectively, be

(A) $\frac{1}{11.6}$ and 0.10 (B) $\frac{1}{10.5}$ and 0.37 (C) $\frac{1}{11.6}$ and 0.24 (D) $\frac{1}{12.9}$ and 0.24

35. Ans: (C)

Sol:

Design speed, R = 120 m

Design speed, V = 60 km/hr (16.67 m/s)

Coefficient of lateral friction, f = 0.15

(i) Superelevation for the development of full friction

$$e + f = \frac{v^2}{gR} \rightarrow e + 0.15 = \frac{16.67^2}{9.87 \times 120}$$

$$e = 0.086 = \frac{1}{11.63} \simeq \frac{1}{11.6}$$

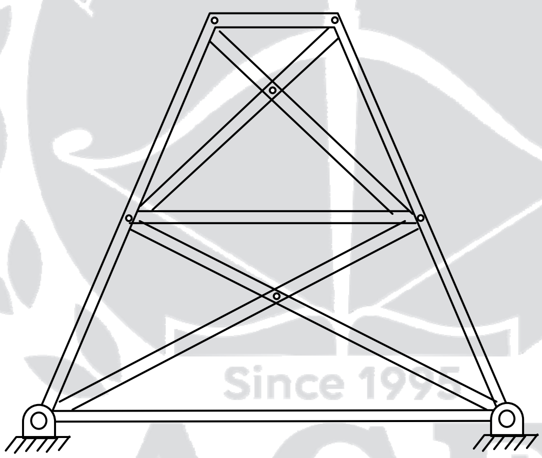
(ii) For no superelevation coefficient of friction required is

$$e + f = \frac{v^2}{gR}$$

$$0 + f = \frac{16.67^2}{9.81 \times 120}$$

$$f = 0.236 = 0.24$$

36. A planar tower structure is shown in the figure:



Consider the following statements about the external and internal determinacies of the truss.

P. Externally Determine

Q. External static Indeterminacy = 1

R. External Static Indeterminacy = 2

S. Internally Determinate

T. Internal Static Indeterminacy = 1

U. Internal Static Indeterminacy = 2

Which one of the following options is correct?

(A) P-False; Q- True; R-False ; S-False ; T-False; U-True

(B) P-False; Q- True; R-False ; S-False ; T-True; U-False

(C) P-False; Q- False; R-True ; S-False ; T-False; U-True

(D) P-True; Q- True; R-False ; S-True ; T-False; U-True

36. Ans: (A)

Sol: Number of support reactions, r = 4

Number of joints, j = 6

Number of members; m = 11

$D_{se} = (r-3) = 1$;

$D_{si} = m - (2j - 3)$

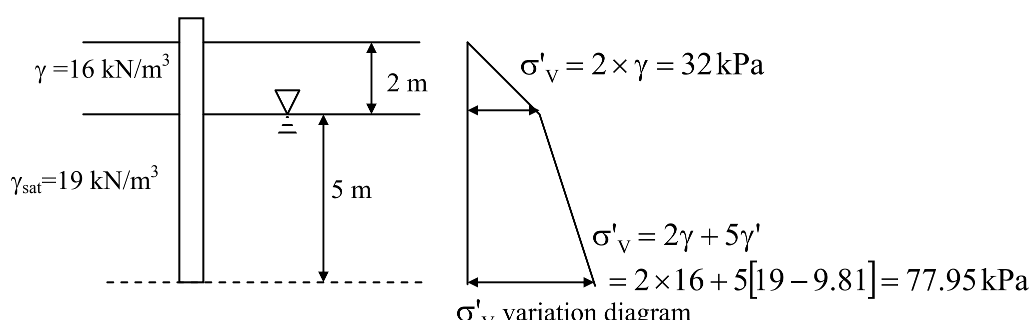
$= 11 - (2\times6 - 3)$

$= 11 - 9 = 2$

37. It is proposed to drive H –piles up to a depth of 7 m at a construction site. The average surface area of the H-pile is 3 m^2 per meter length. The soil at the site is homogenous sand, having an effective friction angle of 32^o . The ground water table (GWT) is at a depth of 2 m below the ground surface. The unit weights of the soil above and below the GWT are 16 kN/m^3 and 19 kN/m^3, respectively. Assume the earth pressure coefficient, K = 1.0, and the angle of wall friction, $\delta = 23^o$. The total axial frictional resistance (in kN, up to one decimal place) mobilized on the pile against the driving is _________

37. Ans: 390.8

Sol:



Dividing the pile length into two convenient parts of 2 m length and 5 m length as shown, the total ultimate frictional resistance is:

Q_s = As. K. $\sigma'_{Va}.\tan\delta$

$$= (3\times 2)\times 1\times\left(\frac{0+32}{2}\right)\tan 23^\circ + (3\times 5)\times 1\times\left(\frac{32+77.95}{2}\right)\tan 23^\circ$$

= 40.75 + 350.03

= 390.78 say 390.8 kN

38. The solution of the equation $\frac{dQ}{dt}+Q=1$ with Q = 0 at t = 0 is

(A) $Q(t) = e^{-t} - 1$ (B) $Q(t) = 1 + e^{-t}$

(C) $Q(t) = 1 - e^{t}$ (D) $Q(t) = 1 - e^{-t}$

38. Ans: (D)

Sol:

$$\frac{dQ}{dt}+Q=1 \text{ with } Q=0 \text{ at } t=0$$

$$\Rightarrow \frac{dQ}{dt} = 1-Q$$

$$\Rightarrow \frac{dQ}{1-Q} = dt$$

$$\Rightarrow \int\frac{dQ}{1-Q} = \int dt$$

$$\Rightarrow \ln(Q-1) = -t + \ln c$$

$$\Rightarrow (Q-1) = e^{-t} + C$$

$$\Rightarrow Q = 1 + e^{-t}\,.\,e^{C} \quad \text{--------(1)}$$

Applying initial condition we get

$$0 = 1 + e^{C}$$

$\Rightarrow e^C = -1$

substituting in (1), we get

$Q = 1 - e^{-t}$

39. The laboratory tests on a soil sample yields the following results; natural moisture content = 18% liquid limit = 60%, plastic limit = 25%, percentage of clay sized fraction = 25%. The liquidity index and activity (as per the expression proposed by Skempton) of the soil, respectively, are

(A) – 0.2 and 1.4
(B) 0.2 and 1.4
(C) – 1.2 and 0.714
(D) 1.2 and 0.714

39. Ans: (A)

Sol: Given

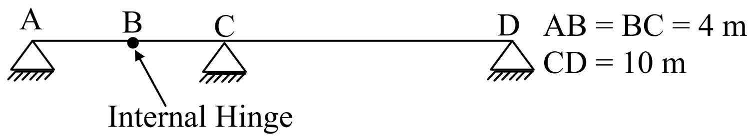
$w = 18\%,\ w_L = 60\%,\ w_P = 25\%,\ C = 25\%$

Liquidity index, $I_L = \frac{w - w_P}{w_L - w_P} = \frac{18-25}{60-25} = -0.2$

$I_P = w_L - w_P = 60 - 25 = 35$

Activity, $A = \frac{I_P}{C} = \frac{35}{25} = 1.4$

40. Consider the beam ABCD shown in figure



For a moving concentrated load of 50 kN on the beam, the magnitude of the maximum bending moment (in kN-m) obtained at the support C will be equal to ____

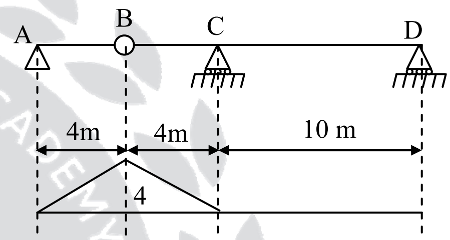
40. Ans: 200

Sol:

So, place the load at B for obtaining move BM at C

$(M_C)_{Maximum} = 50 \times 4$

$= 200$ kN-m



ILD for B.M at C

41. Consider two axially loaded columns, namely. 1 and 2, made of a linear elastic material with Young's modulus 2×10^5 MPa, square cross-section with side 10 mm, and length 1 m. For Column 1, one end is fixed and the other end is free. For column 2, one end is fixed and the other end is pinned. Based on the Euler's theory, the ratio (up to one decimal place) of the buckling load of Column 2 to the buckling load of column is _________

41. Ans: 8

Sol:

Column 1	Column 2
Fix and free $l = 2L$	Fix-hinged $\ell = \frac{1}{\sqrt{2}}$

$$\frac{P_2}{P_1} = \frac{\ell_1^2}{\ell_2^2} = \frac{(2L)^2}{\left(\frac{L}{\sqrt{2}}\right)^2} = 4 \times 2 = 8$$

42. Consider the matrix $\begin{bmatrix} 5 & -1 \\ 4 & 1 \end{bmatrix}$. Which one of the following statements is TRUE for the eigenvalues and eigenvectors of this matrix?

(A) Eigenvalue 3 has a multiplicity of 2, and only one independent eigenvector exists.

(B) Eigenvalue 3 has a multiplicity of 2, and two independent eign vectors exist.

(C) Eigenvalue 3 has a multiplicity of 2, and no independent eigen vector exists

(D) Eigenvalues are 3 and –3, and two independent eigenvectors exist

42. Ans: (A)

Sol:

$$\text{Let } A = \begin{bmatrix} 5 & -1 \\ 4 & 1 \end{bmatrix}$$

$$\lambda^2 - \lambda(6) + (5+4) = 0$$

$$\lambda - 6\lambda + 9 = 0$$

$$(\lambda - 3)^2 = 0$$

$\therefore$ $\lambda = 3, 3$ are eigen values of A

Algebraic multiplicity of eigen value 3 is 2

$$\text{For } \lambda = 3,\ A - \lambda I = A - 3I = \begin{bmatrix} 2 & -1 \\ 4 & -2 \end{bmatrix}$$

$R_2 \to R_2 - 2R_1$

$$A - 3I = \begin{bmatrix} 2 & -1 \\ 0 & 0 \end{bmatrix}$$

Ran of $(A - 3I) = 1$

$\therefore$ No. of LI eigen vectors $= n - r$

$= 2 - 1$

$= 1$

Option A

43. For the function f(x) = a + bx, $0 \le x \le 1$, to be a valid probability density function, which one of the following statements is correct?

(A) a = 1. b = 4 (B) a = 0.5, b = 1 (C) a = 0, b = 1 (D) a = 1, b = –1

43. Ans: (B)

Sol:

f(x) = a + bx, $0 \le x \le 1$

$$\int_{-\infty}^{\infty} f(x)dx = 1 \quad (\because \text{total probability} = 1)$$

$$\int_{0}^{1} (a + bx)dx = 1$$

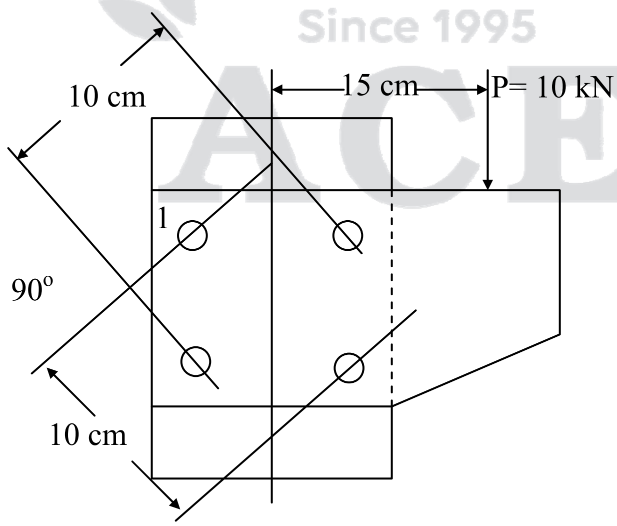
$$\Rightarrow \left(ax + \frac{bx^2}{2}\right)_0^1 = 1$$

$$\Rightarrow a + \frac{b}{2} = 1$$

$\Rightarrow 2a + b = 2$ ………………(1)

Only option B, a = 0.5, b = 1, satisfying equation (2)

44. A column is subjected to a load through a bracket as shown in figure



The resultant force (in kN, up to one decimal place) in the bolt 1 is _________

44. Ans: 5.9

Sol: An eccentric load P may be replaced by set of one direct concentric load (P) and twisting moment (M)

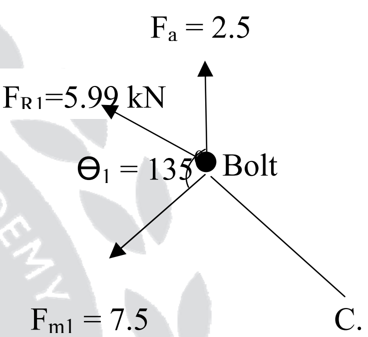
P = 10kN ;

M = P×e. = 10 × 15 = 150 kN-cm

Radial distance $r_1 = r_2 = r_3 = r_4$ = 10/2 = 5cm

Force in each bolt due to direct concentric load (F_a)

$$F_a = \frac{P}{n} = \frac{10}{4} = 2.5\,kN$$



Force in bolt No.1 due to twisting moment (F_m)

$$F_{m1} = \frac{Mr_1}{\Sigma r^2} = \frac{150\times5}{4\times5^2} = 7.5\ kN$$

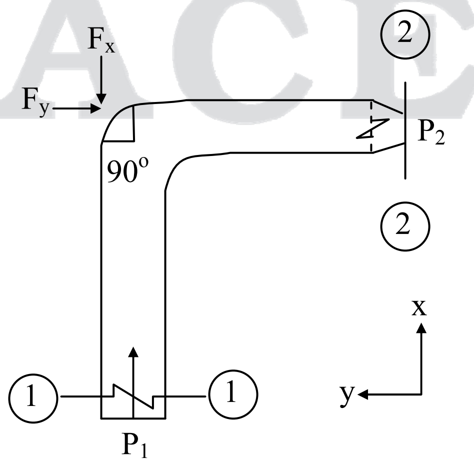
The resultant force in the bolt 1

$$F_{R1} = \sqrt{F_a^2 + F_{m1}^2 + 2\ F_a F_{m1}.\cos\theta_1}$$

$$= \sqrt{2.5^2 + 7.5^2 + 2\times2.5\times7.5\times\cos135^0} = 5.99\text{ kN}$$

The resultant force (F_{R1}) in the bolt 1 (in kN)= 5.99kN= 5.9(Answer)

45. Water flows through a 90° bend in a horizontal plane as depicted in the figure



A pressure of 140 kPa is measured at section 1-1. The inlet diameter marked at a section 1 – 1 is $\frac{27}{\sqrt{\pi}}$ cm. While the nozzle diameter marked at section 2-2 is $\frac{14}{\sqrt{\pi}}$ cm. Assume the following.

(i) Acceleration due to gravity = 10 m/s^2.

(ii) Weights of both the bent pipe segment as well as water are negligible.

(iii) Friction across the bend is negligible

The magnitude of the force (in kN, up to two decimal places) that would be required to hold the pipe section is ________

45. Ans: 397.31

Sol: The pressure at the exit of the nozzle is atmosphere pressure it will be zero

$P_1 = 140$ kPa, $d_1 = \frac{27}{\sqrt{\pi}}$ cm

$P_2 = 0$, $d_2 = \frac{14}{\sqrt{\pi}}$ cm

Apply bernoulie's equation between section (1) and (2)

$$\frac{P_1}{\gamma_w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma_w} + \frac{V_2^2}{2g} + z_2$$

$$\frac{140 \times 10^3}{9.81 \times 10^3} + \frac{V_1^2}{2g} + 0 = 0 + \frac{V_2^2}{2g} + 0$$

$$\frac{V_2^2 - V_1^2}{2g} = \frac{140 \times 10^3}{9.81 \times 10^3}$$

$$V_2^2 - V_1^2 = 280$$

$$\frac{4}{(0.14)^2} Q^2 - \frac{4}{(0.27)^2} Q^2 = 280$$

$$4Q^2 (51.02 - 13.7174) = 280$$

$$Q = 1.3698 \text{ m}^3/\text{sec}$$

Apply momentum equation in x-direction

$$P_1 A_1 - F_x = \rho Q (V_2 - V_1)$$

$$\because V_2 = 0$$

$$140\times10^3\times\frac{\pi}{4}\frac{(0.27)^2}{\pi}-F_x=1000\times1.3698\times\left(0-\frac{1.3698}{A}\right)$$

$$2.5515-F_x=-1369.8\times\frac{1.3698}{\frac{\pi}{4}\times\frac{0.27^2}{\pi}}$$

$F_x = 2.5515 + 102.9548$

$= 105.506$ kN

In y-direction apply momentum

$F_y = \rho Q V_2$

$$=1000\times1.3698\times\frac{1.3698}{\frac{\pi}{4}\times\frac{(0.14)^2}{\pi}}$$

$F_y = 382.9289$ kN

$\therefore$ Resultant force $F_R=\sqrt{F_x^2+F_y^2}$

$=\sqrt{105.506^2+382.9289^2}$

$= 397.1978$ kN

46. A 1 m wide rectangular channel has a bed slope of 0.0016 and the Manning's roughness coefficient is 0.04. Uniform flow takes place in the channel at a flow depth of 0.5 m. At a particular section, gradually varied flow (GVF) is observed and the flow depth is measured as 0.6 m. The GVF profile at that section is classified as

(A) S_1 (B) S_2 (C) M_1 (D) M_2

46. Ans: (C)

Sol:

$y = 0.6$ m

$y_n = 0.5$ m

$B = 1$ m

$S = 0.0016$

$n = 0.04$

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

$$q = \frac{Q}{B} = \frac{B.y_n.V}{B} = y_n^v$$

$$= y_n \times \frac{1}{n} \times R^{2/3} s^{1/2}$$

$$q = y_n \times \frac{1}{n}\left(\frac{y_n}{2}\right)^{2/3} s^{1/2}$$

$$= 0.5 \times \frac{1}{0.04}\left(\frac{0.5}{2}\right)^{2/3} 0.0016^{1/2}$$

$$q = 0.1984 \, m^3/s/m$$

$$y_c = \left(\frac{0.1984^2}{9.81}\right)^{1/3}$$

$$y_c = 0.1589 \text{ m}$$

$\therefore\ y > y_n > y_c$

The GVF profile at section of flow depth 0.6 is M_1

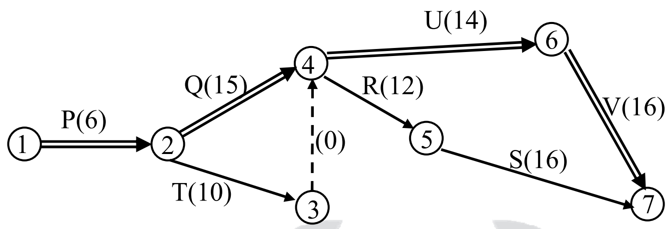
47. The activity details of a project are given below:

Activity	Depends on	Duration (in days)
P	--	6
Q	P	15
R	Q.T	12
S	R	16
T	P	10
U	Q.T	14
V	U	16

The estimated minimum time (in days) for the completion of the project will be ______

47. Ans: 51

Sol:



Path	Duration
P-Q-U-V	6+15+14+16 = 51
P-T-Dummy-U-V	6+10+0+14+16=46
P-T-Dummy-R-S	6+10+0+12+16=44

Minimum time for the completion of the project = 51 days

48. The following observations are made while testing aggregate for its suitability in pavement construction:

i. Mass of oven-dry aggregate in air = 1000 g

ii. Mass of saturated surface-dry aggregate in air = 1025 g

iii. Mass of saturated surface-dry aggregate under water = 625 g

Based on the above observations, the correct statement is

(A) bulk specific gravity of aggregate = 2.5 and water absorption = 2.5%

(B) bulk specific gravity of aggregate = 2.5 and water absorption = 2.4%

(C) apparent specific gravity of aggregate = 2.5 and water absorption = 2.5%

(D) apparent specific gravity of aggregate = 2.5 and water absorption = 2.4%

48. Ans: (A)

Sol: Bulk specific gravity; G

$$G = \frac{\text{oven dry weight}}{\text{Saturated surface dry weight} - \text{weight in water}}$$

$$= \frac{1000}{1025-625}$$

$$= 2.5$$

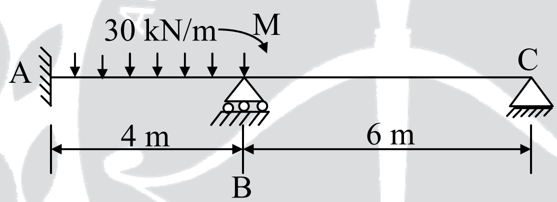
Water absorption; w

$$w = \frac{\text{saturated surface dry weight} - \text{oven dry weight}}{\text{oven dry weight} \times 100}$$

$$= \frac{1025-1000}{1000} \times 100$$

$$= 2.5\%$$

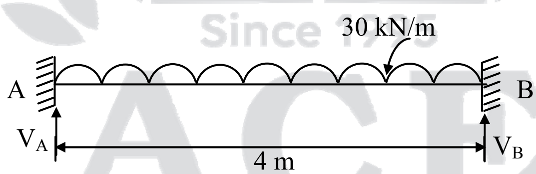
49. The value of M in the beam ABC shown in the figure is such that the joint B does not rotate.



The value of support reaction (in kN) at B should be equal to __________

49. Ans: 60 kN

Sol: If joint B is not allowed to rotate the AB portion behaves like a fixed beam



$$V_A = V_B = \frac{w\ell}{2} = \frac{30\times 4}{2} = 60\,\text{kN}$$

50. Two wastewater streams A and B, having an identical ultimate BOD are getting mixed to form the stream C. The temperature of the stream A to 20°C and the temperature of the stream C is 10°C. It is given that.

i. The 5-day BOD of the stream A measured at 20^o C = 50 mg/*l*

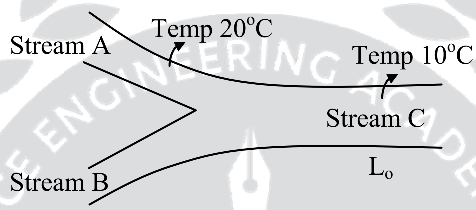
ii. BOD rate constant (base 10) at 20^oC = 0.115 per day

iii. Temperature coefficient = 1.135

The 5-day BOD (in mg/*l* up to one decimal place) of the stream C, calculated at 10^oC is _______

50. Ans: 21.2

Sol:



Ultimate BOD of stream A = ultimate BOD of stream B

$\therefore$ Ultimate BOD of stream 'C' = ultimate BOD of stream A = L_o

5 day BOD @ 20^oC for stream A $y_5^{20^oC}$

= 50 mg/*l*

$$\therefore y_5^{20^oC} = L_o\left[1-10^{-k_{20}\times 5}\right]$$

$$50 = L_o\left[1-10^{-0.115\times 5}\right]$$

$$L_o = 68.126 \text{ mg}/l$$

$$k_T = k_{20}\,(1.135)^{T-20}$$

$$k_{10} = 0.115\,(1.135)^{10-20} = 0.0324\ d^{-1}$$

5 day BOD of stream @ 10^oC

$$y_5^{10^oC} = L_o[1-10^{-k_{10}\times 5}]$$

$$= 68.126\left[1-10^{-0.0324\times 5}\right]$$

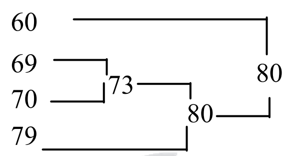
$$= 21.2 \text{ mg}/l$$

51. The equivalent sound power level (in dB) of the four sources with the noise levels of 60 dB, 69 dB, 70 dB and 79 dB is _____

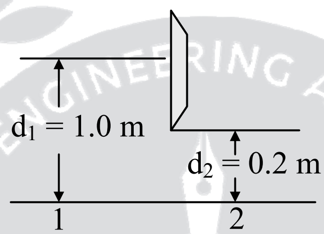
51. Ans: 80

Sol: $L_{equ} = 10\log_{10} \Sigma\left[10^{\frac{L_i}{10}} \times T_i\right]$

$$10\log_{10}\left[10^{\frac{60}{10}} + 10^{\frac{69}{10}} + 10^{\frac{70}{10}} + 10^{\frac{79}{10}}\right] = 79.92 \text{ dB} \simeq 80 \text{ dB}$$

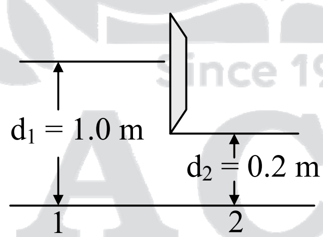


52. A sluice gate used to control the flow in a horizontal channel of unit-width is shown in figure



It is observed that the depth of flow is 1.0 m upstream of the gate, while the depth is 0.2 mm downstream of the gate. Assuming a smooth flow transition across the sluice gate, i.e., without any energy loss, and the acceleration due to gravity as 10 m/s^2, the discharge (in m^3/s, up to two decimal places) passing under the sluice gate is ______

52. Ans: 0.816



Sol: Since it is horizontal surface the specific energy is same at both upstream and downstream sections.

Equating specific energy's

$$E_1 = E_2$$

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

Let y_1 , y_2 and V_1, V_2 are the depths and velocitys of upstream and downstream sections respectively.

q = discharge per meter width

$$q = y_1V_1 \Rightarrow V_1 = \frac{q}{y_1}$$

$$q = y_2V_2 \Rightarrow V_2 = \frac{q}{y_2}$$

$$\therefore\ y_1 + \frac{q^2}{2gy_1^2} = y_2 + \frac{q^2}{2gy_2^2}$$

$$1 + \frac{q^2}{2\times10\times1^2} = 0.2 + \frac{q^2}{2\times10(0.2)^2}$$

$$1+0.05\ q^2 = 0.2 + 1.25q^2$$

$$0.8 = 1.2\ q^2$$

$$q = 0.816\ m^3/sec/m$$

$\therefore$ Discharge Q =0.816 m^3/sec ≈ 0.82

53. Consider the equation $\frac{du}{dt} = 3t^2 + 1$ with u = 0 at t = 0. This is numerically solved by using the forward Euler method with a step size. $\Delta t = 2$. The absolute error in the solution at the end of the first time step is _______

53. Ans: 8

Sol:

$$\frac{du}{dt} = 3t^2 + 1,\ u(0)=0,\ h = \Delta t = 2$$

$$\Rightarrow du = (3t^2 + 1)\ dt$$

$$\Rightarrow \int du = \int (3t^2 + 1)\ dt$$

$$\Rightarrow u = t^3 + t + c\ \ldots\ldots\ldots\ldots\ldots\ldots.\ (1)$$

$$u(0) = 0 : (1) \Rightarrow 0 = C$$

$$(1) \Rightarrow u = t^3 + t$$

Now, at t = 2, u = $2^3 + 2 = 10$ is the exact solution

The first approximation is

$u_1 = u_o + hf(t_o, u_o)$, where $f(t, u) = 3t^2 + 1$

$= 0 + 2\ f(0, 0)$

$= 2(1)$

$u_1 = 2$ is the numeral solution

(or) approximate solution

Error = |exact solution – approximate solution|

$= |10 - 2|$

$= 8$

54. The observed bearings of a traverse are given below

Line	Bearing		Line	Bearing
PQ	$46^o\ 15'$		QP	$226^o\ 15'$
QR	$108^o\ 15'$		RQ	$286^o\ 15'$
RS	$201^o\ 30'$		SR	$20^o\ 30'$
ST	$321^o\ 45'$		TS	$141^o\ 45'$

The station(s) most likely to be affected by the local attraction is /are

(A) Only R (B) Only S (C) R and S (D) P and Q

54. Ans: (a)

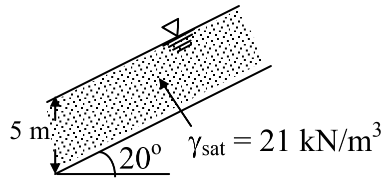
Sol: Difference between FB & BB & PQ = 180^o

Difference between FB & BB of TS = 180^o

Hence stations P,Q,T & S are free from local attraction

But station 'R' is affected by local attraction.

55. The infinite sand slope shown in the figure is on the verge of sliding failure. The ground water table coincides with the ground surface. Unit weight of water $\gamma_w = 9.81$ kN/m^3.



The value of the effective angle of internal friction (in degrees, up to one decimal place) of the sand is ______

55. Ans: 34.3

Sol: For an infinite slope with seepage parallel to slope the F.O safety against sliding,

$$F = \frac{\gamma'}{\gamma_{sat}} \frac{\tan\varphi'}{\tan i} \text{ (For pure sands)}$$

If F = 1, the slope will be at verge of failure

$$\therefore\ 1 = \frac{\gamma'}{\gamma_{sat}} \frac{\tan\varphi'}{\tan i}$$

$$1 = \frac{\gamma_{sat} \cdot \gamma_w}{\gamma_{sat}} \frac{\tan\varphi'}{\tan i}$$

$$1 = \frac{21 - 9.81}{21} \frac{\tan\phi'}{\tan 20°}$$

$$\therefore\ \phi = 34.34°$$

Say = 34.3′

Section: General Aptitude

01. Consider the following sentences.

All benches are beds. No bed is a bulb. Some bulbs are lamps.

Which of the following can be inferred ?

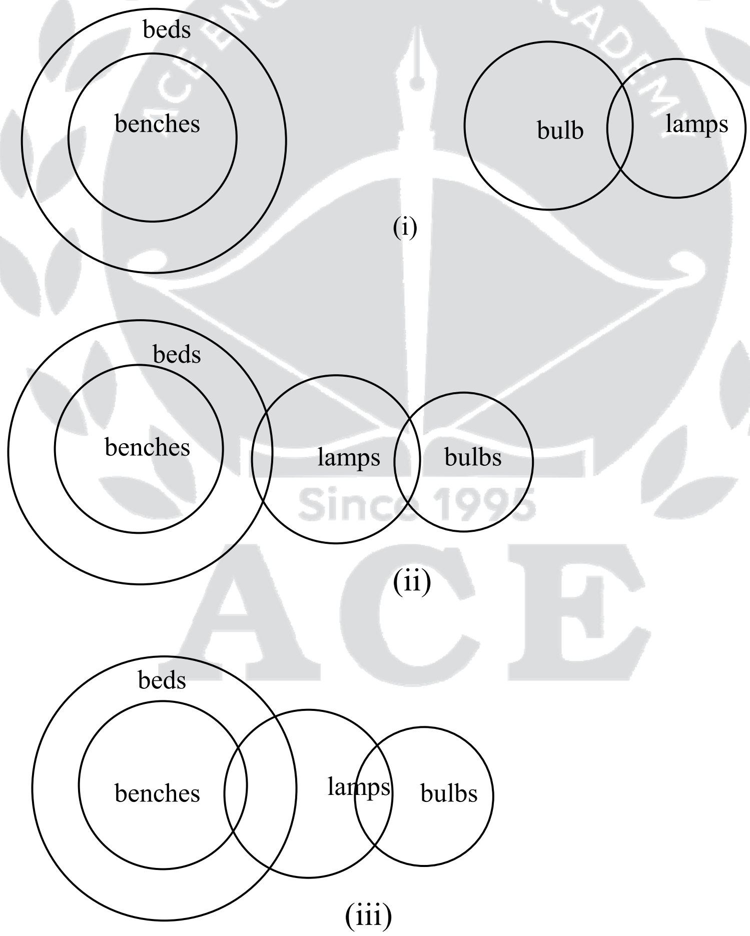
i. some beds are lamps

ii. some lamps are beds

(A) Only i (B) Only ii (C) Both i and ii (D) Neither i nor ii

01. Ans: (D)

Sol: From the given statements, the following venn diagrams are possible



Given conclusions (i) and (ii) are not possible from the above diagrams, so option (D) is correct.

02. The following sequence of numbers is arranged in increasing order: 1, x, x, x, y, y, 9, 16, 18 given that the mean and median are equal, and are also equal to twice the mode, the value of y is

(A) 5 (B) 6 (C) 7 (D) 8

02. Ans: (D)

Sol: Given increasing order of number sequence is

1,x,x,x,y,y,9,16,18

Total number of numbers = 9

Mean = Median = 2 Mode (given)

$$\text{Mean} = \frac{\text{sum of numbers}}{\text{Total no. of numbers}}$$

$$= \frac{1+x+x+x+y+y+9+16+18}{9}$$

$$= \frac{1+3x+2y+16+18+9}{9}$$

$$= \frac{3x+2y+44}{9} \text{ .... (i)}$$

Median ⇒ As number of terms are odd (i.e) 9 so, median will be middle of the sequence = y

Mode = Number showing maximum frequency of repetition = x (three times)

From the given condition

$$y = 2x \text{ .... (ii)}$$

By solving equation (i) and (ii), we get

$$x = 4, y = 8$$

∴ The value of y is 8

03. If the radius of a right circular cone is increased by 50% its volume increases by

(A) 75% (B) 100% (C) 125% (D) 237.5%

03. Ans: (C)

Sol: Volume of a right circular cone

$$V = \frac{1}{3}\pi R^2 H$$

R = radius of a cone

H = height of the cone

$V \propto R^2$

$V_1 = R^2$

$V_2 = (1.5)^2 R^2$ with increasing

$V_2 = 2.25 R^2 = 2.25V_1$

$$\therefore \text{ Volume increases} = \frac{V_2 - V_1}{V_1} \times 100$$

$$= \frac{2.25V_1 - V_1}{V_1} \times 100$$

$$= \frac{V_1(1.25)}{V_1} \times 100$$

$$= 1.25 \times 100 = 125\%$$

04. __________ with someone else's email account is now a very serious offence

(A) Involving (B) Assisting (C) Tampering (D) Incubating

04. Ans: (C)

Sol: Tampering means to carry on under hand or improper negotiations/ to interfere so as to weaken/ change for the worse.

05. The bacteria in milk are destroyed when it ______ heated to 80 degree Celsius.

(A) would be (B) will be (C) is (D) was

05. Ans: (C)

Sol: Habitual action/automatic results.

06. Students applying for hostel rooms are allotted rooms in order of seniority. Students already staying in a room will move if they get a room in their preferred list. Preferences of lower ranked applicants are ignored during allocation.

Given the data below, which room will Ajit stay in?

Names	Student seniority	Current Room	Room preference list
Amar	1	P	R.S.Q
Akbar	2	None	R.S
Anthony	3	Q	P
Ajit	4	S	Q.P.R

(A) P (B) Q (C) R (D) S

06. Ans: (B)

Sol: From given table, According to their preferences Room 'R' is preferred by Amar, Akbar and Ajit but Amar is senior so, Room 'R' is for Amar and from the preference list Akbar is compulsory stay in Room 'S' only, Anthony is preferred only one room 'P' only so, P is for Anthony.

$\therefore$ The room for Ajit is 'Q'

Persons	Rooms to be allotted
Amar	R
Akabr	S
Anthony	P
Ajit	Q

07. Two machines M1 and M2 are able to execute any of four jobs P,Q,R and S. The machines can perform one job on one object at a time. Jobs P,Q,R and S take 30 minutes, 20 minutes, 60 minutes and 15 minutes each respectively. There are 10 objects each requiring exactly 1 job. Job P is to be performed on 2 objects. Job Q on 3 objects. Job R on 1 object and Job S and 4 objects. What is the minimum time needed to complete all the jobs?

(A) 2 hours (B) 2.5 hours (C) 3 hours (D) 3.5 hours

07. Ans: (A)

Sol: If Machine M_1 is able to execute jobs P and Q

If Machine M_2 is able to execute jobs R and S

For Job 'P' time taken 30 minutes with 2 objects

$= 2\times 30 = 60$ min

For Job 'Q' is taken 20 minutes with 3 objects

$= 20 \times 3 = 60$ min

$\therefore$ Total time taken by Machine (M_1) for jobs P and Q

$= 60$ min $+ 60$ min $= 2$ hrs

For Job 'R' is taken 60 min with 1 object

$= 60 \times 1 = 60$ min

For Job 'S' is taken 15 min with 4 objects

$= 4 \times 15 = 60$ min

$\therefore$ Total time taken by machine (M_2) for Jobs R and S $= 60 + 60 = 2$ hrs

08. The last digit of $(2171)^7 + (2172)^9 + (2173)^{11} + (2174)^{13}$ is

(A) 2 (B) 4 (C) 6 (D) 8

08. Ans: (B)

Sol: Given equation

$(2171)^7 + (2172)^9 + (2173)^{11} + (2174)^{13}$

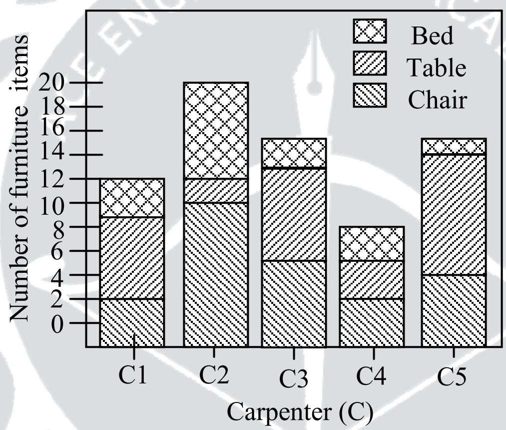
All power values are divide with 4 then the possible remainders are 3, 1, 3 and 1

$(1)^3 + (2)^1 + (3)^3 + (4)^1$

1+2+27+4 = 34

∴ The last digit is '4'

09. The bar graph below shows the output of five carpenters over one month, each of whom made different items of furniture : chairs, tables, and beds



Consider the following statements

i. The number of beds made by carpenter C2 is exactly the same as the number of tables made by carpenter C3.

ii. The total number of chairs made by all carpenters is less than the total number of tables

Which one of the following is true?

(A) Only i (B) Only ii (C) Both i and ii (D) Neither i nor ii

09. Ans: (C)

Sol: From the given bar graph,

(i) The number of beds made by carpenter C_2 = The number tables made by carpenter C_3

8 Nos = 8 Nos

$\therefore$ Statement (i) is true

(ii) The total number of chairs made by all carpenters = $C_1 + C_2 + C_3 + C_4 + C_5$

= 2+10+5+2+4 = 23 Nos

The total numbers of tables made by all carpenters = $C_1 + C_2 + C_3 + C_4 + C_5$

= 7+2+8+3+9 = 29 Nos

23 Nos < 29 Nos

$\therefore$ Statement (ii) is also true

$\therefore$ Both the statements (i) and (ii) are true

10. The old concert hall was demolished because of fears that the foundation would be affected by the construction of the new metro line in the area. Modern technology for underground metro construction tried to mitigate the impact of pressurized air pockets created by the excavation of large amounts of soil. But even with these safeguards, it was feared that the soil below the concert hall would not be stable.

From this, one can infer that

(A) The foundation of old buildings create pressurized air pockets underground, which are difficult to handle during metro construction

(B) Metro construction has to be done carefully considering its impact on the foundations of existing buildings

(C) Old buildings in an area form an impossible hurdle to metro construction in that area

(D) Pressurized air can be used to excavate large amounts of soil from underground areas.

10. Ans: (B)