GATE 2005

1. Consider the matrices $X_{(4,3)}, Y_{(4,3)}$ and $P_{(2,3)}$. The order of $\left(P\left(X^T Y\right)^{-1} P^T\right)^T$ will be

   (A) (2×2) (B) (3×3) (C) (4×3) (D) (3×4)

Answer:- (A)

Exp:- Considering the matrices the order of

$\left(P\left(x^T\ y\right)^{-1} P^T\right)^T$ will be 2×2

2. Consider a non-homogeneous system of linear equations representing mathematically an over-determined system. Such a system will be

   (A) Consistent having a unique solution
   (B) Consistent having many solutions
   (C) Inconsistent having unique solution
   (D) Inconsistent having no solution

Answer:- (A)

3. Which of the following is NOT true for complex number Z_1 and Z_2?

   (A) $\dfrac{Z_1}{Z_2} = \dfrac{Z_1 \overline{Z_2}}{|Z_2|^2}$ (B) $|Z_1 + Z_2| \le |Z_1| + |Z_2|$

   (C) $|Z_1 + Z_2| \le |Z_1| + |Z_2|$ (D) $|Z_1 + Z_2|^2 + |Z_1 - Z_2|^2 = 2|Z_1|^2 + 2|Z_2|^2$

Answer:- (C)

4. Which one of the following statement is NOT true?

   (A) The measure of skewness is dependent upon the amount of dispersion.
   (B) In a symmetric distribution, the values of mean, mode and median are the same
   (C) In a positively skewed distribution: mean > median > mode
   (D) In a negatively skewed distribution: mode>mean>median

Answer:- (D)

5. IS: 1343 – 1980 limits the minimum characteristic strength of pre-stressed concrete for post tensioned works and pretension work as

   (A) 25MPa, 30MPa respectively (B) 25MPa, 35MPa respectively
   (C) 30MPa, 35MPa respectively (D) 30MPa, 40MPa respectively

Answer:- (D)

6. The permissible stress in axial tension s_{st} in steel member on the net effective area of the section shall not exceed the following value (f_y is the yield stress)

   (A) $0.80f_y$ (B) $0.75f_y$ (C) $0.60f_y$ (D) $0.50f_y$

Answer:- (C)

7. The partial factor of safety for concrete as per IS: 456-2000 is

(A) 1.50 (B) 1.15 (C) 0.87 (D) 0.446

Answer:- (A)

Explanation:-The partial factor of safety for concrete as per IS:456-2000 is 1.50

8. The symmetry of stress tensor at a point in the body under equilibrium is obtained from

(A) Conservation of mass (B) Force equilibrium equations

(C) Moment equilibrium equations (D) Conservation of energy

Answer:- (C)

9. The components of strain tensor at a point in the plane strain case can be obtained by measuring longitudinal strain in following directions.

(A) Along any two arbitrary directions

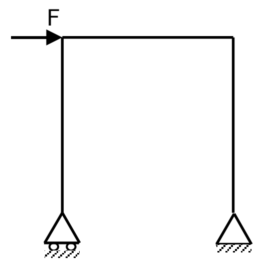
(B) Along any three arbitrary directions

(C) Along two mutually orthogonal directions

(D) Along any arbitrary direction

Answer:- (B)

10. Consider beam as axially rigid, the degree of freedom of a plane frame shown below is



(A) 9

(B) 8

(C) 7

(D) 6

Answer:- (D)

Exp:- Let us take j=number of joints

The degree of freedom of given frame

= {3j-(number of constraints + number of members)}

$= 3 \times 4 - (3+3) = 12 - 6 = 6$

11. For a linear elastic frame, if stiffness matrix is doubled, the existing stiffness matrix, the deflection of the resulting frame will be

(A) twice the existing value (B) half the existing value

(C) the same as existing value (D) indeterminate value

Answer:- (C)

Exp:- The deflection of the resulting frame will be the same as existing value

12. A clayey soil has a maximum dry density of 16kN/m^3 and optimum mo content of 12%. A contractor during the construction of core of an earth d obtained the dry density 15.2kN/m^3 and water content 11%. This construction i acceptable because

(A) The density is less than the maximum dry density and water content is on dry side of optimum.

(B) The compaction density is very low and water content is less than 12%

(C) The compaction is done on the dry side of the optimum

(D) Both the dry density and water content of the compacted soil are within the desirable limits

Answer:- (D)

13. Root time method is used to determine

(A) T, time factor

(B) c_v, coefficient of consolidation

(C) a_v, coefficient of compressibility

(D) m_v, coefficient of volume compressibility

Answer:- (B)

Exp:- Root time method is used to determine c_v' coefficient of consolidation

14. Negative skin friction in a soil is considered when the pile is constructed through a

(A) fill material
(B) dense coarse sand
(C) over consolidated stiff clay
(D) dense fine sand

Answer:- (A)

Exp:- Negative skin friction in a soil is considered when the pile is constructed through a fill material

15. There are two footings resting on the ground surface. One footing is square of dimension 'B'. The other is strip footing with width 'B'. Both of them are subjected to a loading intensity of q. The pressure intensity at any depth below the base of the footing along the centreline would be

(A) Equal in both footings

(B) Large for square footing and small for strip footing

(C) Large for strip footing and small for square footing

(D) More for strip footing at shallow depth (≤B) and more for square footing at large depth (>B)

Answer:- (C)

16. An inert tracer is injected continuously from a point in an unsteady flow field. The locus of locations of all the tracer particles at an instance of time represents

(A) Streamline
(B) Pathline
(C) Steamtube
(D) Strekline

Answer:- (D)

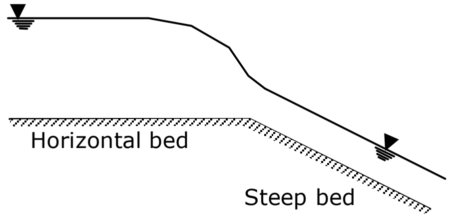
17. A horizontal bed channel is followed by a steep bed channel as shown figure. The gradually-varied profiles over the horizontal and steep beds are

(A) H_2 and S_2 respectively

(B) H_2 and S_1 respectively

(C) H_3 and S_2 respectively

(D) H_3 and S_1 respectively



Answer:- (A)

18. The reading of differential manometer of a Venturimeter, placed at 45º to the horizontal is 11cm. If the Ventruimeter is turned to horizontal position, the manometer reading will be

(A) zero (B) $\frac{11}{\sqrt{2}}$ cm (C) 11cm (D) $11\sqrt{2}$ cm

Answer:- ()

Exp:- The reading of differential manometer of a venturimeter is independent of angle of inclination of venturimeter

19. The intensity of rainfall and time interval of typical storm are

Time interval (minutes)	**Intensity of rainfall (mm / minute)**
0.10	0.7
10-20	1.1
20-30	2.2
30-40	1.5
40-50	1.2
50-60	1.3
60-70	0.9
70-80	0.4

The maximum intensity of rainfall for 20 minutes duration of the storm is

(A) 1.5 mm/min (B) 1.85 mm/min (C) 2.2 mm/min (D) 3.7 mm/min

Answer:- (B)

Exp:- $\text{Intensity} = \frac{\text{Rainfall}}{\text{time}} = \frac{2.2\times10+1.5\times10}{20} = \frac{37}{20} = 1.85\text{mm / minute.}$

20. When the outflow from a storage reservoir is uncontrolled as in a freely operating spillway, the peak of outflow hydrograph occurs at

(A) The point of inter-section of the inflow and outflow hydrographs

(B) A point, after the inter-section of the inflow and outflow hydrographs

(C) The tail of inflow hydrographs

(D) A point, before the inter-section of the inflow and outflow hydrographs

Answer:- (A)

21. On which of the canal systems, R.G. Kennedy, executive engineer in the Punjab Irrigation Department made his observations for proposing his theory on stable channels?

(A) Krishna Western Delta canals
(B) Lower Bari Doab canals
(C) Lower Chenab canals
(D) Upper Bari Doab canals

Answer:- (D)

22. Which one of the following equations represents the downstream profile of Ogee spillway with vertical upstream face? {(x,y) are the co-ordinates of the point on the downstream profile with origin at the crest of the spillway and H_d is the design head}

(A) $\frac{y}{H_d} = -0.5\left(\frac{x}{H_x}\right)^{1.85}$
(B) $\frac{y}{H_d} = -0.5\left(\frac{x}{H_d}\right)^{\frac{1}{1.85}}$
(C) $\frac{y}{H_d} = -2.0\left(\frac{x}{H_d}\right)^{1.85}$
(D) $\frac{y}{H_d} = -2.0\left(\frac{x}{H_d}\right)^{\frac{1}{1.85}}$

Answer:- (A)

Exp:- When down-stream profile Ogee spillway whose up-stream face is vertical, then centre of crest is,

$$x^{1.85} = 2H_d^{0.85} \cdot y \Rightarrow \left[\frac{x}{H_d}\right]^{1.85} = -2\frac{H_d^{0.85}}{H_d^{1.85}} \cdot y = -2\frac{y}{H_d} \Rightarrow \left(\frac{y}{H_d}\right) = -0.5\left(\frac{x}{H_d}\right)^{1.85}$$

23. In aerobic environment, nitrosomonas convert

(A) NH_3 to NO_2
(B) NO_2^- to NO_3^-
(C) NH_3 to N_2O
(D) NO_2^- to HNO_3

Answer:- (A)

Exp:- Oxidation occurs in an aerobic environment.

So, NH_3 converts into NO_2

24. Total Kjeldahl nitrogen is a measure of

(A) Total organic nitrogen
(B) Total organic and ammonia nitrogen
(C) Total ammonia nitrogen
(D) Total inorganic and ammonia nitrogen

Answer:- (B)

Exp:- If an unboiled sample is used to add $KMnO_4$, before boiling, the evolved ammonia gas will measure the sum total of ammonium nitrogen as well as organic nitrogen. It is known as "Kjedahl nitrogen".

25. 1 TCU is equivalent to the colour produced by
(A) 1mg / L of chlorplatinate ion
(B) 1 mg/L of platinum ion
(C) 1mg/L Platinum in form of chlorplatinate ion
(D) 1mg/L of organo-chlorplatinate ion

Answer:- (C)

26. Bulking sludge refers to having
(A) F/M <0.3/d (B) 0.3/d<F/M<0.6/d
(C) F/M = zero (D) F/M>0.6/d

Answer:- (A)

27. Pradhan Mantri Gram Sadak Yojna (PMGSY), launched in the year 2000, aims to provide rural connectivity with all-weather roads. It is proposed to connect the habitations in plain areas of population more than 500 persons by the year
(A) 2005 (B) 2007 (C) 2010 (D) 2012

Answer:- (B)

28. Group I contains some properties of Bitumen. Group II gives a list Laboratory Tests conducted on Bitumen to determine the properties. Match the property with the corresponding test

	Group I		**Group II**
P.	Resistance to flow	1.	Ductility test
Q.	Ability to deform under load	2.	Penetration test
R.	Safety	3.	Flash and Fire point test

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

Answer:- ()

29. The length of Summit Curve on a two lane two way highway depends upon
(A) Allowable rate of change of centrifugal acceleration
(B) Coefficient of lateral friction
(C) Required Stopping Sight Distance (D) Required Overtaking Sight Distance

Answer:- (C)

Exp:- Let N=Deviation angle, S=SSD (Stopping Sight Distance) and L = length of Summit curve

i. if $L > SSD$, then $L = \frac{NS^2}{4.4}$

ii. if $L < SSD$, then $L = 25\frac{4.4}{N}$

Length of summit curve on a two lane two way highway depends upon required SSD

30. Bituminous concrete is a mix comprising of
    (A) Fine aggregate, filler and bitumen
    (B) Fine aggregate and bitumen
    (C) Coarse aggregate, fine aggregate, filler and bitumen
    (D) Coarse aggregate, filler and bitumen

Answer:- (C)

Exp:- Bituminous concrete is a mixture comprising of coarse aggregate, fine aggregate, filler and bitumen.

31. Consider the system of equations $A_{(nxn)}X_{(nxf)} = l_{(nx1)}$ where, 1 is a scalar.

    Let (l_i, x_i) be an eigen-pair of an eigen value and its corresponding eigen vector for real matrix A. Let I be a (n'n) unit matrix. Which one of the following statement is NOT correct?

    (A) For a homogeneous n x n system of linear equations $(A - II)x = 0$ having a nontrivial solution, the rank of (A-II) is less than n.

    (B) For matrix A^m, m being a positive integer, $\left(\lambda_i^x, x_i^m\right)$ will be the eigen-pair for all i.

    (C) If $A^T = A^{-1}$, then $|l_i| = 1$ for all i.
    (D) If $A^T = A$, then l_i is real for all i

Answer:- (D)

Exp:-

32. Transformation to linear form by substituting $v = y^{1-n}$ of the equation

    $\frac{dy}{dt} + p(t)y = q(t)y^n$; n>0 will be

    (A) $\frac{dv}{dt} + (1-n)pv = (1-n)q$
    (B) $\frac{dv}{dt} + (1-n)pv = (1+n)q$
    (C) $\frac{dv}{dt} + (1+n)pv = (1-n)q$
    (D) $\frac{dv}{dt} + (1+n)pv = (1+n)q$

Answer:- (A)

Exp:-

$$\frac{dy}{dt}+P(t)y=q(t)y^n, n>0$$

dividing both sides by y^n we get,

$$y^{-n}\frac{dy}{dt}+P(t)y^{1-n}=P(t)......(i)$$

if $v=y^{1-n}$, then $\frac{dy}{dt}=\left[(1-n)y^{-n}\frac{dy}{dt}\right]$

Putting values in equation (i) we get,

$$\frac{1}{1-n}\frac{dv}{dt}+P(t)v=q(t)$$

Multiplying both sides by $(1-n)$ we get,

$$\frac{dv}{dt}+(1-n)P(t)v=q(t)(1-n)$$

33. A rail engine accelerates from its stationary position for 8 seconds and travels a distance of 280m. According to the Mean Value Theorem, the speedometer at a certain time during acceleration must read exactly

(A) 0km/h (B) 8km (C) 75km/h (D) 126km/h

Answer:- (D)

Exp:- As per Mean value theorem, the speedometer at a centre line during each reading

$$=\frac{\text{Travelled distance}}{\text{Time}}=\frac{280}{8}m/sec=\frac{280}{8}\times\frac{18}{5}kmp/h=128Km/h$$

34. The solution of $\frac{d^2y}{dx^2}+2\frac{dy}{dx}+17y=0;\ y(0)=1$,

$\frac{dy}{dx}\left(\frac{p}{4}\right)=0$ in the range $0<x<\frac{\pi}{4}$ is given by

(A) $e^{-x}\left(\cos 4x+\frac{1}{4}\sin 4x\right)$ (B) $e^{x}\left(\cos 4x-\frac{1}{4}\sin 4x\right)$

(C) $e^{-4x}\left(\cos x-\frac{1}{4}\sin x\right)$ (D) $e^{-4x}\left(\cos 4x-\frac{1}{4}\sin 4x\right)$

Answer:- (A)

Exp:-

$\frac{d^2y}{dx^2}+2.\frac{dy}{dx}+17y=0 \therefore \left(D^2+2D+17\right)y=0$

$\Rightarrow D^2+2D+17=0 \therefore \; D=-1\pm 4i$

So, the solution is $y=e^{-x}\left(c_1e^{+4ix}+c_2e^{-4ix}\right)$

$=e^{-x}\left\{c_1\left(\cos 4x+i\sin 4x\right)+c_2\left(\cos 4x-i\sin 4x\right)\right\}$

$=e^{-x}\left\{\left(c_1+c_2\right)\cos 4x+i\left(c_1-c_2\right)\sin 4x\right\}....(i)$

From given condition

$y(0)=1$

$1=c_1+c_2$

Now, $\frac{dy}{dx}=e^{-x}\left\{-4\left(c_1+c_2\right)\sin 4x+4i\left(c_1-c_2\right)\cos 4x\right\}$

$-e^{x}\left\{\left(c_1+c_2\right).\cos 4x+i\left(c_1-c_2\right)\cos 4x\right\}.....(ii)$

35. Value of the integral $\oint_c\left(xydy-y^2dx\right)$ where c is the square cut from the first quadrant by the line x=1 and y=1 will be (Use Green's theorem to change the line integral into double integral)

(A) $\frac{1}{2}$ (B) 1 (C) $\frac{3}{2}$ (D) $\frac{5}{3}$

Answer:- (B)

Exp:- The value of the integral by using Green's theorem is 1.

36. Consider likely applicability of Cauchy's Integral Theorem to evaluate the following integral counter clockwise around the unit circle c.

$I=\oint_C \sec z \, dz$. z being a complex variable. The value of I will be

(A) I = 0: singularities set = ϕ

(B) I=0: singularities set = $\left\{\pm\frac{2n+1}{2}\pi \; n=0,1,2.........\right\}$

(C) I=$\frac{\pi}{2}$: singularities set = $\left\{\pm n\pi \; | n=0,1,2.........\right\}$ (D) None of these

Answer:- (A)

Exp:- Z being a complex variable the value of I will be '0': singularities set = ϕ

37. A concrete beam of rectangular cross section of 200mm x40mm is pre-stressed with a force 400kN at eccentricity 100mm. the maximum compressive stress in the concrete is

(A) 12.5N/mm^2 (B) 7.5 N/mm^2 (C) 5.0 N/mm^2 (D) 2.5 N/mm^2

Answer:- ()

Exp:- Datas given are

$b = 200mm$

$d = 400mm$

$e = 100mm$

$P = 400kN$

maximum compressive strength in the concrete

$$= \frac{P}{A} + \frac{Pe}{Z} \text{ where } Z = \text{section modulus} = \frac{bd^2}{6}$$

$$= \frac{400 \times 1000}{200 \times 400} + \frac{400 \times 1000 \times 100 \times 6}{200 \times 400^2} = 12.5N/mm^2$$

38. Which of the following is NOT correct for steel sections as per IS: 800-1984?

(A) The maximum bending stress in tension or in compression in extreme fibre calculated on the effective section of a beam shall not exceed $0.66f_y$.

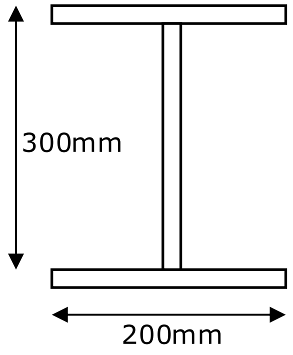
(B) The bearing stress in any part of a beam when calculated on the net area shall not exceed $0.75f_y$.

(C) The direct stress in compression on the gross sectional area of axial loaded compression member shall not exceed $0.6f_y$.

(D) None of these

Answer:- (D)

39. An unstiffened web I section is fabricated from a 10mm thick plate by fillet welding as shown in the figure. If yield stress of steel is 250MPa, the maximum shear load that section can take is



(A) 750kN

(B) 350kN

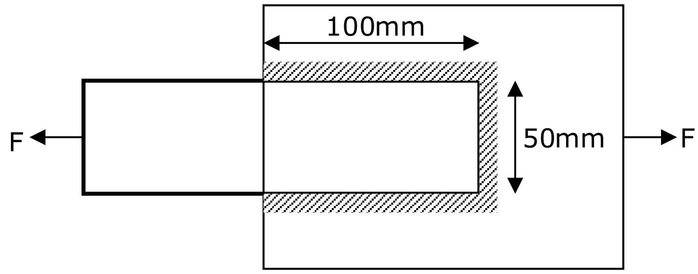
(C) 337.5kN

(D) 300kN

Answer:- (D)

Exp: The maximum shear load the section can take as per figure is 300kN.

40. A fillet-welded joint of 6mm size is shown in the figure. The welded surfaces at 60-90 degree and permissible stress in the fillet weld is 108MPa. The safe that can be transmitted by the joint is



(A) 162.7kN (B) 151.6kN (C) 113.4kN (D) 109.5kN

Answer:- (C)

Exp:- $F = \ell \times t \times P_q$

t = throat thickness

ℓ = effective length $= 2 \times 100 + 50 = 250$mm

P_q = Permissible stress = 108MPa (given)

F = Safe Load

S = Size of fillet weld

$F = 0.7\ell \times S \times P_q$

$= 0.7 \times 250 \times 6 \times 180 = 113.4$kN

41. A cantilever beam of length 1, width b and depth d is loaded with a concentrated vertical load at the tip. If yielding starts at a load P, the collapse load shall be

(A) 2.0P (B) 1.5P (C) 1.2P (D) P

Answer:- (B)

Exp:- The collapse load of the cantilever beam will be 1.5P

42. The flexural strength of M 30 concrete as per IS: 456-2000 is

(A) 3.83MPa (B) 5.47MPa (C) 21.23MPa (D) 30.0MPa

Answer:- (A)

Exp:- Flexural strength of concrete $= 0.7\sqrt{f_{ck}}$

Given M30, hence $f_{ck} = 30\text{N/mm}^2$

$\therefore$ Flexural strength of concrete $= 0.7\sqrt{30} = 3.83$MPa

43. In a random sampling procedure for cube strength of concrete, one sample consists of X number of specimens. The specimens are tested at 28 days and average strength of these X specimens is considered as test result of the sample, provided the individual variation in the strength of specimens is not more than $\pm$Y percent of the average strength. The values of X and Y as per IS: 456-2000 are

(A) 4 and 10 respectively (B) 3 and 10 respectively

(C) 4 and 15 respectively (D) 3 and 15 respectively

Answer:- (D)

Exp:- As per IS:456-2000 for random sampling number of specimens take n = 3
Average strength variation 15% is permitted, x=3, y=15

44. A rectangular column section of 250mm x 400mm is reinforced with five steel bars of grade Fe 500, each of 20mm diameters. Concrete mix is M30. Axial load on the column section with minimum eccentricity as per IS: 456-2000 using limit state method can be applied upto

(A) 1707.37 (B) 1805.30 (C) 1806.40 (D) 1903.7

Answer:- (A)

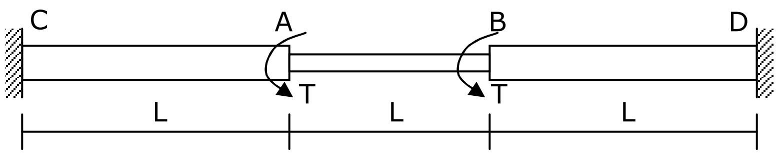
Exp:- $A = 250 \times 400 = 10^5 mm^2$

$A_{sc} = 5 \times \frac{\pi}{4}(20)^2 = 1570 \cdot 8mm^2$

$A_c = A - A_s = 98429 \cdot 2mm^2$, Axial Load $P_n = 0 \cdot 4f_{ck}A_c + 0.67f_y \cdot A_{sc}$

$= 0 \cdot 4 \times 30 \times 98429 \cdot 2 + 0 \cdot 67 \times 500 \times 1570 \cdot 8 = 1707 \cdot 37kN$

45. A circular shaft shown in the figure is subject to torsion T at two points A and B. The torsional rigidity of portions CA and BD is GJ_1 and that of portion AB is GJ_2. The rotations of shaft at points A and B are θ_1 and θ_2. The rotation θ_1 is



(A) $\frac{TL}{GJ_1 + GJ_2}$ (B) $\frac{TL}{GJ_1}$ (C) $\frac{TL}{GJ_2}$ (D) $\frac{TL}{GJ_1 - GJ_2}$

Answer:- (A)

Exp:- Rotation, $\theta = \frac{TL}{GJ_1 + GJ_2}$

46. If the principle stresses in a two-dimensional case are -10MPa and 20MPa respectively, then maximum shear stress at the point is

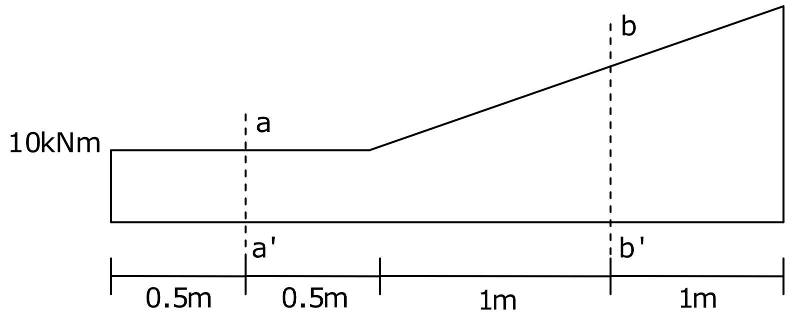
(A) 10MPa (B) 15MPa (C) 20MPa (D) 30MPa

Answer:- (B)

Exp:- Hence $S_1 = 20MPa$ and $S_2 = 10MPa$

Maximum shear stress at a point $= \frac{\sigma_1 - \sigma_2}{2} = \frac{20-(-10)}{2} = 15MPa$

47. The bending Moment diagram for a beam is given below:



The shear force at sections aa′ and bb′ respectively are of the magnitude

(A) 100kN, 150kN (B) zero, 100kN

(C) zero, 50kN (D) 100kN, 100kN

Answer:- ()

Exp:- Shear force at section $aa' = 0\,(\text{because at aa}', \text{BMD} = \text{Constant})$

Shear force at section $bb' = \dfrac{200-100}{2} \times 1 = 50\text{kN}$

48. For a 25cm thick cement concrete pavement, analysis of stresses gives the following values

Wheel load stress due to corner loading	30kg/cm^2
Wheel load stress due to edge loading	32kg/cm^2
Warping stress at corner region during summer	9 kg/cm^2
Warping stress at corner region during winter	7 kg/cm^2
Warping stress at edge region during summer	8 kg/cm^2
Warping stress at edge region during winter	6 kg/cm^2
Frictional Stress during summer	5 kg/cm^2
Frictional Stress during winter	4 kg/cm^2

The most critical stress value for this pavement is

(A) 40 kg/cm^2 (B) 42 kg/cm^2 (C) 44 kg/cm^2 (D) 45 kg/cm^2

Answer:- (C)

Exp:- A. Critical stress combination (during summer)

= (Load stress + war ping stress – frictional stress) (at edge)

$= (32 + 8 - 5) = 35\text{kg/cm}^2$

B. Critical stress combination (during winter)

= (Load stress + war ping stress + frictional stress) (at edge)

$= 32 + 6 + 4 = 42\text{kg/cm}^2$

C. Critical stress combination in summer at midnight

= (Load stress + war ping stress) (at corner)

$= (30 + 9) = 39\text{kg/cm}^2$

D. Critical stress combination at midnight in winter

= (Load stress + war ping stress) (at corner)

$= (39+9) = 39kg/cm^2$

Hence most critical stress value for the pavement is $42kg/cm^2$

49. Match the following:

Group 1

P Slope deflection method

Q Moment deflection method

R Method of three moments

S Castigliano's second theorem

Group 2

1 Force method

2 Deflection method

(A) P-1, Q-2, R-1, S-2 (B) P-1, Q-1, R-2, S2

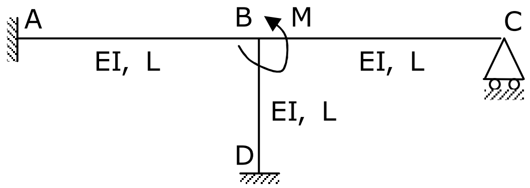
(C) P-2, Q-2, R-1, S-1 (D) P-2, Q-1, R-2, S-1

Answer:- (C)

50. All members of the frame shown below have the same flexural rigidity EI and length L. If a moment M is applied at joint B, the rotation of the joint is

(A) $\frac{ML}{12EI}$ (B) $\frac{ML}{11EI}$

(C) $\frac{ML}{8EI}$ (D) $\frac{ML}{7EI}$



Answer:- (B)

Exp:- M is applied at B

$$\therefore\ M = \frac{4EI\theta_1}{L} + \frac{4EI\theta_2}{L} + \frac{3EI\theta_3}{L}$$

$$\text{Relation at the joint} = \theta_1 + \theta_2 + \theta_3 = \theta \therefore\ \theta = \frac{ML}{11EI}$$

51. A soil mass contains 40% gravel, 50% sand and 10% silt. This soil can be classified as

(A) silty sandy gravel having coefficient of uniformity less that 60

(B) silty gravelly sand having coefficient of uniformity equal to 10.

(C) gravelly silty sand having coefficient of uniformity greater than 60.

(D) gravelly silty sand and its coefficient of uniformity cannot be determined.

Answer:- ()

Exp:- As the soil contains 40% gravel, 50% sand and 10% silt, the soil will be silty, gravelly

52. A saturated soil mass has a total density $22kN/m^3$ and water content of The bulk density and dry density of this soil are

(A) $12kN/m^3$ and $20kN/m^3$ respectively

(B) $22kN/m^3$ and $20kN/m^3$ respectively

(C) $19.8kN/m^3$ and $19.8kN/m^3$ respectively

(D) $23.2kN/m^3$ and $19.8kN/m^3$ respectively

Answer:- (B)

Exp:- Bulk density $= 22kN/m^3$

Dry density, $\gamma_d = \frac{\gamma}{1+\omega} = \frac{22}{1+0.1} = 20kN/m^3$

53. In a constant head permeameter with cross section area of $10cm^2$, when the flow was taking place under a hydraulic gradient of 0.5, the amount of water collected in 60seconds is 600cc. the permeability of soil is

(A) 0.002 cm/s (B) 0.02 cm/s (C) 0.2cm/s (D) 2.0cm/s

Answer:- (D)

Exp:- In a constant head permeameter

$Q = K_iA$

where $Q = \text{discharge} = \frac{600}{60} = 10cc/cm^2$

$i = \text{hydraulic gradient} = 0.5$

$A = \text{area of cross} - \text{section} = 10cm^2$

$K = \text{Permeability of soil}$

$K = \frac{Q}{iA} = \frac{10}{0.5 \times 10} = 2cm/sec$

54. Assuming that a river bed level does not change and the depth of water in river was 10m, 15m and 8m during the months of February, July and December respectively of a particular year. The average bulk density of the soil is $20kN/m^3$. The density of water is $10kN/m^3$. The effective stress at a depth of 10m below the river bed during these months would be

(A) $300kN/m^2$ in February, 350 kN/m^2 July and $320kN/m^2$ in December

(B) $100kN/m^2$ in February, 100 kN/m^2 July and $100kN/m^2$ in December

(C) $200kN/m^2$ in February, 250 kN/m^2 July and $180kN/m^2$ in December

(D) $300kN/m^2$ in February, 350 kN/m^2 July and $280kN/m^2$ in December

Answer:- (B)

Exp:- Effective stress at any depth does not depend upon variation of water level above the bed of river. So,

$\bar{\sigma} = \sigma - u = rh - r_u h$

$= 20 \times 10 - 10 \times 10 = 100kN/m^2$ in December.

55. For a tri-axial shear test conducted on a sand specimen at a confining press... $100kN/m^2$ under drained conditions, resulted in a deviator stress (s_1-s_3) at fai... of $100kN/m^2$. The angle of shearing resistance of the soil would be

(A) 18.43º (B) 19.47º (C) 26.56º (D) 30º

Answer:- (B)

Exp:- As σ_3 = Confining pressure $= 100kN/m^2$

$$\sigma_1 - \sigma_3 = \text{deviator stress} = 100kN/m^2$$

$$\sigma_1 = 100 + \sigma_3 = 100 + 100 = 200kN/m^2$$

$$\sigma_1 = \sigma_3 N_\phi + 2c\sqrt{Nd}\,(\text{given soil sample is sandy}, c = 0)$$

$$\sigma_1 = \sigma_3 N_\phi$$

$$\Rightarrow 200 = 100N_\phi \therefore N_\phi = \frac{200}{100} = 2 \therefore \tan^2\left(45^\circ + \frac{\phi}{2}\right) = 2$$

$$\Rightarrow \tan\left(45^\circ + \frac{\phi}{2}\right) = \sqrt{2} \Rightarrow \left(45^\circ + \frac{\phi}{2}\right) = 54.73$$

$$\therefore \phi = (54.73 - 45) \times 2 = 19.47^\circ$$

56. During the subsurface investigations for design of foundations, a standard penetration test was conducted at 4.5m below the ground surface. The record of number of blows is given below.

Penetration depth (cm)	**No. of blows**
0 - 7.5	3
7.5 – 15	3
15 - 22.5	6
22.5 – 30	6
30 - 37.5	8
37.5 – 45	7

Assuming the water table at ground level, soil as fine sand and correction factor for overburden as 1.0, the corrected 'N' value for the soil would be

(A) 18 (B) 19 (C) 21 (D) 33

Answer:- (C)

Exp:- Assuming the water table at ground level, soil as fine sand and correction factor for overburden as 1.0, the corrected 'N' value for the soil would be 21.

57. For two infinite slopes (one in dry condition and other in submerged condition) in a sand deposit having the angle of shearing resistance 30º, factor of safety was determined as 1.5 (for both slopes). The slope angles would have been

(A) 21.05º for dry slope and 21.05º for submerged slope

(B) 19.47º for dry slope and 18.40º for submerged slope

(C) 18.4º for dry slope and 21.05º for submerged slope

(D) 22.6º for dry slope and 19.47º for submerged slope

Answer:- (A)

Exp:- Infinite slope, for dry soil $F.S. = \frac{\tan\phi}{\tan i}$

$$i = \tan^{-1}\left(\frac{\tan\phi}{F.S}\right) = \tan^{-1}\left(\frac{\tan 30}{1.5}\right) = 21.05^o$$

For submersed condition, $F.S = \frac{\tan\phi'}{\tan i}$

$\therefore\ i = 21.05^o$

58. A strip footing (8m wide) is designed for a total settlement of 40mm. The safe bearing capacity (shear) was 150kN/m^2 and safe allowable soil pressure was 100kN/m^2. Due to importance of the structure, now the footing is to be redesigned for total settlement of 25mm. the new width of the footing will be

(A) 5m (B) 8m (C) 12m (D) 12.8m

Answer:- (D)

Exp:- The new width of the footing will be 12.8m

59. A 3m high retaining wall is supporting a saturated sand (saturated due to capillary action) of bulk density 18 kN/m^2 and angle of shearing resistance 30º. The change in magnitude of active earth pressure at the base due to rise in ground water table from the base of the footing to the ground surface shall ($\gamma_w = 10kN/m^3$)

(A) increase by 20 kN/m^2 (B) decrease by 20 kN/m^2

(C) increase by 30 kN/m^2 (D) decrease by 30 kN/m^2

Answer:- (B)

Exp:- The change in magnitude of active earth pressure at the base due to rise in ground water table from the base of the footing to the ground surface shall decrease by 20kN/m^2

60. Critical depth at a section of a rectangular channel is 1.5m. The specific energy at that section is

(A) 0.75m (B) 1.0m (C) 1.5m (D) 2.25m

Answer:- (D)

Exp:- Specific energy at critical depth for a rectangular channel (critical depth of 1.5m) is $\frac{3}{2}y_i = \frac{3}{2}\times 1.5 = 2.25m$

61. A partially open sluice gate discharges water into a rectangular channel. The tail water depth in the channel is 3mm and Froude number is $\frac{1}{2\sqrt{2}}$. If a free hydraulic jump is to be formed at a downstream of the sluice gate after the vena contracta of the jet coming out of sluice gate, the sluice gate opening should be (coefficient of contraction C_c=0.9)

(A) 0.3m (B) 0.4m (C) 0.69m (D) 0.9m

Answer:- (C)

Exp:- The sluice gate opening should be (co-efficient or contraction C_c=0.9) 0.69m

62. A stream function is given by

$$Y = 2x^2y + (x+1)y^2$$

The flow rate across a line joining points A(3,0) and B(0,2) is

(A) 0.4units (B) 1.1 units (C) 4 units (D) 5 units

Answer:- (C)

Exp:- The flow rate across the line joining A(3, 0) and B(0, 2)

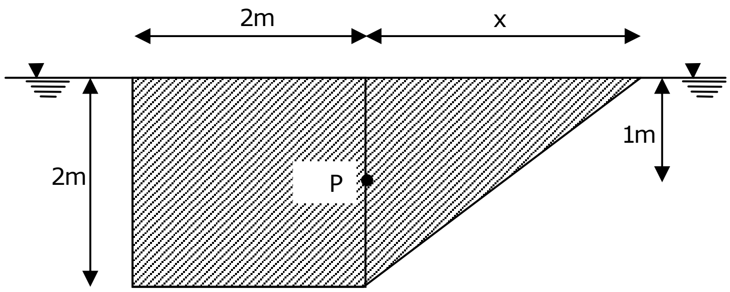
$$Q = (y_2 - y_1) \times 1$$

Where, y_2 = value of the stream function for the curve boundary through point B, and y_1=value of stream function for straight horizontal boundary through point A

$$\psi_2 = \left\{2x^2y + (x+1)y^2\right\}_{(0,2)} = \left\{2 \times 0^2 \times 2 + (0+1)2^2\right\} = 4$$

$$\psi_1 = \left\{(x+1)y^2\right\}_{(3,0)} = (3+1) \times 0^2 = 0, Q = (4-0) = 4 \text{ unit}$$

63. Cross-section of an object (having same section normal to the paper) submerged into a fluid consists of a square of sides 2m and triangle as shown in the figure. The object is hinged at point P that is one meter below the fluid free surface. If the object is to be kept in the position as shown in the figure, the value of 'x' should be



(A) $2\sqrt{3}$ (B) $4\sqrt{3}$ (C) 4m (D) 8m

Answer:- (A)

Exp:- Net down force in $I = v(d-r)g$ = weight buoyancy

where, v = velocity of I

d = density of object

r = density of fluid

Moment of I = Moment of II about P

Taking unit length of object, let v_1 be the velocity of II

$$v(d-r)g \times \frac{2}{2} = v_1(d-r)g \times \frac{x}{3} \Rightarrow x^2 = 12 \Rightarrow x = 2\sqrt{3}$$

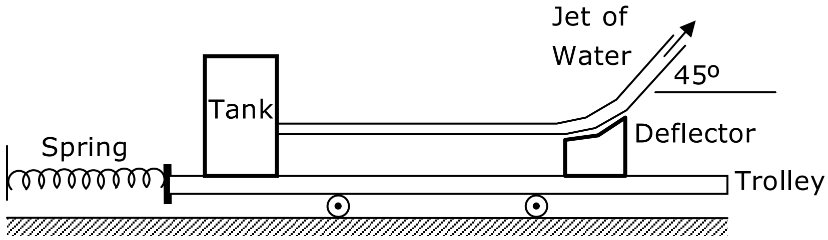
64. The circulation 'G' around a circle of radius 2units for the velocity field u=2
and v=-2y is

(A) -6πunits (B) -12πunits (C) -18πunits (D) -24πunits

Answer:- (B)

Exp:- The circulation 'G' around a circle of radius 2 units for the velocity field $u = 2x + 3y$ and $v = -2y$ is -12π units

65. A tank and a deflector are placed on a frictionless trolley. The tank issues water jet (mass density of water = 1000kg/m^3), which strikes the deflector and turns by 45º. If the velocity of jet leaving the deflector is 4m/s and discharge is 0.1m^3/s, the force recorded by the spring will be



(A) 100N (B) $100\sqrt{2}$ N (C) 200N (D) $200\sqrt{2}$ N

Answer:- (C)

Exp:- The force exerted on fluid in 'x' direction

$$= rQ\left(V_{2x} - V_{1x}\right) = rQ\left(v\cos 45º - 0\right) = rgQv\cos 45º$$

$$= 1000 \times 0.1 \times 4 \times \frac{1}{\sqrt{2}} = \frac{400}{\sqrt{2}} = 200\sqrt{2}\text{N}$$

$\therefore$ Force recorded by the spring = Force exerted on fluid in 'x' direction $= 200\sqrt{2}$N

66. Two observation wells penetrated into a confined aquifer and located 1.5km apart in the direction of flow, indicate head of 45m and 20m. if the coefficient of permeability of the aquifer is 30m/day and porosity is 0.25, the time of travel of an inert tracer from one well to another is

(A) 416.7days (B) 500days (C) 750 days (D) 3000 days

Answer:- (C)

Exp:- Velocity of travel $= \dfrac{\text{Velocity discharged}}{\text{Porosity}}$

$$= \frac{ki}{n} = \frac{30 \times (45 - 20)}{1.5 \times 1000 \times 0.25} = 2\text{m/day}$$

$\therefore$ The time of travel of an inert tracer from one wall to another is

$$= \frac{1.5 \times 1000}{2} = 750 \text{ days}$$

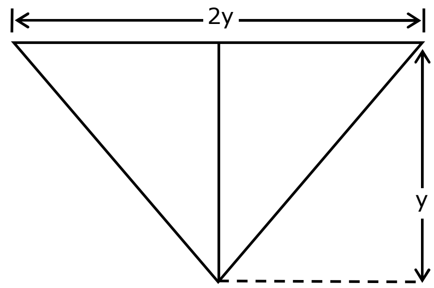
67. A triangular irrigation lined canal carries a discharge of $25m^3/s$ at bed sl
1/6000. If the side slopes of the canal are 1:1 and Manning's coefficient is 0.0
the central depth of flow is equal to

(A) 1.98m (B) 2.98m (C) 3.62m (D) 5.62m

Answer:- ()

Exp:- $V = \frac{1}{n} R^{2/3} S^{1/2}$

$Q = \frac{1}{n} R^{2/3} A^{1/2} \cdot A$



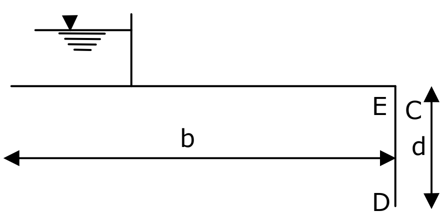
$$\Rightarrow 25 = \frac{1}{0.018} \times \left(\frac{A}{P}\right)^{2/3} \times \left(\frac{1}{6000}\right)^{1/2} \cdot A$$

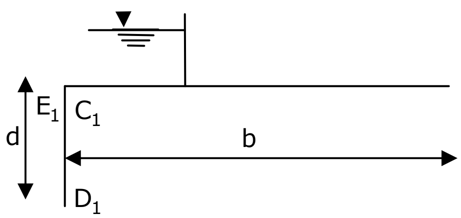
$$\Rightarrow 25 \times 0.018 \times \sqrt{6000} = \frac{A^{5/3}}{P^{2/3}} = \frac{y^{2\times 5/3}}{\left(2\sqrt{2}\right)^{2/3} y^{2/3}} \text{ Here } \theta = 45^o$$

$$\Rightarrow 25 \times 0.018 \times \sqrt{6000} \times \left(2\sqrt{2}\right)^{2/3} = y^{10/3 - 2/3} = y^{8/3}$$

$$\therefore \; y = 4.91 \qquad \left(\text{Here } A = \tfrac{1}{2} \times 2y \times y = y^2, P = 2 \times \sqrt{y^2 + y^2} = 2\sqrt{2}y\right)$$

68. Uplift pressures at points E and D (figure A) of a straight horizontal floor of negligible thickness with a sheet pile at downstream end are 28% and 20%, respectively. If the sheet pile is upstream end of the floor (Figure B), the uplift pressures at points D_1 and C_1 are





(A) 68% and 60% respectively (B) 80% and 72% respectively
(C) 88% and 70% respectively (D) 100% and zero respectively

Answer:- (B)

Exp:- The uplift pressures at points D_1 and C_1 are

$\phi D_1 = 100 - \phi_B = 100 - 20 = 80\%$

$\phi C_1 = 100 - \phi_C = 100 - 28 = 72\%$

69. A launching apron is to be designed at downstream of a weir for discharge intensity of $6.5\ m^3/s/m$. For the design of launching aprons the scour depth is taken two times of Lacey scour depth. The silt factor of the bed material is unity. If the tailwater depth is 4.4m, the length of launching apron in the launched position is

(A) $\sqrt{5}$ m (B) 4.7m (C) 5m (D) $5\sqrt{5}$ m

Answer:- (C)

Exp:- The length of launching apron in the launched position is 5m

70. The culturable commanded area for a distributary is 2 x $10^8 m^2$. The intensity of irrigation for a crop is 40%. If kor water depth and kor period for the crop are 14cm and 4 weeks, respectively, the peak demand discharge is

(A) $2.63 m^3/s$ (B) $4.63 m^3/s$ (C) $8.58 m^3/s$ (D) $11.58 m^3/s$

Answer:- (B)

Exp:- The Kor water depth = 14cm, Kor period for Crop = 4weeks

$$\text{Kor demand} = \frac{864 \times \text{Kor period for Crop}}{\text{Kor water depth for crop}}$$

$$= \frac{864 \times 28\,(\text{days})}{14} = 1728 \text{ ha / cumec}$$

Intensity of irrigation for a crop = 40%

$$\text{Crop area} = 0.4 \times 2 \times 10^8 m^2 = 0.8 \times 10^4 \text{ha}$$

$$\therefore \text{ The peak demand discharge} = \frac{0.8 \times 10^4}{1728} = 4.63 m^3/\text{sec}$$

71. If tomato juice is having a pH of 4.1, the hydrogen ion concentration will be

(A) 10.94×10^{-5} mol/L (B) 9.94×10^{-5} mol/L

(C) 8.94×10^{-5} mol/L (D) 7.94×10^{-5} mol/L

Answer:- (D)

Exp:- The pH of tomato juice = 4.1

We know $\text{pH} = -\log_{10}\left[H^+\right]$

$$\Rightarrow \quad 4.1 = -\log_{10}\left[H^+\right]$$

$$\Rightarrow \quad -4.1 = \log_{10}\left[H^+\right]$$

$$\therefore H^+ = 10^{-4.1} = 7.94 \times 10^{-5} \text{mol/L}$$

72. Group 1 contains some properties of water / wastewater and group 2 contains list of some tests on water / waste water. Match the property with corresponding test.

Group 1

P Suspended solids concentration

Q Metabolism of biodegradable organics

R Bacterial concentration

S Coagulant dose

Group 2

1 BOD

2 MPN

3 Jar test

4 Turbidity

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

Answer:- (B)

73. Match the following

Group 1

P Thickening of sludge
Q Stabilization of sludge
R Conditioning of sludge
S Reduction of sludge

Group 2

1 Decrease in volume of sludge by chemical oxidation
2 Separation of water by heat or chemical treatment
3 Digestion of sludge
4 Separation of water of flotation or gravity

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

Answer:- (A)

74. Match the following

Group 1

P Release valve
Q Check valve
R Gate valve
S Pilot valve

Group 2

1 Reduce high inlet pressure to lower outlet pressure
2 Limit the flow of water to single direction
3 Remove air from the pipeline
4 Stopping the flow of water in the pipeline

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

Answer:- (A)

75. In a certain situation, wastewater discharged into a river, mixes with the river water instantaneously and completely. Following is the data available

Waste water: DO = 2.00mg/L

Discharge rate = $1.10m^3/s$

River water: DO = 8.3 mg/L

Flow rate = 8.70 m^3/s

Temperature = 20ºC

Initial amount of DO in the mixture of waste and river shall be

(A) 5.3mg/L (B) 6.5mg/L (C) 7.6mg/L (D) 8.4mg/L

Answer:- (C)

Exp:- Waste water DO = 2.00mg / L

River water DO = 8.3mg / L

$$\text{DO in mixture} = \frac{2\times 1.1 + 8.3\times 8.7}{(1.1+8.7)} = 7.59\text{m}^3/\text{sec}$$

i.e. 7.6mg / L

76. A circular primary clarifier processes an average flow of 5005 m^3/d of municipal wastewater. The overflow rate is 35m^3/m^2d. The diameter of the clarifier shall be

(A) 10.5m (B) 11.5m (C) 12.5m (D) 13.5m

Answer:- (D)

Exp:- Over flow rate = $35\text{m}^3/\text{m}^2\text{d}$

the average flow = $5005\text{m}^3/\text{d}$

$$\text{Flow area} = \frac{\text{average flow rate}}{\text{over flow rate}} = \frac{5005}{35} = 143\text{m}^2$$

$\therefore \frac{\pi}{4}d^2 = 143$ $\therefore$ The diameter of clarifier shall be

$$d = \sqrt{\frac{143\times 4}{\pi}} = 13.5\text{m}$$

77. A transport company operates a scheduled daily truck service between P and city Q. One-way journey time between these two cities is 85 hours. A minimum layover time of 5 hours is to be provided at each city. How many trucks are required to provide this service?

(A) 4 (B) 6 (C) 7 (D) 8

Answer:- (D)

Exp:- Total, trucks required to provide the service is 8

78. A single lane unidirectional highway has a design speed of 65kmph. The perception-brake-reaction time of drivers is 2.5 seconds and the average length of vehicles is 5m. The coefficient of longitudinal friction of the pavement is 0.4. the capacity of this road in terms of vehicles per hour per lane is

(A) 1440 (B) 750 (C) 710 (D) 680

Answer:- (C)

Exp:- Let V = velocity of vehicle in Km/h

L = Length of vehicle (m)

$$C = 1000\frac{V}{S}$$

$$S = 0.278vt + \frac{V^2}{254F} + L$$

$$= 0.278 \times 65 \times 2.5 + \frac{65^2}{254 \times 0.4} + 5$$

$$= 45.175 + 41.58 + 5 = 91.75m$$

$$\therefore C = 100\frac{V}{S} = \frac{1000 \times 65}{91.75} = 708.32$$

i.e. 710 (Approx) vehicles / hr

79. The following observations were made of an axle-load survey on a road

Axle Load (kN)	Repetitions per day
35-45	800
75-85	400

The standard axle load is 80kN. Equivalent daily number of repetitions for the standard axle – load are

(A) 450 (B) 480 (C) 800 (D) 1200

Answer:- (A)

Exp:- Daily number of repetitions for the standard axle – load are 450

80. A road is having a horizontal curve of 400m radius on which a super-elevation of 0.07 is provided. The coefficient of lateral friction mobilized on the curve when a vehicle is travelling at 100kmph is

(A) 0.07 (B) 0.13 (C) 0.15 (D) 0.4

Answer:- (B)

Exp:- Here $R = 400m, \; e = 0.7$ and $V = 100km/hr$

From formula we get $e + f = \frac{V^2}{127R} \therefore \; F = \frac{V^2}{127R} - e = \frac{100^2}{127 \times 400} - 0.07 = 0.126 = 0.13$

Statement for Linked Answer Questions: 81a & 81b

Given a>0, we wish to calculate its reciprocal value 1/a by using Newton Raphson method for f(x) =0

81a. The Newton Raphson algorithm for the function will be

(A) $x_{K+1} = \frac{1}{2}\left(x_K + \frac{a}{x_K}\right)$ (B) $x_{K+1} = \left(x_K + \frac{a}{2}x_K^2\right)$ (C) $X_{K+1} = 2X_K - aX_K^2$ (D) $X_{K+1} = X_K - \frac{a}{2}X_K^2$

Answer:- (C)

Exp:- The Newton Raphson algorithm for the function will be

$X_{k+1} = 2X_k - ax^2{}_k$

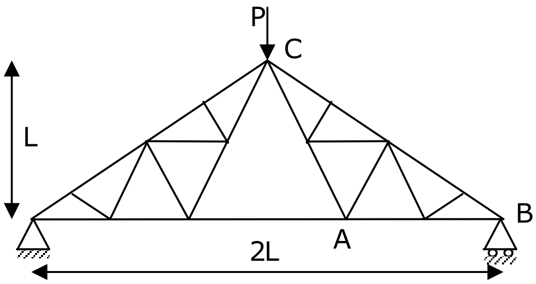
81b. For a=7 and starting with x_0=0.2, the first two iterations will be
(A) 0.11, 0.1299 (B) 0.12, 0.1392 (C) 0.12, 0.1416 (D) 0.13, 0.142

Answer:- (B)

Exp:- The first two iterations will be 0.12, 0.1392

Statement for Linked Answer Questions: 82a & 82b

A truss is shown in the figure. Members are to equal cross section A and same modulus of elasticity E. A vertical force P is applied at point C.



82a. Force in the member AB of the truss is
(A) $P/\sqrt{2}$ (B) $P/\sqrt{3}$ (C) P/2 (D) P

Answer:- (C)

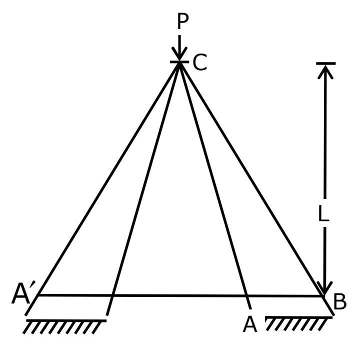
Exp:- Let us take a section at AB

$$P_{CB}\cos\theta = P_{AB}$$

$$P_{CB}\sin\theta = \frac{P}{2}\left(\text{Symmetry vertical reaction of B} = \frac{P}{2}\right)$$

$$\therefore\ P_{AB} = P_{CB}\cos\theta = P_{CB}\sin\theta = \frac{P}{2}\left(\theta = 45^{o}\right)$$

82b. Deflection of the point C is



(A) $\frac{\left(2\sqrt{2}+1\right)}{2}\frac{L}{EA}$ (B) $\sqrt{2}\frac{L}{EA}$ (C) $\left(2\sqrt{2}+1\right)\frac{L}{EA}$ (D) $\left(\sqrt{2}+1\right)\frac{L}{EA}$

Answer:- (A)

Exp:-

As $\theta = 45^o$

$$P_1 \cos 45^o = \frac{P}{2}$$

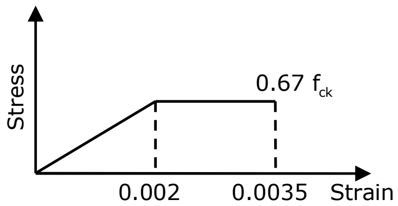
$$\therefore\ P_1 = \frac{P}{\sqrt{2}}$$

Member	P	k	L	A	$\frac{PKL}{A}$
A′c	$\frac{P}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\sqrt{2}\,L$	A	$\frac{PL}{\sqrt{2}}$
BC	$\frac{P}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\sqrt{2}\,L$	A	$\frac{PL}{\sqrt{2}}$
A′B	$-\frac{P}{2}$	$-\frac{1}{2}$	2L	A	$\frac{PL}{\sqrt{2}}$

$$\text{Deflection} = \sigma v = \frac{\Sigma PkL}{AE} = \frac{\left(2\sqrt{2}+1\right)}{2} \cdot \frac{PL}{AE}$$

Statement for Linked Answer Questions: 83a & 83b

Assume straight line instead of parabola for stress-strain curve of concrete as follows and partial factor of safety as 1.0.



A rectangular under-reinforced concrete section of 300mm width and 500mm effective depth is reinforced with 3 bars of grade Fe 415, each of 16mm diameter. Concrete mix is M20.

83a. The depth of the neutral axis from the compression fibre is

(A) 76mm (B) 81mm (C) 87mm (D) 100mm

Answer:- ()

Exp:- $P = \frac{A_{st}}{bd} = \frac{3 \times \frac{\pi}{4} \times 16^2}{300 \times 500} = 0.004021$

$$\therefore\ \frac{x_u}{d} = 2.417 \frac{Pf_y}{f_{ck}} = 2.417 \times 0.004021 \times \frac{415}{20} = 0.20 \therefore\ x_u = 100.8\text{mm}$$

83b. The depth of the neutral axis obtained as per IS:456-2000 differs from the depth of neutral axis obtained in Q. 83a by

(A) 15mm (B) 20mm (C) 25mm (D) 32mm

Answer:- (B)

Exp:- The depth of neutral axis as per IS:456-2000 is 25mm

Statement for Linked Answer Questions: 84a & 84b

A four hour unit hydrograph of a catchment is triangular in shape with base of 80hours. The area of the catchment is $720km^2$. The base flow and f-index are $30m^3/s$ and 1mm/h, respectively. A storm of 4cm occurs uniformly in 4 hours over the catchment.

84a. The peak discharge of four hour unit hydrograph is

(A) $40m^3/s$ (B) $50\ m^3/s$ (C) $60\ m^3/s$ (D) $70\ m^3/s$

Answer:- (B)

Exp:- Peak discharge = xm^3/sec

Volume represented by area of UH = Volume of 1 cm depth over the catchment

$$\Rightarrow \tfrac{1}{2}\times 80\times x\times 60\times 60 = 720\times 10^6\times\frac{1}{100}\ \therefore\ x = \frac{720\times 10^6\times 2}{80\times 60\times 60\times 100} = 50m^3/sec$$

84b. The peak flood discharge due to the storm is

(A) $210m^3/s$ (B) $230\ m^3/s$ (C) $260\ m^3/s$ (D) $720\ m^3/s$

Answer:- (A)

Exp:- Depth of rainfall = 4cm

$\text{Loss} \cong 1mm/hr \text{ for } 4hr = 4mm = 0.4cm$

$\text{Rainf all excess} = 4 - 0.4 = 3.6cm$

$$\text{Peak for 3hr.unit hydrograph} = \frac{\text{Peak of DRH}}{\text{Rain fall excess}}$$

$\Rightarrow \text{Peak of DRH} = 3.6\times 50 = 180cm$

$\therefore\ \text{Peak discharge due to storm} = 180 + 30 = 210m^3/sec$

Statement for Linked Answer Questions: 85a & 85b

A city is going to install the rapid sand filter after the sedimentation tanks. Use the following data.

Design loading rate to the filter	$200m^3/m^2d$
Design flow rate	$0.5m^3/s$
Surface area per filter box	$50m^2$

85a. The surface area required for the rapid sand filter will be

(A) $210m^2$ (B) $215\ m^2$ (C) $216\ m^2$ (D) $218\ m^2$

Answer:- (C)

Exp:- Design loading rate to filter $= 200m^3/m^2day$

Design flow rate $= 0.5m^3/sec = 0.5m^3\times 3600\times 24m^2/day$

Surface area per filter box = $50m^2$

Surface area required for rapids sand filter

$$= \frac{\text{Design flow rate}}{\text{design loading rate to filter}} = \frac{0.5 \times 3600 \times 24}{200} = 216\text{m}^2$$

85b. The number of filters required shall be

(A) 3 (B) 4 (C) 6 (D) 8

Answer:- (B)

Exp:- The total number of filters required

$$= \frac{216}{50} = 4.32$$

Option (C) is the nearest answer