GATE 2015 –CE on 8th February, 2015 – (Afternoon Session)

General Aptitude Questions

Q.No-1-5 Carry One Mark Each

1. Choose the most appropriate word from the options given below to complete the following sentence The official answered _________ that the complaints of the citizen would be looked into.

(A) respectably (B) respectfully

(C) reputably (D) respectively

Answer: (B)

2. Choose the statement where underlined word is used correctly

(A) The minister insured the victims that everything would be all right.

(B) He ensured that the company will not have to bear any loss.

(C) The actor got himself ensured against any accident.

(D) The teacher insured students of good results

Answer: (B)

Exp: *insured*-the person, group, or organization whose life or property is covered by an insurance policy.

ensured- to secure or guarantee

3. Four cards are randomly selected from a pack of 52 cards. If the first two cards are kings, what is the probability that the third card is a king?

(A) 4/52 (B) 2/50

(C) $1/52 \times (1/52)$ (D) $1/52 \times (1/52) \times (1/50)$

Answer: (B)

Exp: There are 4 kings in a pack of 52 cards.

If 2 cards are selected and both are kings, remaining cards will be 50 out of which 2 will be kings.

4. Which word is not a synonym for the word *vernacular*?

(A) regional (B) indigeneous

(C) indigent (D) colloquial

Answer: (C)

Exp: *vernacular*- expressed or written in the native language of a place

indigent -deficient in what is requisite

5. Mr. Vivek walks 6 meters North-East, then turns and walks 6 meters South- East, both at 60 degrees to East. He further moves 2 meters South and 4 meters West. What is the straight distance in meters between the point he started from and the point he finally reached?

(A) $2\sqrt{2}$ (B) 2 (C) $\sqrt{2}$ (D) $1/\sqrt{2}$

Answer: (A)

Q. No. 6 - 10 Carry Two Marks Each

6. How many four digit numbers can be formed with the 10 digits 0, 1, 2, ... 9 if no number can start with 0 and if repetitions are not allowed?

Answer: 4536

Exp: In thousands place, 9 digits except 0 can be placed

In hundreds place, 9 digits can be placed (including 0, excluding the one used in thousands place)

In tens place, 8 digits can be placed (excluding the ones used in thousands and hundreds place)

In ones place, 7 digits can be placed (excluding the one used in thousands, hundreds and tens place)

Total number of combinations $= 9 \times 9 \times 8 \times 7 = 4536$

7. The word similar in meaning to 'dreary' is

(A) cheerful (B) dreamy

(C) hard (D) dismal

Answer: (D)

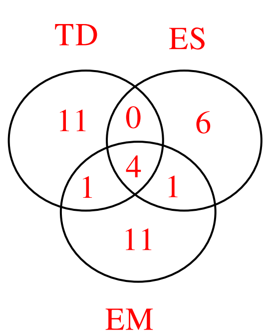
Exp: *dreary*- depressingly dull and bleak or repetitive.

8. There are 16 teachers who can teach Thermodynamics (TD), 11 who can teach Electrical Sciences (ES), and 5 who can teach both TD and Engineering Mechanics (EM). There are a total of 40 teachers, 6 cannot teach any of the three subjects, i.e. EM, ES or TD. 6 can teach only ES. 4 can teach all three subjects, i.e. EM, ES and TD. 4 can teach ES and TD. How many can teach both ES and EM but not TD?

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

Answer: (A)

Exp:



9. Read the following table giving sales data of five types of batteries for years 2006 to 2012

Year	Type I	Type II	Type III	Type IV	Type V
2006	75	144	114	102	108
2007	90	126	102	84	126
2008	96	114	75	105	135
2009	105	90	150	90	75
2010	90	75	135	75	90
2011	105	60	165	45	120
2012	115	85	160	100	145

Out of the following, which type of battery achieved highest growth between the years 2006 and 2012?

(A) Type V (B) Type III

(C) Type II (D) Type I

Answer: (D)

Exp: Type-I achieved a growth of 53% in the period which is higher than any other type of battery

10. The given question is followed by two statements: select the most appropriate option that solves the question

Capacity of a solution tank A is 70% of the capacity of tank B. How many gallons of solution are in tank A and tank B?

Statements:

I. Tank A is 80% full and tank B is 40% full

II. Tank A if full contains 14,000 gallons of solution

(A) Statement I alone is sufficient

(B) Statement II alone is sufficient

(C) Either statement I or II alone is sufficient

(D) Both the statements I and II together are sufficient

Answer: (D)

Exp: Statement I can be used to solve the question if capacity of both tanks is already known

Statement-II can be used if it is known what quantity of each tank is full/empty.

Therefore, by using both statements

Let capacity of tank B is x

$$\frac{70}{100}x = 14000$$
$$\Rightarrow x = 20000 \text{ gallons}$$
$$\text{Solution in tank A} = \frac{80}{100} \times 14000 = 11200 \text{ gallons}$$
$$\text{Solution in tank B} = \frac{40}{100} \times 20000 = 8000 \text{ gallons}$$
$$\therefore \text{Total solution} = 11200 + 8000 = 19200 \text{ gallons}$$

Section Name: Civil Engineering

Q. No. 1-25 Carry One Mark Each

1. A column of size 450 mm × 600 mm has unsupported length of 3.0 m and is braced against side sway in both directions. According to IS 456:2000, the minimum eccentricities (in mm) with respect to major and minor principle axes are

(A) 20.0 and 20.0 (B) 26.0 and 21.0
(C) 26.0 and 20.0 (D) 21.0 and 15.0

Answer: (B)

Exp: $e_{min} = \frac{L}{500} + \frac{D}{30}$ (or) 20mm which ever is minimum.

$$e_{xx} = \frac{3000}{500} + \frac{600}{30} = 26\text{mm}$$
$$e_{yy} = \frac{300}{500} + \frac{450}{30} = 21\text{mm}$$

2. The relationship between the length scale ratio (L_r) and the velocity scale ratio (V_r) in hydraulic models, in which Froude dynamic similarity is maintained, is

(A) $V_r = L_r$ (B) $L_r = \sqrt{V_r}$ (C) $V_r = L_r^{1.5}$ (D) $V_r = \sqrt{L_r}$

Answer: (D)

Exp: Fround number $= \frac{V}{\sqrt{gy}}$

$$V \alpha \sqrt{y}$$
$$V.\alpha \sqrt{L_r} \qquad \because y \,\alpha\, L_r$$

3. Given $i = \sqrt{-1}$, the value of the definite integral, $I = \int_0^{\pi/2} \frac{\cos x + i \sin x}{\cos x - i \sin x} dx$ is:

(A) 1 (B) -1 (C) i (D) –i

Answer: (B)

Exp: $I = \int_0^{\pi/2} \frac{\cos x + i\sin x}{\cos x - i\sin x} dx$

$$= \int_0^{\pi/2} \frac{e^{ix}}{e^{-ix}} dx = \int_0^{\pi/2} e^{2ix} dx$$

$$= \left(\frac{e^{2ix}}{2}\right)_0^{\pi/2}$$

$$= \frac{1}{2}\left[e^{\frac{2i\pi}{2}} - e^0\right]$$

$$= \frac{1}{2}\left[e^{\pi i} - e^0\right]$$

$$= \frac{1}{2}[\cos\pi + i\sin\pi - 1]$$

$$= \frac{1}{2}[-1 + 0 - 1] = -1$$

4. SO_2 and CO adversely affect

(A) oxygen carrying capacity of blood and functioning of lungs respectively

(B) functioning of the respiratory system and brain respectively

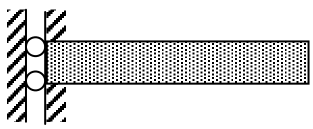
(C) functioning of the respiratory system and oxygen carrying capacity of blood respectively

(D) functioning of air passages and chest respectively.

Answer: (C)

Exp: Carbon monoxide effects the bloods carrying capacity

5. A guided support as shown in the figure below is represented by three springs (horizontal, vertical and rotational) with stiffness k_x, k_y and k_θ respectively. The limiting values of k_x, k_y and k_θ are



(A) ∞, 0, ∞ (B) ∞, ∞, ∞

(C) 0, ∞, ∞ (D) ∞, ∞, 0

Answer: (A)

Exp: As rotation and horizontal deflection in zero as per given figure. Therefore its stiffness is '∞' as deflection $= 0$. stiffness $= \frac{\text{Force}}{\text{deflection}}$

and stiffness is zero in y direction

6. Let $A = [\alpha_{ij}], 1 \le i, j \le n$ with $n \ge 3$ and $a_{ij} = i.j$. The rank of A is

(A) 0 (B) 1

(C) $n - 1$ (D) n

Answer: (B)

Exp: Given A = $[a_{ij}]$ $1 \le i, j \le n, n \ge 3$

and $a_{ij} = i.j$

$$\Rightarrow A = \begin{bmatrix} 1 & 2 & 3 & --- \\ 2 & 4 & 6 & --- \\ 3 & 6 & 9 & --- \\ - & - & - & --- \end{bmatrix}$$

If we apply R_2-$2R_1$, R_3-$3R_1$……..

Every row will be zero row, except first row in echelon form

$\therefore \rho(A) = 1$

7. A hydraulic jump takes place in a frictionless rectangular channel. The pre-jump depth is y_p. The alternate and sequent depths corresponding to y_p are y_a and y_s respectively. The correct relationship among y_p, y_a and y_s is

(A) $y_a < y_s < y_p$ (B) $y_p < y_s < y_a$

(C) $y_p < y_s = y_a$ (D) $y_a = y_s = y_p$

Answer: (B)

8. A steel member '*M*' has reversal of stress due to live loads, whereas another member '*N*' has reversal of stress due to wind load. As per IS 800:2007, the maximum slenderness ratio permitted is

(A) less for member '*M*' than that of member '*N*'

(B) more for member '*M*' than for member '*N*'

(C) same for both the members

(D) not specified in the Code

Answer: (A)

Exp: M – due to live load

N – due to wind load

As per IS800. $M - \lambda - 180$ $N - \lambda - 350$ $M < N$

9. $\lim_{x \to \infty} \left(1 + \frac{1}{x}\right)^{2x}$ is equal to

(A) e^{-2} (B) e (C) 1 (D) e^2

Answer: (D)

Exp: $\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{2x}$

$$=\left(\lim_{x\to\infty}\left(x+\frac{1}{x}\right)^{x}\right)^{2}$$

$$=e^{2}$$

10. In a leveling work, sum of the Back Sight (B.S.) and Fore Sight (F.S.) have been found to be 3.085 m and 5.645 m respectively. If the Reduced Level (R.L.) of the starting station is 100.000 m, the R.L. (in m) of the last station is _______.

Answer: 97.440

Exp: $\sum BS = 3.085 \qquad \sum F.s = 5.645m$

$$\text{Fall} = \sum Fs - \sum BS = 5.645 - 3.085 = 2.560$$

$$\text{R.L of last station} = \text{R.L first} - \text{fall}$$

$$= -100 - 2.560 = 97.440m$$

11. In friction circle method of slope stability analysis, if *r* defines the radius of the slip circle, the radius of friction circle is

(A) r sin ϕ (B) r (C) r cos ϕ (D) r tan ϕ

Answer: (A)

12. Net ultimate bearing capacity of a footing embedded in a clay stratum

(A) increases with depth of footing only

(B) increases with size of footing only

(C) increases with depth and size of footing

(D) is independent of depth and size of footing

Answer: (D)

Exp: Because $q_u = CN_c + 8DN_q + 0.5\gamma BN_r$

It is clay $\therefore \phi = 0 \Rightarrow N_r = 0, N_q = 1$

$$q_u = CN_C + \gamma D$$

$$q_{nu} = CN_C + \gamma D - \gamma D = CN_C$$

13. A groundwater sample was found to contain 500 mg/L total dissolved solids (TDS). TDS (in %) present in the sample is ________.

Answer: 0.05

Exp: $TDS = 500 mg/lit$ $\quad$ $1\text{ lit} = 500\text{ mg} = 500\times10^{-3}\text{ gm}$

$\%\,TDS = \frac{500}{1000}\times10^{-3}\times100$ $\quad$ $1\text{ lit} = 1000\text{ gm}$

14. In Newton-Raphson iterative method, the initial guess value (x_{ini}) is considered as zero while finding the roots of the equation: $f(x) = -2 + 6x - 4x^2 + 0.5x^3$. The correction, Δx, to be added to x_{ini} in the first iteration is ___________.

Answer: 0.3333

Exp: $f(x) = -2+6x-4x^2+(0.5)x^3$

$x_0 = 0$

$f'(x) = 6 - 8x + 1.5x^2$

$f(0) = -2 \qquad f'(0) = 6$

By Newton-Raphson method

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = 0 - \frac{(-2)}{6}$$

$$= \frac{2}{6}$$

$$= 0.3333$$

$$\Delta x = x_1 - x_0 = 0.3333 - 0 = 0.3333$$

15. Prying forces are

(A) shearing forces on the bolts because of the joints

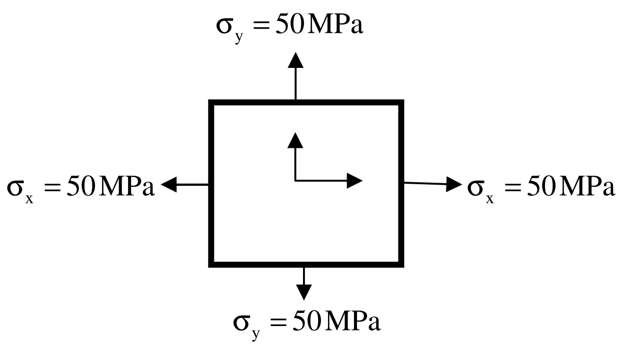
(B) tensile forces due to the flexibility of connected parts

(C) bending forces on the bolts because of the joints

(D) forces due the friction between connected parts

Answer: (B)

16. For the plane stress situation shown in the figure, the maximum shear stress and the plane on which it acts are



(A) –50 MPa, on a plane 45° clockwise w.r.t. x-axis

(B) –50 MPa, on a plane 45° anti-clockwise w.r.t. x-axis

(C) 50 MPa, at all orientations

(D) Zero, at all orientations

Answer: (D)

Exp: $\tau_\theta = \frac{\sigma_x - \sigma_y}{z}\sin 2\theta + \tau_{xy}\cos 2\theta$

$\tau_{xy} = 0$ & σ_x & σ_y are equal

$\therefore \sigma_x - \sigma_y = 0$

$\therefore \tau_\theta = 0$ in any direction

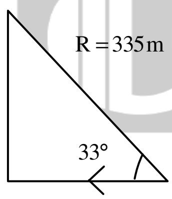
17. A superspeedway in New Delhi has among the highest super-elevation rates of any track on the Indian Grand Prix circuit. The track requires drivers to negotiate turns with a radius of 335 m and 33° banking. Given this information, the coefficient of side friction required in order to allow a vehicle to travel at 320 km/h along the curve is

(A) 1.761 (B) 0.176

(C) 0.253 (D) 2.530

Answer: **0.685**

Exp:



$$V = 320\,\text{kmph}$$

$$= 320 \times \frac{5}{18}$$

$$= \frac{800}{9}\,\text{m/s}$$

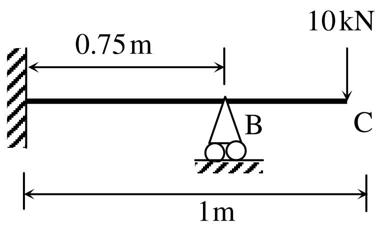
$$\frac{V^2}{gR} = \frac{\tan\theta + f}{1 - f\tan\theta}$$

$$\Rightarrow \frac{(800/g)^2}{9.81 \times 335} = \frac{\tan 33° + f}{1 - f \times \tan 33°}$$

$$\Rightarrow 2.40 = \frac{0.64g + f}{1 - f \times 0.649}$$

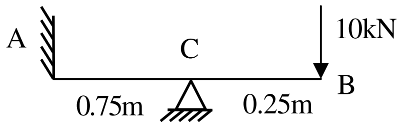
$$\Rightarrow f = 0.685$$

18. A horizontal beam ABC is loaded as shown in the figure below. The distance of the point of contraflexure from end A (in m) is __________.



Answer: 0.25

Exp:



$D_S = 1$

Let us take R_C as redundant

Deflection at B due to load at C

Deflection at C due to load at B (ΔBC)

[By Marshall reciprocal theorem]

$$\text{so}, \Delta_{BC} = \frac{10\times(.75)^3}{3E_I} + \frac{10\times(.75)^2}{2E_I}\times 0.25$$

$$= \frac{2.11}{E_I}\downarrow$$

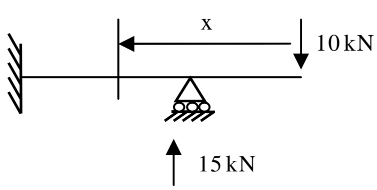
Deflection at C due to Redundant R_C

$$\Delta_{cc} = R_C \times \frac{(.75)^3}{3E_I} = \frac{0.141R_C}{E_I}\uparrow$$

$$\because \Delta_C = 0$$

$$\Rightarrow \frac{2.11}{E_I} - \frac{.141R_C}{E_I} = 0$$

$$\Rightarrow R_C = 15\,kN$$



M_x = 10×x-15×(x-.25) = 0

⇒ 10x-15x-3.75 = 0

⇒ x = 0.75m

So, distance of point of contraflexure from end A

= 1-0.75 = 0.25m

19. In the water content of a fully saturated soil mass is 100% the void ratio of the sample is

(A) Less than specific gravity of soil

(B) equal to specific gravity of soil

(C) greater than specific gravity of soil

(D) independent of specific gravity of soil

Answer: (B)

Exp: $S = 100\%\ e = \frac{wn}{S_r} = e = \frac{100G}{100} = G$

20. The relationship between porosity (η), specific yield (S_y) and specific retention (S_r) of an unconfined aquifer is

(A) $S_y + S_r = \eta$ (B) $S_y + \eta = S_r$ (C) $S_r + \eta = S_y$ (D) $S_y + S_r + \eta = 1$

Answer: (A)

21. While minimizing the function f(x), necessary and sufficient conditions for a point, x_0 to be a minima are:

(A) $f'(x_0) > 0$ and $f''(x_0) = 0$ (B) $f'(x_0) < 0$ and $f''(x_0) = 0$

(C) $f'(x_0) = 0$ and $f''(x_0) < 0$ (D) $f'(x_0) = 0$ and $f''(x_0) > 0$

Answer: (D)

22. The combined correction due to curvature and refraction (in m) for distance of 1 km on the surface of Earth is

(A) 0.0673 (B) 0.673

(C) 7.63 (D) 0.763

Answer: (A)

Exp: $C = 0.0673d^2 = 0.0673 \times 1$

23. Surcharge loading required to placed on the horizontal backfill of a smooth retaining vertical wall so as to completely eliminate tensile crack is:

(A) 2 c (B) 2 ck_a (C) $2c\sqrt{k_a}$ (D) $2c/\sqrt{k_a}$

Answer: (D)

Exp: Surcharge load to be placed as $= \frac{2c}{\sqrt{k_a}}$

24. A nozzle is so shaped that the average flow velocity changes linearly from 1.5 m/s at the beginning to 15 m/s at its end in a distance of 0.375 m. The magnitude of the convective acceleration (in m/s^2) at the end of the nozzle is _________.

Answer: 54

Exp: Convective acceleration $= u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}$

$$= 1.5\frac{(15-1.5)}{0.375} = 54\,m/s^2$$

25. The following statements are made related to the lengths of turning lanes at signalised intersections

(i) 1.5 times the average number of vehicles (by vehicle type) that would store in turning lane per cycle during the peak hour.

(ii) 2 times the average number of vehicles (by vehicle type) that would store in turning lane per cycle during the peak hour.

(iii) Average number of vehicles (by vehicle type) that would store in the adjacent through lane per cycle during the peak hour.

(iv) Average number of vehicles (by vehicle type) that would store in all lanes per cycle during the peak hour.

As per the IRC recommendations, the correct choice for design length of storage lanes is

(A) Maximum of (ii and iii) (B) Maximum of (i and iii)

(C) Average of (i and iii) (D) Only (iv)

Answer: (A)

Q. No. 26-55 Carry Two Marks Each

26. Ultimate BOD of a river water sample is 20 mg/L. BOD rate constant (natural log) is 0.15 day^{-1}. The respective values of BOD (in %) exerted and remaining after 7 days are:

(A) 45 and 55 (B) 55 and 45

(C) 65 and 35 (D) 75 and 25

Answer: (C)

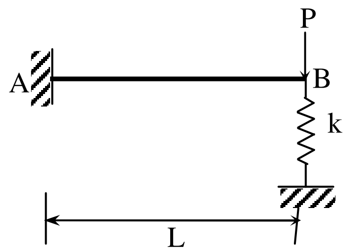
Exp: $y_u = 20mg/L$

After 7 days $= y_u e^{-kt} = 20 \times e^{0.15\times7} = 7$

$\%$ is $= \frac{7}{20} = 35\%$

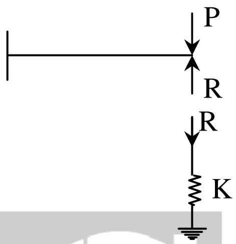
exerted $= 100 - 35 = 65\%$

27. A steel strip of length, L = 200 mm is fixed at end A and rests at B on a vertical spring of stiffness, k = 2 N/mm. The steel strip is 5 mm wide and 10 mm thick. A vertical load, P = 50 N is applied at B, as shown in the figure. Considering E = 200 GPa, the force (in N) developed in the spring is _________.



Answer: 3

Exp:



$k = F/\delta$

$k = R/\delta$

$\delta = R/K$

δ for cantilever

$$\delta = \frac{(P-R)L^3}{3EI} = R/K$$

$$\frac{(50-R)200^3}{3\times200\times10^5\times\frac{5\times10^5}{12}} = R/z$$

$R = 3N$

28. Match the information related to test on aggregates given in Group-I with that in Group-II.

Group-I	**Group-II**
P. Resistance to impact	**1.** Hardness
Q. Resistance to wear	**2.** Strength
R. Resistance to weathering action	**3.** Toughness
S. Resistance to crushing	**4.** Soundness

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

Answer: (B)

Exp: Resistance to impact → Toughness

Resistance to wear → Hardness

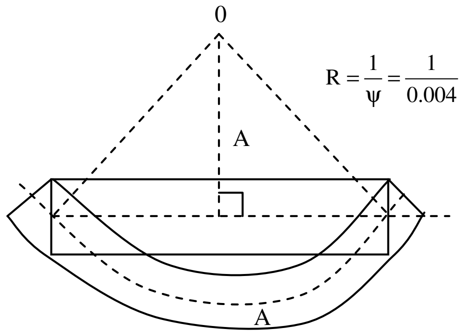
Resistance to weathering → Soundness

Resistance to crushing → Strength

29. A simply supported reinforced concrete beam of length 10 m sags while undergoing shrinkage. Assuming a uniform curvature of 0.004 m^{-1} along the span, the maximum deflection (in m) of the beam at mid-span is _______.

Answer: 0.0005

Exp:



$$R=\frac{1}{\psi}=\frac{1}{0.004}=250\,m$$

$$OA=\sqrt{(250)^2-\left(\frac{1}{2}\right)^2}=249.9995m$$

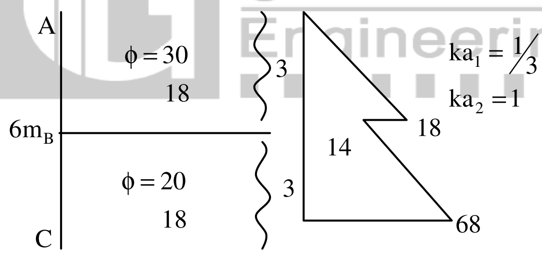
$$\Delta AA'=0.0005m$$

30. A 6 m high retaining wall having a smooth vertical back face retains a layered horizontal backfill. Top 3 m thick layer of the backfill is sand having an angle of internal friction, φ = 30° while the bottom layer is 3 m thick clay with cohesion, *c* = 20 kPa. Assume unit weight for both sand and clay as 18 kN/m3. The totalactive earth pressure per unit length of the wall (in kN/m) is:

(A) 150 (B) 216 (C) 156 (D) 196

Answer: (A)

Exp:



$$\text{above} = B = ka_1 8H = \frac{1}{2}\times18\times3=18kal$$

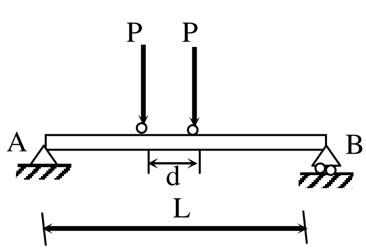
$$\text{below } B = ka_2 8E - 2c\sqrt{ka_2}$$

$$=1\times18\times3-2\times20\sqrt{1}=14\text{ kN/m}^2$$

$$P_C = Ka_2\gamma z-2c\sqrt{ka_2}=18\times6-2\times20$$

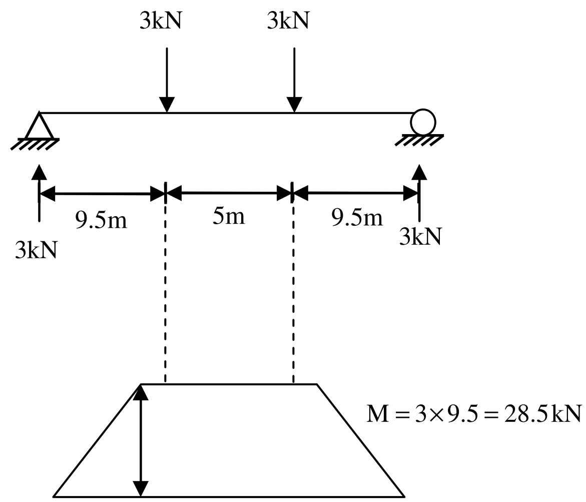
$$P_a=\frac{1}{2}\times18\times3+\frac{1}{2}(14+68)\times3=150\text{ kN/m}^2$$

31. A simply supported beam AB of span, L = 24 m is subjected to two wheel loads acting at a distance, d = 5 m apart as shown in the figure below. Each wheel transmits a load, P = 3 kN and may occupy any position along the beam. If the beam is an I-section having section modulus, S = 16.2 cm^3, the maximum bending stress (in GPa) due to the wheel loads is ___________



Answer: 1759.2

Exp: Maximum bending stress occurs at the point of maximum bending moment. Maximum B.M. will occur under one of the point load such that resultant of the load system and point load under consideration is equidistant from the centre.



$$\sigma = \frac{M}{I}.y = \frac{M}{Z} = \frac{28.5\times 10^6}{16.2\times 10^3} = 1759.2 \text{ GPa}$$

32. For probability density function of a random variable, x is

$$f(x) = \frac{x}{4}\left(4-x^2\right) \text{for } 0\le x\le 2$$
$$=0 \text{ otherwise}$$

The mean μ_z of the random varialbe is ______

Answer: 1.0667

Exp: $f(x) = \frac{x}{4}\left(4-x^2\right) \quad 0\le x\le 2$

$$\text{mean} = \mu_x = E(x)$$

$$= \int_0^2 x f(x)\,dx$$

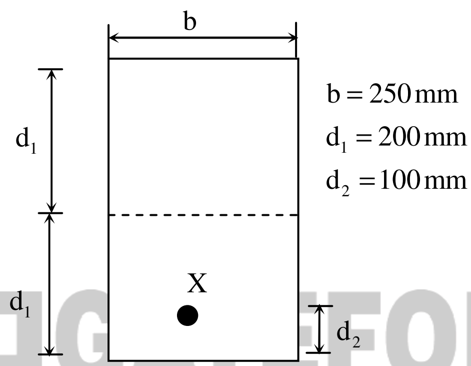
$$= \int_0^2 x\left(\frac{x}{4}\right)\left(4-x^2\right)dx$$

$$= \frac{1}{4}\int_0^0 \left(4x^2 - x^4\right)dx$$

$$= \frac{1}{4}\left[\frac{4x^3}{3} - \frac{x^5}{5}\right]_0^2$$

$$= \frac{1}{4}\left[4.\frac{8}{3} - \frac{32}{5}\right]$$
$$= \frac{32}{4}\left[\frac{1}{3} - \frac{1}{5}\right]$$
$$= 8\left[\frac{2}{15}\right] = \frac{16}{15} = 1.0667$$

33. In a pre-stressed concrete beam section shown in the figure, the net loss is 10% and the final pre-stressing force applied at X is 750 kN. The initial fiber stresses (in N/mm^2) at the top and bottom of the beam were:



(A) 4.166 and 20.833 (B) –4.166 and –20.833
(C) 4.166 and –20.833 (D) –4.166 and 20.833

Answer: (D)

Exp: Loss = 10%

Find force = 750 kN

$$\text{Initial force } = \frac{750}{0.9} = 833.33\,kN$$

$$\text{Top \& Bottom stress } = \frac{P}{A} \pm {}^{m}\!/_{z}$$

$$= \frac{833.33}{250 \times 400} \times 10^3 \pm \frac{833.33 \times 10^3 \times 100 \times 6}{250 \times 400^2}$$

$$= 8.33 \pm 12.5$$

Top = -4.166 (T)

Bottom = 20.833 (C)

34. A 588 cm^3 volume of moist sand weighs 1010 gm. Its dry weight is 918 gm and specific gravity of solids, G is 2.67. Assuming density of water as 1 gm/cm^3, the void ratio is __________.

Answer: 0.71

Exp: e = ?

$$\gamma_{\text{moist sand}} = \frac{1010}{588} = 1.717\ g/cc \qquad \gamma_d = \frac{G\gamma_\omega}{1+e}$$

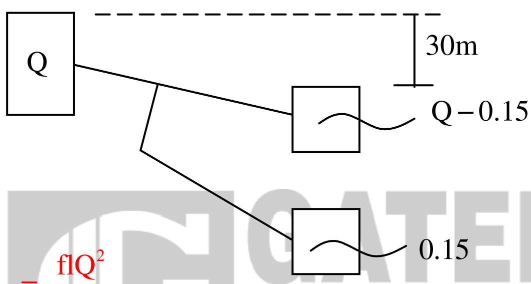
$$\gamma_d = \frac{918}{588} = 1.561\ g/cc \qquad 1.561 = \frac{2.67\times1}{1+e}$$

$$e = 0.71$$

35. A pipe of 0.7 m diameter has a length of 6 km and connects two reservoirs A and B. The water level in reservoir A is at an elevation 30 m above the water level in reservoir B. Halfway along the pipe line, there is a branch through which water can be supplied to a third reservoir C. The friction factor of the pipe is 0.024. The quantity of water discharged into reservoir C is 0.15 m^3/s. Considering the acceleration due to gravity as 9.81 m/s^2 and neglecting minor losses, the discharge (in m^3/s) into the reservoir B is __________.

Answer: 0.5716

Exp:



$$h_f = \frac{flQ^2}{12.1d^5}$$

$$h_{f_1} + h_{f_2} = 30m \rightarrow \text{in parallel}$$

$$\frac{0.024\times3000\times Q^2}{12.1\times0.7^5} + \frac{0.024\times3000(Q-0.15)^2}{12.1\times0.7^5} = 30$$

$$Q = 0.7216\ m^3/s$$

$$Q_B = Q - 0.15 = 0.5716\ m^3/s$$

36. A 4 m thick layer of normally consolidated clay has an average void ratio of 1.30. Its compression index is 0.6 and coefficient of consolidation is 1 m^2/yr. If the increase in vertical pressure due to foundation load on the clay layer is equal to the existing effective overburden pressure, the change in the thickness of the clay layer is ______ mm.

Answer: 314

Exp:

$$\Delta H = \frac{C_C}{1+e_0}H_0\log_{10}\left(\frac{\sigma_0+\Delta\sigma}{\sigma_0}\right)$$

$$= \frac{0.6}{1+1.3}\times4\log_{10}\left(\frac{\sigma_0+\sigma_0}{\sigma_0}\right)$$

$$= 0.314\ m$$

$$\Delta_H = 314mm$$

37. According to the concept of Limit State Design as per IS456: 2000, the probability of failure of a structure is __________.

Answer: 0.097

38. Two pegs A and B were fixed on opposite banks of a 50 m wide river. The level was set up at A and the staff readings on Pegs A and B were observed as 1.350 m and 1.550 m, respectively. Thereafter the instrument was shifted and set up at B. The staff readings on Pegs B and A were observed as 0.750 m and 0.550 m, respectively. If the R.L. of Peg A is 100.200 m, the R.L. (in m) of Peg B is _____

Answer: 100

Exp: Reciprocal leveling

$$\Delta_h = \frac{(b_1 - a_1) + (b_2 - a_2)}{2} = \frac{(1.55 - 1.35) + (10.75 - 0.55)}{2}$$

$$\Delta h = 0.20$$

$$\text{RL of } B = \text{RL of } A - 0.20 = 100\text{m}$$

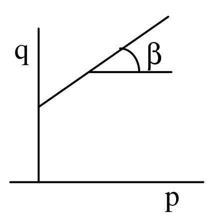
From the reading we can see A is at higher level than B.

39. Stress path equation for tri-axial test upon application of deviatoric stress is, $q = 10\sqrt{3} + 0.5p.$. The respective values of cohesion, *c* (in kPa) and angle of internal friction, φ are:

(A) 20 and 20°
(B) 20 and 30°
(C) 30 and 30°
(D) 30 and 20°

Answer: (B)

Exp: Stress path equations



$$\frac{\sigma_1 - \sigma_3}{2} = C\cos\phi + \frac{\sigma_1 + \sigma_3}{2}\sin\phi$$

$$q = 10\sqrt{3} + 0.5P$$

$$C\cos\phi = 10\sqrt{3}$$

$$\text{Tan}\beta = \sin\phi = 0.5 \qquad \phi = \sin^{-1}\cos 7 = 30^o$$

$$C\cos 30 = 10\sqrt{3} \qquad C = 20^o$$

40. The velocity components of a two dimensional plane motion of a fluid are

$$u = \frac{y^3}{3} + 2x - x^2 y \text{ and } v = xy^2 - 2y - \frac{x^3}{3}$$

The correct statement is:

(A) Fluid is incompressible and flow is irrotational
(B) Fluid is incompressible and flow is rotational
(C) Fluid is compressible and flow is irrotational
(D) Fluid is compressible and flow is rotational

Answer: (A)

Exp: For incompressible flow. $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$ ....(i)

For irrotational flow. $\frac{1}{2}\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)=0$ ...(ii)

(1) $\frac{\partial}{\partial x}\left(\frac{y^3}{3}+2x-x^2y\right)+\frac{\partial}{\partial y}\left(xy^2-2y-\frac{x^3}{3}\right)=0$

$$2-2xy+2xy-2=0$$

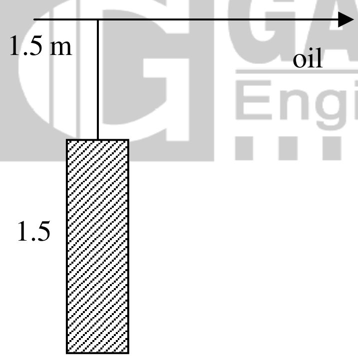
(2) $\frac{\partial}{\partial x}\left(xy^2-2y-\frac{x^3}{3}\right)-\frac{\partial}{\partial x}\left(\frac{y^3}{3}+2x-x^2y\right)$

$y^2-x^2-y^2+x^2=0$

41. A triangular gate with a base width of 2 m and a height of 1.5 m lies in a vertical plane. The top vertex of the gate is 1.5 m below the surface of a tank which contains oil of specific gravity 0.8. Considering the density of water and acceleration due to gravity to be 1000 kg/m^3 and 9.81 m/s^2, respectively, the hydrostatic force (in kN) exerted by the oil on the gate is __________.

Answer: 29.43

Exp:



Force on gate $=\frac{1}{2}\times1.5\times2\times G\gamma_{\omega}\left(1.5+\frac{2}{3}\times1.5\right)$

$=0.8\times9810\times2.5\times1.5$

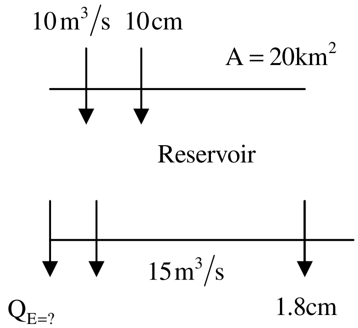
$=29.43\text{ kN}$

42. The average surface area of a reservoir in the month of June is 20 km^2. In the same month, the average rate of inflow is 10 m^3/s, outflow rate is 15 m^3/s, monthly rainfall is 10 cm, monthly seepage loss is 1.8 cm and the storage change is 16 million m^3. The evaporation (in cm) in that month is

(A) 46.8 (B) 136.0 (C) 13.6 (D) 23.4

Answer: (B)

Exp:



$\because$ change in storage = inflow-outflow

$$\Delta S = Q_i + Q_R - Q_0 - Q_S - Q_E$$

$$\Rightarrow 16\times10^6 = (10\times86400\times30) + (0.1\times20\times10^6)$$
$$-(15\times86400\times30) - (1.8\times10^{-2}\times20\times10^6)$$

$$\Rightarrow Q_E = \frac{27320000}{20\times10^6} = 1.366\,m \simeq 136.6\,cm$$

43. The two Eigen values of the matrix $\begin{bmatrix} 2 & 1 \\ 1 & p \end{bmatrix}$ have a ratio of 3 : 1 for $p = 2$. What is another value of p for which the Eigen values have the same ratio of 3 : 1?

(A) –2 (B) 1 (C) 7/3 (D) 14/3

Answer: (D)

Exp: Let $A = \begin{bmatrix} 2 & 1 \\ 1 & p \end{bmatrix}$

Given that two eigen values of A are in 3:1

Ratio for p = 2

$\Rightarrow$ Characteristic equation $\lambda^2-4\lambda+3 = 0$ (by substituting p=2)

$\Rightarrow \lambda=1,3$

If we take $p = \frac{14}{3}$ then $A = \begin{bmatrix} 2 & 1 \\ 1 & \frac{14}{3} \end{bmatrix}$

$$\Rightarrow \lambda^2 - \left(2+\frac{14}{3}\right)\lambda + \left(\frac{28}{3}-1\right) = 0$$

$$\Rightarrow \lambda^2 - \frac{20}{3}\lambda + \frac{25}{3} = 0$$

$$\Rightarrow 3\lambda^2 - 20\lambda + 25 = 0$$

$$\lambda = 5, \frac{5}{3}$$

Eigen values $5, \frac{5}{3}$ are in ratio 3:1

$$\therefore p = \frac{14}{3}$$

44. Consider the following second order linear differential equation

$$\frac{d^2y}{dx^2} = -12x^2 + 24x - 20$$

The boundary conditions are at x = 0, y = 5 and at x = 2, y = 21

The value of at x = 1 is __________.

Answer: -2

Exp: Given

$$\frac{d^2y}{dx^2} = -12x^2 + 24x - 20$$

$$y(0) = 5 \quad y(2) = 21$$

$$y(1) = ?$$

Auxillary equation $m^2 = 0$

$$m = 0, 0$$

$$y_c = (c_1 + c_2 x)e^{0x} = c_1 + c_2 x$$

$$y_p = \frac{1}{D^2}\left(-12x^2 + 24x - 20\right)$$

$$= -12\frac{x^4}{12} + 24.\frac{x^3}{6} - 20.\frac{x^2}{2!}$$

$$= -x^4 + 4x^3 - 10x^2$$

$$y = c_1 + c_2 x + 10x^2 + 4x^3 - x^4$$

$$y(0) = 5 \quad \Rightarrow c_1 = 5$$

$$y(2) = 21 \quad \Rightarrow 21 = 5 + 2c_2 + 40 + 32 - 16$$

$$21 = 2c_2 + 61$$

$$c_2 = -20$$

$$y = 5 - 20x + 10x^2 + 4x^3 - x^4$$

$$y(1) = 5 - 20 + 10 + 4 - 1$$

$$= -2$$

45. For step-size $\Delta x = 0.4$, the value of following integral using Simpson's 1/3 rule is _________.

$$\int_0^{0.8} \left(0.2 + 25x - 200x^2 + 675x^3 - 900x^4 + 400x^5\right)dx$$

Answer: -3.8293

Exp: Given h = Δx = 0.4

$$f(x) = 0.2 + 25x - 200x^2 + 675x^3 - 900x^4 + 400x^5$$

$$x_0 = 0 \quad x_n = 0.8 \Rightarrow n = \frac{0.8-0}{0.4} = 0$$

x	0	0.4	0.8
$y = f(x)$	0.2	24.456	−126.744

By Simpson's $\frac{1}{3}$ Rule

$$\int_0^{0.8} f(x)\,dx = \frac{0.4}{3}\left[(0.2 - 126.744) + 4(24.456)\right] = -3.8293$$

46. A field channel has cultivable commanded area of 2000 hectares. The intensities of irrigation for gram and wheat are 30% and 50% respectively. Gram has a kor period of 18 days, kor depth of 12 cm, while wheat has a kor period of 18 days and a kor depth of 15 cm. The discharge (in m^3/s) required in the field channel to supply water to the commanded area during the kor period is _____.

Answer: 1.427

Exp: Rafi crops Gran and wheat

$$Q_1 = \frac{A_1}{D_1} = \frac{200 \times 0.3}{8.64 \times \frac{18}{0.12}} = 0.463\,m^3/s \quad ; \quad \text{Duty} = 8.64\frac{B}{\Delta}$$

$$Q_2 = \frac{A_2}{D_2} = \frac{2000 \times 0.5}{8.64 \times \frac{18}{0.15}} = 0.964\,m^3/s$$

$\therefore Q_1 + Q_2$ is required $= 0.964 + 0.463 = 1.427\,m^3/s$

47. The relation between speed u (in km/h) and density k (number of vehicles/km) for a traffic stream on a road is u = 70 – 0.7k. The capacity on this road is __________ vph (vehicles/hour).

Answer: 175

Exp: $u = 70 - 7k$

$\text{Capacity} = u \times k, q = uk$

$q = (70 - 0.7k)k$

$$\frac{dq}{dk} = 70 - 0.7 \times 2k = 0 \Rightarrow k = 50\ V/km.$$

$q = (70 - 0.7 \times 50) \times 50 = 175\ V/hr.$

48. A water treatment plant of capacity, 1 m^3/s has filter boxes of dimensions 6 m × 10 m. Loading rate to the filters is 120 m^3/day/m^2. When two of the filters are out of service for back washing, the loading rate (in m^3/day/m^2) is _______

Answer: 144

Exp: Total water filters $= 24 \times 3600 \times 1 = 86400\,m^3 / day.$

$$S.A = \frac{86400}{120} = 720\ m^2.$$

Area of one filter $= 6 \times 10 = 60\ m^2.$

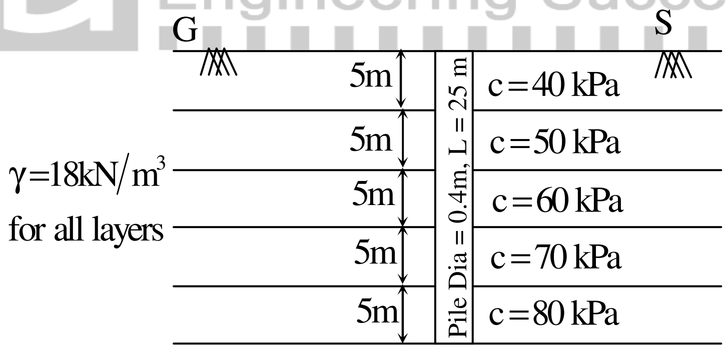
$$\text{Total no. o f filters } = \frac{720}{60} = 12 \text{ filters.}$$

2 out of services, total filters =10.

S.A of filters $= 60 \times 10 = 600\ m^2.$

$$\text{The loading rate} = \frac{86400}{600} = 144\ m^3 / day / m^2.$$

49. A pile of diameter 0.4 m is fully embedded in a clay stratum having 5 layers, each 5 m thick as shown in the figure below. Assume a constant unit weight of soil as 18 kN/m^3 for all the layers. Using λ-method (λ = 0.15 for 25 m embedment length) and neglecting the end bearing component, the ultimate pile capacity (in kN) is ________.



Answer: 1060.29

Exp: Ultimate Bearing capacity, Q_u

$= \lambda\,(\sigma_{v.avg} + 2c_u)A_s$

$= 0.15\,[18 \times 12.5 + 2C_u] \times [\pi \times 0.4 \times 25]$

w = 0

$\Rightarrow q_u = 1060.29$ kN

50. In Marshall method of mix design, the coarse aggregate, fine aggregate, fines and bitumen having respective values of specific gravity 2.60, 2.70, 2.65 and 1.01, are mixed in the relative proportions (% by weight) of 55.0, 35.8, 3.7 and 5.5 respectively. The theoretical specific gravity of the mix and the effective specific gravity of the aggregates in the mix respectively are

(A) 2.42 and 2.63 (B) 2.42 and 2.78

(C) 2.42 and 2.93 (D) 2.64 and 2.78

Answer: (A)

Exp: $$G_t = \frac{w_1 + w_2 + w_3 + w_4}{\frac{w_1}{G_1} + \frac{w_2}{G_2} + ...}$$

$$= \frac{100}{\frac{55}{2.0} + \frac{35.8}{2.7} + \frac{3.7}{2.65} + \frac{5.5}{1.01}} = 2.424$$

Eff 'G' of aggregates G (fine+coarse)

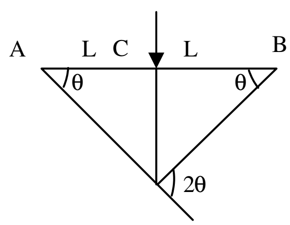
$$G = \frac{(55 \times 2.6) + (35.8 \times 2.7)}{55 + 35.8} = 2.64$$

51. In a system two connected rigid bars AC and BC are of identical length, L with pin supports at A and B. The bars are interconnected at C by a frictionless hinge. The rotation of the hinge is restrained by a rotational spring of stiffness, k. The system initially assumes a straight line configuration, ACB. Assuming both the bars as weightless, the rotation at supports, A and B, due to a transverse load, P applied at C is

(A) $\frac{PL}{4k}$ (B) $\frac{PL}{2k}$ (C) $\frac{P}{4k}$ (D) $\frac{Pk}{4L}$

Answer: (A)

Exp:



External work done

$$= \frac{1}{2} \times \rho \times L.\theta \_\_\_\_(i)$$

Strain energy stored in spring

$$= \frac{1}{2} \times k \times (2\theta) \times (2\theta)$$

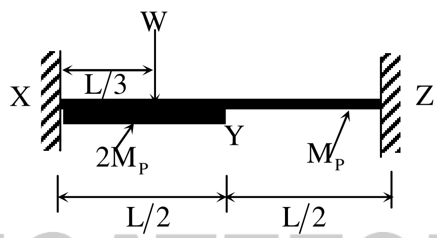
$$= 2k.\theta^2 \ \_\_\_ (ii)$$

$$(i) = (ii)$$

$$\Rightarrow \frac{1}{2} PL\theta = 2k.\theta^2$$

$$\Rightarrow \theta = \frac{PL}{4k}$$

52. A fixed end beam is subjected to a load, *W* at 1/3rd span from the left support as shown in the figure. The collapse load of the beam is

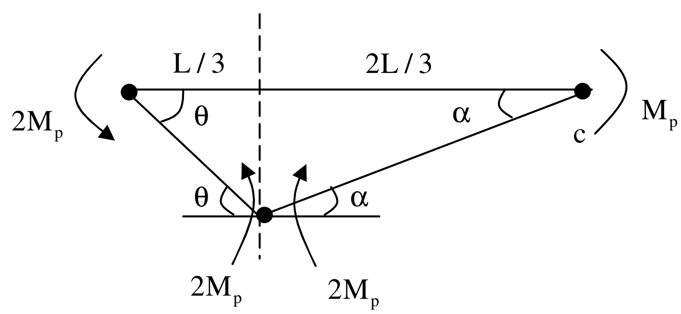


(A) 16.5 M_P/L (B) 15.5 M_P/L (C) 15.0 M_P/L (D) 16.0 M_P/L

Answer: (C)

Exp: Plastic hinges formed =3

(1)



$$\alpha = \frac{\theta}{2}$$

$$\theta = 2\alpha$$

$$\theta = \frac{\Delta}{L/3}$$

$$\Delta = \frac{L}{3}\theta$$

$$\Delta = \frac{\alpha 2L}{3}.$$

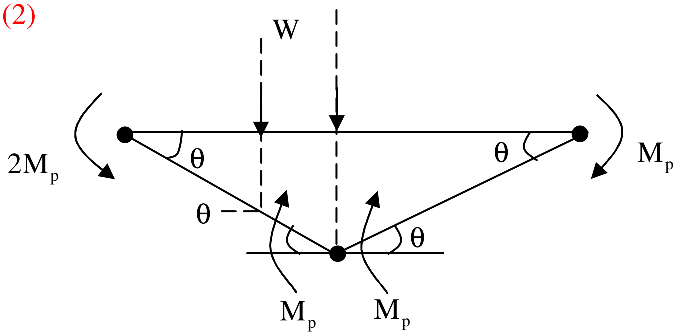
$$\theta = 2\alpha.$$

$$2M_p\theta + 2M_p\theta + 2M_p\alpha + M_p\alpha = W\Delta$$

$$2M_p\theta + 2M_p\theta + M_p\theta + M_p\frac{\theta}{2} = W \times \frac{L}{3}\theta$$

$$5.5M_p = \frac{WL}{3} \Rightarrow W = \frac{16.5}{L}M_p$$

(2)



$$2M_p\theta + M_p\theta + M_p\Delta + M_p\theta = W \times \Delta$$

$$5M_p\theta = W\frac{L}{3}\theta$$

$$15\frac{M_p}{L} = W$$

Lowest is collapse load $\frac{15M_p}{L}$

53. In a wastewater treatment plant, primary sedimentation tank (PST) designed at an overflow rate of 32.5 m^3/day/m^2 is 32.5 m long, 80 m wide and liquid depth of 2.25 m. If the length of the weir is 75 m, the weir loading rate (in m^3/day/m) is ___________.

Answer: 112.67

Exp: $Q = 32.5\,m^3/d/m^2$

$L = 32.5m$

$B = 8m$

$D = 2.25m$

$$V_0 = \frac{Q}{BL}$$

$$Q = V_0 BL$$

$$= 32.5 \times 32.5 \times 8$$

$$= 8450\,m^3/d$$

Weir length =75m.

$$q = \frac{8450}{75} = 112.67\,m^3/d/m$$

54. A landfill is to be designed to serve a population of 200000 for a period of 25 years. The solid waste (SW) generation is 2 kg/person/day. The density of the un-compacted SW is 100 kg/m^3 and a compaction ratio of 4 is suggested. The ratio of compacted fill (i.e. SW + cover) to compacted SW is 1.5. The landfill volume (in million m^3) required is _______.

Answer: 21.9

Exp: Total solid waste generated = $2\text{kg}\times2\times10^5$

$= 400000$ kg/day

For 25 years $= 400000\times365\times25$

$= 3.65\times10^9$ kg

$$\text{compaction ratio} = 0.4 = \frac{\text{volume after compaction}}{\text{volume before compaction}}$$

$$V = \frac{3.65\times10^9}{100} = 3.65\times10^7\,m^3$$

$$V' = 0.4\times3.65\times10^7 = 1.46\times10^7\,m^3$$

$$\frac{sw+cover}{sw} = \frac{sw}{sw}+\frac{cover}{sw} = 1.5$$

$$\Rightarrow \frac{cover}{sw} = 0.5$$

$$\Rightarrow cover = 0.5\times1.46\times10^7 = 0.73\times10^7\,m^3$$

$$\text{Total volume} = \left(1.46+0.73\times10^7\right) = 21.9\times10^6\,m^3$$

$$= 21.9 \text{ million } m^3$$

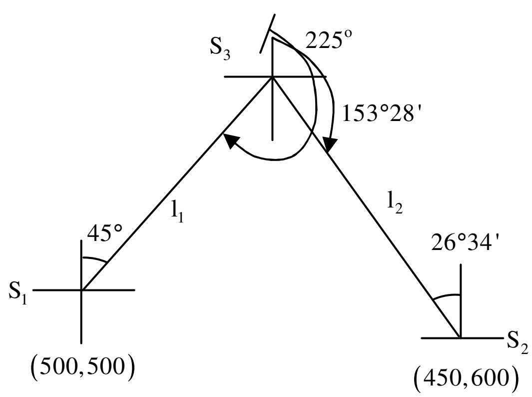
55. The bearings of two inaccessible stations, S_1 (Easting 500 m, Northing 500 m) and S_2 (Easting 600 m, Northing 450 m) from a station S_3 were observed as 225° and 153° 26′ respectively. The independent Easting (in m) of station S_3 is:

(A) 450.000 (B) 570.710

(C) 550.000 (D) 650.000

Answer: (C)

Exp:



Let $s_1s_3 = l_1$, $s_2s_3 = l_2$

$$\text{Northing of } S_3 = 500 + l_1 \cos 45°$$
$$= 450 + l_2 \cos 26°34'$$
$$\Rightarrow l_1 \cos 45° - l_2 \cos 26°34' = -50$$

Easting of S_3

$$500 + l_1 \sin 45° = 600 - l_2 \sin 26°34'$$
$$l_1 \sin 45° + l_2 \sin 26°34' = 100$$
$$\Rightarrow l_1 = 70.71, l_2 = 111.80$$
$$\text{Easting of } S_3 = 500 + 70.71 \times \sin 45°$$
$$= 549.99\,\text{m} \simeq 550\,\text{m}$$

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