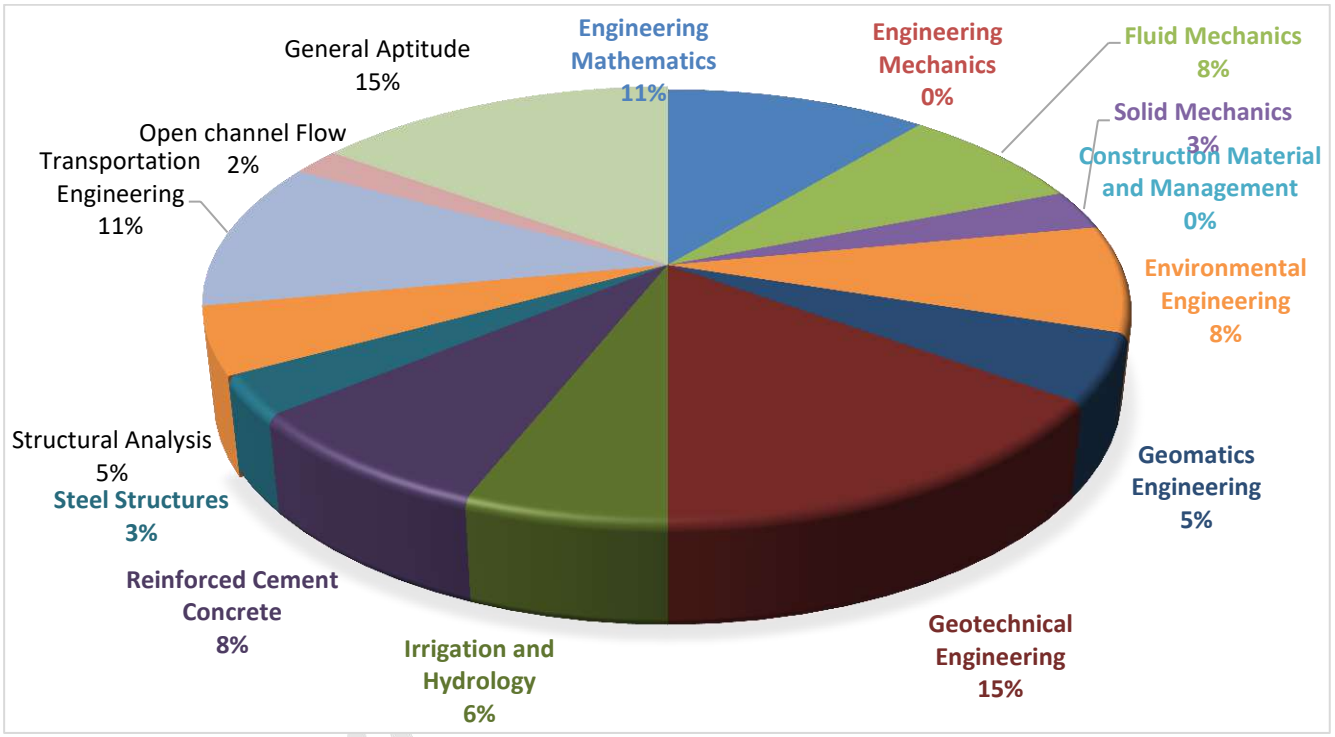
ANALYSIS OF GATE 2019

Civil Engineering



CE ANALYSIS-2019_Feb-10_Afternoon

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 5 2 Marks: 3	Differential equation, Vector calculus, Laplace transform, Linear algebra	Moderate	11
Engineering Mechanics	1 Marks: 0 2 Marks: 0	-	-	0
Fluid Mechanics	1 Marks: 2 2 Marks: 3	Pipe flow, Fluid kinematics	Moderate	8
Solid Mechanics	1 Marks: 1 2 Marks: 1	Shear stress, Rotational springs	Easy	3
Construction Material and Management	1 Marks: 0 2 Marks: 0	-	-	0
Environmental Engineering	1 Marks: 2 2 Marks: 3	Air pollution, Alkalinity disinfection	Moderate	8
Geomatics Engineering	1 Marks: 1 2 Marks: 2	Transverse survey, photographic survey, Simpson rule	Moderate	5
Geotechnical Engineering	1 Marks: 5 2 Marks: 5	Permeability	Tough	15
Irrigation and Hydrology	1 Marks: 2 2 Marks: 2	Ground Water Technology	Moderate	6
Reinforced Cement Concrete	1 Marks: 2 2 Marks: 3	Compressive strength of cement, W/C ratio, Concrete technology	Moderate	8
Steel Structures	1 Marks: 1 2 Marks:1	Plate girder	Moderate	3
Structural Analysis	1 Marks: 1 2 Marks:2	Static indeterminacy, Influence ILD	Moderate	5
Transportation Engineering	1 Marks: 3 2 Marks:4	Traffic engineering, Railway engineering, Pavement	Moderate	11
Open channel Flow	1 Marks: 0 2 Marks:1	Hydraulic pump	Moderate	2
General Aptitude	1 Marks: 5 2 Marks:5	Data interpretation, Grammar, Percentage, Time and Work	Moderate	15
Total	65			100
Faculty Feedback	Overall paper is moderate level. Compare to last year, this year paper was slightly higher level. Geotechnical question were more, no questions from engineering mechanics and CMM.			

GATE 2019 Examination*

Civil Engineering

Test Date: 10-FEB-2019

Test Time: 12.30 AM to 5:30 PM

Subject Name: Civil Engineering

General Aptitude

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

1. The growth rate of ABC Motors in 2017 was the same _____ XYZ Motors in 2016.
   (A) as that of
   (B) as off
   (C) as that off
   (D) as those of
   [Ans. A]
   We use '**as that of**' while overall comparison.
   The growth of ABC motors was same in 2017 as that of XYZ motors in 2016.

2. A retaining wall with measurements 30m × 12m × 6m was constructed with bricks of dimensions 8cm × 6cm × 6cm. If 60% of the wall consists of bricks, the number of bricks used for the construction is _____ lakhs.
   (A) 45
   (B) 40
   (C) 30
   (D) 75
   [Ans. A]
   Number of bricks = x
   $\Rightarrow 30 \times 12 \times 6 \times 10^6 \times 0.6 = 8 \times 6 \times 6 \times x$;
   $x = 4.5 \times 106 = 45 \times 10^5 = 45$ lakhs bricks

3. Daytime temperatures in Delhi can _____ 40°.
   (A) reach
   (B) get
   (C) peak
   (D) stand
   [Ans. A]
   In summer, the temperature of Delhi can reach 40°

4. Suresh wanted to lay a new carpet in his new mansion with an area of 70×55 sq. mts. However an area of 550sq.mts. had to be left out for flower pots. If the cost of carpet is Rs.50 per sq.mts, how much money (in Rs.) will be spent by Suresh for the carpet now?
(A) Rs.1,65,000
(B) Rs.1,92,500
(C) Rs.2,75,000
(D) Rs.1,27,500
[Ans. A]
Area of complete floor $=70 \times 55$ sq. metres $= 3850\ m^2$
area vacant for potting the flowers $=550\ m^2$
Area left for the carpet to be bought $= 3850 - 550 = 3300\ m^2$
$\therefore$ Cost of carpet used $= 3300 \times Rs50 = Rs165000 = Rs1.65$ lakhs

5. Hima Das was _____ only Indian athlete to win _____ gold for India.
(A) the, a
(B) an, the
(C) an, a
(D) the, many
[Ans. A]
Hima Das was the only woman to win a Gold medal.

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

6. Population of state X increased by x% and the population of state Y increased by y% from 2001 to 2011. Assume that x is greater than y. Let P be the ratio of the population of state X to state Y in a given year. The percentage increase in P from 2001 to 2011 is _____
(A) $x - y$
(B) $\frac{x}{y}$
(C) $\frac{100(x-y)}{100+x}$
(D) $\frac{100(x-y)}{100+y}$
[Ans. D]

Let a, b be initial population

Given $\frac{a}{b} = p(\text{ratio earliler})$

$\frac{a\left(1+\frac{x}{100}\right)}{b\left(1+\frac{y}{100}\right)} = p'(\text{new ratio})$

So, required % change,

$$\frac{p'-p}{p} \times 100 = \left[\frac{\frac{a}{b}\left(\frac{100+x}{100+y}\right)-\frac{a}{b}}{\frac{a}{b}}\right] \times 100 = \frac{100(x-y)}{100+y}$$

7. An oil tank can be filled by pipe X in 5 hours and pipe Y in 4 hours, each pump working on its own. When the oil tank is full and the drainage hole is open, the oil is drained in 20 hours. If initially the tank was empty and someone started the two pumps together but left the drainage hole open. How many hours will it take for the tank to be filled? (Assume that the rate of drainage is independent of the head)

(A) 4.00
(B) 2.50
(C) 1.50
(D) 2.00

[Ans. B]

Pump A can fill the tank in 4 hours.
In 1 hour, part of tank filled by Pump A alone =1/4
Pump B can fill the tank in 5 hours.
In 1 hour, part of tank filled by Pump B alone = 1/5
Leakage can empty the tank in 20 hours.
In 1 hour, part of tank emptied by the leakage = 1/20
So, overall part of tank filled in 1 hour if Pump A, Pump B and the leakage works simultaneously $= \frac{1}{4} + \frac{1}{5} - \frac{1}{20} = \frac{8}{20} = \frac{2}{5}$ parts
So, complete tank can be filled in $\frac{1}{\left(\frac{2}{5}\right)}$ hours i. e. 2.5 hours

8. Mohan, the manger wants his four workers to work in pairs. No pair should work for more than 5 hours. Ram and John have worked together for 5 hours. Krishna and Amir have worked as a team for 2 hours. Krishna does not want to work with Ram. Whom should Mohan allot to work with John, if he wants all the workers to continue working?

(A) Amir
(B) Krishna
(C) Ram
(D) None of the three

[Ans. B]

Ram and John = 5 hours
Krishna and Amir = 2 hours
Krishna does not work with Ram.
Now pair will be
John and Krishna
Ram and Amir
Given all the workers to continue working.
John and Krishna will be one pair.

9. "Popular Hindi fiction, despite-or perhaps because of – its wide reach, often does not appear in our cinema. As ideals that viewers are meant to look up to rather than identify with, Hindi film protagonists usually read books of aspirational value: textbooks, English books or high value literature."
   (A) Though popular Hindi fiction has wide reach, it often does not appear in the movies
   (B) Protagonists in Hindi movies, being ideals for viewers, read only books of aspirational value
   (C) Textbooks, English books or high literature have aspirational value, but not popular Hindi fiction
   (D) People do not look up to writers of textbooks, English books or high value literature

   [Ans. D]

   The statement "Protagonists in Hindi movies read ONLY books of aspirational value" is contradictory to the expression in the passage "Hindi film protagonists usually read books of aspirational value: textbooks, English books, or high value literature."

10. The newspaper reports that over 500 hectares of tribal land spread across 28 tribal settlements in Mohinitampuram forest division have already been "alienated". A top forest official said, "First the tribals are duped out of their land holdings. Second, the families thus rendered landless are often forced to encroach further into the forest."
    On the basis of the information available in the paragraph, _____ is/are responsible for duping the tribals.
    (A) forest officials
    (B) landless families
    (C) The Newspaper
    (D) It cannot be inferred who

    [Ans. D]

    The Newspaper is just reporting the matter, it cannot be responsible for duping the tribals.
    A top forest official made statement about tribals being duped hence officials cannot be responsible for duping the tribals.

Technical

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

1. The Laplace transform of sin h(at) is:

(A) $\frac{a}{s^2 - a^2}$

(B) $\frac{a}{s^2 + a^2}$

(C) $\frac{s}{s^2 - a^2}$

(D) $\frac{a}{s^2 + a^2}$

[Ans. A]

$L(\sinh(at)) = \frac{a}{s^2 - a^2}$

2. The command area of a canal grows only one crop, i.e. wheat. The base period of wheat is 120 days and its total water requirement, Δ, is 40cm. If the canal discharge is $2 m^3/s$, the area in hectares rounded off to the nearest integer, which could be irrigated (neglecting all losses) is _____

[Ans. *]Range: 5180 to 5190

Given data:

Base period, B = 120 days

Delta of crop, Δ = 40 cm

Discharge, $Q = 2\ m^3/s$

Area to be irrigated, A = ?

$\therefore$ Duty of water, $\Delta = \frac{864 \times B}{\Delta}$ ha/cumec

and Area to be irrigated; $A = Q \times D$

$\Rightarrow A = 2 \times m^3/s \times \frac{864 \times 120}{40} \times \frac{ha}{cumec}$

$\Rightarrow A = 5184$ ha

3. The speed-density relationship in a mid-block section of a highway follows the Greenshield's model. If the free flow speed is v_f and the jam density is k_j, the maximum flow observed on this section is:

(A) $v_f k_j$

(B) $\frac{v_f k_j}{2}$

(C) $\frac{v_f k_j}{4}$

(D) $\frac{v_f k_j}{8}$

[Ans. C]

maximum flow $= \frac{1}{4} V_f k_j$

4. The following inequality is true for all x close to 0.

$2 - \frac{x^2}{3} < \frac{x\sin x}{1-\cos x} < 2$

What is the value of $\lim_{x\to 0} \frac{x\sin x}{1-\cos x}$?

(A) 0
(B) 1/2
(C) 1
(D) 2

[Ans. D]

$\lim_{x\to 0} \frac{x\sin x}{1-\cos x}$

$\lim_{x\to 0} \frac{x\sin x}{\frac{1-\cos x}{x}} = \lim_{x\to 0} \frac{\frac{\sin x}{x}}{\frac{1-\cos x}{x^2}} = \frac{1}{\frac{1}{2}} = 2$

5. The notation "SC" as per Indian Standard Soil Classification System refers to:

(A) Sandy clay
(B) Silty clay
(C) Clayey silt
(D) Clayey sand

[Ans. D]

SC → Clayey sand

6. Construction of a new building founded on a clayey soil was completed in January 2010. In January 2014, the average consolidation settlement of the foundation in clay was recorded as 10mm. The ultimate consolidation settlement was estimated in design as 40mm. Considering double drainage to occur at the clayey soil site, the expected consolidation settlement in January 2019 (in mm, round off to the nearest integer) will be_____

[Ans. *]Range: 15 to 15

Jan. 2010 – Jan. 2014 (4 years)

⇒ Settlement is 10mm

$\Delta H = 40$mm

Settlement in Jan. 2019 (in 9 years) = ?

In 4 years, $\%\ U = \frac{\Delta h}{\Delta H} \times 100 = \frac{10}{40} \times 100 = 25\%$

$T_v = C_V \frac{t}{d^2}$

$\Rightarrow T_v = \frac{\pi}{4} U^2$

$\frac{\pi}{4}\left(\frac{25}{100}\right)^2 = \frac{C_v}{d^2} \times 4 \text{ years}$

In 9 years $T_v = \frac{C_v t}{d} = \left\{\frac{\pi}{4} \times \frac{(0.25)^2}{4}\right\} \times 9\text{years} = 0.11044$

$\because (T_v)_{60} = 0.283$

$\therefore \ \%U < 60\%$

$\therefore T_v = 0.11044 = \frac{\pi}{4} U^2$

%U=0.3749=37.499%

$\therefore \%\ U = \frac{\Delta h}{\Delta H} \times 100 = \frac{\Delta h}{40\text{mm}} \times 100 = 37.499$

$\Delta h = 14.99\text{mm} = 15\text{mm}$

7. Structural failure considered in the mechanistic method of bituminous pavement design are
(A) Fatigue and Rutting
(B) Fatigue and Shear
(C) Rutting and Shear
(D) Shear and Slippage
[Ans. A]

8. A solid sphere of radius r and made of material with density ρ_s is moving through the atmosphere (constant pressure p) with a velocity v. The net force ONLY due to atmospheric pressure (F_p) acting on the sphere at any time t is:
(A) $\pi r^2 p$
(B) $4\pi r^2 p$
(C) $\frac{4}{3}\pi r^3 \rho_s \frac{dv}{dt}$
(D) Zero
[Ans. D]

9. A closed thin-walled tube has thickness t mean enclosed area within the boundary of the centerline of tube's thickness A_m and shear stressτ. Torsional moment of resistance T of the section would be:
(A) $0.5\tau A_m t$
(B) $\tau A_m t$

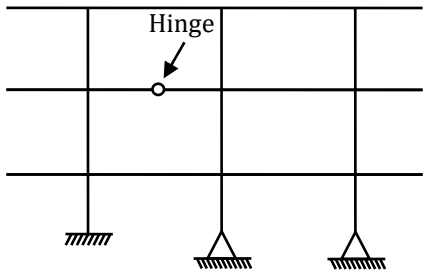
(C) $2\tau A_m t$
(D) $4\tau A_m t$
[Ans. C]

Shear stress, $\tau = \frac{T}{J}R = \frac{T}{2\pi R^3 t}R$

$\tau + \frac{T}{2\pi R^3 t} = \frac{T}{2A_m.t}$

$\therefore T = 2\tau A_m t$

10. The degree of static indeterminacy of the plane frame as shown in the figure is _____



[Ans. *]Range: 15 to 15

$D_{se} = 7 - 3 = 4$

$D_{si} = (3 \times 4) - (2 - 1) = 11$

$D_s = 15$

11. The characteristic compressive strength of concrete required in a project is 25MPa and the standard deviation in the observed compressive strength expected at site is 4MPa. The average compressive strength of cubes tested at different water-cement (w/c) ratios using the same material as is used for the project is given in the table.

w/c (%)	45	50	55	60
Average compressive strength of cubes (MPa)	35	25	20	15

The water-cement ratio (in percent, round off to the lower integer) to be used in the mix is_____

[Ans. *]Range: 46 to 46

Target mean strength $= f_{ck} + 1.65\sigma$

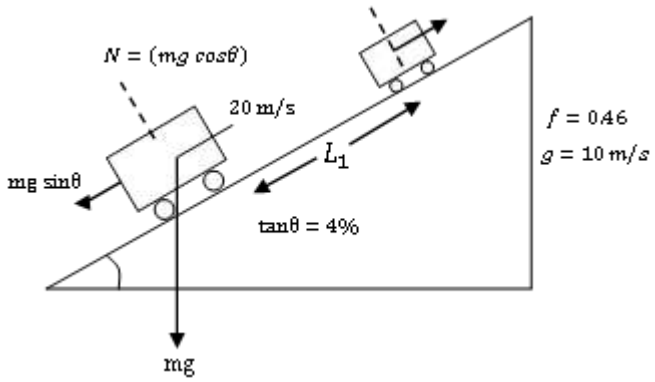
$= 25 + 1.65 \times 4.0 = 31.6$

Water content required, $= 50 - \frac{(50-45)}{(35-25)} \times (31.6 - 25) = 46.7\%$

say 46%(round off to the lower integer)

12. A vehicle is moving on a road of grade +4% at a speed of 20m/s. Consider the coefficient of rolling friction as 0.46 and acceleration due to gravity at $10 m/s^2$. On applying brakes to reach a speed of 10m/s, the required braking distance (in m, round off to nearest integer) along the horizontal is _____

[Ans. *]Range: 30 to 30



$\tan\theta = 4\% = 0.04$

$\theta = 2.29°$

$\cos\theta = 0.999$

Δ K. E = work done

$\frac{1}{2}m_2^2 - \frac{1}{2}mv_1^2 = -L[mg\sin\theta + fmg\cos\theta]$

$\frac{m}{2}[v_2^2 - v_1^2] = -Lmg\,[\tan\theta + f]$

$v_1^2 - v_2^2 = L[\tan\theta + f]$

$\frac{v_1^2 - v_2^2}{2g} = L[0.04 + 0.46]$

$L = 30$ m

Now braking distance along horizontal = [L cosθ]

$= 30 \times 0.999 = 29.97 \sim 30$m (Near integer)

13. The data from a closed traverse survey PQRS (run in the clockwise direction) are given in the table.

Line	Included angle (in degrees)
PQ	88
QR	92
RS	94
SP	89

The closing error for the traverse PQRS (in degrees) is _____

[Ans. *]Range: 3 to 3

Assuming it as anticlockwise traverse.

Mathematically sum of interior angle for a closed traverse

$= (2n - 4) \times 90 = (2 \times 4 - 4) \times 90 = 4 \times 90 = 360°$

Given sum of interior angles,
$= 88 + 92 + 94 + 89 = 363°$
Then error in interior angle $= 363 - 360 = 3°$
Note: In this question as per clockwise traverse included angle should be taken as exterior angle. But if we take exterior angle then we get all interior angles more than 180°.

14. The value of the function f(x) is given at n distinct values of x and its value is to be interpolated at the point x* using all the n points. The estimate is obtained first by the Language polynomial denoted by I_L and then by the Newton polynomial denoted by I_N. which one of the following statements is correct?
(A) I_L is always greater than I_N
(B) I_L and I_N are always equal
(C) I_L is always less than I_N
(D) No definite relation exists between I_L and I_N
[Ans. B]

15. Euclidean norm (length) of the vector $[4 \quad -2 \quad -6]^T$ is:
(A) $\sqrt{12}$
(B) $\sqrt{24}$
(C) $\sqrt{48}$
(D) $\sqrt{56}$
[Ans. D]
$x = \begin{bmatrix} 4 \\ -2 \\ -6 \end{bmatrix}$
Euclidean norm length $= \sqrt{16 + 4 + 36} = \sqrt{56}$

16. If the fineness modulus of a sample of fine aggregates is 4.3, the mean size of the particles in the sample is between:
(A) 150μm and 300μm
(B) 300μm and 600μm
(C) 1.18mm and 2.36mm
(D) 2.36mm and 4.75mm
[Ans. C]
The sieves that are to be used for the sieve analysis of the aggregate (coarse, fine, or all-in-aggregate) for concrete as per IS:2386 (Part I) -1963 are, 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 μm, 300 μm and 150 μm. The fineness modulus can be regarded as a weighted average size of a sieve on which material is retained and the sieves being counted from the first sieve. Fineness modulus of 4.3 indicates size between 4th and 5th sieve i.e., between 1.18 mm and 2.36 mm.

17. Analysis of a water sample revealed that the sample contains the following species.
$CO_3^{2-}, Na^+, H^+, PO_4^{3-}, Al^{3-}, H_2CO_3, Cl^-, Ca^{2+}, Mg^{2+}, HCO_3^-, Fe^{2+}, OH^-$
Concentrations of which of the species will be required to compute alkalinity?
(A) $CO_3^{2-}, H^+, H_2CO_3^-, OH^-$
(B) $CO_3^{2-}, H^+, H_2CO_3, HCO_3^-$
(C) $CO_3^{2-}, H_2CO_3, HCO_3^-, OH^-$
(D) $H^+, H_2CO_3, HCO_3^-, OH^-$
[Ans. A]
Alkalinity is defined as ability of water to neutralize the acid or hydronium ion
Alkalinity (A_r) of water
$= [HCO3-] + [CO32-] + B(OH)4-] + [H3(SiO4)-] + [HS-] + [organicanions] + [OH-] - [H+]$
From given options of ions in problem answer is (a).
i. e. $CO_3^{2-}, H^+, HCO_3-, OH-$

18. What is curl of the vector field $2x^2yi + 5z^2j - 4yzk$?
(A) $6zi + 4xj - 2x^2k$
(B) $6zi - 8xyj + 2x^2yk$
(C) $-14zi + 6yj + 2x^2k$
(D) $-14zi - 2x^2k$
[Ans. D]
$$\text{curl}\bar{F} = \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 2x^2y & 5Z^2 & -4yz \end{vmatrix}$$
$= \bar{i}(-4z - 10z) - \bar{j}(0 - 0) + \bar{k}(0 - 2x^2)$
$= -14zi - 2x^2k$

19. The velocity field in a flow system is given by $v = 2i+(x + y)\, j + (xyz)\, k$. The acceleration of the fluid at (1, 1, 2) is:
(A) $2i + 10k$
(B) $4i + 12k$
(C) $j + k$
(D) $4j + 10k$
[Ans. D]
$\vec{v} = 2\hat{i} + (x + y)\hat{j} + xyzk$
u=2
v=x + y
w=xyz
$$a_x = U.\frac{\partial U}{\partial x} + V\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t} = 0$$

$$a_y = U.\frac{\partial V}{\partial x} + V\frac{\partial V}{\partial y} + w\frac{\partial V}{\partial z} + \frac{\partial V}{\partial t} = 2 + (x + y)$$

$$a_y = x + y + 2$$

$$a_z = U.\frac{\partial W}{\partial x} + V\frac{\partial W}{\partial y} + w\frac{\partial W}{\partial z} + \frac{\partial W}{\partial t}$$

$$= 2(yz) + (x + y)(xz) + xyz\,(xy)$$

$$a_2 = 2yz + x^2z + xyz + x^2y^2z$$

$$\text{At } (1,1,2) = a_y = 1 + 1 + 2 = 4$$

$$a_z = 2(1)(2) + (1)^2(2) + (1)(1)(2) + (1)^2(1)^2(2)$$

$$= 4 + 2 + 2 + 2 = 10$$

$$\vec{a} = 4\hat{j} + 10\hat{k}$$

20. An anisotropic soil deposit has coefficient of permeability in vertical and horizontal directions as k_z and k_x respectively. For constructing a flow net, the horizontal dimension of the problem's geometry is transformed by a multiplying factor of:

(A) $\sqrt{\frac{k_z}{k_x}}$

(B) $\sqrt{\frac{k_x}{k_z}}$

(C) $\frac{k_x}{k_z}$

(D) $\frac{k_z}{k_x}$

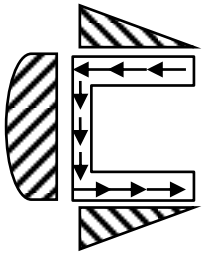
[Ans. A]

$$X = X_T\sqrt{\frac{k_x}{k_z}}$$

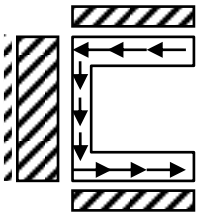
Transformed horizontal dimension, $X_T = X\sqrt{\frac{k_z}{k_x}}$

21. For a channel section subjected to a downward vertical shear force at its centroid, which one of the following represents the correct distribution of shear stress in flange and web?

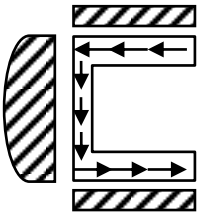
(A)



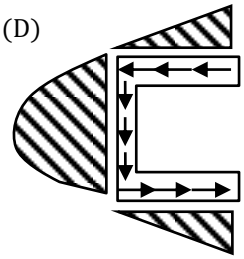
(B)



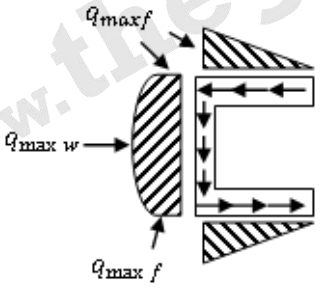
(C)



(D)



[Ans. A]

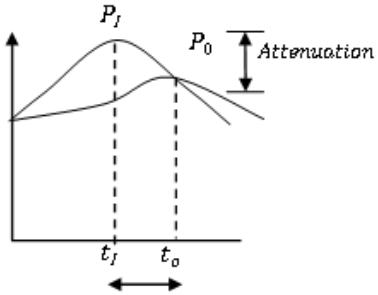


22. Which one of the following options contains ONLY primary air pollutants?
(A) Hydrocarbons and nitrogen oxides
(B) Hydrocarbons and ozone
(C) Ozone and Peroxyacetyl nitrate
(D) Nitrogen oxides and peroxyacetyl nitrate
[Ans. A]
Hydrocarbons and nitrogen oxides are considered primary air pollutants.

23. An inflow hydrograph is routed through a reservoir to produce an outflow hydrograph. The peak flow of the inflow hydrograph is P_I and the time of occurrence of the peak is t_I. The peak flow of the outflow hydrograph is P_O and the time of occurrence of the peak is t_O. Which one of the following statements is correct?

(A) $P_I > P_O$ and $t_I > t_O$
(B) $P_I < P_O$ and $t_I > t_O$
(C) $P_I > P_O$ and $t_I < t_O$
(D) $P_I < P_O$ and $t_I < t_O$

[Ans. C]



The outflow from the reservoir is uncontrolled therefore peak of outflow hydrograph will occur at the junction of inflow and outflow hydrograph.

$P_I > P_0$

$t_I < t_0$

24. A steel column is restrained against both translation and rotation at one end and is restrained only against rotation but free to translate at the other end. Theoretical and design (IS: 800-2007) value respectively of effective length factor of the column are:

(A) 1.0 to 1.0
(B) 1.2 to 1.0
(C) 1. 2 to 1.2
(D) 1.0 to 1.2

[Ans. D]

25. An earthen dam of height H is made of cohesive soil whose cohesion and unit weight are c and γ respectively. If the factor of safety against cohesion is F_c, the Taylor's stability number (S_n) is:

(A) $\frac{cF_c}{\gamma H}$
(B) $\frac{F_c \gamma H}{c}$
(C) $\frac{c}{F_c \gamma H}$
(D) $\frac{\gamma H}{cF_c}$

[Ans. C]

$$S_n = \frac{c}{\gamma H_c} = \frac{c}{\gamma F_c H}$$

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

26. The inverse of the matrix $\begin{bmatrix} 2 & 3 & 4 \\ 4 & 3 & 1 \\ 1 & 2 & 4 \end{bmatrix}$ is

(A) $\begin{bmatrix} 10 & -4 & -9 \\ -15 & 4 & 14 \\ 5 & -1 & -6 \end{bmatrix}$

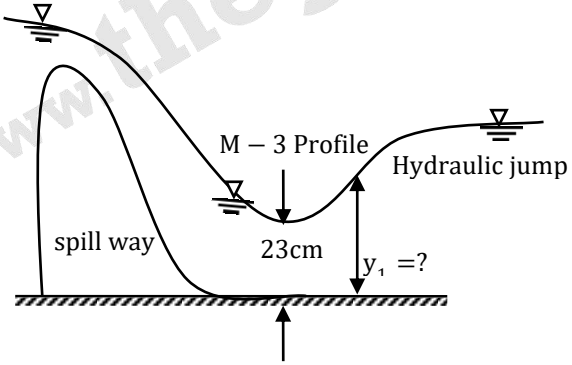
(B) $\begin{bmatrix} -10 & 4 & 9 \\ 15 & -4 & -14 \\ -5 & 1 & 6 \end{bmatrix}$

(C) $\begin{bmatrix} -2 & 4/5 & 9/5 \\ 3 & -4/5 & -14/5 \\ -1 & 1/5 & 6/5 \end{bmatrix}$

(D) $\begin{bmatrix} 2 & -4/5 & -9/5 \\ -3 & 4/5 & 14/5 \\ 1 & -1/5 & -6/5 \end{bmatrix}$

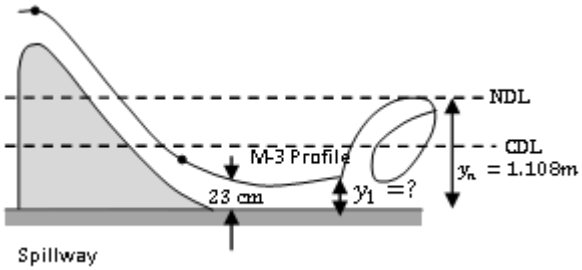
[Ans. C]

27. At the foot of spillway, water flows at a depth of 23cm, with a velocity of 8.1m/s as shown in figure



The flow enters as a M – 3 profile in a long wide rectangular channel with bed slope=1/1800 and Manning's n=0.015. A hydraulic jump is formed at a certain distance from the foot of spill way. Assume the accerlation due to gravity, $g = 9.81\ m/s^2$, Just before the hydraulic jump, the depth of flow y_1,(in m, round off to 2 decimal places) is _____

[Ans. *] Range: 0.41 to 0.43



$Y = 0.23M, V = 8.1\ m/s$

$\therefore q = Vy = 0.23 \times 8.1 = 1.863\ m^3/s - m$

$S_0 = \frac{1}{800}$

D=0.015

y_n = Normal depth of flow

R = y for wide rectangular channel

By Manning's equation

$\therefore q = \frac{Y_n}{n} R^{\frac{2}{3}} S_0^{\frac{1}{2}}$

$\Rightarrow 1.863 = \frac{y_n^{\frac{5}{3}}}{0.015} \times \left(\frac{1}{1800}\right)^{\frac{1}{2}}$

y_1 is conjugate depth of y_0

$\therefore \frac{y_1}{y_n} = -1 + \frac{\sqrt{1 + 8Fr_n^2}}{2}$

$\left(Fr_n^2 = \frac{q^2}{gy_n^3}\right)$

$\therefore y_1 = -1 + \frac{\sqrt{1 + 8 \times \frac{1.863^2}{9.81 \times 1.108^3}}}{2} \times 1.108$

$= 0.418\ m \sim 0.42\ m$

28. The probability density function of a continuous random variable distributed uniformly between X and Y (for Y>X) is

(A) $\frac{1}{X - Y}$

(B) $\frac{1}{Y - X}$

(C) $X - Y$

(D) $Y - X$

[Ans. B]

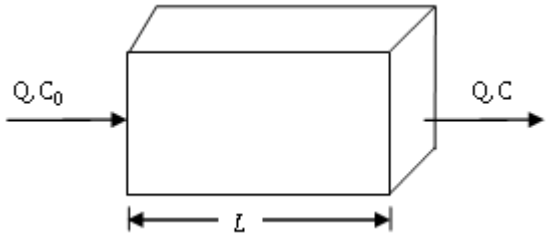
Probability density function of uniform distribution is

$$f(x) = \frac{1}{y - x}$$

29. The speed density Relationship of highway is given as
$u = 100 - 0.5K.$
Where, u=speed in km per hour, k=density in vechicles per km. the maximum flow (in vechicles per hour, round off to the nearest integer) is _____
[Ans. *] Range: 5000 to 5000
$u = 100 - 0.5k$
$$u = 100\left[1 - \frac{k}{(\frac{100}{0.5})}\right]$$
Green shield model $u = V_f\left(1 - \frac{k}{k_j}\right)$
Vf = free mean speed = 100 kmph
k_j = Jam density $= \frac{100}{0.5} = 200$ veh./km
Max flow: $q_{max} = \frac{1}{4}V_f k_j$
$= \frac{1}{4} \times 100 \times 200 = 5000$ veh/hr

30. Consider the reactor shown in figure the flow rate through the reactor is Q m^3/hr. The concentration (mg/l) of a compound in the influent and effluent are Co and C respectively. The compound is degraded in the reactor following the I^{st} order reaction. The mixing condition of reactor can be varied such that the reactor becomes either a completely mixed flow reactor (PFR). The length of reactor can be adjusted in these two mixing conditions to L_{CMFR} and L_{PFR} while keeping cross of section of the reactor constant. Assuming steady state and for $C/Co = 0.8$ the value of L_{CMFR}/L_{PFR} (up to decimal place) is _____

[Ans. *] Range: 1.10 to 1.15



For (CMFR) completely mixed flow reactor

$c = \frac{c_0}{1 + kt}$

For (PFR) plug flow reactor

$c = c_o e^{-kt}$

As $c/c_0 = 0.8$

For CMFR $= 0.8 = \frac{1}{1 + kt_{CMFR}}$

$\Rightarrow \quad t_{CMFR} = \frac{0.25}{k}$ ... (i)

For PFR $0.8 = e^{-kt_{PFR}}$

$\Rightarrow \quad t_{PFR} = \frac{0.22314}{k}$ ... (ii)

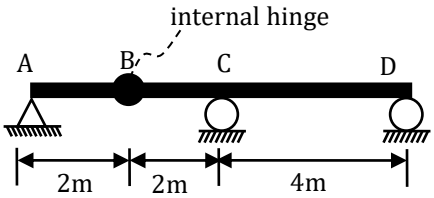
Now for steady state

v= constant and

L=vt

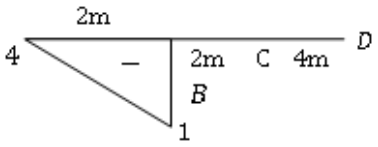
So, $\frac{L_{CMFR}}{L_{PFR}} = \frac{vt_{CMFR}}{vt_{PFR}} = \frac{0.25}{0.22314} = 1.12$

31. A long uniformly distributed load of 10 kN/m and a concentrated load of 60kN are moving together on the beam ABCD shown in the figure (not drawn to scale). The relative positions of the two loads are not fixed. The maximum shear force (in kN, round off to the nearest interger) caused at the internal hinge B due to the two loads is _____



[Ans. *] Range: 70 to 70

ILD for V_B



Maximum shear $V_B = -\left[\left(\frac{1}{2} \times 2 \times 1 \times 10\right) + (60 \times 1)\right] = -70$ kN

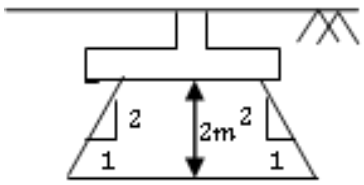
32. A 2m × 4m rectangular footing has to carry a uniformly distributed load of 120kpa. As per the 2:1 dispersion method of stress distribution, the increment in vertical stress (inb kpa) at a depth of 2m below the footing is _____

[Ans. *] Range: 40 to 40

The area of rectangular footing = 2 m × 4 m

q = 120 kPa

As 2:1 dispersion method of stress distribution



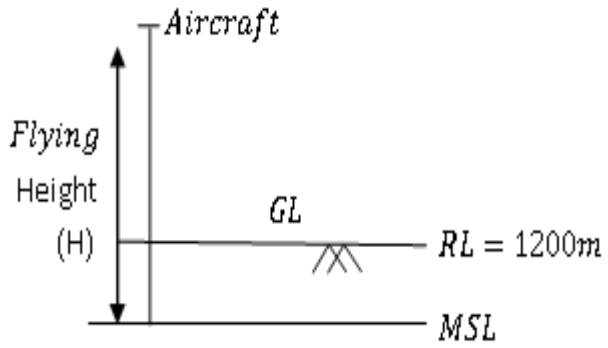
$$\Delta\bar{\sigma} = \frac{q(B \times L)}{(B + 2nZ)(L + 2nZ)} = \frac{120 \times 2 \times 4}{\left(2 + 2 \times \frac{1}{2} \times 2\right)\left(4 + 2 \times \frac{1}{2} \times 2\right)}$$

$\Delta\bar{\sigma} = 40$kPa

33. A camera with a focal length of 20cm fitted in an aircraft is used for taking vertical aerial photographs of a terrain. The average elevation of the terrtain is 1200m above mean sea level MSL. What is the height above MSL at which an aircraft must fly in order to get the aerial photographs at a scale of 1:8000?

(A) 3200m
(B) 2800m
(C) 2600m
(D) 3000m

[Ans. B]



Given focal length = 20 cm

As we know scale of vertical photograph= $\frac{f}{H-h_{avg}}$

It's given as 1:8000

Hence, $\frac{f}{H-h_{avg}} = \frac{1}{8000}$

$$\frac{20cm}{H-1200\times 100cm} = \frac{1}{8000}$$

$\Rightarrow H = 2800$ m

34. A broad gauge railway line passes through a horizontal curved section (radius=875 m) of length 200m. the allowable speed on this portion is 100 km/h. for calculating the cant, consider the gauge as center-to-center distance between the rail heads, equal to 1750 mm. the maximum permissible cant(in mm, round off to 1 decimal place) with respect to the center-to center distance between the rail heads is _____

[Ans. *] Range: 157.3 to 157.6

Allowable speed is given as 100 kmph

$e_{th} = \frac{GV_{max}^2}{127R}$

$e_{th} = 1.750 \times \frac{100^2}{127 \times 875}$

$e_{th} = 15.75cm$

$\therefore e_{th} = e_{act} + C.D$ (Assume C.D.=7.6 cm)

$e_{act} = e_{th} - C.D = 15.75 - 7.6$

$e_{act} = 8.15$ cm$\underline{\sim}$81.5 mm

35. A square footing of 2m sides rests on the surface of a homogeneous soil bed having the properties: cohesion c=24 kpa, angle of internal friction $\phi = 25°$, and unit weight $\gamma = 18\text{kN/m}^3$. Terzaghi's bearing capacity factors for $\phi = 25°$ are $N_c = 25.1. N_q = 12.7, N_\gamma = 9.7, N_c' = 14.8, N_q' = 5.6$ and $N_\gamma' = 3.2$. the ultimate bearing capacity of the foundation (in kpa, round off to 2 decimal places) is _____

[Ans. *] Range: 350 to 355

$c = 24\ \text{kN/m}^2, \phi = 25°, \gamma = 18\text{kN/m}^3$

$N_c = 25.1, N_q = 12.7, N_\gamma = 9.7$

$N_c' = 14.8, N_q = 5.6, N_\gamma = 3.2$

Square footing $B = 2\ \text{m}, L = 2\ \text{m}, D_f = 0$(Surface footing)

Since, $\phi = 25° < 28° \rightarrow$ Assume local shear failure

Hence, $c_m = \frac{2}{3}c = \frac{2}{3} \times 24 = 16\text{kN/m}^2$

$N_c' = 14.8, N_q' = 5.6,\ N_\gamma = 3.2$

Ultimate bearing capacity of square footing,

$q_u = 1.3c_m N_c' + \gamma D_f N_q' + 0.4\gamma B N_\gamma'$

$q_u = 1.3 \times 16 \times 14.8 + 0 + 0.4 \times 18 \times 2 \times 3.2$

$q_u = 307.84 + 46.08$

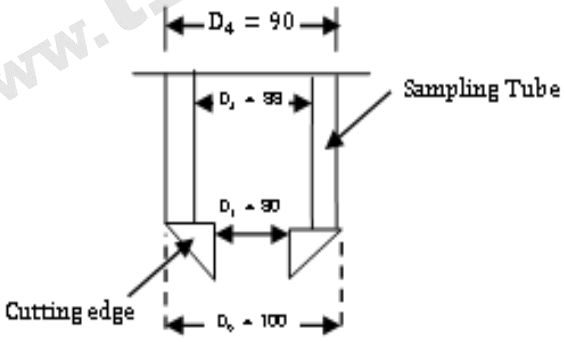
$q_u = 353.92\ \text{kN/m}^2$

36. The dimension of a soil sampler are given in the table.

Parameter	Cutting edge	Sampling tube
Inside diameter (mm)	80	86
Outside diameter (mm)	100	90

For this sampler, the outside clearance ratio (in percent, round off to 2 decimal places) is

[Ans. *] Range: 11.10 to 11.12



Outside clearance

$$\text{Outside clearance} = \left[\frac{D_2 - D_4}{D_4}\right] \times 100$$

$$\text{Outside clearance} = \left[\frac{100 - 90}{90}\right] \times 100 \quad = 11.11\%$$

37. An ordinary differential equation is given below.

$$\left(\frac{dy}{dx}\right)(x \ln x) = y$$

The solution for the above equation is

(Note: K denotes a constant in the options)

(A) $y = kx \ln x$

(B) $y = kxe^{x}$

(C) $y = kxe^{-x}$

(D) $y = k \ln x$

[Ans. D]

$$\frac{d_y}{d_x}(x \ln x) = y$$

$$\frac{d_y}{y} = \frac{d_x}{x \ln x}$$

$$\int \frac{dy}{y} = \int \frac{1}{x \ln x} dx + \ln k$$

$\ln x = t$

$$\frac{1}{x} dx = dt$$

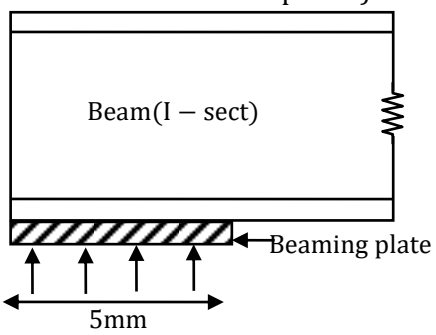
$$\ln y = \int \frac{dy}{t} + \ln k$$

$\ln y = \ln t + \ln k$

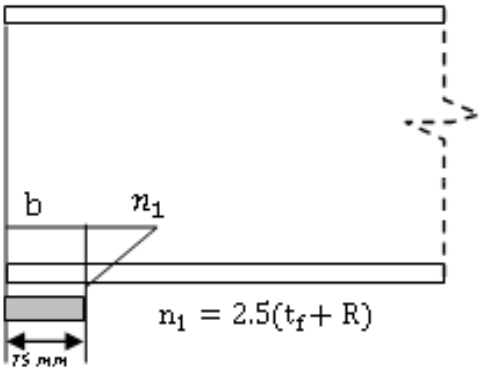
$\ln y = kt$

$y = k \ln x$

38. A rolled I section beam is supported on a 75mm wide bearing plate as shown in figure. Thickness of the flange and web of the I section are 20mm and 8mm respectively .Root radius of the I-section is 10mm. Assume material yield stress fy = 250MPa and partial safety factor of material (γ_{mo}) = 1.10. As per IS:800-200>, the web beaming strength (in kN round off to 2 decimal places) of the beam is _____



[Ans. *]Range: 272.60 to 272.80



Web bearing strength $= [b + 2.5(t_r + R)] \times t_W \times \dfrac{f_y}{\gamma_{mo}}$

$= [75 + 2.5(20 + 10)] \times 8 \times \dfrac{250}{1.1}$

$= 272.73$ kN

39. A timber pile of length 8m and diameter 0.2m is driven with a 20kN drop hammer, falling freely from a height of 1.5m. The total penetration of the pile in the last 5 blows is 40mm. use the engineering News Record expression. Assume a factor of safety of 6 and empirical factor (allowing reduction in the theoretical set due to energy losses) of 2.5cm. the safe load carrying capacity of the pile (in kN , round off to 2 decimal places) is _____

[Ans. *]Range: 151 to 152

$L = 8$ m; $d = 0.2$ m, kN $= W \rightarrow$ drop hammer

H=1.5 m

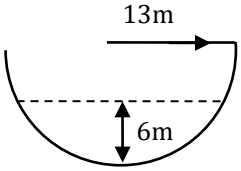
Penetration in 5 blows = 40 mm

$\therefore$ in 1 blow $= \dfrac{40}{5} = 8$ mm $= 0.8$ cm

$Q_{safe} = \left(\dfrac{WH}{s + c}\right) \times \dfrac{1}{FOS} = \dfrac{1}{6}\left[\dfrac{20\text{kN} \times (1.5 \times 100)}{0.8\text{cm} + 2.5\text{cm}}\right]$

$Q_{safe} = 151.51$ kN

40. Consider the hemi-spherical tank of radius 13m as shown in the figure. What is the volume of water(in m^3) when the depth of water at the centre of the tank is 6m?



(A) 78π
(B) 156π
(C) 396π
(D) 468π

[Ans. C]

Volume of water $= \frac{1}{3}\pi h^2(3r - h)$

$= \frac{1}{3}\pi \times 6^2 \times (3 \times 13 - 6) = 396\pi$

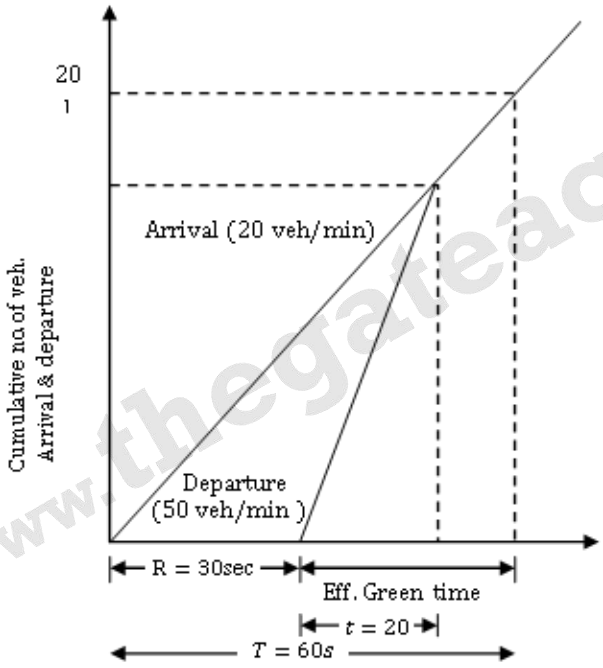
41. The uniform arrival and uniform service rates observed on an approach road to a signalized intersection are 20 & 50 vechicles/min respectively. For this signal the red time=30 sec, effective green time=30 sec & co=60sec. assuming that initially there are no vehicles in the queue, the average delay per vehicle using the approach road during a cycle length (in sec, round of two decimal places)_____

[Ans.*] Range: 12 to 13

Arrival rate = 20 veh/min

Service rate = 50 veh/min

$R = 30$ sec, $G_i = 30$ sec, Cycle length $= 60$ sec



Time corresponding to which no. of arrival becomes same as no. of

$\Rightarrow 20 \times (R + t) = 50t$

$20 \times (30 + t) = 50t$

$600+20t = 50t$

$t = \frac{600}{30} = 20$ sec

Avg. Delay $= \left(\frac{\text{Area under arrival line} - \text{Area under depatureline}}{\text{Cumulativenumber of vehicle arrival}}\right)$

42. Chlorine is used as the disinfectant in a municipal water treatment plant. It achievers 50% of disinfection efficiency measured in terms of killing the indicator microorganism (E-coil) in 3-minutes. The minimum time required to achieve 99% disinfection efficiency would be
(A) 9.93 min
(B) 21.93 min
(C) 19.93 min
(D) 11.93 min
[Ans. C]
During disinfection variations of micro-organism is given by
$N_t = N_o e^{-kt}$
$N_t = \text{No. of micro} - \text{organism at time t}$
$N_o = \text{No. of micro} - \text{organism at time 0}$
So, disinfection efficiency at any time't' , $\eta_t = \frac{N_o - N_t}{N_o} \times 100$
For $t = 3$ min; $\eta = 50\%$
$\eta_3 = N_o - \frac{N_o e^{-k\times 3}}{N_o} \times 100 = 50$
$k = 0.231 \text{min}^{-1}$
Now for $\eta_t = 99\%$
$\eta_t = \frac{N_o - N_t}{N_o} \times 100 = 99$
$N_o - \frac{N_o e^{-0.231\times t}}{N_o} \times 100 = 99$
t = 19.93 min

43. Raw municipal solid waste (MSW) collected from a city contains 70% decomposable material that can be converted to methane. The water content of the decomposable material is 35%. An elemental analysis of the decomposable material yields the following mass%
C: H : O : N : other 44 : 6 : 43 : 0.8 : 6.2
The methane production of the decomposable material is governed by the following stoichiometric relation.
$CaH_bO_cN_d + nH_2o \rightarrow mCH_4 + S\,co_2 + dNH_3$
Given atomic weight C=12, H=1, 0=16, N=14. The mass of methane produced (in grams, round off two decimal places) per kg of raw MSW will be _____
[Ans. *] Range: 271 to 271
mass of MSW = 1 kg
mass of decomposable material $= 0.7 \times 10^3 = 700$ gm
mass of decomposable solid $= 0.65 \times 700 = 455$ gm
% mass C : H : O : N : other =44 : 6 : 43 : 0.8 : 6.2
Moles of C $= \frac{455}{12} \times \frac{44.00}{100} = 16.68$ (a)

$$H = \frac{455}{1} + \frac{6}{100} = 27.3(b)$$

$$Q = \frac{455}{16} \times \frac{43}{100} = 12.22(c)$$

$$N = \frac{455}{14} \times \frac{0.8}{100} = 0.26(d)$$

$$C_aH_bO_cN_d + \left(a - \frac{b}{4} - \frac{c}{2} + \frac{3}{4}d\right)H_2O \rightarrow \left(\frac{a}{2} + \frac{b}{8} - \frac{c}{4} - \frac{3d}{8}\right)CH_4 + \left(\frac{a}{2} - \frac{b}{8} + \frac{c}{4} + \frac{3d}{8}\right)CO_2 + dNH_3$$

Moles of CH4 formed by, 1 mole of decomposable material

$$= \frac{a}{2} + \frac{b}{8} - \frac{c}{4} - \frac{3d}{8}$$

$$= \frac{16.68}{2} + \frac{27.3}{8} - \frac{12.22}{4} - \frac{3}{8} \times 0.26 = 16.93$$

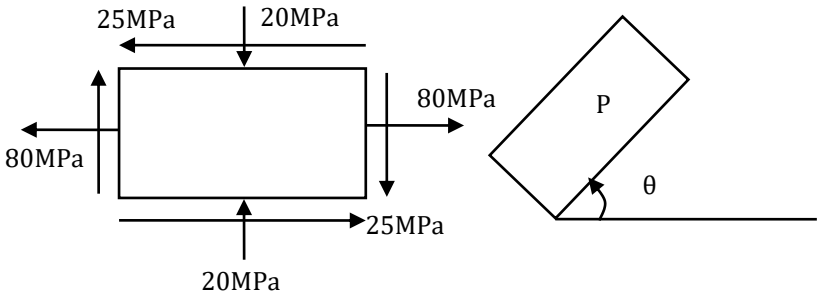
mass of CH_4 formed $= 16.93 \times 16 = 271$ gm

44. A flexible pavement has the following class of loads during a particular hour of the day.
(i) 80 buses with 2-axles(each axle load of 40kN)
(ii) 160 trucks with 2-axis(front and rear axle load of 40kN and 80kN respectively)
The equivalent standard axle load repetition for this vechicle combination as per IRC − 37 − 2012 would be
(A) 180
(B) 250
(C) 240
(D) 320
[Ans. A]
(i) 80 buses with 2 axle with 40 kN each.
$N_1 = 80 \times 2 = 160$
$L_1 = 40$ kN
(ii) 160 trucks $\begin{cases}\text{Front axle} \rightarrow 40 \text{ kN} \\ \text{Rear axle} \rightarrow 80 \text{ kN}\end{cases}$
$N_1 = 160, L_1 = 40$ kN
$N_2 = 160, L_2 = 80$ kN
(iii) Total no. of recetitions $\begin{cases}\text{For 40 kN} = 160 + 160 = 320 \\ \text{For 80 kN} = 160\end{cases}$
$N_1 = 320, L_1 = 40$ kN
$N_2 = 160, L_2 = 80$ kN
As per 4^{th} power law

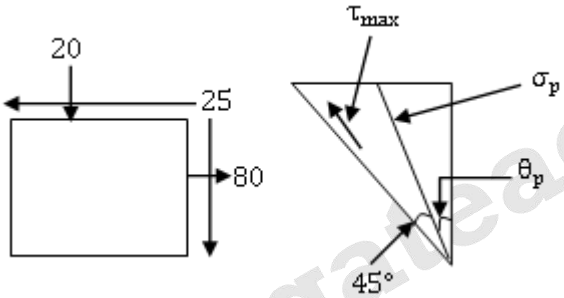
$$N_s = N_1\left(\frac{L_1}{L_5}\right)^4 + N_2\left(\frac{L_2}{L_s}\right)^4$$

$$= 320\left(\frac{40}{80}\right)^4 + 160\left(\frac{80}{80}\right)^4 = 20 + 160 = 180$$

45. For a plane stress problem, the state of stress at a point is represented by the stress element as shown in figure. By how much angle (θ indegree) the stress element should be rotate in order to get the planes of maximum shear stress?



(A) 13.3
(B) 26.6
(C) 31.7
(D) 48.3
[Ans. C]



$\sigma_x = 80, \sigma_y = -20 \tau_{xy} = -25$
Angle of plane of max shear
$\theta = \theta_p + 45°$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y} = -\frac{50}{100}$$

$\theta = -13.28°$
$\therefore\ \theta = 31.71°$

46. The ordinates of a 2-hour unit hydrograph (i.e., for 1 cm of effective rain). For a catchment are shown in the table.

t(hour)	0	1	2	3	4	5	6	7	8	9	10	11	12
u(m^3/s	0	2	8	18	32	45	30	19	12	7	3	1	0

A 6-hour storm occurs over the catchment such that the effective rainfall intensity is 1 cm/hour for the first two hours. Zero for the two hours, and 0.5 cm/hour for the last two hours. If the base flow is constant at $5\ m^3/s$. The peak flow due to this strom ($in\ m^3/s$, round off to 1 decimal place) will be _____
[Ans. *] Range: 96.5 to 97.5

Rainfall excess in 1st two hours,

$R_1 = 1\frac{cm}{hr} \times 2\ hr\ = 2\ cm$

Rainfall excess in 2nd two hours

$R_2 = 0$

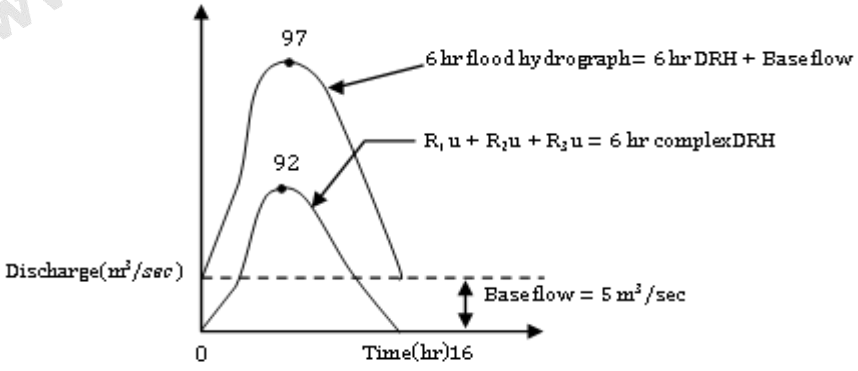
Rainfall excess in 3rd two hours,

$R_3 = 0.5\ cm/hr\ \times 2\ hr\ = 1\ cm$

Time (hr)	Ord. of 2 hr UH say u	$R_1u = 2u$	$R_2u = 0$	$R_3u = 1.u$	Ord. of 6 hr Complex DRH	Ord. of 6 hr Flood Hyd.=6 hr DRH+ base flow
0→	0→	0→	−→	−→	0	
1→	2→	4→	−→	−→	4	
2→	8→	16→	0→	−→	16	
3→	18→	36→	0→	−→	36	Peak flow
4→	32→	64→	0→	0→	64	
5→	45→	90→	0→	2→	92	$92 + 5$
6→	30→	60→	0→	8→	68	$= 97\ m^3/sec$
7→	19→	38→	0→	18→	56	
8→	12→	24→	0→	32→	56	
9→	7→	14→	0→	45→	56	
10→	3→	6→	0→	30→	36	
11→	1→	2→	0→	19→	21	
12→	0→	0→	0→	12→	12	
				7→	7	
				3→	3	
				1→	1	
				0→	0	

Alternate method:

Flood peak $= (90 + 2) + 5 = 97\ m^3/s$



47. Constant head permeability tests were performed on two soil specimens, S1 and S2. The ratio of height of the two specimens (Ls1:Ls2) is 1.5, the ratio of the diameter of specimens (Ds1:Ds2) is 0.5, and the ratio of the constant head (hs1:hs2) applied on the specimens is 2.0. if the discharge from both specimens is equal, the ratio of the permeability of the soil specimens (ks1:ks2) is _____

[Ans. *] Range: 3 to 3

$\frac{L_{s_1}}{L_{s_2}} = 1.5$

$\frac{D_{s_1}}{D_{s_2}} = 0.5$

$\frac{h_{s_1}}{h_{s_2}} = 2$

$\frac{k_{s_1}}{k_{s_2}} = ?$

Discharge is same

$k_1 i_1 A_1 = k_2 i_2 A_2$

$k_1 \frac{h_{s1}}{L_{s1}} \times \frac{\pi}{4} \times D_{s_1}^2 = k_2 \frac{h_{s2}}{L_{s2}} \times \frac{\pi}{4} \times D_{s_2}^2$

$\frac{k_{s1}}{k_{s2}} = \frac{L_{s1}}{L_{s2}} \times \frac{h_{s2}}{h_{s1}} \times \frac{D_{s_2}^2}{D_{s_1}^2} = 1.5 \times \frac{1}{2} \times \left(\frac{1}{0.5}\right) = 3$

48. The critical bending compressive stress in the extreme fibre of a structural steel section is 1000MPa. It is given that the yield strength of the steel is 250MPa. Width of flange is 250mm and thickness of flange is 15mm. as per the provisions of IS:800-2007, the non-dimensional slenderness ratio of the steel cross-section is

(A) 2.00
(B) 0.75
(C) 0.50
(D) 0.25

[Ans. B]

$\gamma = \sqrt{\frac{f_y}{f_{cr}}} = \sqrt{\frac{250}{1000}} = 0.5$

49. In the context of provisions relating to durability of concrete, consider the following assertions:

Assertion (1): as per IS 456-2000 , air entrainment to the extent of 3% to 6% is required for concrete exposed to marine environment.

Assertion (2): the equivalent alkali content (in terms of Na_2O equivalent) for a cement containing 1% and 0.6% of Na_2O and K_2o respectively is approximately 1.4% (rounded to 1 decimal place)

Which one of the following statement is CORRECT?

(A) Assertion (1) is FALSE and Assertion (2) is TRUE

(B) Assertion (1) IS TRUE and Assertion (2) is FALSE

(C) Both Assertion (1) and Assertion (2) are TRUE

(D) Both Assertion (1) and Assertion (2) are FALSE

[Ans. A]

(1) As per IS: 456-2000, Cl. 8.2.2.3.

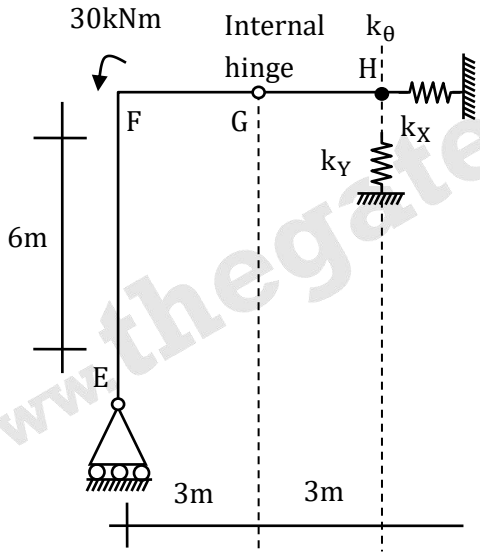
(2) Percentage of Na_2O (equivalent)

$= Na_2O(\%) + 0.658 \times K_2O(\%)$

$= 1.0 + 0.658 \times 0.60 = 1.40\%$ (Approx)

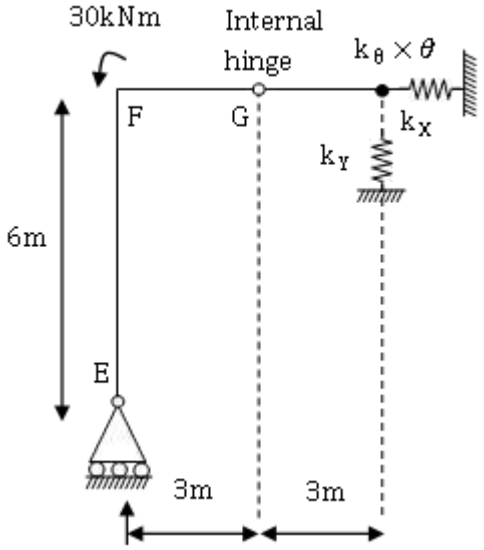
Both Assertions are correct.

50. A plane frame shown in the figure (not to scale) has linear elastic springs at node H. the spring constants are $k_x = k_y = 5 \times 10^5 \frac{kN}{m}$ and $k_\theta = 3 \times 10^5$ kNm/rad.



For the externally applied moment of 30 kNm at node F, the rotation (in degrees , round off to 3 decimals) observed in the rotational spring at node H is _____

[Ans. *] Range: 0.005 to 0.007



No moment can be taken by segment FE

$\therefore M_{FE} = 0$

$M_\theta = k_\theta \times \theta$

$30\ \text{kNm} = 3 \times 10^5\ \text{kNm/rad} \times \theta$

$\theta = 1 \times 10^{-4}\text{radians} = 0.0057°$

51. A water treatment plant treats 6000 m^3 of water per day. As a part of the treatment process, discrete particles are required to be settled in a clarifier. A column test indicates that an overflow rate of 1.5 m per hour would produce the desired removal of particles through settling in the clarifier having a depth of 3.0 m. the volume of the required clarifier (in m^3, round off to 1 decimal place) would be _____

[Ans. *] Range: 495 to 505

Design discharge, $Q_0 = 6000\ m^3/d$

Overflow rate OFR (v_s) = 1.5 m/hr

$$SA = \frac{Q_0}{OFR}$$

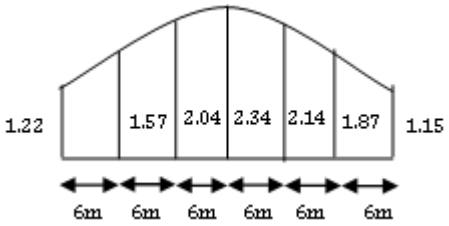
Volume, V = SA × Depth (H)

$$= \frac{Q_0}{OFR} \times H = \frac{6000 \times 3}{1.5 \times 24}$$

$V = 500\ m^3$

52. A series of perpendicular offsets taken from a curved boundary wall to a straight survey line at an interval of 6m are 1.22, 1.67, 2.04, 2.34, 2.14, 1.87 and 1.15m. the area (in m^2, round off to 2 decimal places) bounded by the survey line, curved boundary wall, the first and the last offsets, determined using Simpson's rule is _____

[Ans. *] Range: 67 to 70



Area by Simpson's rule

$$A = \frac{d}{3}[h_0 + h_n + 4(h_1 + h_3 + \cdots) + 2(h_2 + h_4 + \cdots)]$$

$$= \frac{6}{3}[1.22 + 1.15 + 4 \times (1.67 + 2.34 + 1.87) + 2(2.04 + 2.14)]$$

$$= 68.50\ m^2$$

53. When a specimen of M25 concrete is loaded to a stress level of 12.5 MPa, a strain of 500×10^{-6} is recorded. If the load is allowed to stand for a long time, the strain increases to 1000×10^{-6}. In accordance with the provisions of IS:456-2000. Considering the long-term effects, the effective modulus of elasticity of the concrete (in MPa) is_____

[Ans. *] Range: 3 to 3

Initial strain $= 500 \times 10^{-6}$

stress $= 12.5 N/mm^2$

$$E_c = \frac{\text{stress}}{\text{strain}} = \frac{12.5}{500 \times 10^{-6}} = 25000\ N/mm^2$$

$$E_c = 5000\sqrt{25} = 25000\ N/mm^2$$

Total strain after long time $= 1000 \times 10^{-6}$

$$E_{ce} = \frac{E_c}{1 + \theta}$$

$$\theta = \frac{\text{Ultimate starin due tocreep}}{\text{Elastic strain}} = \frac{(1000 - 500) \times 10^{-6}}{500 \times 10^{-6}} = 1.0$$

Effective modulus of elasticity

$$E_{ce} = \frac{E_c}{1 + \theta} = \frac{25000}{1 + 1.0} = 12500\ N/mm^2$$

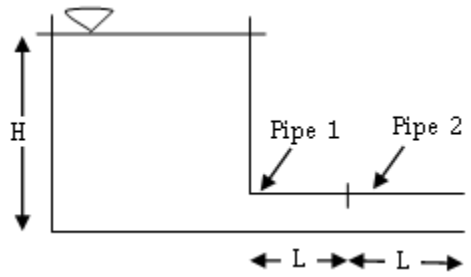
54. Two identical pipes (i.e., having the same length, same diameter, and same roughness) are used to withdraw water from a reservoir. In the first case, they are attached in series and discharge freely into the atmosphere. In the second case, they are attached in parallel and also discharge freely into the atmosphere. Neglecting all minor losses, and assuming that the friction factor is same in both the cases, the ratio of the discharge in the parallel arrangement to that in the series arrangement (round off to 2 decimal places) is _____

[Ans. *] Range: 2.80 to 2.90

Given: Two identical pipes of same length (L), diameter (D) and roughness (k_s).

1^{st} = case (series)

Assume height of reservoir = H

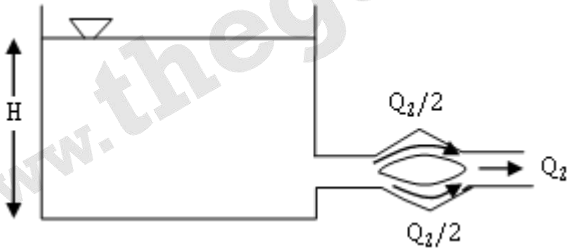


$$H = h_{f1} + h_{f2}$$

$$H = 2h_{f1}$$

$$H = 2\left[\frac{8Q_1^2}{\pi^2 g} \times \frac{f.L}{D^5}\right]$$

2nd case (Parallel)



$$H = \frac{8}{\pi^2 g}\left(\frac{Q_2}{2}\right)^2 \times \frac{fL}{D^5}$$

$$H = \frac{8}{\pi^2 g} \times \frac{fL}{D^5} \times \frac{Q_2^2}{4}$$

By eq. (i) and (ii)

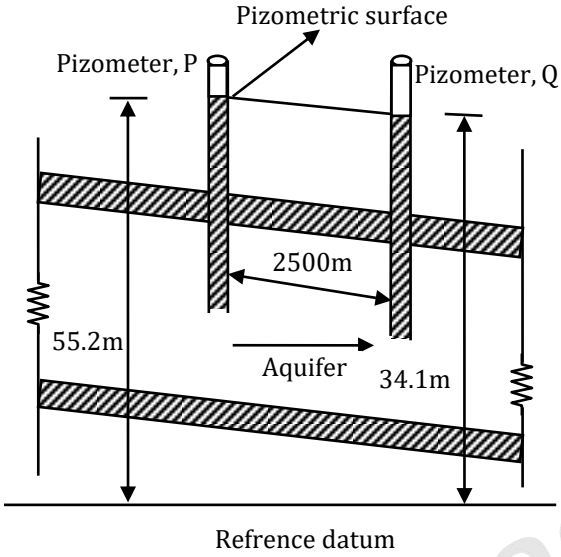
$$2\left[\frac{8Q_1^2}{\pi^2 g} \times \frac{f.L}{D^5}\right] = \frac{8}{\pi^2 g} \times \frac{\frac{fL}{D^5}Q_2^2}{4}$$

$$\frac{8}{\pi^2 g} \times \frac{fL}{D^5} 2Q_1^2 = \frac{8}{\pi^2 g} \times \frac{fL}{D^5}\frac{Q_2^2}{4}$$

$\frac{Q_2}{Q_1} = \sqrt{8}$

= 2.83 (round off to 2 decimal place)

55. A confined aquifer of 15m constant thickness is sandwiched between two aquicludes as shown in the figure (not drawn to scale).



[Ans.*] Range: 924 to 926

V=ki

$v_s = \frac{ki}{n}$

$v_s = \frac{80m}{day} \times \left(\frac{55.2 - 34.1}{2500} \times \frac{1}{0.25}\right) = \frac{2500}{times}$

time = 925.651 day

= 925.7 days