MADE EASY

MADE EASY

India's Best Institute for IES, GATE & PSUs

GATE 2019
Civil Engineering

Click here for
Questions and Solutions

Date of Exam : 10/2/2019 (Afternoon)

Scroll down to view

www.madeeasy.in

Corporate Office: 44-A/1, Kalu Sarai, New Delhi - 110016 | **Ph:** 011-45124612, 9958995830

Delhi | Hyderabad | Noida | Bhopal | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

GENERAL APTITUDE

Q.1 Suresh wanted to lay a new carpet in his new mansion with an area of 70 x 55 sq. mts. However an area of 550 sq. 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. 2,75, 000
(c) Rs. 1,92, 500
(d) Rs. 1,27, 500

Ans. (a)

Cost of carpet = [70 × 55 – 550] × 50 = Rs. 1,65,000

End of Solution

Q.2 Daytime temperatures in Delhi can______40°C.

(a) get
(b) peak
(c) reach
(d) stand

Ans. (c)

Daytime temperatures in Delhi can **reach** 40°.

End of Solution

Q.3 A retaining wall with measurements 30 m x 12 m x 6 m was constructed with bricks of dimensions 8 cm x 6 cm x 6 cm If 60% of the wall consists of bricks, the number of bricks used for the construction is________lakhs.

(a) 30
(b) 40
(c) 75
(d) 45

Ans. (d)

Number of bricks = x

$$\Rightarrow 30 \times 12 \times 6 \times 10^6 \times 0.6 = 8 \times 6 \times 6 \times x$$

$$x = 4.5 \times 10^6 = 45 \times 10^5 = 45 \text{ lakhs bricks}$$

End of Solution

Q.4 Hima Das was_____only Indian athlete to win_______gold for India.

(a) the, a
(b) an, a
(c) an, the
(d) the, many

Ans. (a)

Hima Das was **the** only Indian athlete to win **a** gold for India.

End of Solution

Q.5 The growth rate of ABC Motors in 2017 was the same__________XYZ Motors in 2016.

(a) as that off
(b) as those of
(c) as off
(d) as that of

Ans. (d)

The growth of ABC motors was same in 2017 as that of *XYZ* motors in 2016.
Subject of the sentence is 'The growth of *ABC* motors'. It is to be compared with the growth of *XYZ* motors hence use of 'that of' is appropriate.

End of Solution

Q.6 Mohan, the manager, 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.

End of Solution

Q.7 "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."

Which one of the following CANNOT be inferred from the paragraph above?

(a) Protagonists in Hindi movies, being ideals for viewers, read only books of aspirational value
(b) People do not look up to writers of textbooks, English books or high value literature
(c) Though popular Hindi fiction has wide reach: it often does not appear in the movies
(d) Textbooks, English books or high literature have aspirational value, but not popular Hindi Fiction

Ans. (a)

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."

End of Solution

Q.8 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__________.

ESE 2019

Mains Classroom Program
Conventional Ques. Practice Program

Commencing from

20th Feb, 2019

These batches are offered only at **Delhi** Centre.

Mains Test Series
Conventional Test Series

Commencing from

17th Mar, 2019

Test series will be conducted at **all MADE EASY** centres across India.

Features :

- Very useful to develop numerical solving approach & improving writing skills.
- Special focus on improving answer layout specially for theory questions.
- Classes will be delivered by senior faculties.
- Updated Mains workbook for every subject having varied practice question sets.
- Test series will be conducted on every Sunday in synchronisation with the subject taught in class.
- Discussion on probable questions.
- Comprehensive and in-depth discussion on variety of conventional questions, thus strengthening fundamental concepts.

Batch Details	Course Duration	Class Duration	Test Series
	90 days | 300 - 350 hours	5-6 days a week and 6-7 hours a day	Every Sunday

Streams	Batch Code	Batch Commencing Date	Venue (Delhi)	Timing
ME	A	20-Feb-2019	Ghitorni Centre	7:30 AM to 1:30 PM
ME	B	20-Feb-2019	Ghitorni Centre	3:00 PM to 9:00 PM
ME	C	20-Feb-2019	Saket Centre	7:30 AM to 1:30 PM
CE	A	21-Feb-2019	Ignou Road Centre	7:30 AM to 1:30 PM
CE	B	21-Feb-2019	Kalu Sarai Centre	3:00 PM to 9:00 PM
EE	A	22-Feb-2019	Lado Sarai Centre	7:30 AM to 1:30 PM
EE	B	22-Feb-2019	Kalu Sarai Centre	3:00 PM to 9:00 PM
EC	A	22-Feb-2019	Lado Sarai Centre	7:30 AM to 1:30 PM

Hostel facility will be arranged

Fee Structure	Program	Ex. MADE EASY Students Enrolled in Postal, Rank Improvement, Mains, GS, Post-GATE, ESE+ GATE, GATE Batches	Non MADE EASY students
	Mains Exclusive Batch (Inclusive of ESE-2019 Mains Offline Test Series)	₹ 18,500	₹ 22,500
	ESE 2019 Mains Offline Test Series	Rs. ~~3,500~~/- Rs. 2,500/-	Rs. ~~4,500~~/- Rs. 3,500/-

Rs. 1000/- Discount on test series valid till **15-02-2019**

Corporate office : 44-A/1, Kalu Sarai, New Delhi - 1100 16 011-45124612, 9958995830

Click here to enroll

(a) $\frac{x}{y}$

(b) $\frac{100(x-y)}{100+y}$

(c) $x - y$

(d) $\frac{100(x-y)}{100+x}$

Ans. (b)

Let a, b be initial population

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

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

So, required % change,

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

End of Solution

Q.9 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) 1.50
(c) 2.00
(d) 2.50

Ans. (d)

Let inlet pipes, A = 4 hours

B = 5 hours

outlet pipe, C = 20 hours

In 1 hour ($A + B + C$) can fill $= \frac{1}{4}+\frac{1}{5}-\frac{1}{20} = \frac{8}{20} = \frac{2}{5}$

($A + B + C$) together $= \frac{5}{2} = 2.5$ hours

End of Solution

Q.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 forests".

On the basis of the information available in the paragraph, ________ is/are responsible for duping the tribals.

(a) The Newspaper
(b) it cannot be inferred who
(c) forest officials
(d) landless families

Ans. (b)

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.

End of Solution

■■■■

CIVIL ENGINEERING

Q.1 The notation "SC" as per Indian Standard Soil Classification System refers to

(a) Silty clay
(b) Clayey sand
(c) Sandy clay
(d) Clayey silt

Ans. (b)

SC $\rightarrow$ Clayey sand

End of Solution

Q.2 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) $\frac{v_f k_j}{4}$
(b) $\frac{v_f k_j}{2}$
(c) $v_f k_j$
(d) $\frac{v_f k_j}{8}$

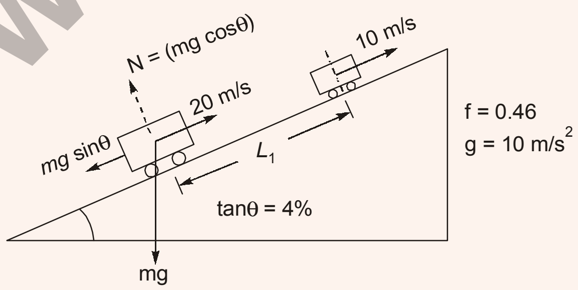
Ans. (a)

$$\text{maximum flow} = \frac{1}{4} v_f k_j$$

End of Solution

Q.3 A vehicle is moving on a road of grade +4% at a speed of 20 m/s. Consider the coefficient of rolling friction as 0.46 and acceleration due to gravity as 10 m/s^2. On applying brakes to reach a speed of 10 m/s, the required braking distance (in m, round off to nearest integer) along the horizontal, is ____________.

Ans. (30)



$$\tan\theta = 4\% = 0.04$$
$$\theta = 2.29°$$
$$\cos\theta = 0.999$$
$$\Delta K.E = \text{work done}$$
$$\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = -L[mg\sin\theta + fmg\cos\theta]$$

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

$$\Rightarrow \quad \frac{v_1^2 - v_2^2}{2g} = L[\tan\theta + f]$$

$$\frac{20^2 - 10^2}{2\times 10} = L[0.04 + 0.46]$$

$$L = 30 \text{ m}$$

Now braking distance along horizontal = $[L\cos\theta]$

$= 30 \times 0.999 = 29.97 \text{ m} \simeq 30 \text{ m}$ (Near integer)

End of Solution

Q.4 The Laplace transform of sin$h$(at) is

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

(c) $\frac{a}{s^2 - a^2}$ (d) $\frac{a}{s^2 + a^2}$

Ans. (c)

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

End of Solution

Q.5 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 Lagrange 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) No definite relation exists between I_L and I_N
(c) I_L and I_N are always equal
(d) I_L is always less than I_N

Ans. (b)

End of Solution

Q.6 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 stress, τ. Torsional moment of resistance T, of the section would be

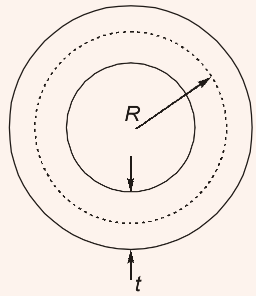
(a) $2\tau A_m t$
(b) $4\tau A_m t$
(c) $\tau A_m t$
(d) $0.5\tau A_m t$

Ans. (a)

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

$$\tau = \frac{T}{2\pi R^2 t} = \frac{T}{2A_m \cdot t}$$

$$\therefore \quad T = 2\tau A_m t$$



End of Solution

Q.7 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) 300 μm and 600 μm
(b) 2.36 mm and 4.75 mm
(c) 1.18 mm and 2.36 mm
(d) 150 μm and 300 μm

Ans. (c)

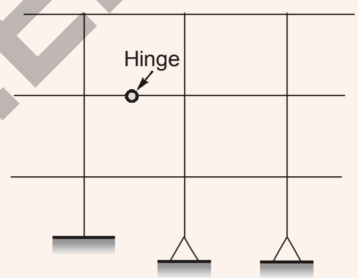
The sieves that are to be used for the sieve analysis of the aggregate (coarse, fine, or all-in-aggregate) for concrete as per IS:2386 (Part I) -1963 are, 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 μm, 300 μm and 150 μm.

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.

End of Solution

Q.8 The degree of static indeterminacy of the plane frame as shown in the figure is_______



Ans. (15)

$$D_{se} = 7 - 3 = 4$$
$$D_{si} = (3 \times 4) - (2 - 1) = 11$$
$$D_s = 15$$

End of Solution

Q.9 The characteristic compressive strength of concrete required in a project is 25 MPa and the standard deviation in the observed compressive strength expected at site is 4 MPa. 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. (46)

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

$= 25 + 1.65 \times 4.0 = 31.6$

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

say 46%(round off to the lower integer)

End of Solution

Q.10 Structural failures considered in the mechanistic method of bituminous pavement design are

(a) Fatigue and Rutting
(b) Fatigue and Shear
(c) Shear and Slippage
(d) Rutting and Shear

Ans. (a)

End of Solution

Q.11 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 $\lim\limits_{x\to 0} \dfrac{x\sin x}{1-\cos x}$?

(a) 1
(b) 0
(c) $\frac{1}{2}$
(d) 2

Ans. (d)

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

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

End of Solution

Q.12 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 40 cm. 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. **(5184)**

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, $\Delta = \dfrac{864 \times B}{\Delta}$ ha/cumec

and Area to be irrigated; A = Q × D

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

$$\Rightarrow \quad A = 5184 \text{ ha}$$

End of Solution

Q.13 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) $4\pi r^2 p$

(b) $\dfrac{4}{3}\pi r^3 \rho_s \dfrac{dv}{dt}$

(c) $\pi r^2 p$

(d) zero

Ans. **(d)**

End of Solution

Q.14 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) values, respectively, of effective length factor of the column are

(a) 1.0 and 1.2

(b) 1.2 and 1.0

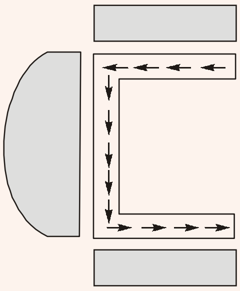
(c) 1.0 and 1.0

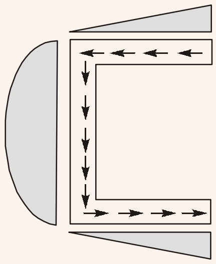
(d) 1.2 and 1.2

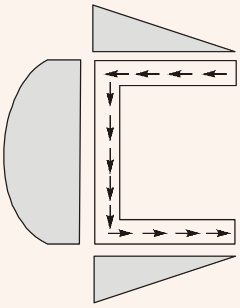
Ans. **(a)**

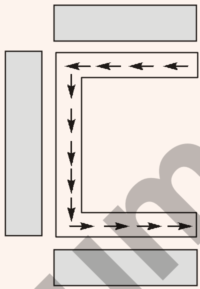
End of Solution

Q.15 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) 

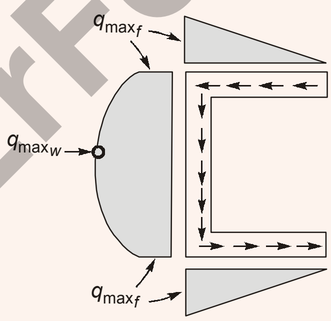
(b) 

(c) 

(d) 

Ans. **(c)**

Shear flow distribution for channel.



End of Solution

Q.16 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) $\dfrac{k_x}{k_z}$

(b) $\sqrt{\dfrac{k_z}{k_x}}$

(c) $\sqrt{\dfrac{k_x}{k_z}}$

(d) $\dfrac{k_z}{k_x}$

Ans. (b)

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

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

End of Solution

Q.17 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) $\frac{c}{F_c\gamma H}$

(b) $\frac{cF_c}{\gamma H}$

(c) $\frac{\gamma H}{cF_c}$

(d) $\frac{F_c\gamma H}{c}$

Ans. (a)

$$S_n = \frac{c}{\gamma H_c} = \frac{c}{\gamma F_c H} \qquad \left\{\because F_c = \frac{H_c}{H}\right\}$$

End of Solution

Q.18 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) 4i + 12**k**

(b) 2i + 10**k**

(c) j + **k**

(d) 4j + 10**k**

Ans. (d)

$$\vec{v} = 2\hat{i} + (x+y)\hat{j} + xyz\hat{k}$$

$$u = 2$$

$$v = x + y$$

$$w = xyz$$

$$a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t} = 0$$

$$a_y = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} + \frac{\partial v}{\partial t} = 2 + (x + y)$$

$$a_y = x + y + 2$$

$$a_z = u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} + \frac{\partial w}{\partial t}$$

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

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

At (1, 1, 2)

$$a_y = 1 + 1 + 2 = 4$$

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

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

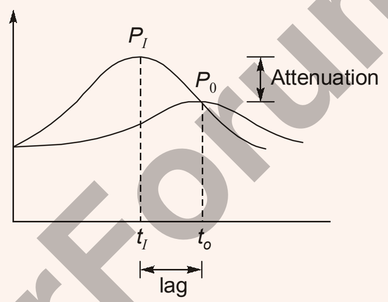
$$\vec{a} = 4\hat{j} + 10\hat{k}$$

End of Solution

Q.19 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. (b)



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

$$P_I > P_0$$
$$t_I < t_0$$

End of Solution

Q.20 Euclidean norm (length) of the vector $[4 \quad -2 \quad -6]^T$ is

(a) $\sqrt{48}$
(b) $\sqrt{56}$
(c) $\sqrt{24}$
(d) $\sqrt{12}$

Ans. (b)

$$x = \begin{bmatrix} 4 \\ -2 \\ -6 \end{bmatrix}$$

Euclidean norm length = $\sqrt{16+4+36} = \sqrt{56}$

End of Solution

Q.21 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. (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°.

End of Solution

Q.22 What is curl of the vector field $2x^2y\mathbf{i} + 5z^2\mathbf{j} - 4uyz\mathbf{k}$?

(a) $-14z\mathbf{i} - 2x^2\mathbf{k}$
(b) $6z\mathbf{i} + 4x^2\mathbf{j} - 2x^2\mathbf{k}$
(c) $-14z\mathbf{i} + 6y\mathbf{j} + 2x^2\mathbf{k}$
(d) $6z\mathbf{i} - 8xy\mathbf{j} + 2x^2y\mathbf{k}$

Ans. (a)

$$\text{curl}\,\bar{F} = \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 2x^2y & 5z^2 & -4yz \end{vmatrix}$$

$$= \bar{i}(-4z - 10z) - \bar{j}(0 - 0) + \bar{k}(0 - 2x^2)$$

$$= -14z\mathbf{i} - 2x^2\mathbf{k}$$

End of Solution

Q.23 Analysis of a water sample revealed that the sample contains the following species.

$CO_3^{2-}, Na^+, PO_4^{3-}, Al^{3+}, H_2CO_3, Cl^-, Ca^{2+}, Mg^{2+}, HCO_3^-, Fe^{2+}, OH^-$

Concentrations of which of the species will be required to compute alkalinity?

(a) $CO_3^{2-}, H^+, HCO_3^-, OH^-$
(b) $H^+, H_2CO_3, HCO_3^-, OH^-$
(c) $CO_3^{2-}, H_2CO_3, HCO_3^-, OH^-$
(d) $CO_3^{2-}, H^+, H_2CO_3, HCO_3^-$

Ans. (a)

Alkalinity is defined as ability of water to neutralize the acid or hydronium ion

Alkalinity (A_T) of water = $[HCO_3^-] + [CO_3^{2-}] + [B(OH)_4^-] + [H_3(SiO_4)^-] + [HS^-]$ + [organic anions] + $[OH^-] - [H^+]$

From given options of ions in problem answer is (a).

i.e. CO_3^{2-}, H^+, HCO_3^-, OH^-

End of Solution

Q.24 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 10 mm. The ultimate consolidation settlement was estimated in design as 40 mm. Considering double drainage to occur at the clayey soil site, the expected consolidation settlement in January 2019 (in mm, roundoff to the nearest integer) will be ________.

Ans. (15)

Jan. 2010 – Jan. 2014 (4 years)

⇒ Settlement is 10 mm

$\Delta H = 40$ mm

2 – way drainage

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

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

$$T_v = C_v\frac{t}{d^2} \qquad \because \%U < 60\%$$

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

$$\frac{\pi}{4}\left(\frac{25}{100}\right)^2 = \frac{C_v}{d^2}\times 4\,\text{years} \qquad ...(1)$$

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

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

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

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

$$\%U = 0.3749 = 37.499\%$$

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

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

End of Solution

Q.25 Which one of the following options contains ONLY primary air pollutants?

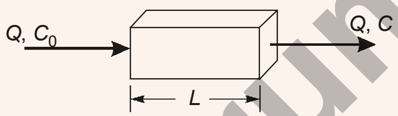
(a) Ozone and peroxyacetyl nitrate
(b) Hydrocarbons and ozone
(c) Hydrocarbons and nitrogen oxides
(d) Nitrogen oxides and peroxyacetyl nitrate

Ans. (c)

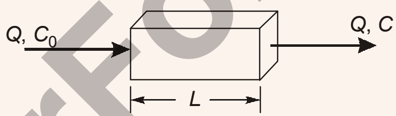
Hydrocarbons and nitrogen oxides are considered primary air pollutants.

End of Solution

Q.26 Consider the reactor shown in the figure. The flow rate through the reactor is Q m^3/h. The concentrations (in mg/L) of a compound in the influent and effluent are C_o and C, respectively. The compound is degraded in the reactor following the first order reaction. The mixing condition of the reactor can be varied such that the reactor becomes either a completely mixed flow reactor (CMFR) or a plug-flow reactor (PFR). The length of the reactor can be adjusted in these two mixing conditions to L_{CMFR} and L_{PFR} while keeping the cross-section of the reactor constant. Assuming steady state and for C/C_o = 0.8, the value of L_{CMFR}/L_{PFR} (round off to 2 decimal places) is________.



Ans. (1.12)



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

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

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

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

Now for steady state

$$v = \text{constant}$$

and $$L = vt$$

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

End of Solution

MADE EASY

India's Best Institute for IES, GATE & PSUs

RRB-JE
Examination, 2019

Admission Open in

Classroom Course for RRB-JE (CBT-1)

Classroom Centres : Delhi | Lucknow | Patna

Batches commencing from
15th Feb, 2019

All streams are eligible

Fee Structure : Classroom Course (RRB-JE)				
Exam	Course Duration	Timing	Freshers	Ex. MADE EASY Students Enrolled in any classroom/postal courses
CBT 1 (only)	50 Days (180-200 hours)	7 days a week 4 hours per day	Rs. 10,170 + GST = Rs. 12,000/-	Rs. 7,628 + GST = Rs. 9,000/-

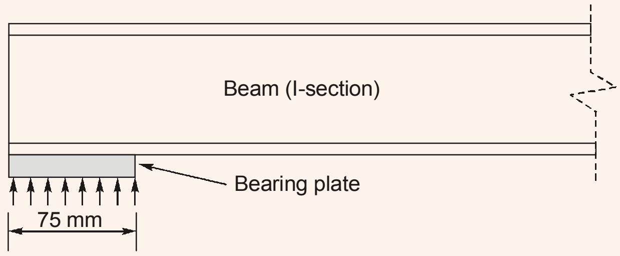
Delhi : 7303231082, 7303212325

Lucknow : 09919111168, 08400029422

Patna : 0612-2356615, 9955991166

www.madeeasy.in

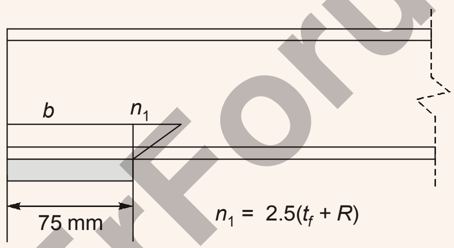
Q.27 A rolled I-section beam is supported on a 75 mm wide bearing plate as shown in the figure. Thicknesses of flange and web of the I-section are 20 mm and 8 mm, respectively. Root radius of the I-section is 10 mm. Assume: material yield stress, f_y = 250 MPa and partial safety factor for material. γ_{mo} = 1.10.



As per IS: 800-2007, the web bearing strength (in kN, round off to 2 decimal places) of the beam is________.

Ans. (272.73)

$$\text{Web bearing strength} = [b + 2.5(t_f + R)] \times t_w \times \frac{f_y}{\gamma_{mo}}$$



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

$$= 272.73 \text{ kN}$$

End of Solution

Q.28 The probability density function of a continuous random variable distributed uniformly between x and y (for $y > x$) is

(a) $y - x$

(b) $\frac{1}{y - x}$

(c) $x - y$

(d) $\frac{1}{x - y}$

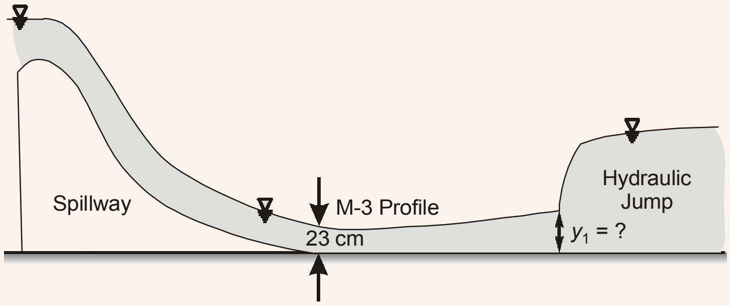
Ans. (b)

Probability density function of uniform distribution is

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

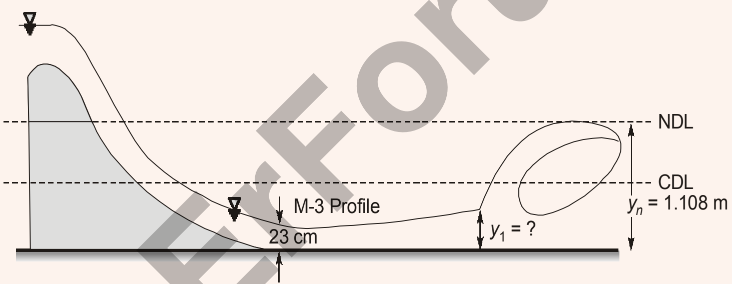
End of Solution

Q.29 At the foot of a spillway, water flows at a depth of 23 cm with a velocity of 8.1 m/s, as shown in the figure.



The flow enters as an M-3 profile in the long wide rectangular channel with bed slope $= \dfrac{1}{1800}$ and Manning's n = 0.015. A hydraulic jump is formed at a certain distance from the foot of the spillway. Assume the acceleration 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. (0.42)



$$y = 0.23\text{m}, \quad V = 8.1 \text{ m/s}$$

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

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

$$D = 0.015$$

y_n = Normal depth of flow

$R = y$ for wide rectangular channel

By Manning's equation

$$\therefore \quad q = \frac{y_n}{n} R^{2/3} S_0^{1/2}$$

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

$$\Rightarrow \quad y_n = 1.108 \text{ m}$$

y_1 is conjugate depth of y_0,

$$\therefore \qquad \frac{y_1}{y_n} = \frac{-1+\sqrt{1+8Fr_n^2}}{2} \qquad \left(Fr_n^2 = \frac{q^2}{gy_n^3}\right)$$

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

$$= 0.418 \text{ m} \simeq 0.42 \text{ m}$$

End of Solution

Q.30 The ordinates, u, 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 next 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 storm (in m^3/s, round off to 1 decimal place) will be________.

Ans. (97.0)

Rainfall excess in 1st two hours,

$$R_1 = 1 \text{ cm/hr} \times 2 \text{ hr} = 2 \text{ cm}$$

Rainfall excess in 2nd two hours

$$R_2 = 0$$

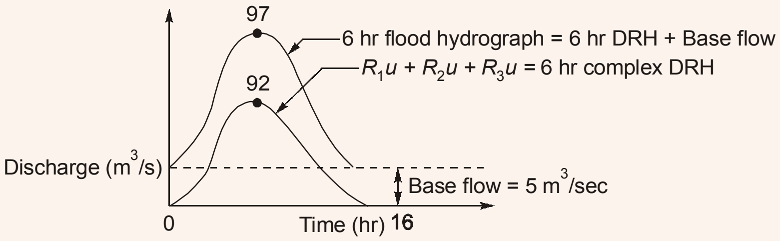
Rainfall excess in 3rd two hours,

$$R_3 = 0.5 \text{ cm/hr} \times 2\text{hr} = 1 \text{ cm}$$

Time (hr)	ord. of 2 hr UH say u	$R_1u = 2u$	$R_2u = 0$	$R_3u = 1\cdot u$	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	59	
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



End of Solution

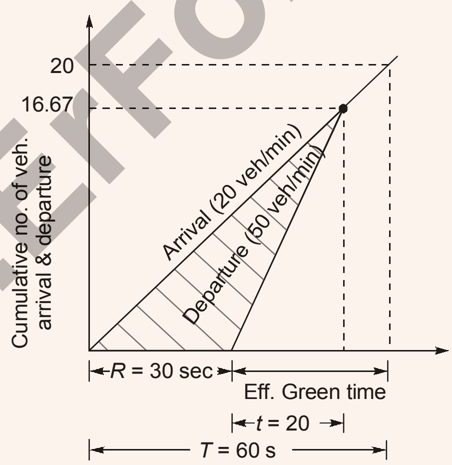
Q.31 The uniform arrival and uniform service rates observed on an approach road to a signalized intersection are 20 and 50 vehicles/minute, respectively. For this signal, the red time is 30 s, the effective green time is 30 s, and the cycle length is 60 s. Assuming that initially there are no vehicles in the queue, the average delay per vehicle using the approach road during a cycle length (in *s*, round off to 2 decimal places) is_______.

Ans. (12.50)

$$\text{Arrival rate} = 20 \text{ veh/min}$$

$$\text{Service rate} = 50 \text{ veh/min}$$

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



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

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

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

$$600 + 20t = 50t$$

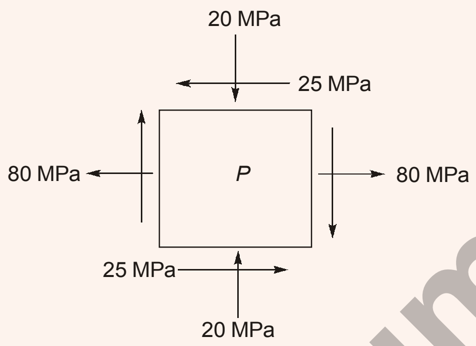
$$t = \frac{600}{30} = 20 \text{ sec}$$

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

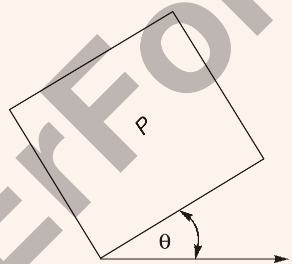
$$= \left(\frac{\frac{1}{2}\times 16.67\times 50-\frac{1}{2}\times 16.67\times 25}{20}\right) = 12.50 \text{ sec}$$

End of Solution

Q.32 For a plane stress problem, the state of stress at a point P is represented by the stress element as shown in figure.

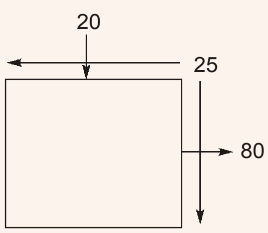


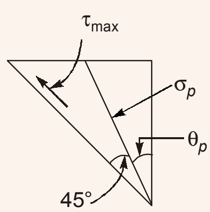
By how much angle (θ) in degrees the stress element should be rotated in order to get the planes of maximum shear stress?



(a) 31.7
(b) 13.3
(c) 26.6
(d) 48.3

Ans. (a)





$$\sigma_x = 80,\ \sigma_y = -20,\ \tau_{xy} = -25$$

Angle of plane of max shear

$$\theta = \theta_p + 45°$$

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

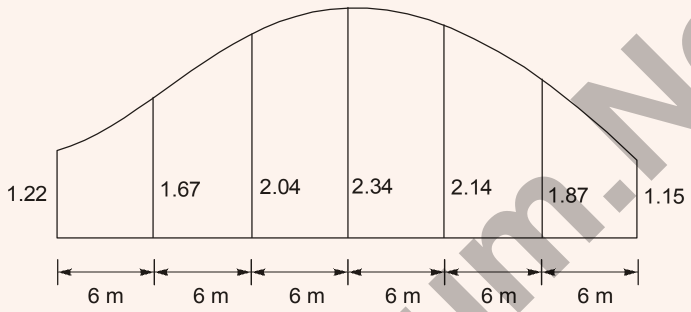
$$\theta_p = -13.28°$$

$$\therefore \quad \theta = 31.71°$$

End of Solution

Q.33 A series of perpendicular offsets taken from a curved boundary wall to a straight survey line at an interval of 6 m are 1.22, 1.67, 2.04, 2.34, 2.14. 1.87, and 1.15 m. 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. **(68.50)**



Area by Simpson's rule

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

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

$$= 68.50 \text{ m}^2$$

End of Solution

Q.34 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 40 kN);

(ii) 160 trucks with 2-axles (front and rear axle loads of 40 kN and 80 kN, respectively)

The equivalent standard axle load repetitions for this vehicle combination as per IRC:37-2012 would be

(a) 250 (b) 320

(c) 180 (d) 240

Ans. **(c)**

(i) 80 buses with 2 axle with 40 kN each.

$$N_1 = 80 \times 2 = 160$$

$$L_1 = 40 \text{ kN}$$

$$\text{(ii) 160 trucks} \begin{cases} \text{Front axle} \rightarrow 40 \text{ kN} \\ \text{Rear axle} \rightarrow 80 \text{ kN} \end{cases}$$

$$N_1 = 160,\ L_1 = 40 \text{ kN}$$
$$N_2 = 160,\ L_2 = 80 \text{ kN}$$

$$\text{Total no. of repetitions} \begin{cases} \text{For } 40 \text{ kN} = 160 + 160 = 320 \\ \text{For } 80 \text{ kN} = 160 \end{cases}$$

$$N_1 = 320,\ L_1 = 40 \text{ kN}$$
$$N_2 = 160,\ L_2 = 80 \text{ kN}$$

As per 4th power law

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

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

End of Solution

Q.35 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) $\begin{bmatrix} 2 & -\frac{4}{5} & -\frac{9}{5} \\ -3 & \frac{4}{5} & \frac{14}{5} \\ 1 & -\frac{1}{5} & -\frac{6}{5} \end{bmatrix}$

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

Ans. (d)

End of Solution

Q.36 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 statements is CORRECT?
(a) Both Assertion (1) and Assertion (2) are FLASE
(b) Assertion (1) is TRUE and Assertion (2) is FLASE
(c) Both Assertion (1) and Assertion (2) are TRUE
(d) Assertion (1) is FLASE and Assertion (2) is TRUE

Ans. (c)
(1) as per IS : 456-2000, Cl. 8.2.2.3.
(2) percentage of Na_2O (equivalent)
$$= Na_2O(\%) + 0.658 \times K_2O(\%)$$
$$= 1.0 + 0.658 \times 0.60 = 1.40\% \quad \text{(Approx.)}$$
Both Assertions are correct.

End of Solution

Q.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) $y = Kxe^{x}$
(b) $y = Kxe^{-x}$
(c) $y = K\ln x$
(d) $y = Kx\ln x$

Ans. (c)
$$\frac{dy}{dx}(x\ln x) = y$$
$$\frac{dy}{y} = \frac{dx}{x\ln x}$$
$$\int\frac{dy}{y} = \int\frac{1}{x\ln x}dx + \ln k$$
$$\ln x = t$$
$$\frac{1}{x}dx = dt$$
$$\ln y = \int\frac{dy}{t} + \ln k$$
$$\ln y = \ln t + \ln k$$
$$\ln y = kt$$
$$y = k\ln x$$

End of Solution

Q.38 Constant head permeability tests were performed on two soil specimens, S1 and S2. The ratio of height of the two specimens (L_{s1}:L_{s2}) is 1.5, the ratio of the diameter of specimens (D_{s1}:D_{s2}) is 0.5, and the ratio of the constant head (h_{s1}:h_{s2}) applied on the specimens is 2.0. If the discharge from both the specimens is equal, the ratio of the permeability of the soil specimens (k_{s1}:k_{s2}) is__________.

Ans. (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.

$$k_1 i_1 A_1 = k_2 i_2 A_2$$

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

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

End of Solution

Q.39 A timber pile of length 8 m and diameter 0.2 m is driven with a 20 kN drop hammer, falling freely from a height of 1.5 m. The total penetration of the pile in the last 5 blows is 40 mm. 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 2.5 cm. The safe load carrying capacity of the pile (in kN, round off to 2 decimal places) is __________.

Ans. (151.51)

$L = 8$ m; $d = 0.2$ m, 20 kN $= W \rightarrow$ drop hammer

$$H = 1.5 \text{ m}$$

Penetration in 5 blows = 40 mm

$$\therefore \quad \text{in 1 blow} = \frac{40}{5} = 8 \text{ mm} = 0.8 \text{ cm}$$

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

$$Q_{safe} = 151.51 \text{ kN}$$

End of Solution

Q.40 A broad gauge railway line passes through a horizontal curved section (radius = 875 m) of length 200 m. The allowable speed on this portion is 100 km/h. For calculating the cant, consider the gauge as centre-to-centre 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 centre-to-centre distance between the rail heads is________

Ans. (81.5)

Allowable speed is given as 100 kmph

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

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

$$e_{th} = 15.75 \text{ cm}$$

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

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

$$e_{act} = 8.15 \text{ cm} \simeq 81.5 \text{ mm}$$

End of Solution

Q.41 The dimensions of a soil sampler are given in the table.

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

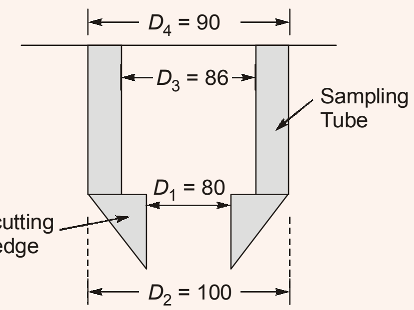
For this sampler, the outside clearance ratio (in percent, round off to 2 decimal places) is _________.

Ans. (11.11)

Outside clearance,

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

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



End of Solution

Q.42 A square footing of 2 m sides rests on the surface of a homogeneous soil bed having the properties: cohesion c = 24 kPa, angle of internal friction ϕ = 25°, and unit weight γ = 18 kN/m^3. Terzaghi's bearing capacity factors for ϕ = 25° are N_c = 25.1, N_q = 12.7, N_γ = 9.7, N_c' = 14.8., N_q' = 5.6, and N_γ' = 3.2. The ultimate bearing capacity of the foundation (in kPa, round off to 2 decimal places) is__________

Ans. **(353.92)**

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

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

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

Square footing $B = 2$ m, $L = 2$ 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,

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

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

$$q_u = 307.84 + 46.08$$

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

End of Solution

Q.43 The speed-density relationship of a highway is given as

$$u = 100 - 0.5k$$

where, u = speed in km per hour, k = density in vehicles per km. The maximum flow (in vehicles per hour, round off to the nearest integer) is ________.

Ans. **(5000)**

$$u = 100 - 0.5k$$

$$u = 100\left[1 - \frac{k}{(100/0.5)}\right]$$

Green shield model $$u = V_f\left(1 - \frac{k}{k_J}\right)$$

$$V_f = \text{free mean speed} = 100 \text{ kmph}$$

$$k_J = \text{Jam density} = \frac{100}{0.5} = 200 \text{ veh./km}$$

Max flow: $$q_{max} = \frac{1}{4}V_f k_j$$

$$= \frac{1}{4}\times 100 \times 200 = 5000 \text{ veh/hr}$$

End of Solution

Q.44 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. (500.0)

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

Overflow rate OFR $(v_s) = 1.5$ m/hr

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

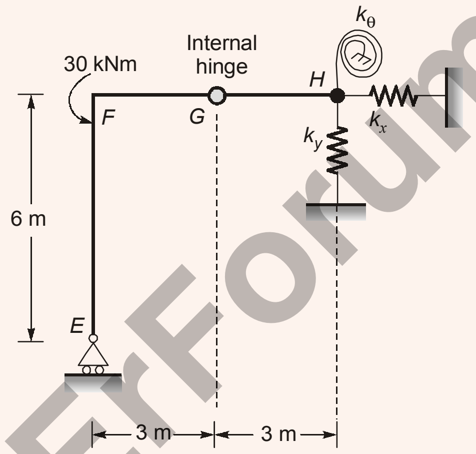
$$\text{Volume, } V = SA \times \text{Depth (H)}$$

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

$$V = 500 \text{ m}^3$$

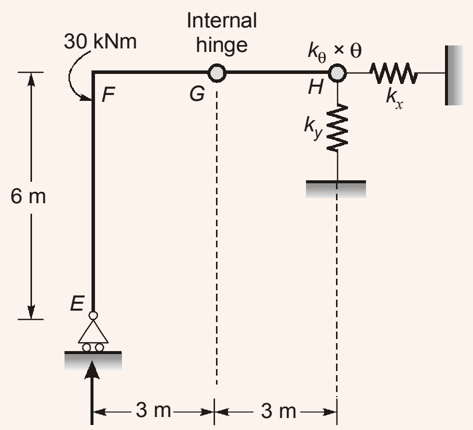
End of Solution

Q.45 A plane frame shown in the figure (not to scale) has linear elastic springs at node H. The spring constants are $k_x = k_y = 5 \times 10^5$ kN/m and $k_\theta = 3 \times 10^5$ kNm/rad.



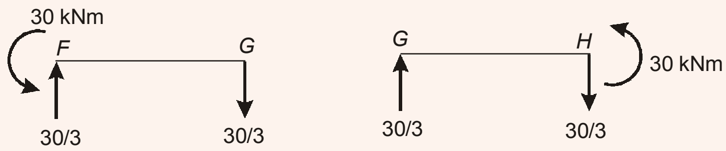
For the externally applied moment of 30 kNm at node F, the rotation (in degrees, round off to 3 decimals) observed in the rotational spring at node H is__________

Ans. (0.006)



No moment can be taken by segment FE

$\therefore$ $M_{FE} = 0$



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

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

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

End of Solution

Q.46 The critical bending compressive stress in the extreme fibre of a structural steel section is 1000 MPa. It is given that the yield strength of the steel is 250 MPa, width of flange is 250 mm and thickness of flange is 15 mm. As per the provisions of IS: 800-2007. the non-dimensional slenderness ratio of the steel cross-section is

(a) 0.50
(b) 0.75
(c) 0.25
(d) 2.00

Ans. (a)

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

End of Solution

Q.47 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 percent.

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

$$C_aH_bO_cN_d + nH_2O \rightarrow mCH_4 + sCO_2 + dNH_3$$

Given atomic weights: C = 12, H = 1, O = 16, N = 14. The mass of methane produced (in grams, round off to 1 decimal place) per kg of raw MSW will be________.

Ans. (271)

mass of MSW = 1 kg

mass of decomposable material = 0.7×10^3 = 700 gm

mass of decomposable solid = 0.65×700 = 455 gm

% mass C : H : O : N : other = 44 : 6 : 43 : 0.8 : 6.2

$$\text{Moles of } C = \frac{455}{12} \times \frac{44.00}{100} = 16.68\ (a)$$

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

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

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

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

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

Moles of CH_4 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 × 16 = 271 gm

End of Solution

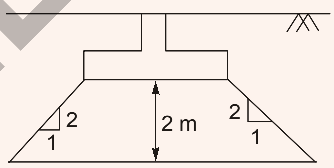
Q.48 A 2 m × 4 m rectangular footing has to carry a uniformly distributed load of 120 kPa. As per the 2:1 dispersion method of stress distribution, the increment in vertical stress (in kPa) at a depth of 2 m below the footing is ________.

Ans. (40)

The area of rectangular footing = 2 m × 4 m

q = 120 kPa

as 2:1 dispersion method of stress distribution



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

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

End of Solution

Q.49 A camera with a focal length of 20 cm fitted in an aircraft is used for taking vertical aerial photographs of a terrain. The average elevation of the terrain is 1200 m 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) 3200 m
(b) 2600 m
(c) 3000 m
(d) 2800 m

General Studies & Engineering Aptitude Batches for ESE 2020

(Preliminary Examination)

MADE EASY

India's Best Institute for IES, GATE & PSUs

Syllabus Covered

1. Current issues of national and international importance relating to social economic and industrial development.
2. Engineering Aptitude covering Logical reasoning and Analytical ability.
3. Engineering Mathematics and Numerical Analysis.
4. General Principles of Design, Drawing, Importance of Safety.
5. Standards and Quality practices in production, construction, maintenance and services.
6. Basic of Energy and Environment : Conservation, Environmental pollution and degradation, Climate Change, Environmental impact assessment.
7. Basic of Project Management.
8. Basics of Material Science and Engineering.
9. Information and Communication Technologies (ICT) based tools and their applications in Engineering such as networking, e-governance and technology based education.
10. Ethics and values in engineering profession.

Course Duration

Regular Batches : 2.5 months
Weekend Batches : 4 months

Timings

Regular : 6 to 7 days a week and 4-6 hours a day
Weekend : Sat, Sun & public holiday, 8 hours each day

Teaching Hours

250-300 hours

Batch Type	Commencing Dates	Venue	Timing
Regular Batch	20th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 12:00 PM
Weekend Batch	24th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 5:00 PM
Weekend Batch	24th Feb, 2019	Noida Centre	8:00 AM to 5:00 PM

Fee Structure

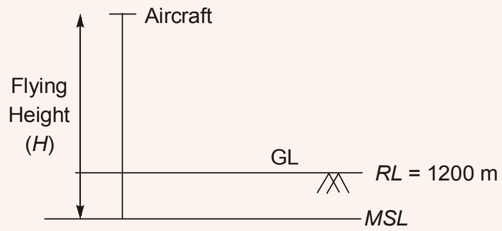
Non-MADE EASY Students	Ex. MADE EASY Students Enrolled in Postal, Rank Improvement, Mains, GS, GATE, GATE + ESE Batches
₹ 25,000 • GS & Engg Aptitude Books will be issued.	₹ 18,000 • GS & Engg Aptitude Books will NOT be issued. • Interested students can avail books by paying the fee of Rs. 2,000/-

Corporate office : 44-A/1, Kalu Sarai, New Delhi - 1100 16 011-45124612, 9958995830

Noida office : D-28, Sector - 63, Noida, Uttar Pradesh - 201301 0120-6524612, 08860378009

ADMISSION OPEN

Ans. (d)



Given focal length = 20 cm

as we know scale of vertical photograph = $\dfrac{f}{H - h_{avg.}}$

its given as 1 : 8000

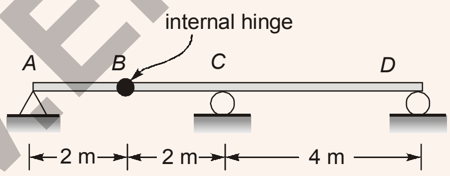
Hence, $\dfrac{f}{H - h_{avg.}} = \dfrac{1}{8000}$

$$\frac{20\,\text{cm}}{(H - 1200) \times 100\,\text{cm}} = \frac{1}{8000}$$

$\Rightarrow$ $H = 2800$ m

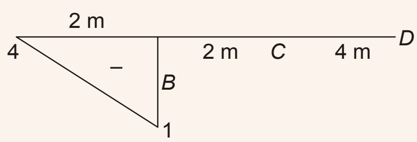
End of Solution

Q.50 A long uniformly distributed load of 10 kN/m and a concentrated load of 60 kN are moving together on the beam ABCD shows 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 integer) caused at the internal hinge B due to the two loads is_______



Ans. (–70)

ILD for V_B



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

End of Solution

Q.51 Chlorine is used as the disinfectant in a municipal water treatment plant. It achieves 50 percent of disinfection efficiency measured in terms of killing the indicator microorganisms (E-Coli) in 3 minutes. The minimum time required to achieve 99 percent disinfection efficiency would be

(a) 19.93 minutes
(b) 11.93 minutes
(c) 9.93 minutes
(d) 21.93 minutes

Ans. (a)

During disinfection variations of micro-organism is given by

$$N_t = N_o e^{-kt}$$

N_t = No. of micro-organism at time t

N_o = No. of micro-organism at time 0

So, disinfection efficiency at any time 't', $\eta_t = \dfrac{N_o - N_t}{N_o} \times 100$

For $t = 3$ min; $\eta_3 = 50\%$

$$\eta_3 = \frac{N_o - N_o e^{-k \times 3}}{N_o} \times 100 = 50$$

$$k = 0.231 \text{ min}^{-1}$$

Now for $\eta_t = 99\%$

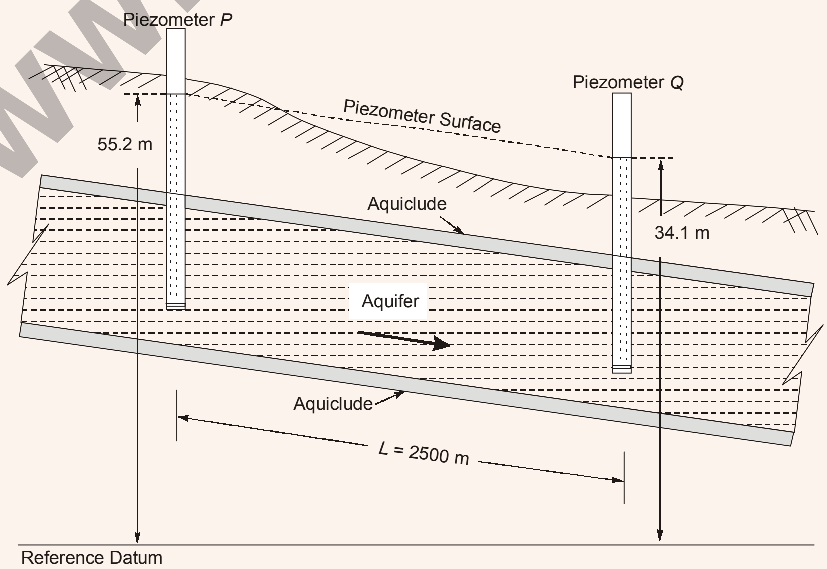
$$\eta_t = \frac{N_o - N_t}{N_o} \times 100 = 99$$

$$\frac{N_o - N_o e^{-0.231 \times t}}{N_o} \times 100 = 99$$

$$t = 19.93 \text{ min}$$

End of Solution

Q.52 A confined aquifer of 15 m constant thickness is sandwiched between two aquicludes as shown in the figure (not drawn to scale).



The heads indicated by two piezometers P and Q are 55.2 m and 34.1 m, respectively. The aquifer has a hydraulic conductivity of 80 m/day and its effective porosity is 0.25. If the distance between the piezometers is 2500 m, the time taken by the water to travel through the aquifer from piezometer location P to Q (in days, round off to 1 decimal place) is________.

Ans. (925.7)

$$v = ki$$

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

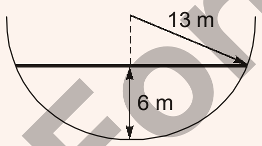
$$v_s = 80\text{m/day} \times \left(\frac{55.2 - 34.1}{2500} \times \frac{1}{0.25}\right) = \frac{2500}{\text{time}}$$

$$\text{time} = 925.651 \text{ day}$$

$$= 925.7 \text{ days}$$

End of Solution

Q.53 Consider the hemi-spherical tank of radius 13 m as shown in the figure (not drawn to scale). What is the volume of water (in m^3) when the depth of water at the centre of the tank is 6 m?



(a) 156π
(b) 396π
(c) 468π
(d) 78π

Ans. (b)

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

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

End of Solution

Q.54 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 this 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. (12500)

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

$$\text{stress} = 12.5 \text{ N/mm}^2$$

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

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

Total strain after long time

$$= 1000 \times 10^{-6}$$

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

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

Effective modulus of elasticity

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

End of Solution

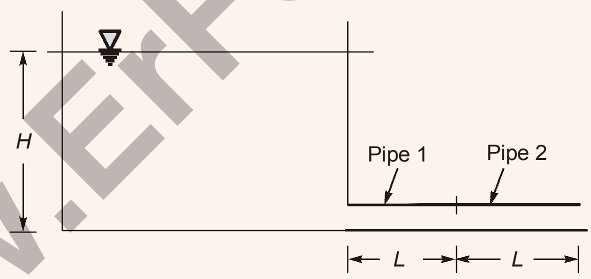
Q.55 Two identical pipes (i.e., having the same length, same diameter, and same roughness) are used to withdraw water from a reservoir. In the first case, they are attached in series and discharge freely into the atmosphere. In the second case, they are attached in parallel and also discharge freely 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. (2.83)

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

1st case (series)

Assume height of reservoir = H

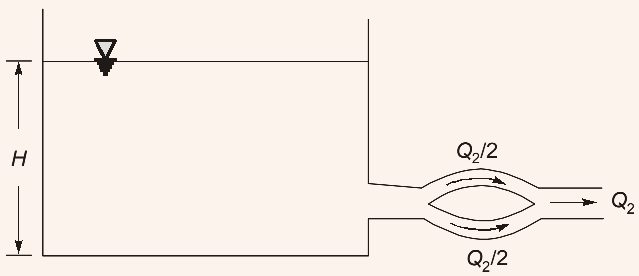


$$H = h_{f1} + h_{f2} \quad \text{...(i)}$$

$$H = 2h_{f1} \quad (h_{f_1} = h_{f_2})$$

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

2nd case (Parallel)



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

$$H = \frac{8}{\pi^2 g} \times \frac{fL}{D^5} \times \frac{Q_2^2}{4} \quad \text{..(ii)}$$

By eq. (i) and (ii)

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

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

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

$$= 2.83 \quad \text{(round off to 2 decimal place)}$$

End of Solution

■■■■