Solutions of

of

Civil Engineering

GATE-2016

Session 5 | Set-1

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Section - I (General Aptitude)

One Mark Questions

Q.1 Out of the following four sentences, select the most suitable sentence with respect to grammar and usage.

(a) I will not leave the place until the minister does not meet me.

(b) I will not leave the place until the minister doesn't meet me.

(c) I will not leave the place until the minister meet me.

(d) I will not leave the place until the minister meets me.

Ans. **(d)**

End of Solution

Q.2 A rewording of something written or spoken is a _____.

(a) paraphrase (b) paradox

(c) paradigm (d) paraffin

Ans. **(a)**

End of Solution

Q.3 Archimedes said, "Give me a lever long enough and a fulcrum on which to place it, and I will move the world." The sentence above is an example of a _____ statement.

(a) figurative (b) collateral

(c) literal (d) figurine

Ans. **(a)**

End of Solution

Q.4 If 'relftaga' means carefree, 'otaga' means careful and 'fertaga' means careless, which of the following could mean 'aftercare'?

(a) zentaga (b) tagafer

(c) tagazen (d) relffer

Ans. **(c)**

End of Solution

Q.5 A cube is built using 64 cubic blocks of side one unit. After it is built, one cubic block is removed from every corner of the cube. The resulting surface area of the body (in square units) after the removal is _____.

(a) 56 (b) 64

(c) 72 (d) 96

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Basic Engineering	:	50 Q
Engineering Mathematics	:	20 Q
Reasoning & Aptitude	:	20 Q
General English	:	10 Q

100 marks | 100 questions | 2 hours

Per question: 1 mark, Negative marking : 0.33 marks

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Civil
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Ans. **(d)**

Original surface area = $6\ (4)^2 = 96$

If corner cubes are removed, three exposed surfaces are removed which will create 3 new surfaces in original large cube. So surface area will remain unchanged, i.e. 96

End of Solution

Two Marks Questions

Q.6. A shaving set company sells 4 different types of razors, Elegance, Smooth, Soft and Executive. Elegance sells at Rs. 48, Smooth at Rs. 63, Soft at Rs. 78 and Executive at Rs. 173 per piece. The table below shows the numbers of each razor sold in each quarter of a year.

Quarter/ Product	Elegance	Smooth	Soft	Executive
Q1	27300	20009	17602	9999
Q2	25222	19392	18445	8942
Q3	28976	22429	19544	10234
Q4	21012	18229	16595	10109

Which product contributes the greatest fraction to the revenue of the company in that year?

(a) Elegance
(b) Executive
(c) Smooth
(d) Soft

Ans. **(b)**

Elegance $(27300 + 25222 + 28976 + 21012) \times 48 = A$

Executive $(999 + 8942 + 10234 + 10234 + 10109) \times 173 = B$

Smooth $(20009 + 9392 + 22429 + 18229) \times 63 = C$

Soft $(17602 + 18445 + 19544 + 16595) \times 78 = D$

Which is highest for B (executive).

End of Solution

Q.7 Indian currency notes show the denomination indicated in at least seventeen languages. If this is not an indication of the nation's diversity, nothing else is. Which of the following can be logically inferred from the above sentences?

(a) India is a country of exactly seventeen languages.
(b) Linguistic pluralism is the only indicator of a nation's diversity.
(c) Indian currency notes have sufficient space for all the Indian languages.
(d) Linguistic pluralism is strong evidence of India's diversity.

Ans. **(d)**

End of Solution

Q.8 Consider the following statements relating to the level of poker play of four players P, Q, R and S. I. P always beats Q II. R always beats S III. S loses to P only sometimes IV. R always loses to Q Which of the following can be logically inferred from the above statements? (i) P is likely to beat all the three other players (ii) S is the absolute worst player in the set

(a) (i) only
(b) (ii) only
(c) (i) and (ii)
(d) neither (i) nor (ii)

Ans. **(a)**

Following Hierarchy can be drawn.

P
Q
R
S

Individual comparisons are given so, P is more likely to beat other three as he beats Q and Q beats R and R beats S, so (i) follows.

But no absolute comparison of P and S given in any given. So (ii) cannot be confirmed.

End of Solution

Q.9 If $f(x) = 2x^7 + 3x - 5$, which of the following is a factor f(x) ?

(a) $(x^3 + 8)$
(b) $(x - 1)$
(c) $(2x - 5)$
(d) $(x + 1)$

Ans. **(b)**

$$f(x) = 2x^7 + 3x - 5$$

Use option (b), if $(x - 1)$ will be a factor then on putting $x - 1 = 0$ i.e. $(x = 1)$ in f(x).

$$f(1) = 2(1)^7 + 3 - 5 = 5 - 5 = 0$$

End of Solution

Q.10 In a process, the number of cycles to failure decreases exponentially with an increase in load. At a load of 80 units, it takes 100 cycles for failure. When the load is halved, it takes 10000 cycles for failure. The load for which the failure will happen in 5000 cycles is _____.

(a) 40.00
(b) 46.02
(c) 60.01
(d) 92.02

Ans. **(b)**

End of Solution

Section - II (Civil Engineering)

One Mark Questions

Q.1 Newton-Raphson method is to be used to find foot of equation $3x - e^x + \sin x = 0$. If the initial trail value of the roots is taken as 0.333, the next approximation for the root would be _____

Ans. **(0.4828)**

According to Newton Raphton Method:

$$X_{N+1} = X_N - \frac{f(X_N)}{f'(X_N)}$$

$$f(x) = 3x - e^x + \sin x$$

$$f'(x) = 3 - e^x + \cos x$$

$$\Rightarrow \quad X_1 = X_0 - \frac{f(0.333)}{f'(0.333)}$$

$$= 0.333 - \frac{3 \times 0.333 - e^{0.333} + \sin 0.333}{3 - e^{0.333} + \cos 0.333}$$

$$\therefore \quad X_1 = 0.4828$$

End of Solution

Q.2 The type of partial differential equation

$$\frac{\partial^2 P}{\partial x^2} + \frac{\partial^2 P}{\partial y^2} + 3\frac{\partial^2 P}{\partial x \partial y} + 2\frac{\partial P}{\partial x} - \frac{\partial P}{\partial y} = 0 \text{ is}$$

(a) elliptic
(b) parabolic
(c) hyperbolic
(d) none of these

Ans. **(c)**

End of Solution

Q.3 If the entries in each column of a square matrix M add up to 1, then an eigen value of M is

(a) 4
(b) 3
(c) 2
(d) 1

Ans. **(d)**

End of Solution

Q.4 Type II error in hypothesis testing is

(a) acceptance of the null hypothesis when it is false and should be rejected

(b) rejection of the null hypothesis when it is true and should be accepted

(c) rejection of the null hypothesis when it is false and should be rejected

(d) acceptance of the null hypothesis when it is true and should be accepted

Ans. **(a)**

End of Solution

Q.5 The solution of the partial differential equation $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$ is of the form

(a) $C\cos(kt)\left|C_1 e^{(\sqrt{k/\alpha})} + C_2 e^{-(\sqrt{k/\alpha})x}\right|$

(b) $Ce^{kt}\left|C_1 e^{(\sqrt{k/\alpha})x} + C_2 e^{-(\sqrt{k/\alpha})x}\right|$

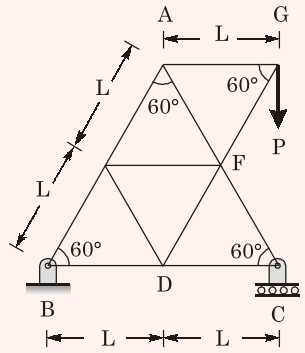
(c) $Ce^{kt}\left|C_1 \cos(\sqrt{k/\alpha})x + C_2 \sin(-\sqrt{k/\alpha})x\right|$

(d) $C\sin(kt)\left|C_1 \cos(\sqrt{k/\alpha})x + C_2 \sin-(\sqrt{k/\alpha})x\right|$

Ans. **(b)**

End of Solution

Q.6 Consider the plane truss with load P as shown in the figure. Let the horizontal and vertical reactions at the joint B be H_B and V_B, respectively and V_C be vertical reaction at the joint C.



Which one of the following sets gives the correct values of V_B, H_B and V_C?

(a) $V_B = 0;\ H_B = 0;\ V_C = P$

(b) $V_B = P/2;\ H_B = 0;\ V_C = P/2$

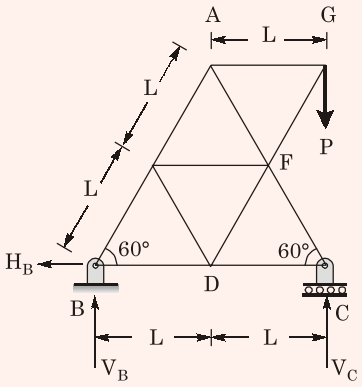
(c) $V_B = P/2;\ H_B = P\ (\sin 60°);\ V_C = P/2$

(d) $V_B = P;\ H_B = P\ (\cos(60°));\ V_C = 0$

Ans. **(a)**

$$V_B + V_C = P \qquad \text{... (i)}$$

$$\Sigma M_B = 0$$



$$V_C \times 2L - P \times 2L = 0$$

$$\Rightarrow \quad V_C = P$$

From (i) $\quad V_B = 0$

$$\Sigma F_x = 0$$

$$\Rightarrow \quad H_B = 0$$

End of Solution

Q.7 In shear design of an RC beam, other than allowable shear strength of concrete (τ_c), there is also an addition check suggested in IS 456-2000 with respect to the maximum permissible shear stress (τ_{cmax}). The check τ_{cmax} is required to take care of

(a) additional shear resistance from reinforcing steel
(b) additional shear stress that comes from accidental loading
(c) possibility of failure of concrete by diagonal tension
(d) possibility of crushing of concrete by diagonal compression

Ans. **(d)**

End of Solution

Q.8 The semi-compact section of a laterally unsupported steel beam has an elastic section modulus, plastic section modulus and design bending compressive stress of 500 cm^3, 650 cm^3 and 200 MPa respectively. The design flexural capacity (expressed in kNm) of the section is_____.

Ans. **(90.91)**

Design flexural capacity of semi-compact section $= \dfrac{f_y z_e}{\gamma_{m_0}}$

$$= \frac{200 \times 500}{1.1} \times 10^{-3} = 90.91 \text{ kNm}$$

End of Solution

Q.9 Bull's trench kiln is used in the manufacturing of

(a) lime (b) cement

(c) bricks (d) none of these

Ans. **(c)**

Bull trench kiln is a continuous kiln generally oval in plan. It is 50 to 100 m long and 1.5 – 2.5 m deep below ground level. It is divided into 8-12 sections which is used for manufacturing of bricks.

End of Solution

Q.10 The compound which is largely responsible for initial setting and early strength gain of Ordinary Portland Cement is

(a) C_3A (b) C_3S

(c) C_2S (d) C_4AF

Ans. **(b)**

Tricalcium Silicate (C_3S) hardens rapidly and is largely responsible for initial set and early strength. In general, the early strength of portland cement concrete is higher with increased percentages of C_3S.

End of Solution

Q.11 In the consolidated undrained triaxial test on a saturated soil sample, the pore water pressure is zero

(a) during shearing stage only

(b) at the end of consolidation stage only

(c) both at the end of consolidation and during shearing stages

(d) under none of the above conditions

Ans. **(b)**

End of Solution

Q.12 A fine grained soil is found to be plastic in the water content range of 26-48%. As per Indian Standard Classification System, the soil is classified as

(a) CL (b) CH

(c) CL-ML (d) CI

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Ans. **(d)**

Soil is plastic in the range of 26-48%.

Hence plastic limit = 26% and liquid limit = 48%. Because liquid limit is in the range of 35% to 50%. Hence intermediate compressible soil.

End of Solution

Q.13 A vertical cut is to be made in a soil mass having cohesion c, angle of internal friction φ, and unit weight γ. Considering K_a as the K_p as the coefficients of active and passive earth pressure, respectively, the maximum depth of unsupported excavation is

(a) $\dfrac{4c}{\gamma\sqrt{K_p}}$

(b) $\dfrac{2c\sqrt{K_p}}{\gamma}$

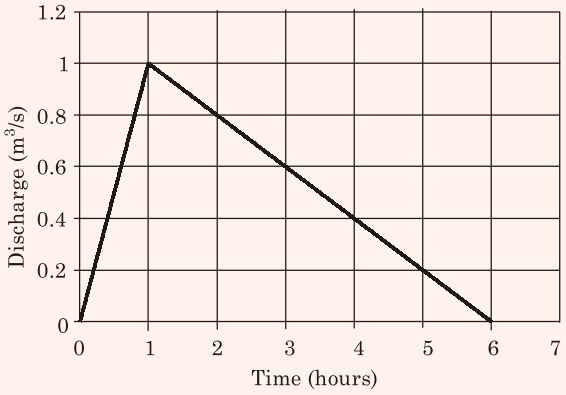
(c) $\dfrac{4c\sqrt{K_p}}{\gamma}$

(d) $\dfrac{4c}{\gamma\sqrt{K_a}}$

Ans. **(d)**

End of Solution

Q.14 The direct runoff hydrograph in response to 5 cm rainfall excess in a catchment is shown in the figure. The area of catchment (expressed in hectares) is_____.



Ans. **(21.6)**

$$\frac{1}{2}\times 1\times 6\times 3600 = A\times\frac{5}{100}$$

$$\Rightarrow \quad 2160\times 100 = A$$

$$\Rightarrow \quad A = 216000\ \text{m}^2$$

$$A = 21.6\ \text{Ha}$$

End of Solution

Q.15 The type of flood routing (Group I) and the equation(s) used for the purpose (Group II) are given below.

Group I		Group II	
P	Hydrologic flood routing	1.	Continuity equation
Q	Hydraulic flood routing	2.	Momentum equation
		3.	Energy equation

(a) P-1; Q-1, 2 and 3
(b) P-1; Q-1 and 2
(c) P-1 and 2; Q-1
(d) P-1 and 2; Q-1 and 2

Ans. **(b)**

End of Solution

Q.16 The pre-jump Froude Number for a particular flow in a horizontal rectangular channel is 10. The ratio of sequent depths (i.e., post-jump depth to pre-jump depth) is_____

Ans. **(13.65)**

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1+\sqrt{1+8F_1^2}\right]$$

$$= \frac{1}{2}\left[-1+\sqrt{1+8\times 100}\right]$$

$$\frac{y_2}{y_1} = 13.65$$

End of Solution

Q.17 Pre-cursors to photochemical oxidants are

(a) NO_X, VOCs and sunlight
(b) SO_2, CO_2 and sunlight
(c) H_2S, CO and sunlight
(d) SO_2, NH_3 and sunlight

Ans. **(a)**

Photochemical smog is formed in the atmosphere when pre-cursor pollutants including Nitrogen Oxide (NO_X) and Volatile Organic Compounds (VOCs) undergo reaction in sunlight to form smog, of which ozone is the principle component.

End of Solution

Q.18 Crown corrosion in a reinforced concrete sewer is caused by:

(a) H_2S
(b) CO_2
(c) CH_4
(d) NH_3

Ans. **(a)**

Bacteria in the slime under flowing sewage convert sulphate in the sewage into sulphides. Sulphides in the liquid make their way to the surface of the sewage and reduced into the sewer atmosphere or Hydrogen Sulphide (H_2S) gas. Bacterial action converts atmospheric H_2S gas to Sulphuric Acid which causes corrosion in the crown of the pipe and this corrosion is called crown corrosion.

End of Solution

Q.19 It was decided to construct a fabric filter, using bags of 0.45 m diameter and 7.5 m long, for removing industrial stack gas containing particulates. The expected rate of airflow into the filter is higher integer required for continuous cleaning operation is

(a) 27 (b) 29

(c) 31 (d) 32

Ans. **(b)**

$$\text{Surface area of one bag} = \pi \times d \times l$$

$$= \pi \times 0.45 \times 7.5 = 10.6028 \text{ m}^2$$

$$\text{The required area of fabric filter} = \frac{10}{\left(\frac{2}{60}\right)} = 300 \text{ m}^2$$

$$\therefore \quad \text{Number of bag required} = \frac{300}{10.6028} = 28.294$$

So No. of bag required will be 29.

End of Solution

Q.20 Match the items in Group - I with those in Group - II and choose the right combination

Group - I	**Group - II**
P. Activated sludge process	1. Nitrifiers and denitrifiers
Q. Rising of sludge	2. Autotrophic bacteria
R. Conventional nitrification	3. Heterotrophic bacteria
S. Biological nitrogen removal	4. Denitrifiers

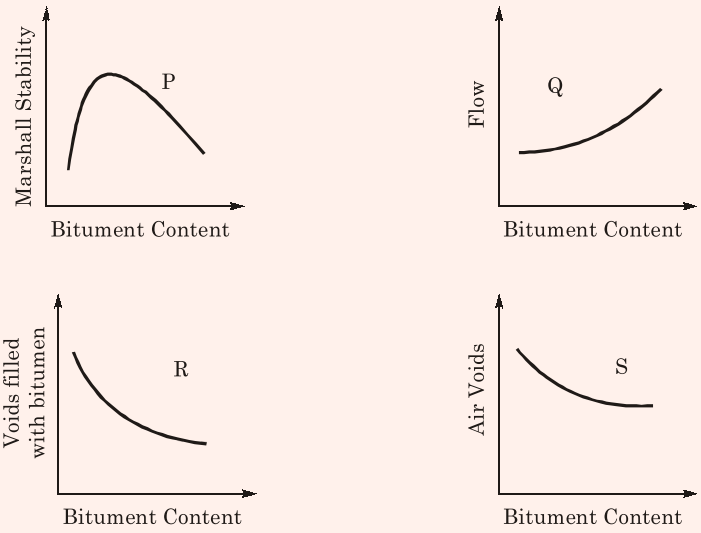
(a) P-3, Q-4, R-2, S-1 (b) P-2, Q-3, R-4, S-1

(c) P-2, Q-2, R-4, S-1 (d) P-1, Q-4, R-2, S-3

Ans. **(a)**

End of Solution

Q.21 During a forensic investigation of pavement failure, an engineer reconstructed the graphs P, Q, R and S, using partial and damaged old reports.

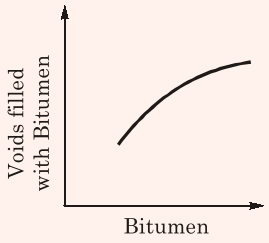


Theoretically plausible correct graphs according to the 'Marshall mixture design output' are

(a) P, Q, R
(b) P, Q, S
(c) Q, R, S
(d) R, S, P

Ans. **(b)**

The graph between VFB and Bitumen content is



End of Solution

Q.22 In a one-lane one-way homogeneous traffic stream, the observed average headway is 3.0 s. The flow (expression vehicles/hr) in this traffic stream is _____.

Ans. **(1200)**

Given : Average headway = 3.0 sec

$$\text{Flow of traffic stream} = \frac{1}{\text{headway}}$$

$$= \left(\frac{1}{\frac{3}{60\times 60}}\right) \text{veh/ hr} = 1200 \text{ veh/hr}$$

End of Solution

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Q.23 The minimum number of satellites needed for a GPS to determine its position precisely is

(a) 2 (b) 3
(c) 4 (d) 24

Ans. **(c)**

At a minimum, four satellite must be in view of the receiver for it to compute four unknown quantity (three position coordinate and one for clock deviation from satellite time).

End of Solution

Q.24 The system that uses the Sun as a source of electromagnetic energy and records the naturally radiated and reflected energy from the object is called

(a) Geographical Information System (b) Global Positioning System
(c) Passive Remote Sensing (d) Active Remote Sensing

Ans. **(c)**

The sun provide a very convenient source of energy for remote sensing. The Sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then re-emitted, as it is for thermal infrared wavelengths. Remote sensing system which measure energy i.e., naturally available are called as passive remote sensing.

End of Solution

Q.25 The staff reading taken on a workshop floor using a level is 0.645 m. The inverted staff reading taken to the bottom of a beam is 2.960 m. The reduced level of the floor is 40.500 m. The reduced level (expressed in m) of the bottom of the beam is

(a) 44.105 (b) 43.460
(c) 42.815 (d) 41.145

Ans. **(a)**

Height of instrument, HI = R.L. of floor + staff reading from floor
= 40.500 + 0.645
= 41.145 m

R.L. of bottom of beam = HI + inverted staff reading taken from bottom of beam
= 41.145 + 2.960
= 44.105

End of Solution

Two Marks Questions

Q.26 Probability density function of a random variable X is given below

$$f(x) = \begin{bmatrix} 0.25 & \text{if } 1 \le x \ge 5 \\ 0 & \text{otherwise} \end{bmatrix}$$

$P(X < 4)$

(a) $\frac{3}{4}$ (b) $\frac{1}{2}$

(c) $\frac{1}{4}$ (d) $\frac{1}{8}$

Ans. **(a)**

End of Solution

Q.27 The value of $\int_0^\infty \frac{1}{1+x^2}dx + \int_0^\infty \frac{\sin x}{x}dx$ is

(a) $\frac{\pi}{2}$ (b) π

(c) $\frac{3\pi}{2}$ (d) 1

Ans. **(b)**

End of Solution

Q.28 The area of the region bounded by the parabola $y = x^2 + 1$ and the straight line $x + y = 3$ is

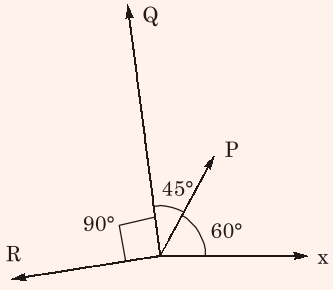
(a) $\frac{59}{6}$ (b) $\frac{9}{2}$

(c) $\frac{10}{3}$ (d) $\frac{7}{6}$

Ans. **(b)**

End of Solution

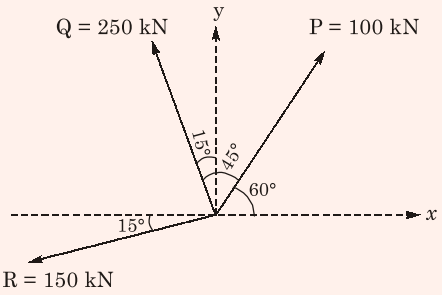
Q.29 The magnitudes of vectors P, Q and R are 100 kN, 250 kN and 150 kN, respectively as shown in the figure



The respective values of the magnitude (in kN) and the direction (with respect to the x-axis) of the resultant vector are

(a) 290.9 and 96.0°
(b) 368.1 and 94.7°
(c) 330.4 and 118.9°
(d) 400.1 and 113.5°

Ans. **(c)**



Resultant force in x-direction

$$\begin{aligned} R_x &= P\cos 60° - Q\sin 15° - R\sin 15° \\ &= 100\cos 60° - 250\sin 15° - 150\cos 15° \\ &= -159.59 \text{ kN } (\rightarrow) \\ &= 159.59 \text{ kN } (\leftarrow) \end{aligned}$$

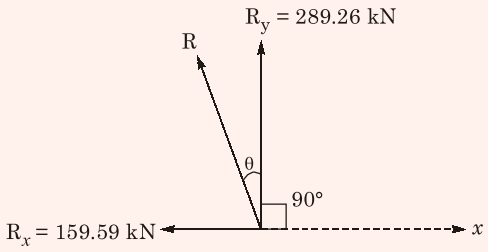
Resultant force in y-direction,

$$\begin{aligned} R_y &= P\sin 60° + Q\cos 15° - R\sin 15° \\ &= 100\sin 60° + 250\cos 15° - 150\sin 15° \\ &= 289.26 \text{ kN } (\uparrow) \end{aligned}$$

Final resultant force, $R = \sqrt{R_x^2 + R_y^2} = 330.4$ kN

$$\theta = \tan^{-1}\left(\frac{159.59}{289.56}\right)$$

$$\theta = 28.9°$$



Direction with respect to x-axis $= \theta + 90°$

$$= 28.9° + 90°$$

$$= 118.9°$$

End of Solution

Q.30 The respective expressions for complimentary function and particular integral part of the solution of the differential equation $\frac{d^4y}{dx^4} + 3\frac{d^2y}{dx^2} = 108x^2$ are

(a) $\left[c_1 + c_2x + c_3\sin\sqrt{3x} + c_4\cos\sqrt{3x}\right]$ and $\left[3x^4 - 12x^2 + c\right]$

(b) $\left[c_2 + c_3\sin\sqrt{3x} + c_4\cos\sqrt{3x}\right]$ and $\left[5x^4 - 12x^2 + c\right]$

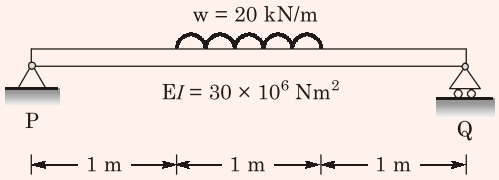
(c) $\left[c_1 + c_3\sin\sqrt{3x} + c_4\cos\sqrt{3x}\right]$ and $\left[3x^4 - 12x^2 + c\right]$

(d) $\left[c_1 + c_2x + c_3\sin\sqrt{3x} + c_4\cos\sqrt{3x}\right]$ and $\left[5x^4 - 12x^2 + c\right]$

Ans. **(a)**

End of Solution

Q.31 A 3 m long simply supported beam of uniform cross section is subjected to a uniformly distributed load of w = 20 kN/m in the central 1 m as shown in the figure

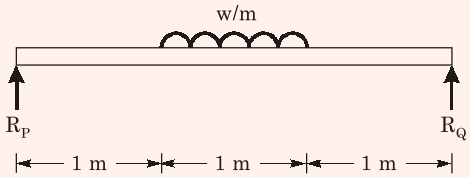


If the flexural rigidity (EI) of the beam is 30×10^6 N-m^2, the maximum slope (expressed in radians) of the deformed beam is

(a) 0.681×10^{-7} (b) 0.943×10^{-7}

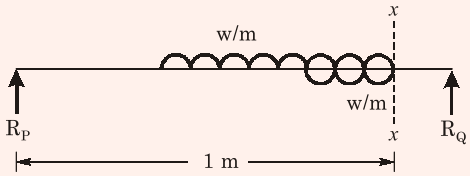
(c) 4.310×10^{-7} (d) 5.910×10^{-7}

Ans. **(*)**



Due to symmetrical loading,

$$R_P = R_Q = \frac{w \times 1}{2} = \frac{w}{2}$$



$$M_x = R_P x \,/\, -\frac{w}{2}(x-1)^2 \,/\, +\frac{w}{2}(x-2)^2$$

According to Macaulay method

$$EI\frac{d^2y}{dx^2} = R_p x \,/\!-\frac{w}{2}(x-1)^2 \,/\!+\frac{w}{2}(x-2)^2$$

After integrating once

$$EI\frac{dy}{dx} =$$

$$\frac{R_P x^2}{2} + c_1 \,/\!-\frac{w}{6}(x-1)^3 \,/\!+\frac{w}{6}(x-2)^3$$

Due to symmetrical loading slope will be zero at mid section (x = 1.5 m)

$\therefore$ at x = 15 m, $\frac{dy}{dx} = 0$

$$0 = \frac{R_P(1.5)^2}{2} + c_1 - \frac{w}{6}(1.5-1)^3$$

$$= \frac{9R_P}{8} + c_1 - \frac{w}{48} = \frac{9w}{16} + c_1 - \frac{w}{48}$$

$\therefore$ $$c_1 = \frac{w}{48} - \frac{9w}{16} = -\frac{26w}{48} = -\frac{13w}{24}$$

$\therefore$ Equation of slope.

$$EI\cdot\frac{dy}{dx} = \frac{R_P x^2}{2} - \frac{13w}{24} \,/\!-\frac{w}{6}(x-1)^3 \,/\!+\frac{w(x-2)^3}{6}$$

The slope will be max at the support

$$\therefore\ \theta_{max(x\,=\,0)} = \frac{-13w}{24EI} = \frac{-13\times 20\times 10^3}{24\times 30\times 10^6} = -0.361\times 10^{-3}\ \text{rad}$$

End of Solution

Q.32 Two beams PQ (fixed at P with a roller support at Q, as shown in Figure I, which allows vertical movement) and XZ (with a hinge at Y) are shown in the Figures I and II respectively. The spans of PQ and XZ are L and 2L respectively. Both the beams are under the action of uniformly distributed load (w) and have the same flexural stiffness, EI (where, E and I respectively denote modulus of elasticity and moment of inertia about axis of bending). Let the maximum deflection and maximum rotation be δ_{max1} and θ_{max1}, respectively, in the case of beam PQ and the corresponding quantities for the beam XZ be δ_{max2} and θ_{max2}, respectively.

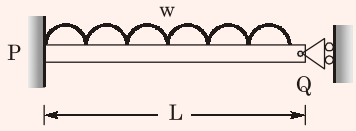


Figure - I