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Questions & Solutions

Exam held on 06/02/2021
Afternoon Session

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SECTION - A GENERAL APTITUDE

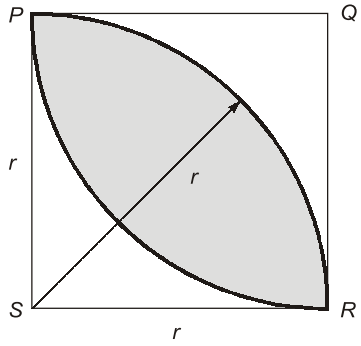
Q.1 Select the grammatically correct statement:

(a) Arun's family is here
(b) Arun's families is here
(c) Arun and Aruna are here
(d) Arun and Aruna is here

Ans. (a, c)

End of Solution

Q.2 In the figure shown below, PQRS is a square, the shaded portion is formed by intersection of sectors of circle with radius equal to the side of square and centre at *S* and *Q*.

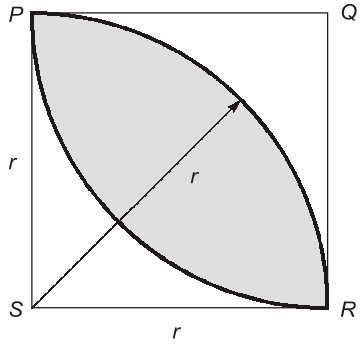


The probability that any point picked randomly within square falls in shaded area is

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

(c) $\frac{\pi}{2}-1$ (d) $\frac{\pi}{4}$

Ans. (c)



$$\text{Probability} = \frac{fA}{TA}$$

$$fA = \left(\frac{\pi r^2}{4} - \frac{r^2}{2}\right) \times 2$$

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$$\frac{fA}{TA} = \frac{\left(\frac{\pi r^2}{4} - \frac{r^2}{2}\right) \times 2}{r^2} = \left(\frac{\pi}{2} - 1\right)$$

End of Solution

Q.3 If the codes are given as

$$P \odot Q = P - Q \text{ and } P \oplus q = P \times q$$

then, value of $9 \odot (6 \oplus 7) \odot (7 \oplus (6 \odot 5))$ is _____.

(a) –40 (b) +40

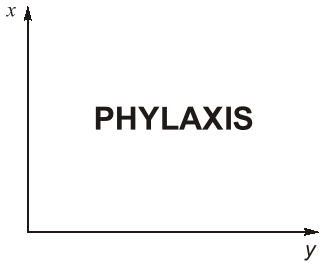
(c) –20 (d) +20

Ans. (a)

$$[9 - (6 \times 7)] - [7 \times 1] = -33 - 7$$
$$= -40$$

End of Solution

Q.4 Find mirror image about x-axis.



Sol.

SIXALYHP

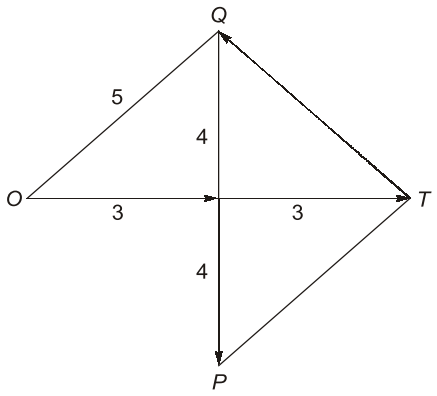
End of Solution

Q.5 On a planer field, you travelled for 3 units east from point O, next you travelled 4 units South to arrive at point *P*. Then you travelled from *P* in North-East direction such that you arrive at a point that is 6 units East of point *O*. Next you travelled in North west directions, so that you arrive at point *Q* that is 8 units North of point *P*, distance of point *Q* to point *O* in same units is

(a) 6 (b) 4

(c) 5 (d) 3

Ans. (c)



End of Solution

Q.6 Considering the given statements definitely correct, choose the conclusion which logically follows the statements.

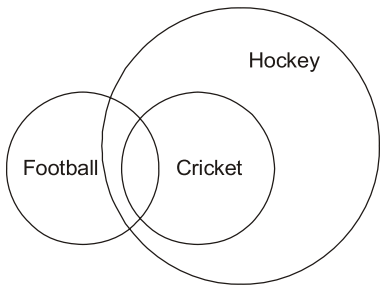
Statements : Some football players play cricket.

All cricket players play hockey.

Conclusions :

(a) All football players play hockey.
(b) Some football players play hockey.
(c) No football player play hockey.
(d) All hockey players play football.

Ans. (b)



End of Solution

Q.7 Four persons P, Q, R, S are to be seated in a row. R should not be seated in 2nd position from left end of the row, the number of distinct seating arrangement possible is

(a) 6
(b) 18
(c) 24
(d) 9

Ans. (b)

Number of arrangements = $3 \times 3!$

$= 18$

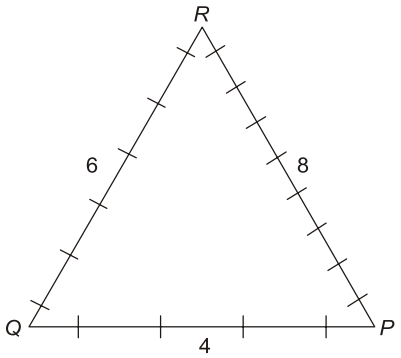
End of Solution

Q.8 Equilateral triangle PQR sides are divided as PQ in 4 equal parts, QR in 6 equal parts, RP in 8 equal parts. Each is in (cm). Find minimum area of triangle in cm^2.

(a) $144\sqrt{3}$ (b) $48\sqrt{3}$

(c) 18 (d) 24

Ans. (a)



For $\left(\frac{a}{4}, \frac{a}{6}, \frac{a}{8}\right)$ to be integer, a must be LCM of 4, 6 and 8. So $a = 24$

$$\text{Area} = \frac{\sqrt{3}}{4}a^2 = \frac{\sqrt{3}}{4} \times 24^2 = 144\sqrt{3}$$

End of Solution

■■■■

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SECTION - B TECHNICAL

Q.1 A soil sample with initial effective stress (p_o) and preconsolidation stress (p_c), effective stress is increased to final stress ($p_o + \Delta p$) such that ($p_o < p_c < p_o + \Delta p$). For the given soil sample, swelling index is c_r and compression index (c_c). The consolidation settlement is given as

(a) $\frac{c_r H_o}{1+e_o}\log\left(\frac{p_c}{p_o}\right)+\frac{c_c H_o}{1+e_o}\log\left(\frac{p_o+\Delta p}{p_c}\right)$

(b) $\frac{c_c H_o}{1+e_o}\log\left(\frac{p_c}{p_o}\right)+\frac{c_r H_o}{1+e_o}\log\left(\frac{p_o+\Delta p}{p_c}\right)$

(c) $\frac{c_r H_o}{1+e_o}\log\left(\frac{p_o}{p_c}\right)+\frac{c_c H_o}{1+e_o}\log\left(\frac{p_c}{p_o+\Delta p}\right)$

(d) $\frac{c_c H_o}{1+e_o}\log\left(\frac{p_o}{p_c}\right)+\frac{c_r H_o}{1+e_o}\log\left(\frac{p_c}{p_o+\Delta p}\right)$

Ans. (a)

$$\Delta H = \frac{H_o c_r}{1+e_o}\log\left(\frac{P_c}{P_o}\right)+\frac{H_o c_c}{1+e_o}\log\left(\frac{P_o+\Delta P}{P_c}\right)$$

End of Solution

Q.2 The sampler having Internal diameter 48 mm and outer diameter 52 mm is used. Find the area ratio.

Ans. (17.36)

Outside diameter = 52 mm

Inside diameter = 48 mm

$$A_r = \frac{\frac{\pi}{4}(D_2)^2 - \frac{\pi}{4}(D_1)^2}{\frac{\pi}{4}(D_1)^2}\times 100$$

$$A_r = \frac{(52)^2-(48)^2}{(48)^2}\times 100 = 17.36\%$$

End of Solution

Q.3 Which of the following triaxial test is performed for long-term stability of clay excavation?

(a) Consolidated drained test
(b) Unconfined compression test
(c) Consolidated undrained test
(d) Unconsolidated undrained test

Ans. (a)

End of Solution

Q.4 Two soil specimen M and N are given. The void ratio of first specimen decreases from 0.575 to 0.510, when the stress is increased to 180 kN/m^2 from 120 kN/m^2. For the same stress increment the void ratio of second specimen decreases from 0.60 to 0.55. The ratio of hydraulic conductivity of M and N is 0.125. What is the ratio of coefficient of consolidation for M and N?

Ans. (0.0947)

$$m_v = \frac{a_v}{1+e_0}$$

$$\frac{C_{v_1}}{C_{v_2}} = \frac{\frac{k_1}{m_{v_1}\gamma_w}}{\frac{k_2}{m_{v_2}\gamma_w}}$$

$$= \frac{k_1}{k_2} \times \frac{m_{v_2}}{m_{v_1}} = 0.125\left(\frac{1.575}{1.6}\right) \times \left(\frac{0.60-0.55}{0.575-0.510}\right)$$

$$= 0.0947$$

End of Solution

Q.5 A soil sample with following data is botain:
W_L = 60%, W_P = 27%, W_N = 32%, I_f = 27 then, toughness index and liquidity index for the soil is respectively

(a) 0.151, 1.22 (b) 1.22, 0.151
(c) 1.151, 12.2 (d) 12.2, 15.1

Ans. (b)

Flow index = 27

$$I_P = W_L - W_P = 33$$

$$I_T = \frac{I_P}{I_f} = \frac{33}{27} = 1.22$$

$$I_L = \frac{W_n - W_P}{W_L - W_P} = 0.151$$

End of Solution

Q.5 The correct sequence of surveying is :

(a) Reconnaissance → Field Observations → Data Analysis → Map making
(b) Reconnaissance → Data analysis → Field observations → Map making
(c) Data analysis → Reconnaissance → Field observations → Map making
(d) Data analysis → Field observations → Reconnaissance → Map making

Ans. (a)

End of Solution

Q.6 The most probable value of the angle Q.

S.No.	Angle	Weight
1	36°30	4
2	36°	3
3	35°30	8
4	36°30	4

Ans. (36)

$$\text{MPV} = \frac{(36°30' \times 4) + (36° \times 3) + (35°30' \times 8) + (36°30' \times 4)}{4+3+8+4}$$

$$= 36°$$

End of Solution

Q.7 For a traverse latitudinal and departure are calculated and it is found that:
Sum of latitude = +2.1 m.
Sum of departure = –2.8 m
Length and bearing of closing error respectively is
(a) 0.35 m and 53°53′SE
(b) 0.35 m and 53°7′NW
(c) 3.5 m and 53°7′SE
(d) 3.5 m and 53°7′NW

Ans. (d)

$$e = \sqrt{e_L^2 + e_D^2}$$

$$= \sqrt{(2.1)^2 + (2.8)^2} = 3.5 \text{ m}$$

$$\text{Bearing of closing error} = \tan^{-1}\left(\frac{e_D}{e_L}\right)$$

$$= \tan^{-1}\left(\frac{-2.8}{2.1}\right) = -53.13° = 53°7' \text{ NW}$$

End of Solution

Q.8 For a three phase four legged intersection signal, total loss time is 2 seconds per phase. Critical flow ratio for each phase is 0.18, 0.32 and 0.22 respectively. Then optimum cycle time as per Webster method is

Ans. (50)

$$L = 2 \times 3 = 6 \text{ seconds}$$
$$n = 3$$

$$y = (0.18 + 0.32 + 0.22)$$

$$C_0 = \left(\frac{1.5L+5}{1-y}\right) = \left(\frac{1.5\times 6+5}{1-(0.18+0.32+0.22)}\right)$$

$$= 50 \text{ seconds}$$

End of Solution

Q.9 In an aggregate mix, percentage weight of coarse aggregate, fine aggregate, mineral fillers are 55%, 40%, 5% respectively. Bulk specific gravities of coarse aggregate, fine aggregate and mineral filler are 2.55, 2.65, 2.70 respectively. The bult specific gravity of aggregate mix is _____ (round off to 2 decimal places).

Ans. (2.596)

$$G_m = \frac{55+40+5}{\frac{55}{2.55}+\frac{40}{2.65}+\frac{5}{2.70}}$$

$$= 2.596$$

End of Solution

Q.10 Considering 2° curve for high speed BG rail maximum speed sanctioned is 100 km/h and equilibrium speed = 80 kmph.
Considering dynamic gauge for B.G. rail 1750 mm.
The degree of curve defined as angle substained at its center by 30.5 m arc, the cant deficiency in mm _____.

Ans. (56.77)

$$I = R \times D$$

$$\frac{30.5\times 180}{2^\circ \times \pi} = R$$

$$R = 873.76 \text{ m}$$

$$e_d = e_{th} - e_{act}$$

$$= \frac{GV_{max}^{\ 2}}{127R} - \frac{GV_{eq}^{\ 2}}{127R}$$

$$= \frac{1.750\times (100)^2}{127\times 873.76} - \frac{1.750\times (80)^2}{127\times 873.76}$$

$$= 56.77 \text{ mm}$$

End of Solution

Q.11 Softening point of bitumen is measured in units of

(a) Temperature (b) Viscosity
(c) Time (d) Distance

Ans. (a)

End of Solution

Q.12 Relationship between traffic speed and density is described using a negatively sloped straight line. If V_f is free flow speed then the speed at which max flow will occur.

(a) $\frac{V_f}{4}$ (b) V_f

(c) 0 (d) $\frac{V_f}{2}$

Ans. (d)

End of Solution

Q.13 Given that stopping sight distance of a vehicle travelling with 90 kmph with decceleration 3.5 m/s^2 is 140 m (g = 9.81 m/s^2). What is the perception (reaction) time?

Ans. (2.02)

$$SSD = Vt_R + \frac{V^2}{2gf}$$

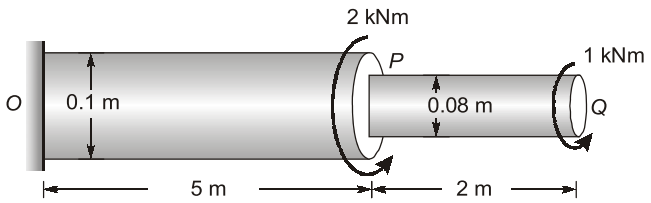
$$a = gf$$

$$140 = \left(\frac{5}{18} \times 90 \times t_R\right) + \frac{\left(\frac{5}{18} \times 90\right)^2}{2 \times 3.5}$$

$$t_R = 2.02 \text{ seconds}$$

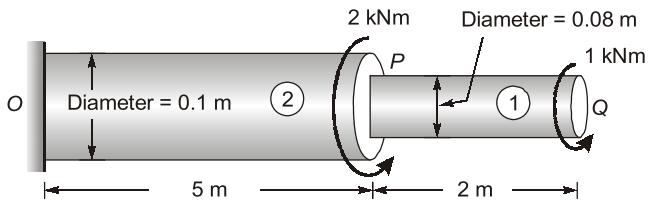
End of Solution

Q.14 Solid circular torsion member OPQ is subjected to torsional moment as shown in figure below.



The yield stress strength of the member is 160 MPa. Find absolute maximum shear stress in the member. [in MPa and round off to one decimal place]

Ans. (15.286)



$$\tau_{max1} = \frac{16T_1}{\pi d_1^3} = \frac{16\times1\times10^3}{\pi(0.08)^3} = 9.952 \text{ MPa}$$

$$\tau_{max2} = \frac{16T_2}{\pi d_2^3} = \frac{16\times3\times10^3}{\pi(0.1)^3} = 15.286 \text{ MPa}$$

$$\tau_{max} = 15.286 \text{ MPa}$$

End of Solution

Q.15 Strain Hardening means:

(a) Strengthening steel member externally for reducing strain experienced.

(b) Increase in stress when material is strained beyond yield point.

(c) Strain hardening occurs before plastic strain

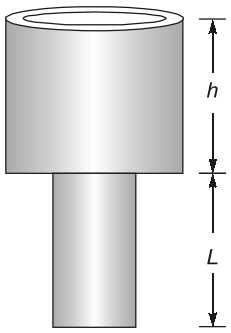
(d) Stress is less than yield stress

Ans. (b)

End of Solution

Q.16 Find the height of water tank provided on the top of column having diameter 75 mm and inner diameter of water tank was 1.5 m E value 200 GPa density of water 1000kg/m^3 and g =10 m/s^2 and height of column is 4 m.

Ans. (2.708)



Given :

L = 4 m, ρ = 1000 kg/m^3, g = 10 m/s^2, E = 200 GPa, D_i = 1.5 m, d = 75 mm

$$P_e = \frac{\pi^2 EI}{L_e^2}$$

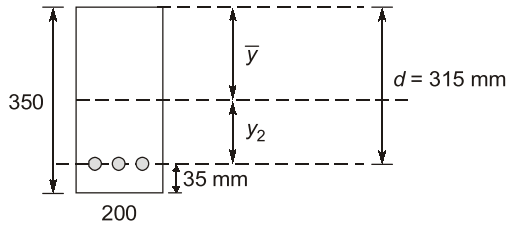
$$\frac{\pi}{4}D_1^2 \times h \times \rho g = \frac{\pi^2 E \times \frac{\pi}{64}d^4}{(2L)^2}$$

$$h = 2.708 \text{ m}$$

End of Solution

Q.17 Overall depth of rectangular beam was 350 mm deep and 200 mm wide clear cover 35 mm, 3 reinforcement of 16 mm diameter modulus of elasticity of concrete 2×10^4 MPa and modulus of elasticity of steel is 2.1×10^5 MPa. Find out distance from reinforcement CG to neutral axis depth, for uncracked section of singly reinforced beam.

Ans. (129.41)



$$m = \frac{E_s}{E_c} = \frac{2.1\times10^5}{2\times10^4} = 10.5$$

$$A_{st} = 3\times\frac{\pi}{4}(16)^2 = 603.20 \text{ mm}^2$$

$$\bar{y} = \frac{\left(B\cdot D\cdot\frac{D}{2}+(m-1)\times A_{st}\times d\right)}{(B\cdot D+(m-1)\cdot A_{st})}$$

$$= \frac{\left(200\times\frac{350^2}{2}+(10.5-1)\times603.2\times315\right)}{(200\times350+(10.5-1)\times603.2)} = 185.59 \text{ mm}$$

Distance of N-A from reinforcement

$$y_2 = d - \bar{y}$$
$$= 315 - 185.59 = 129.41 \text{ mm}$$

End of Solution

Q.18 Seasoning in timber is done to:
(a) To make surface soft
(b) To remove the defects due to knots
(c) To increase strength and durability of timber
(d) To cut timber in proper sizes

Ans. (c)

End of Solution

Q.19 Maximum depth of lake is 60 m. Mean atmospheric pressure is 91 kPa, unit weight of lake water is 9790 N/m^3. Calculate absolute pressure at maximum depth of the lake.

Ans. **(678.4)**

Absolute pressure at maximum depth of the lake = $P_{atm} + \rho gh$

$$= 91 + \frac{9790(60)}{1000} = 678.4 \text{ kPa}$$

End of Solution

Q.20 Ratio of momentum correction factor to energy correction factor for laminar flow in circular pipe :

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

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

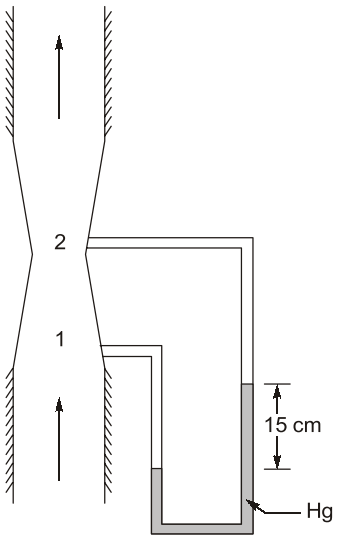
Ans. **(b)**

Momentum correction factor for laminar flow in circular pipe = $\frac{4}{3}$

Energy correction factor for laminar flow in circular pipe = 2

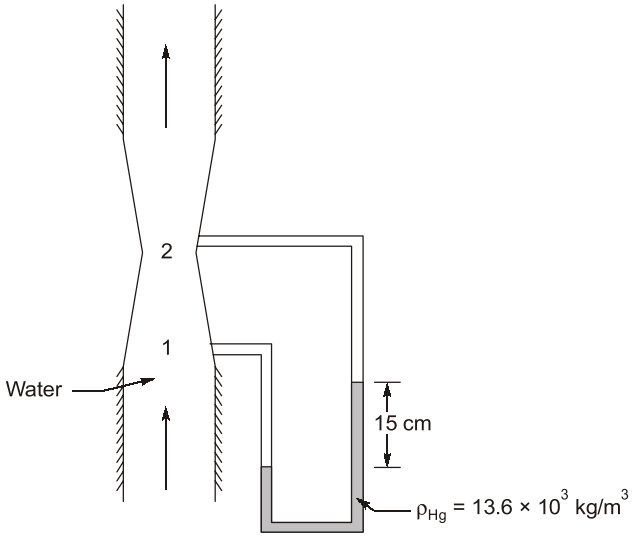
End of Solution

Q.21 A flow is taking place through pipe and venturimeter is fixed as shown as figure



Pipe diameter = 20 cm
Throat diameter = 10 cm
Specific gravity of mercury = 13.6
Then the discharge taking place through pipe in lps is _____.

Ans. (49.395)



$$\text{Discharge } (Q) = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2gh} \qquad [C_d = 1]$$

$$h = X\left(\frac{\rho_m}{\rho} - 1\right) = 0.15\left(\frac{13.6 \times 10^3}{10^3} - 1\right)$$

$$= 1.89 \text{ m}$$

$$Q = \frac{A_1 A_2}{A_2\sqrt{\left(\frac{A_1}{A_2}\right)^2 - 1}} \times \sqrt{2 \times 9.81 \times 1.89}$$

$$= \frac{\frac{\pi}{4}(0.2)^2}{\sqrt{(2)^4 - 1}} \times \sqrt{2 \times 9.81 \times 1.89}$$

$$= 49.395 \text{ } l/\text{s}$$

End of Solution

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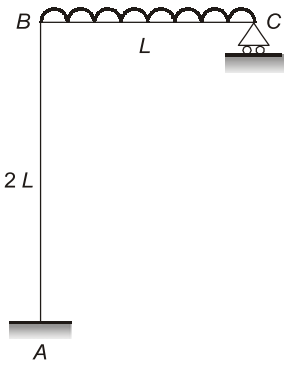
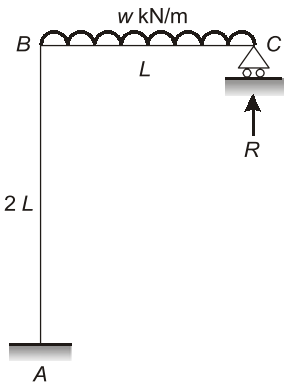
Q.22 Find reaction at *C*



Ans. (0.482 wL)



Compatibility condition

$$\frac{\partial U}{\partial R} = 0$$

$$\Rightarrow \quad \frac{\partial}{\partial R}\left[\int \frac{M^2}{2EI}dx\right] = 0$$

$$\Rightarrow \frac{\partial}{\partial R}\left[\int_0^L \frac{\left(Rx - \frac{wx^2}{2}\right)^2}{2EI}dx + \int_0^{2L} \frac{\left(RL - \frac{wL^2}{2}\right)^2}{2EI}dx\right] = 0$$

$$\Rightarrow \int_0^L \frac{2\left(Rx - \frac{wx^2}{2}\right)}{2EI}(x)dx + \int_0^{2L} \frac{\left(RL - \frac{wL^2}{2}\right)^2}{EI}dx = 0$$

$$\Rightarrow \int_0^L \frac{\left(Rx^2 - \frac{wx^3}{2}\right)}{EI}dx + \int_0^{2L} \frac{\left(RL^2 - \frac{wL^3}{2}\right)}{EI}dx = 0$$

$$\Rightarrow \frac{RL^3}{3} - \frac{w}{2} \times \frac{L^4}{4} + RL^2(2L) - \frac{wL^3}{2}(2L) = 0$$

$$\Rightarrow \frac{RL^3}{3} - \frac{wL^4}{8} + 2RL^3 - wL^4 = 0$$

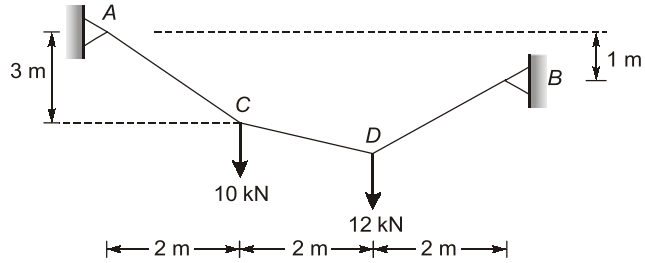
$$\Rightarrow 2RL^3 + \frac{RL^3}{3} = \frac{wL^4}{8} + wL^4 = \frac{9}{8}wL^4$$

$$\Rightarrow \frac{7RL^3}{3} = \frac{9}{8}wL^4$$

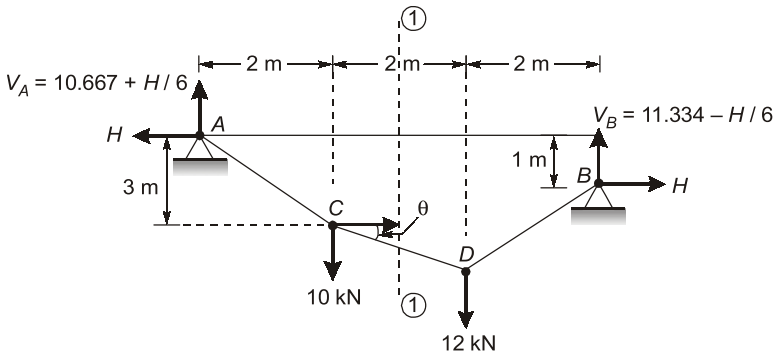
$$\Rightarrow R = \frac{27}{56}wL$$

End of Solution

Q.23 Find tension in portion *CD* for the cable structure given below:



Ans. (8.246)



$$\Sigma M_{C\circlearrowright} = 0$$

$$\left(10.667 + \frac{H}{6}\right) \times 2 - 3H = 0$$

$$\Rightarrow (10.667 \times 2) + \frac{H}{3} - 3H = 0$$

$$\Rightarrow H = \frac{(10.667 \times 2)}{2.667} = 8.00 \text{ kN}$$

$$\Rightarrow V_A = 10.667 + \frac{8}{6} = 12.00 \text{ kN}$$

$$\Rightarrow \quad V_B = 11.334 - \frac{8}{6} = 10.00 \text{ kN}$$

Consider LHS of section (1)-(1)

$$T\cos\theta = 8.0$$

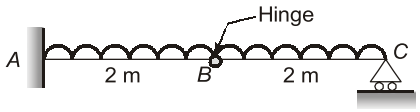
$$T\sin\theta = 12.00 - 10 = 2.0$$

$$\therefore \quad T^2\cos^2\theta + T^2\sin^2\theta = (8)^2 + (2)^2$$

$$\Rightarrow \quad T = 8.246 \text{ kN}$$

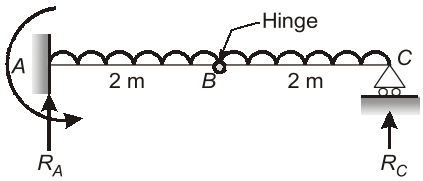
End of Solution

Q.24 A proposed cantilever beam *ABC* of length 4 m with an internal hinge at the middle, is carrying a uniformly distributed load of 10 kN/m as shown in figure.



The vertical reaction at *A* (in kN in integer) is _____.

Ans. (30)



BM = 0 at B

$$R_C \times 2 - 10 \times 2 \times 1 = 0$$

$$R_C = 10 \text{ kN}$$

$$R_A + R_C = 10 \times 4$$

$$R_A + 10 = 40$$

$$R_A = 30 \text{ kN}$$

End of Solution

Q.25 An reservoir with live capacity of 300 million cubic metres irrigates 40000 hectares of crop with two filling. If base period of a crop is 120 days, then what will be the duty of the crop (in ha/cumecs)

Ans. (691.2)

Live storage = 300 Mm^3

Area = 40000 hectare

Since 2 filling so volume of water needed = 600 Mm^3

B = 120 days

$$\text{Duty} = \frac{8.64B}{\Delta}$$

$$\Delta = \frac{600 \times 10^6}{40000 \times 10^4} = 1.5 \text{ m}$$

$$\text{Duty} = \frac{8.64 \times 120}{1.5} = 691.2 \text{ ha/cumec}$$

End of Solution

Q.26 A water filtration unit is made of uniform – size particles of 0.4 mm diameter with a shape factor of 0.84 and specific gravity of 2.55. The depth of the filter bed is 0.70 m and the porosity is 0.35. The filter bed is to be expanded to a porosity of 0.65 by hydraulic backwash. If the terminal settling velocity of sand particles during backwash is 4.5 cm/s, the required backwash velocity is

(a) 6.35×10^{-3} m/s (b) 5.79×10^{-3} m/s

(c) 0.75 cm/s (d) 6.69 cm/s

Ans. (a)

n' = Porosity of expanded bed

$$n' = \left(\frac{V_B}{V_s}\right)^{0.22}$$

$$0.65 = \left(\frac{V_B}{4.5 \text{ cm/s}}\right)^{0.22}$$

$$V_B = 6.35 \times 10^{-3} \text{ m/s}$$

End of Solution

Q.27 The colour change observed in the hardness test using 0.01M EDTA with EBT as a indicator is

(a) Blue to colourless (b) Wine red to blue

(c) Reddish brown to pinkish (d) Green to red

Ans. (b)

End of Solution

Q.28 A grit chamber of rectangular cross-section is to be designed to remove particle with diameter of 0.25 mm and specific gravity is 2.7. The terminal settling velocity of particles is estimated as 2.5 cm/sec. The chamber having a width 5 m and has to carry a peak waste water flow of 9720 m^3/day at a depth of flow as 0.75 m. The horizontal velocity along the chamber is 0.3 m/s, then the length of chamber for 100% particles removal of 0.25 mm size is

Ans. (9)

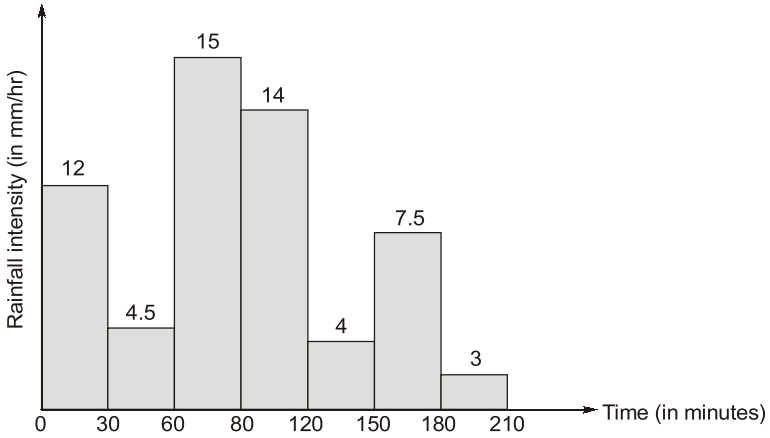
Grit chamber, d = 0.25 mm, G_s = 2.7, V_s = 2.5 cm/s, B = 0.5 m, Q = 9720 m^3/d, y = 0.75 m

$$V_S = \frac{Q}{\text{Plan Area}} = \frac{Q}{BL}$$

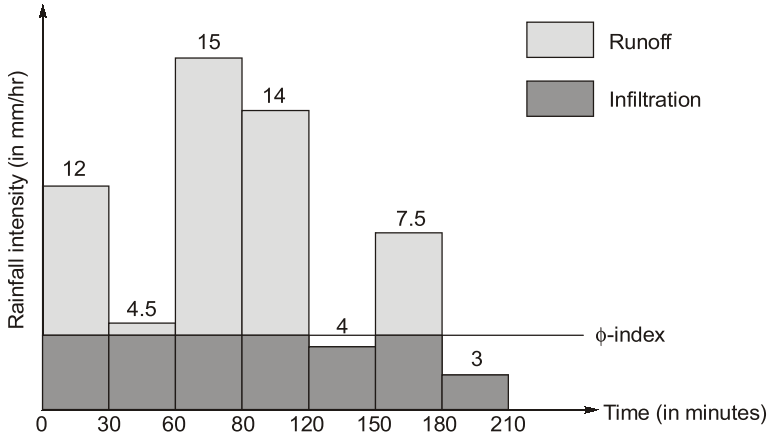
L = 9 m

End of Solution

Q.29 The hyetograph given below corresponds to a rainfall event of 3 cm. If rainfall event has produced a direct runoff of 1.6 cm, the ϕ-index (in mm/hr round off to 1 decimal place).



Ans. (4.2)



Total rainfall = 3 cm

Total runoff = 1.6 cm

∴ Total infiltration = 3 – 1.6 = 1.4 cm

$$\therefore \quad \text{W-index} = \frac{\text{Total infiltration}}{\text{Total duration of storm}}$$

$$= \frac{1.4}{(210/60)} \text{ cm/hr}$$

$$= 0.4 \text{ cm/hr} = 4 \text{ mm/hr}$$

As ϕ-index > W-index

Hence storm of intensities 4 mm/hr and 3 mm/hr will not produce rainfall exam.

$$\phi\text{-index} = \frac{\text{Total infiltration in which rainfall excess occur}}{\text{Time period in which rainfall excess occur}}$$

$$= \frac{\text{Total infiltration} - \text{Infiltration in which no rainfall excess occur}}{T_{excess}}$$

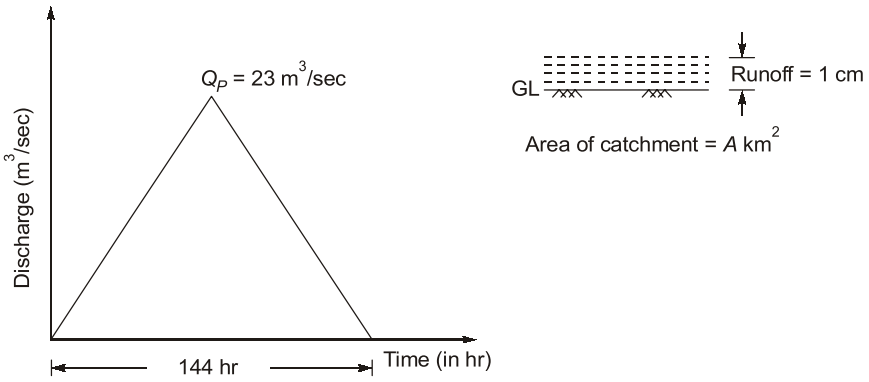
$$= \frac{14 \text{ mm} - \left(4 \times \frac{30}{60} + 3 \times \frac{30}{60}\right) \text{mm}}{\left(\frac{150}{60}\right) \text{hr}}$$

$$= 4.2 \text{ mm/hr}$$ Ans.

End of Solution

Q.30 A 12 hr UH (1 cm rain fall excess) of a catchment is of a triangular shape with a base width of 144 hr and a peak discharge of 23 m^3/s. The area of catchment in km^2 is _____.

Ans. (596.16)



Area of hydrograph = Total direct runoff volume

$$\Rightarrow \frac{1}{2} \times 23 \text{ m}^3/\text{sec} \times 144 \times 3600 \text{ sec} = \text{Area of catchment} \times \text{Runoff depth}$$

$$\Rightarrow \frac{1}{2} \times 23 \times 144 \times 3600 \text{m}^3 = A \times \frac{1}{100} \text{ m}$$

$$A = 596.16 \times 10^6 \text{ m}^2$$

$\therefore$ Area of catchment = 596.16 km^2 Ans.

End of Solution

Q.31 Consider the beam given below, plastic moment capacity of the beam is calculated for collapse condition under static and kinematic mechanism. Which of the following statement is correct regarding collapse moment capacity.

(a) $M_{p\,\text{static}} = \frac{2PL}{9} = M_{p\,\text{kinematic}}$

(b) $M_{p\,\text{static}} = \frac{2PL}{9} < M_{p\,\text{kinematic}}$

(c) $M_{p\,\text{static}} = \frac{2PL}{9} > M_{p\,\text{kinematic}}$

(d) $M_{p\,\text{static}} \neq \frac{2PL}{9} \neq M_{p\,\text{kinematic}}$

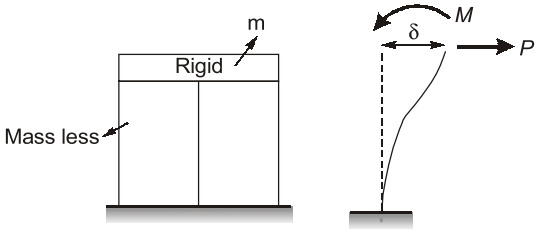
Ans. (a)

In static and kinematic methods, result is same.

$$M_{p\,\text{static}} = \frac{2PL}{9} = M_{p\,\text{kinematic}}$$

End of Solution

Q.32 SDOF model mass m as shown in figure below. What is the natural frequency for system for horizontal oscillation?



(a) $6\sqrt{\frac{EI}{mL^3}}$

(b) $2\sqrt{\frac{6EI}{mL^3}}$

(c) $\frac{2}{L}\sqrt{\frac{6EI}{mL^3}}$

(d) $\frac{1}{L}\sqrt{\frac{2EI}{m}}$

Ans. (a)

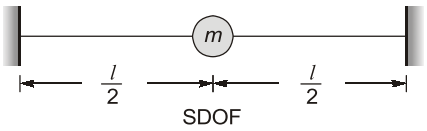
$$\omega = \sqrt{\frac{k}{m}}$$

$$k = \frac{36EI}{L^3}$$

$$\therefore \quad \omega = 6\sqrt{\frac{EI}{mL^3}}$$

End of Solution

Q.33 Flexural stiffness of beam = $4\pi^2$ kN/m. Mass, m = 10 kg. What is the natural frequency of the beam (Hz) in flexure is



Ans. (10)

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{4\pi^2 \times 1000}{10}}$$

$$= 10 \text{ Hz}$$

End of Solution

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Q.34 Determine the critical depth for rectangular channel section if width is 6 m and discharge is 20 m^3/s.

Ans. (1.042)

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{20^2}{6^2 \times 9.81}\right)^{1/3}$$

$$= 1.042 \text{ m}$$

End of Solution

Q.35 Two unbiased dice are thrown simultaneously. The probability of getting both even is _____.

Ans. (0.25)

$$n(S) = 6 \times 6 = 36$$
$$n(E) = 3 \times 3 = 9$$

$$P(E) = \frac{9}{36} = \frac{1}{4}$$

End of Solution

Q.36 The value (round off to 1 decimal place) of $\int_{-1}^{1} xe^{|x|}dx$ is _____.

Ans. (0)

$$\int_{-1}^{1} xe^{-|x|}dx = \text{Odd function}$$

$$f(-x) = -f(x)$$

$$\int_{-1}^{1} xe^{-|x|}dx = 0$$

End of Solution

Q.37 A is a square matrix the condition for orthogonality is

(a) $AA^T = I$ (b) $AA^T = A^{-1}$

(c) $A^2 = I$ (d) $AA^T = 0$

Ans. (a)

If, $AA^T = I$ or $A^{-1} = A^T$

The matrix is orthogonal.

End of Solution

Q.38 $A=\begin{bmatrix}2 & -2\\ -1 & 6\end{bmatrix}$, the smallest eigen value and corresponding eigen vector of the matrix is

Ans.

$$A=\begin{bmatrix}2 & -2\\ -1 & 6\end{bmatrix}\Rightarrow |A-\lambda I|=0$$

$$\Rightarrow \quad \lambda = (4+\sqrt{6}) \text{ and } (4-\sqrt{6})$$

$$AX=\lambda X$$

$$(A-\lambda I)X=0$$

$$\begin{bmatrix}2-(4-\sqrt{6}) & -2\\ -1 & 6-(4-\sqrt{6})\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}=\begin{bmatrix}0\\ 0\end{bmatrix}$$

$$x_1=\left(\frac{2}{-2+\sqrt{6}}\right)x_2$$

Let, $x_2 = K$ then $x_1 = \left(\frac{2}{-2+\sqrt{6}}\right)K$

$$\Rightarrow \quad \begin{bmatrix}x_1\\ x_2\end{bmatrix}=\begin{bmatrix}\frac{2}{-2+\sqrt{6}}K\\ K\end{bmatrix}\approx\begin{bmatrix}2\\ -2+\sqrt{6}\end{bmatrix}$$

End of Solution

Q.39 Normal vector $\phi = x^2 + y^2 + z^2 - 48 = 0$ at (4, 4, 4)

(a) $\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}}$ (b) $\frac{1}{\sqrt{5}},\frac{1}{\sqrt{5}},\frac{1}{\sqrt{5}}$

(c) $\frac{2}{\sqrt{2}},\frac{2}{\sqrt{2}},\frac{2}{\sqrt{2}}$ (d) None of these

Ans. **(a)**

$$\phi = x^2 + y^2 + z^2 - 48,\ P(4,\ 4,\ 4)$$

$$\text{grad}\,\phi = \vec{\nabla}\phi = \hat{i}\frac{\partial\phi}{\partial x}+\hat{j}\frac{\partial\phi}{\partial y}+\hat{k}\frac{\partial\phi}{\partial z}$$

$$= (2x)\hat{i}+(2y)\hat{j}+(2z)\hat{k}$$

$$\vec{n} = (\text{grad}\,\phi)_P = 8\hat{i}+8\hat{j}+8\hat{k}$$

$$\hat{n} = \frac{\vec{n}}{|\vec{n}|}=\frac{8\hat{i}+8\hat{j}+8\hat{k}}{\sqrt{64+64+64}}=\frac{\hat{i}+\hat{j}+\hat{k}}{\sqrt{3}}$$

$$\simeq \left(\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\right)$$

End of Solution

Q.40 The solution of $\frac{dy}{dx}-\frac{y}{x}=1$ with k as a constant is

(a) $y = k\ln(kx)$
(b) $y = x\ln(kx)$
(c) $y = xk\ln(kx)$
(d) $y = x\ln k$

Ans. (b)

$$\frac{dy}{dx}-\frac{y}{x} = 1$$

$$\frac{dy}{dx}+Py = Q$$

$$P = -\frac{1}{x},\ Q = 1$$

$$IF = e^{\int P dx} = e^{\int \frac{-1}{x}dx} = \frac{1}{x}$$

$$y(IF) = \int Q(IF)dx + c$$

$$y\left(\frac{1}{x}\right) = \int 1\cdot\frac{1}{x}dx + \ln k$$

$$y = x\ln(xk)$$

End of Solution

Q.41 Solve $\lim\limits_{x\to\infty}\left(\frac{x\ln x}{1+x^2}\right)$

(a) 0.5
(b) ∞
(c) 1
(d) 0

Ans. (d)

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

$$\lim_{x\to\infty}\left(\frac{0+\frac{1}{x}}{2}\right) = \lim_{x\to\infty}\left(\frac{1}{2x}\right) = \frac{1}{2\times\infty} = 0$$

End of Solution

Q.42 $A=\begin{bmatrix}5 & 0 & -5 & 0\\ 0 & 2 & 0 & 1\\ -5 & 0 & 5 & 0\\ 0 & 1 & 0 & 2\end{bmatrix}$ rank of the matrix is

Ans. (3)

$$\begin{bmatrix} 5 & 0 & 1 & 0 \\ 0 & 2 & 0 & 1 \\ -5 & 0 & -1 & 0 \\ 0 & 1 & 0 & 2 \end{bmatrix} \xrightarrow{R_1 \longleftrightarrow R_1 + R_3} \begin{bmatrix} 5 & 0 & 1 & 0 \\ 0 & 2 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 2 \end{bmatrix}$$

$$\xrightarrow{R_4 \longleftrightarrow R_4 - \frac{1}{2}R_2} \begin{bmatrix} 5 & 0 & 1 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{3}{2} \end{bmatrix}$$

$$R_3 \longleftrightarrow R_4 \begin{bmatrix} 5 & 0 & 1 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & \frac{3}{2} \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\text{Rank}(A) = 3$

End of Solution

Q.43 For a function $f = xe^y$, directional derivative at (2, 0) along a line joining (2, 0) and $\left(\frac{1}{2}, 0\right)$

Ans.

$f = xe^y$ then DD at (2, 0) line $P\left(\frac{1}{2}, 0\right)$ and $Q(0, 2)$

$$DD = (\text{grad}\phi) \cdot \hat{PQ}$$

$$\text{grad}\phi = \hat{i}(e^y) + \hat{j}(xe^y) + \hat{k}(0)$$

$$(\text{grad}\phi)_A = \hat{i} + 2\hat{j}$$

$$\overrightarrow{PQ} = \overrightarrow{OQ} - \overrightarrow{OP} = (0\hat{i} + 2\hat{j}) - \left(\frac{1}{2}\hat{i} + 0\hat{j}\right)$$

$$= \left(-\frac{1}{2}\hat{i} + 2\hat{j}\right)$$

$$\text{Required } DD = (\text{grad}\phi)_A \cdot \widehat{PQ} = (\hat{i} + 2\hat{j}) \cdot \frac{\left(-\frac{1}{2}\hat{i} + 2\hat{j}\right)}{\sqrt{\frac{1}{4} + 4}} = \frac{-\frac{1}{2} + 4}{\sqrt{\frac{17}{4}}} = \frac{7}{\sqrt{17}}$$

End of Solution

■■■■