PRE-GATE-2019

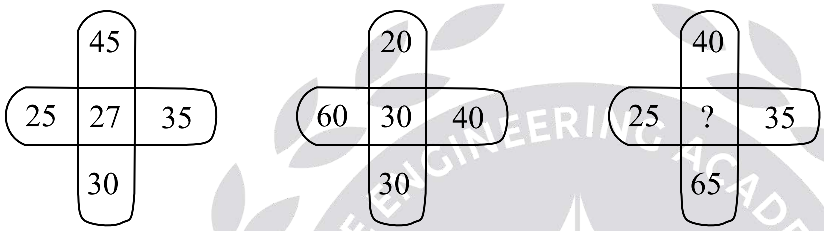
Civil Engineering

(Questions with Detailed Solutions)

The GA section consists of 10 questions. Questions 1 to 5 are of 1 mark each, and Questions 6 to 10 are of 2 marks each.

Q. 1 – Q. 5 carry one mark each.

01. Find the missing number from the given alternatives



(A) 36 (B) 33

(C) 45 (D) 60

01. Ans: (B)

Sol: As, $25 + 45 + 35 + 30 = 135 = \frac{135}{5} = 27$

And $60 + 20 + 40 + 30 = 150 = \frac{150}{5} = 30$

Similarly $25 + 40 + 35 + 65 = 165$

$$\therefore \frac{165}{5} = 33$$

Hence option (B) is correct.

02. Identify the correct sentence as per the standard English

(A) I taught the dog to lay down and roll over.

(B) I taught the dog to lie down and roll over.

(C) I taught the dog to laid down and roll over.

(D) I taught the dog to lied down and roll over.

02. Ans: (B)

03. Fill in the blank with an appropriate phrase

The gardens were ___ with lawns and flower beds.

(A) laid about (B) laid out

(C) laid off (D) laid by

03. Ans: (B)

04. 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 will 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.

04. Ans: (D)

05. Which of the following options is closest in meaning to the underlined word?

There was a homogeneity of outlook.

(A) diversity (B) unspoiled freshness

(C) similarity (D) stubbornness

05. Ans: (C)

Q. 6 – Q. 10 carry Two marks each.

06. Nine men and seven women can complete a piece of work in five days. The same work can be completed by seven men and eleven women in four days. Which of the following statements is true regarding the efficiency of the men and women?

(A) Men are more efficient than women by $88\frac{8}{9}\%$

(B) Women are more efficient than men by $88\frac{8}{9}\%$

(C) Men are more efficient than women by $18\frac{8}{9}\%$

(D) Women are more efficient than men by $18\frac{8}{9}\%$

06. Ans: (B)

Sol: 9 men and 7 women complete $\frac{1}{5}$th of the work in 1 day

$\therefore$ 45 men and 35 women can complete the work in 1 day

7 men and 11 women can complete $\frac{1}{4}$th of the same work in 1 day

$\therefore$ 28 men and 44 women can complete the work in 1 day

$\therefore$ 45 men + 35 women

$\Rightarrow$ 28 men + 44 women

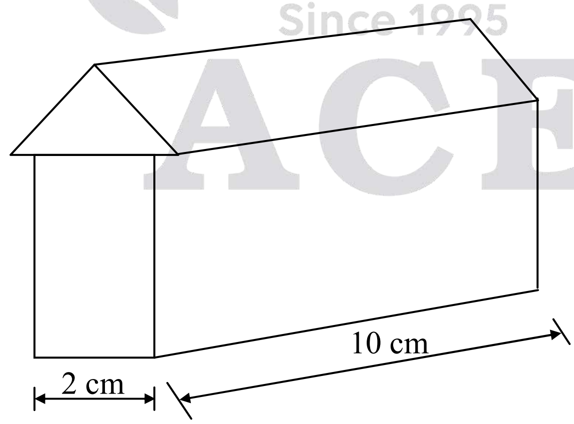
$\Rightarrow$ 17 men = 9 women

$\Rightarrow \frac{\text{women}}{\text{men}} = \frac{17}{9} = 1\frac{8}{9}$

$\therefore$ Women are more efficient by $\frac{8}{9} \times 100 = 88\frac{8}{9}\%$

Hence option (B) is correct

07. What is the approximate volume of the piece shown in the given figure which has a rectangular prism surrounded by a triangular prism (of cross-section equilateral triangle)? The height of the entire piece is 13 cm and that of the rectangular piece is 10 cm



(A) 252 cm^3 (B) 400 cm^3

(C) 216 cm^3 (D) 236 cm^3

07. Ans: (A)

Sol: The total height of the piece is 13 cm and the height of the rectangular piece is 10 cm, the height of the triangular piece = 13 – 10 = 3 cm since the triangular piece is an equilateral triangle, from its height 3 cm, we get the side of the triangle as $2\sqrt{3}$ cm.

Volume of the top portion = Area × length = $\frac{\sqrt{3}}{4}\times(\text{side})^2\times\text{length}$

$$= \frac{\sqrt{3}}{4}\times\left(2\sqrt{3}\right)^2\times 10 = 30\sqrt{3} = 52\text{cm}^3$$

Volume of the bottom portion = 10 × 10 × 2 = 200 cm^3

$\therefore$ Total volume = 252 cm^3

$\therefore$ Hence option (A) is correct

08. In a primary school, the average weight of male students is 65.9 kg and the average weight of female students is 57 kg. If the average weight of all the students (both male and female) is 60.3 kg and the number of male students in the school is 66, then what is the number of female students in the school?

(A) 152 (B) 162

(C) 168 (D) 112

08. Ans: (D)

Sol: Average weight of male students = 65.9 kg

Average weight of female students = 57.0 kg

Average weight of total students = 60.3 kg

Let the total number of students be 'x'

Then, $\frac{65.9\times 66+(x-66)\times 57}{x} = 60.3$

$$65.9 \times 66 + 57x - 57 \times 66 = 60.3x$$

$$(65.9 - 57) \times 66 = 3.3\,x$$

$$8.9 \times 66 = 3.3\,x$$

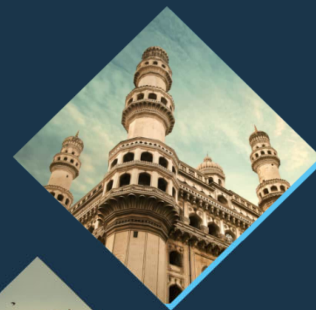
$$x = 178$$

$\therefore$ Number of female students = 178 – 66 = 112

Hence option (D) is correct

ESE – 2019

STAGE-II (MAINS)



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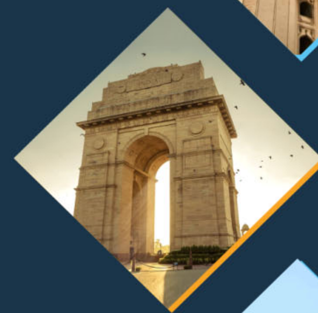

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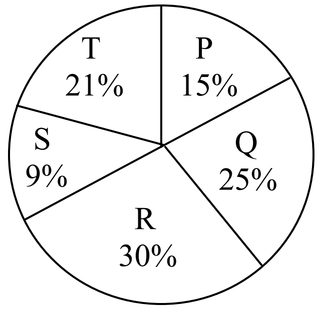
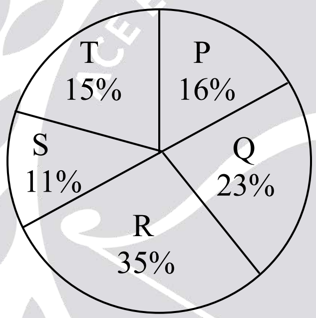
09. Study the following pie charts and answer the given question. Distribution of total number of Dell laptops sold by 5 stores



Total number = 2400

Distribution of number of Laptops (both Dell and Lenovo) sold by 5 stores in 2011



Total number = 4500

What is the difference between number of Laptops (both Dell and Lenovo) sold by store Q and total number of Lenovo Laptops sold by store 'R' and 'S' together?

(A) 185 (B) 99 (C) 91 (D) 119

09. Ans: (B)

Sol: Number of laptops (Dell and Lenovo) sold by store Q = $4500 \times \frac{23}{100} = 45 \times 23 = 1035$

Now, total number of Laptops (Lenovo and Dell) sold by R and S together = $4500 \times \frac{46}{100} = 2070$

Number of Dell laptops sold by 'R' and 'S' together = $2400 \times \frac{39}{100} = 936$

Number of Lenovo laptops = 2070 – 936 = 1134

$\therefore$ Required difference = 1134 – 1035 = 99

10. Stronger patent laws are needed to protect inventions from being pirated. With that protection manufacturers would be encouraged to invest in the development of new products and technologies. Such investment frequently results in an increase in manufacturer’s productivity.

Which of the following conclusions can most properly be drawn from the information above?

(A) Stronger patent laws tend to benefit financial institutions as well as manufacturers.

(B) Increased productivity in manufacturing is likely to be accompanied by the creation of more manufacturing jobs.

(C) Manufacturers will decreases investment in the development of new products and technologies unless there are stronger patent laws.

(D) Stronger patent laws would stimulate improvements in productivity for many manufacturers.

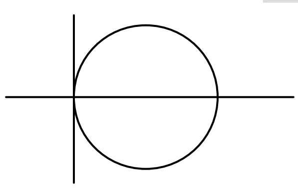
10. Ans: (D)

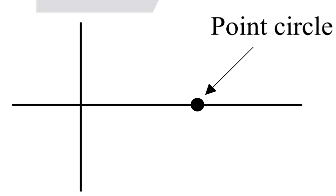
Sol: Stronger patent laws increase protection; protection encourages investment; investment often raises productivity. Thus, stronger patent laws initiate a chain of events that often culminates in improved productivity. Choice D expresses that and is, therefore, the best answer.

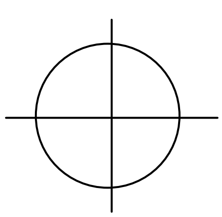
Choice A is inappropriate because the role, if any, that financial institutions would play in investments is left open. The increased productivity mentioned in B may mean fewer hours of labour for a given level of output, and may, thus, threaten jobs. Investments of the sort described in C may already be at the lowest possible level.

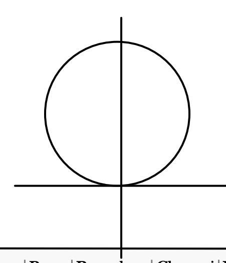
Q. 11 – Q. 35 carry one mark each.

11. Which of the following Mohr circle is correct representation of pure shear in a beam acting on the centroidal axis?

(A) 

(B) 

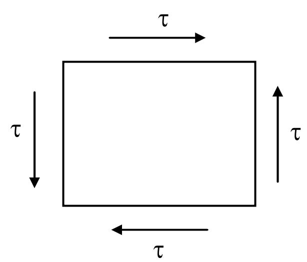
(C) 

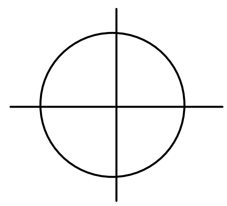
(D) 

11. Ans: (C)

Sol: For pure shear at the centroidal axis of the beam element is shown in figure below.

The corresponding Mohr circle should be concentric with origin.





Distractor logic:

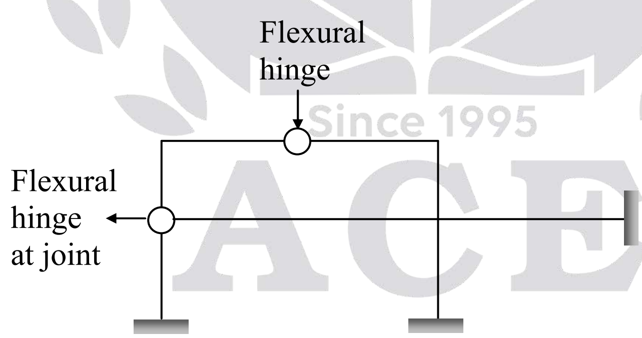
(A) This option is for axial tension member

(B) Point circle is for hydrostatic stress system.

(C) This is pure shear condition

(D) Centre of Mohr circle should be on the x-axis. The given Mohr circle is not possible

12. The degree of kinematic indeterminacy for the frame shown below, considering Beams only as axially rigid, is

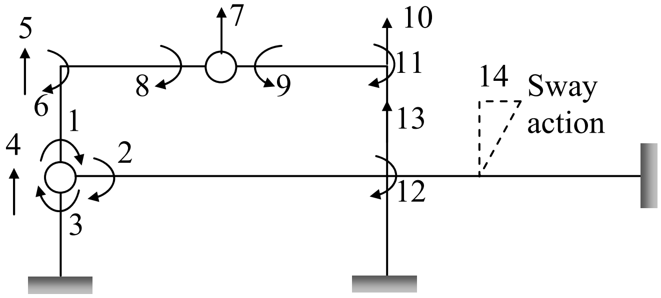


(A) 10 (B) 14

(C) 15 (D) 16

12. Ans: (B)

Sol:



Value of $j = 8$, $r = 3\times3 = 9$

$D'_K = 3j - r = 3\times 8 - 9 = 15$

Final D_K (taking hinges effect) $= 15 + 2 + 1 = 18$

Considering Beams only rigid $D_K = 18 - 4 = 14$

Distractor logic:

Option A: Wrong answer

$D_K = 18 - 8 = 10$ (Taking all members as axially rigid)

Option B: Correct Answer

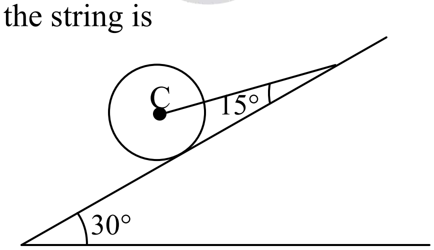
Option C: Wrong Answer

$D_K = 18 - 3 = 15$ (Taking top beam as single member)

Option D: Wrong Answer

$D'_K = (3j - r) + 4 = 19$; $D_K = 19 - 3 = 16$

13. A roller of weight 20 kN is in equilibrium on the inclined plane with string connected as shown in the figure. The tension force in the string is

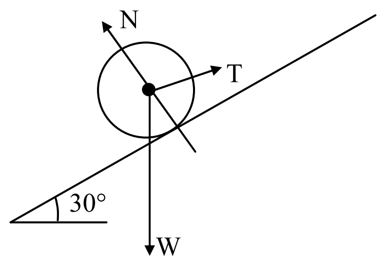


(A) 15.2 kN (B) 8.3 kN

(C) 10.35 kN (D) 20 kN

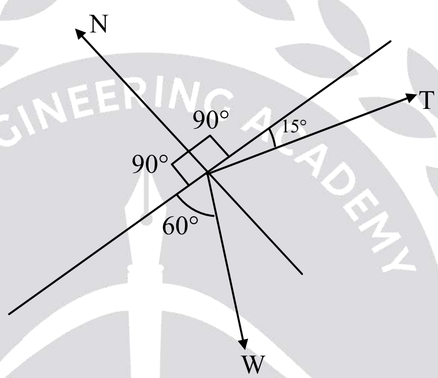
13. Ans: (C)

Sol: Free body diagram of Roller



For equilibrium, all the forces should form concurrent force system.

Applying Lami's theorem,



$$\frac{T}{\sin 150°} = \frac{W}{\sin 105°}$$

$T = 10.35$ kN

14. An unconfined aquifer has an area of 325 km^2, thickness of 24.5 m and a porosity of 30%. What is the specific retention if it can yield 1890 Mm^3 of free draining water?

(A) 0.2374 (B) 0.0626

(C) 0.5375 (D) 0.7626

14. Ans: (B)

Sol: A = 325 km^2, H = 24.5 m, n = 30%

Volume of free draining water = 1890 Mm^3

$$S_y = \frac{\text{Vol.of draining water}}{A \times H}$$

$$= \frac{1890 \times 10^6}{325 \times 10^6 \times 24.5} = 0.2374$$

$S_y + S_r = n$

$0.2374 + S_r = 0.3$

$S_r = 0.0626$

Distractor Logic

(A) If only S_y is found
(B) Correct answer
(C) If equation is wrongly written
(D) If sum is taken equal to 1

15. The stiffness coefficient K_{ij} indicate

(A) Force at i due to a unit deformation at j
(B) Deformation at j due to unit force at i
(C) Deformation at i due to a unit force at j
(D) Force at j due to a unit deformation at i

15. Ans: (A)

16. The general solution of $x^2\dfrac{d^2y}{dx^2}-5x\dfrac{dy}{dx}+9y=0$ is

(A) $(C_1 + C_2x)e^{3x}$
(B) $(C_1 + C_2\, l\text{n}x)x^3$
(C) $(C_1 + C_2x)x^3$
(D) $(C_1 + C_2\, l\text{n}x)\, e^{x^3}$

(Here, C_1 & C_2 are arbitrary constants)

16. Ans: (B)

Sol: Given $x^2\dfrac{d^2y}{dx^2}-5x\dfrac{dy}{dx}+9y=0$

Put z = logx or $x = e^z$ and $D = \dfrac{d}{dz}$

The given equation becomes,

$$D(D-1)y - 5Dy + 9y = 0$$

$$(D^2 - 6D + 9)y = 0$$

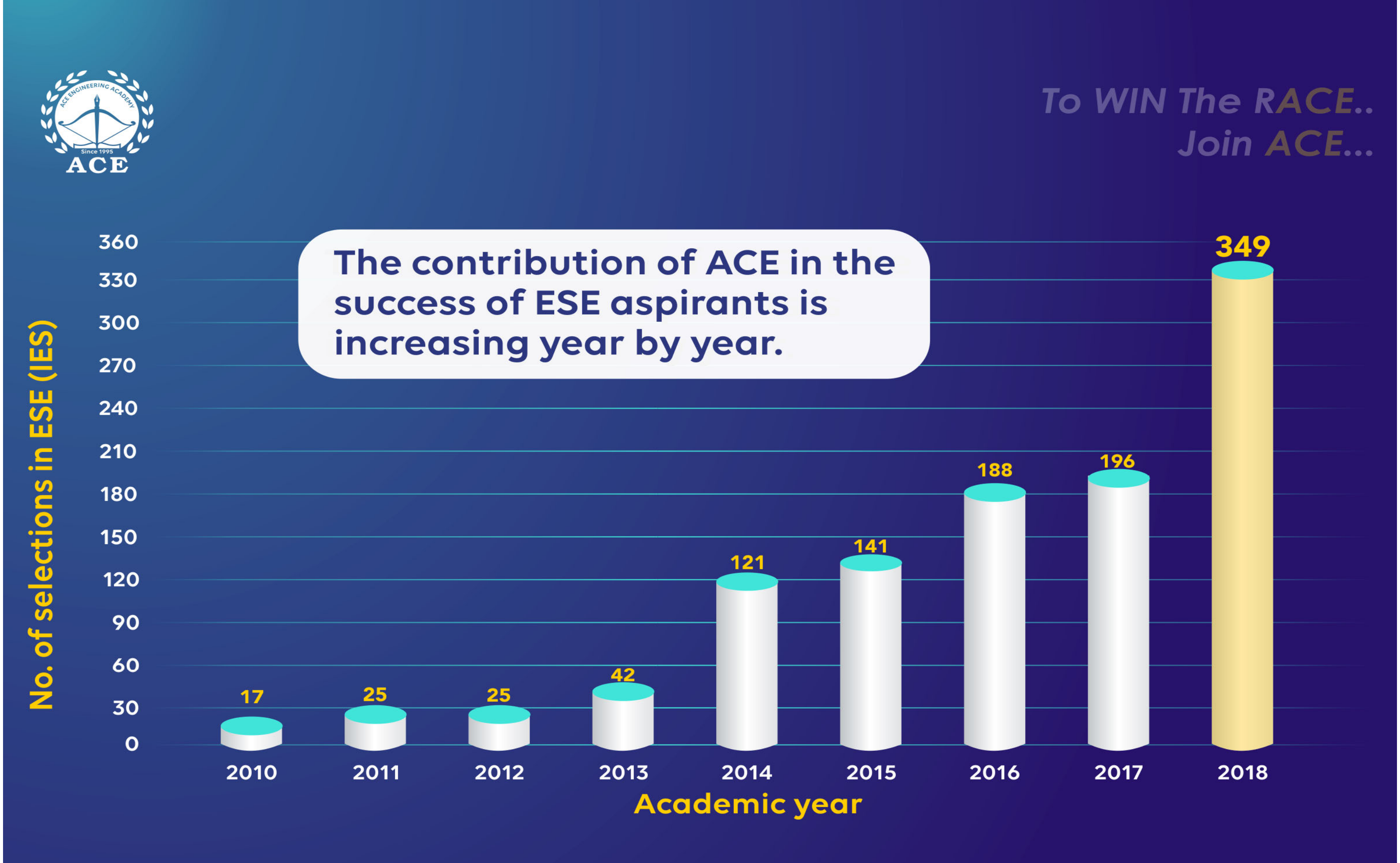
The Auxiliary equation is $D^2 - 6D + 9 = 0$

Roots are 3, 3

The general solution is $y = (C_1 + C_2\, z)e^{3z}$

$$\therefore\ y = (C_1 + C_2\, l\text{n}x)x^3$$

Hence, option (B) is correct.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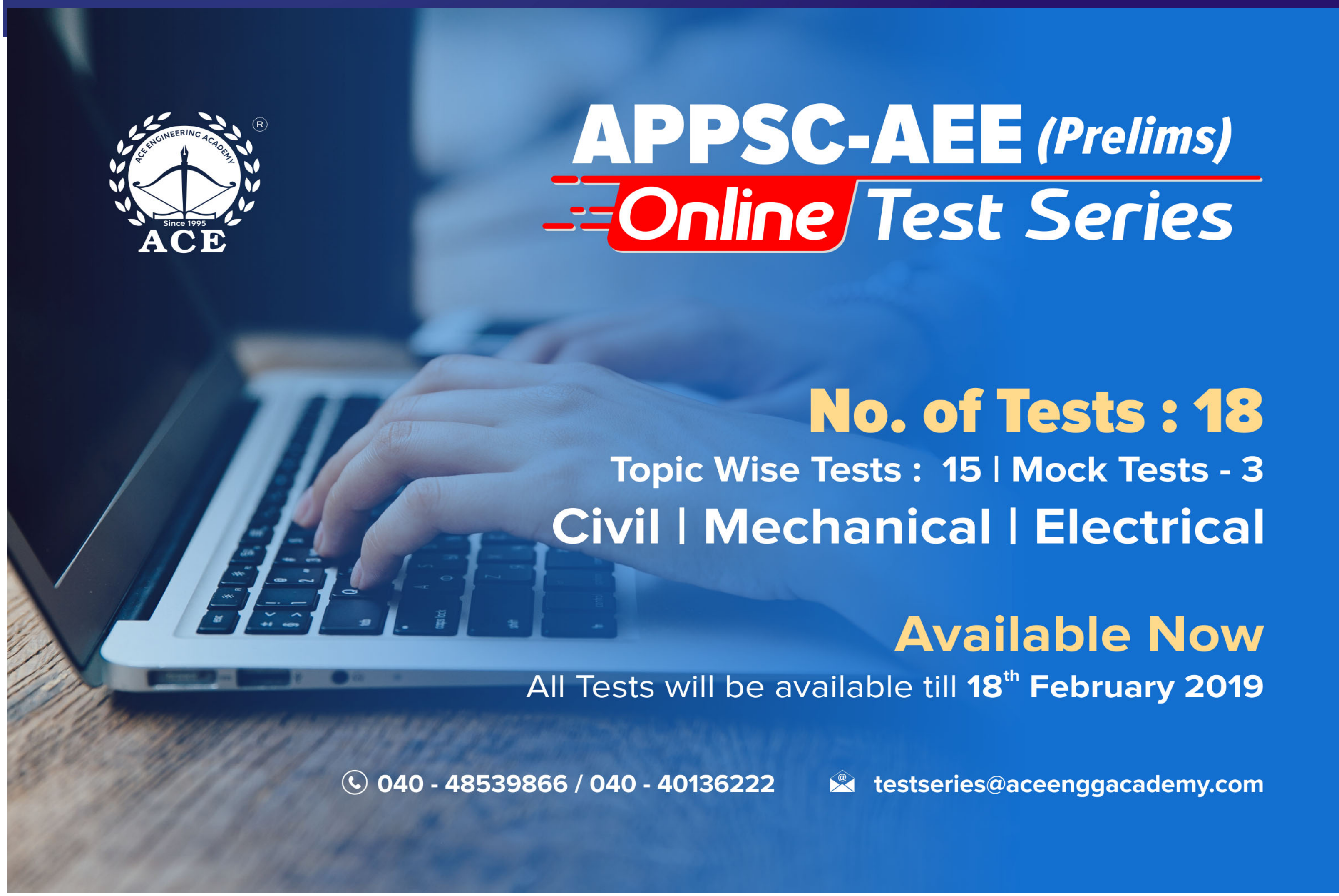
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17. When a fair coin is tossed 200 times then mean and standard deviation are

(A) 100, 50 (B) 100, $\sqrt{50}$

(C) 50, 100 (D) $\sqrt{100}$, 50

17. Ans: (B)

Sol: $n = 200, p = \frac{1}{2}, q = \frac{1}{2}$

Mean $= E(X) = np = 200 \times \frac{1}{2} = 100$

Variance $= V(X) = npq = 200 \times \frac{1}{2} \times \frac{1}{2} = 50$

Standard deviation = $\sqrt{50}$

18. The ordinates of a 4-hour unit hydrograph of a basin in m^3/s at one hour time intervals starting from time t = 0 are 0, 4, 25, 44, 60, 70, 61, 52, 45, 38, 32, 27, 22, 18, 14, 11, 8, 6, 4, 2, 1 & 0. The maximum ordinate of S-curve derived using 4 hour UH would be _______ .

(A) 544 m^3/s (B) 272 m^3/s

(C) 181 m^3/s (D) 136 m^3/s

18. Ans: (D)

Sol: D = 4 hr, Δt = 1 hour,

$\sum D = 0+4+25+44+60+70+61+52+45+38+32+27+22+18+14+11+8+6+4+2+1+0$

$= 544$

Area of UH = C.A $\times$ 0.01

$1\times3600\times544 = C.A\times 0.01$

C.A = 195.84 km^2

$Q_c = 2.778\times \frac{A}{D}$

$= 2.778\times\frac{195.84}{4} = 136\ m^3/s$

Distractor logic

(A) If D is taken as 1 decimal answer will be 544

(B) $\frac{544}{2} = 272$

(C) If solved by table & incomplete table

(D) Correct answer is (D)

19. The fineness modulus of fine aggregate is 2.5 and of coarse aggregate is 7.5 and the desired fineness modulus of mixed aggregate is 5.5. What is the amount of coarse aggregate to be mixed with one part of fine aggregate?

A) 0.4 part (B) 1 part

(C) 1.5 part (D) 1.7 part

19. Ans: (C)

Sol: Required answer $= \frac{\text{Proportion of coarse aggregate (C)}}{\text{Proportion of fine aggregate (F)}}$

$$\text{say } X = \frac{C}{F}$$

$$5.5 = \frac{2.5F + 7.5C}{F + C} = \frac{2.5 + 7.5(C/F)}{1 + C/F}$$

$$5.5 = \frac{2.5 + 7.5X}{1 + X}$$

$$X = 1.5$$

20. The Recursion relation to solve $x = e^x$ using Newton-Raphson method is

(A) $x_{n+1} = e^{x_n}$ (B) $x_{n+1} = x_n - e^{x_n}$

(C) $x_{n+1} = \frac{(1 - x_n)e^{x_n}}{1 - e^{x_n}}$ (D) $x_{n+1} = \frac{(1 + x_n)e^{x_n}}{1 - e^{x_n}}$

20. Ans: (C)

Sol: Given equation $x = e^x$

Let $f(x) = x - e^x$

$\Rightarrow f'(x) = 1 - e^x$

By Newton-Raphson Formula

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$= x_n - \frac{\left(x_n - e^{x_n}\right)}{1-e^{x_n}}$$

$$= \frac{x_n - x_n e^{x_n} - x_n + e^{x_n}}{1-e^{x_n}}$$

$$x_{n+1} = \frac{(1-x_n)e^{x_n}}{1-e^{x_n}}$$

21. A sample of water has 100 mg/*l* as Ca^{2+} and 5 m.eq/lit of Mg^{2+} then the total hardness in terms of mg/*l* as $CaCO_3$ is

(A) 500 (B) 271

(C) 250 (D) 200

21. Ans: (A)

Sol: Total Hardness "TH" = $Ca^{2+}(mg/\ell) \times \frac{50}{20} + Mg^{2+}(m.eq/\ell it) \times 50$

$$= 100 \times \frac{50}{20} + 5 \times 50 = 500 \text{ mg}/l \text{ as } CaCO_3$$

22. The radius of gyration of a ship is 12 m & its metacentric height is 0.9 m. The time period of oscillation experienced by the ship is

(A) 12.68 sec (B) 19.03 sec

(C) 25.37 sec (D) 31.72 sec

22. Ans: (C)

Sol: $T = 2\pi\sqrt{\frac{K^2}{g.GM}}$

$$= 2\pi\sqrt{\frac{12^2}{9.81 \times 0.9}}$$

= 25.375 sec

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AIR 8  ROHIT BANSAL ME

AIR 9  SHANAVAS CP E&T

AIR 9  SOUVIK DEB ROY EE

AIR 9  ROOPESH MITTAL CE

AIR 10  PRATHAMESH E&T

AIR 10  MILAN KRISHNA EE

AIR 10  SRICHAND POONIYA CE

TOTAL SELECTIONS in Top 10	34

	E&T	EE	CE	ME
TOP 10	10	10	8	6

and many more...

23. The creep co-efficient, when the age at loading is 14 days (As per IS: 456-2000), is

(A) 2.2 (B) 1.9

(C) 1.7 (D) 1.6

23. Ans: (b)

Sol:

Age of loading	Creep co-efficient
7 days	2.2
28 days	1.6

Creep co-efficient

$$\theta - 2.2 = 0.6 \times \frac{\log 14 - \log 7}{\log 7 - \log 28} = 1.9$$

24. The initial pore water pressure at a point A in a submerged clay layer was 10 kPa. A surcharge of 15 kN/m^2 was placed on Ground surface. The excess pore water pressure at beginning and end of the consolidation of clay layer are (in kN/m^2)

(A) 15 and 0 (B) 25 and 15

(C) 25 and 0 (D) 25 and 10

24. Ans: (A)

Sol: Increase in vertical stress $= \Delta\bar{\sigma} = 15\,\text{kPa}$

Initial excess pore water pressure = $\Delta u = 15\,\text{kPa}$

This dissipates and become zero at end

25. In a 2% solution of waste water sample tested for 5 day BOD depleted 3 mg/*l* of DO at 20^{o}C then 5 day BOD at 20^{o}C is

(A) 300 mg/*l* (B) 100 mg/*l*

(C) 150 mg/*l* (D) 75 mg/*l*

25. Ans: (C)

Sol: 5 day BOD at 20°C $y_5^{20^\circ C} = [(DO)_I - (DO)_F] \times \text{Dilution Factor}$

$$\text{Dilution Factor} = \frac{100}{\%\ \text{Sludge dilution}} = \frac{100}{2}$$

$(DO)_I - (DO)_F = 3$ mg/l

$$y_5^{20^\circ C} = 3 \times \frac{100}{2} = 150\ \text{mg}/l$$

26. Let $A = \begin{bmatrix} 2 & -3 \\ a & 5 \end{bmatrix}$. If one of the Eigen values of A is 3, then a = _____.

26. Ans: 0.6667 **Range: (0.65 to 0.67)**

Sol: Let λ be the second Eigen value of A.

We know that, sum of the Eigen values of A = Trace of A

$\Rightarrow 3 + \lambda = 2 + 5$

$\Rightarrow \lambda = 4$

Again, product of the Eigen values of A = |A|

$\Rightarrow 12 = 10 + 3a$

$\Rightarrow a = \frac{2}{3} = 0.6667$

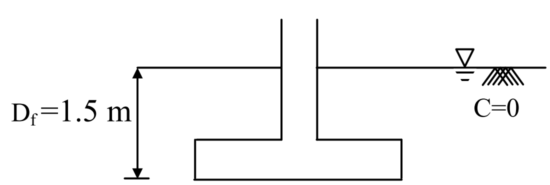
27. A strip foundation is to be provided at a depth of 1.5 m below ground surface. Water table is close to the ground level and the soil is cohesionless. The footing is supposed to carry a net safe load of 400 kN/m^2 with factor of safety of 3.0. Given γ_{sat} = 20.85 kN/m^3, ϕ = 30°, γ_w = 9.81 kN/m^3, N_q = 41.4 , N_γ = 42.4.

The width of footing under general failure criteria of Terzaghi is _________ m.

27. Ans: 2.27 m **Range: 2.25 to 2.30**

Sol: q_{ns} = 400 kN/m^2 (given)

$$q_{ns} = \frac{q_{nu}}{F}$$



$q_{nu} = q_{ns} \times F = 400 \times 3 = 1200$ kN/m^3

$q_{nu} = CN_C + q(N_q - 1) + 0.5B\gamma_{sub}N_\gamma$

$q = \gamma_{sub} D_f$

$\gamma_{sub} = \gamma_{sat} - \gamma_w = 20.85 - 9.81 = 11.04 \text{ kN/m}^2$

$1200 = 11.04 \times 1.5\,(41.4–1) + 0.5B \times 42.4 \times 11.04$

$1200 = 669.024 + 234.048\,B$

$B = 2.268$ m

28. If $f(x) = x^2$ and $g(x) = x^3$ then, the mean value C satisfying Cauchy's Mean Value theorem in the interval (1, 2) is ______.

28. Ans: 1.555 **Range: 1.5 to 1.6**

Sol: Here, f(x) and g(x) satisfy the conditions of Cauchy's mean value theorem.

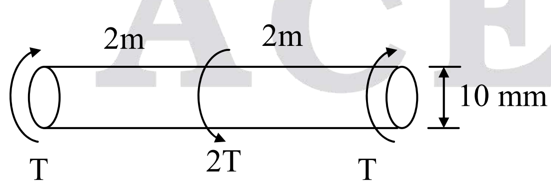
By Cauchy's mean value theorem, there exists a value $C \in (1, 2)$ such that

$$\frac{f'(C)}{g'(C)} = \frac{f(2)-f(1)}{g(2)-g(1)} \text{ .... (1)}$$

$$\Rightarrow \quad \frac{2C}{3C^2} = \frac{4-1}{8-1}$$

$$\therefore C = \frac{14}{9} = 1.555$$

29. A shaft shown in figure is subjected to torsion due to belt drives connected. The maximum shear stress developed (in MPa) __________.



T=100 N-m; G=80 GPa

29. Ans: 509.29 **Range: 509.00 to 509.50**

Sol: The maximum torsion on the shaft = T = 100 N-m

$= 100 \times 10^3$ N-mm

From Torsion equation $\frac{T}{J} = \frac{\tau}{r}$

$$\tau_{max} = \frac{T}{J} r_{max} = \frac{T}{Z_p} = \frac{100 \times 10^3}{\frac{\pi}{16}(10^3)}$$

$$\therefore \tau_{max} = 509.295 \text{ MPa} \simeq 509.30 \text{ MPa}$$

30. A rigid retaining wall 6 m high has a saturated backfill of soft clay soil. γ_{sat} = 17.56 kN/m^3. A surcharge of intensity 36 kN/m^2 is required to avoid tension cracks. The depth of tension cracks is __________ (m), when surcharge is removed.

30. Ans: 2.05 **Range : 2 to 3**

Sol: Clay

$\phi = 0$

$k_a = 1$

Surcharge required to avoid tension cracks = q

$k_a q = 2C\sqrt{k_a}$

$q = \frac{2C}{\sqrt{k_a}} = 2C$

As $k_a = 1$

$q = 36$ kN/m^2 (Given)

$= 2C$

$C = 18$ kN/m^2

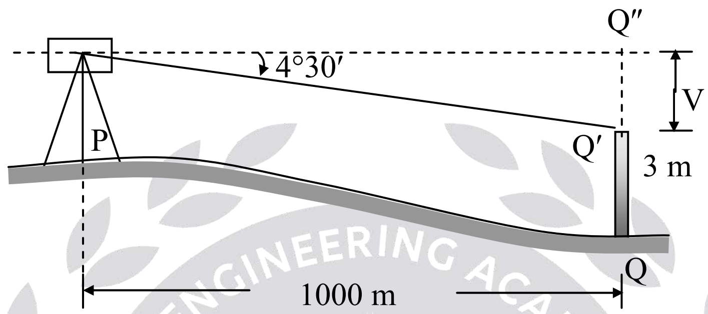
Depth of tension crack = $Z_o = \frac{2C}{\gamma\sqrt{k_a}}$

$$\frac{2C}{\gamma_{sat}\sqrt{k_a}} = \frac{2 \times 18}{17.56} = (2.05\,\text{m})$$

31. An instrument was set up at P and the angle of depression to a vane 3 m above the foot of the staff held at Q was $4^o\ 30'$. The horizontal distance between P and Q was known to be 1000 m. If the height of instrument axis is 450.250 m, the R.L of the staff station 'Q' (in m, upto two decimal places) is _______________. (Consider the combined correction).

31. Ans: 368.617 m **Range: 368.60 to 368.63**

Sol:



$V = 1000 \tan 4^o30' = 78.70$ m

Correct value of $V = 78.70 - 0.06735 \times 1^2 = 78.633$ m

RL of Q = $450.250 - 78.633 - 3 = 368.617$ m

32. The average water content of mixed sample consists of two soils each of 1 kg weight and having water contents of 40% and 60% is__________%.

32. Ans: 49.30 **Range: 48.80 to 49.80**

Sol: Soil A:

$$\text{Water content} = \frac{W_w}{W_s} = 40\%$$

$$W_w = \frac{2}{5} W_s$$

$$W_w + W_s = 1 \text{ kg}$$

$$\frac{2}{5} W_s + W_s = 1$$

$$\frac{7}{5} W_s = 1$$

$$W_s = \frac{5}{7}; W_w = \frac{2}{7}$$

Soil B:

Water content $= \dfrac{W_w}{W_s} = 60\% = \dfrac{3}{5}$

$$W_w = \frac{3}{5} W_s$$

$$W_w + W_s = 1 \text{ kg}$$

$$\frac{3}{5} W_s + W_s = 1$$

$$W_s = \frac{5}{8} \;;\; W_w = \frac{3}{8}$$

For mixed soil,

Water content $= \dfrac{W_w}{W_s} = \left[\dfrac{\frac{3}{8}+\frac{2}{7}}{\frac{5}{8}+\frac{5}{7}}\right] = 0.4933 = 49.3\%$

33. On a highway the time head way is 3 sec. The flow expressed in vehicles/hr in traffic stream is_________.

33. Ans: 1200 Veh/hr

Sol: Time head way = 3 sec

Traffic flow, $q = \dfrac{3600}{H_t} = \dfrac{3600}{3} = 1200$ Veh/hr

34. A fluid of viscosity 0.1 poise and density 800 kg/m^3 flows through a pipe of diameter 1 cm at velocity of 1 m/s. Assuming flow to be fully developed the Darcy-Weisbach friction factor for the flow is ______.

34. Ans: 0.08

Sol: $Re = \dfrac{\rho VD}{\mu} = \dfrac{800 \times 1 \times 0.01}{0.01} = 800 < 2000$

$\Rightarrow$ Flow is laminar

For laminar flow

$$f = \frac{64}{Re} = \frac{64}{800} = 0.08$$

35. The size (area) of an oxidation pond required in "ha" for a population 10000 producing a per capita BOD of 40 gm/day at place, when BOD loading rate adopted is 200 kg/ha/day is______.

35. Ans: 2

Sol: Total BOD = Qy_i = Population × Per capita BOD

$= 10000 \times 40 \times 10^{-3}$

$= 400$ kg/day

Area of oxidation pond $= \frac{Qy_i}{OLR} = \frac{400}{200} = 2\text{ha}$

Q. 36 – Q. 65 carry Two marks each.

36. A Pelton water wheel turbine is receiving flow rate of water 900 litres per second, the water jet velocity at turbine runner is 65 m/s and the peripheral velocity of the runner wheel is 25 m/s. The blade friction coefficient is 0.9 and the water jet is deflected by 160° by the bucket at exit, then the runner power developed (in MW) is:

(A) 1.66 (B) 2.67

(C) 16.7 (D) 26.7

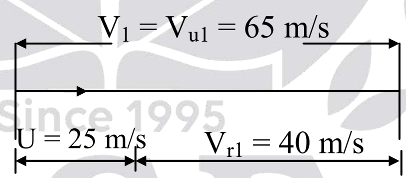
36. Ans: (A)

Sol: $V_1 = V_{u1} = 65$ m/s

$u = 25$ m/s

$V_{r1} = 65 - 25 = 40$ m/s

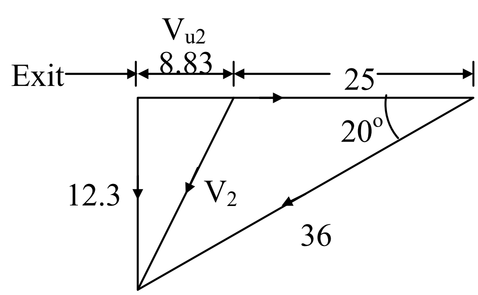
$V_{r2} = 0.9 \times V_{r1} = 36$ m/s



As 36 cos 20 = 33.82 < 25 the shape of the exit triangle is as in figure.

$V_{u2} = 36 \cos 20 - 25$

$= 33.83 - 25 = 8.83$ m/s



In the opposite direction of V_{u1} hence addition

$P = 900 \times 25\ (65 + 8.83) = 1.661$ MW

ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	21st Jan 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	19th Jan 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	13th Jan, 2nd Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2021	Weekend Batch	13th Jan 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE + GATE+PSUs - 2020 & 21	Evening Batch	09th Jan 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
PUNE	GATE+PSUs - 2020	Weekend Batch	19th Jan 2019
PUNE	ESE+GATE+PSUs - 2021	Weekend Batch	26th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020 & 21	Weekend Batch	12th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019

37. Data from a pile load test on a 300 mm diameter pile is given below:

Load (kN)	20	40	60	80	100	120	140	160	180	200
Total settlement (mm)	3	5	9	13	16	23	28	32	42	50

The design load on the pile is (in kN)

(A) 50 (B) 75

(C) 150 (D) 37.5

37. Ans: (A)

Sol: The criteria for determining the design load is that it shall be taken lower of

(i) Half the load at which pile settlement is 10% of the pile diameter

10% of pile diameter means 30 mm from given data load corresponds to 30 mm settlement is 150 kN, after interpolation from the data given

But we take half load only i.e. 75 kN ……………….(1)

(ii) 2/3 load at which pile total settlement is 12 mm

$$\begin{matrix} 9\text{ mm} \to 60 \\ 12\text{ mm} \to y \\ 13\text{ mm} \to 80 \end{matrix} \Rightarrow \begin{matrix} 3 \to y - 60 \\ 4 \to 20 \end{matrix}$$

from that y = 75

But take 2/3 of load only i.e $75 \times \frac{2}{3} = 50$ kN ……….(2)

From above 2 equations least load is 50 kN

38. What are the values of constants a and b for which the vector

$\vec{F} = \left[x^2 + y + (a-b)z\right]\vec{i} + \left[(a+b)x - y^2 - z\right]\vec{j} + \left[2x - y + z^2\right]\vec{k}$ is irrotational ?

(A) $a = \frac{3}{2}, b = \frac{1}{2}$ (B) $a = \frac{1}{2}, b = \frac{3}{2}$

(C) $a = \frac{-1}{2}, b = \frac{3}{2}$ (D) $a = \frac{3}{2}, b = \frac{-1}{2}$

38. Ans: (D)

Sol: curl $\vec{F} = \nabla \times \vec{F} = 0$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x^2 + y + (a-b)z & (a+b)x - y^2 - z & 2x - y + z^2 \end{vmatrix} = 0$$

$$\Rightarrow \vec{i}(-1+1) - \vec{j}(2-(a-b)) + \vec{k}[(a+b)-1] = 0$$

$$\Rightarrow 0\,\vec{i} + \vec{j}[(a-b)-2] + \vec{k}[(a+b)-1] = 0\,\vec{i} + 0\,\vec{j} + 0\,\vec{k}$$

$a - b - 2 = 0$; $a + b - 1 = 0$

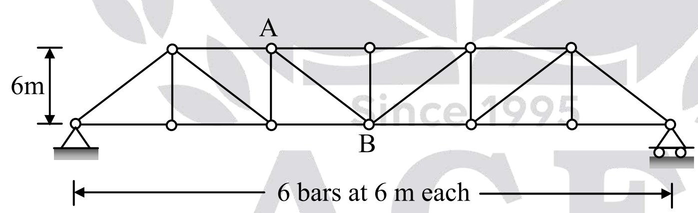
$a - b = 2$

$a + b = 1$

on solving these two equations, we get $a = \frac{3}{2}, b = \frac{-1}{2}$

$\therefore$ Option (D) is correct.

39. Influence line for member force in AB of the truss shown is obtained by



(A) $\sqrt{2}$ times the ordinates of influence line for bending moment at A

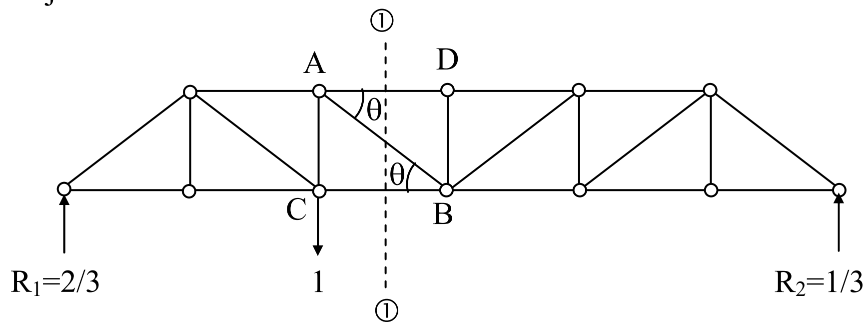
(B) $\sqrt{2}$ times the ordinates of influence line for shear in 3rd panel from left

(C) $\sqrt{2}$ times the ordinates of influence line for shear in 3rd panel from right

(D) $\sqrt{2}$ times the ordinates of influence line for bending moment at B

39. Ans: (B)

Sol: When unit load at joint 'C'

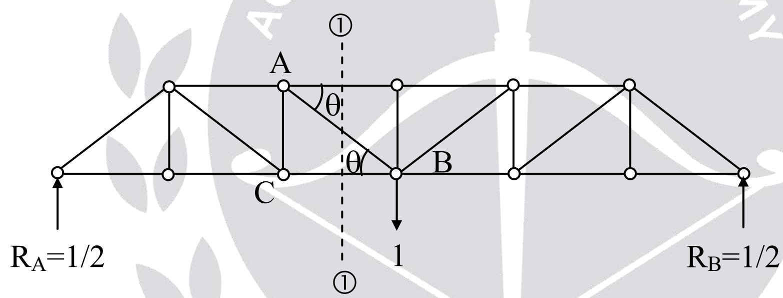


$\sum V = 0$ [Right part]

$F_{AB} \sin 45° + R_2 = 0$

$F_{AB} = -\sqrt{2}R_2$ (compressive)

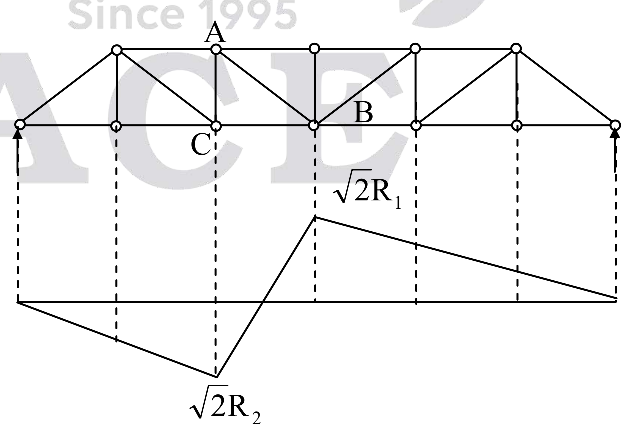
When unit load at joint 'B'



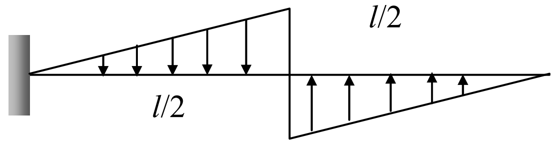
$\sum V = 0$ [left part]

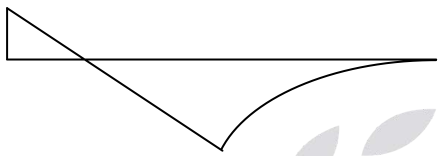
$F_{AB} \sin 45° = R_1$

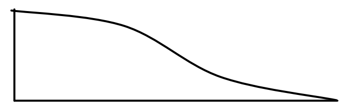
$F_{AB} = \sqrt{2}\, R_1$ [Tension]

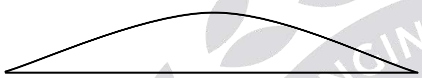


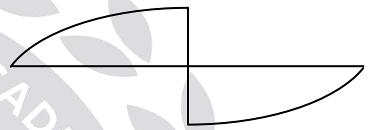
40. A cantilever beam is subjected to loading as shown in figure. What will be corresponding bending moment diagram?



(A)


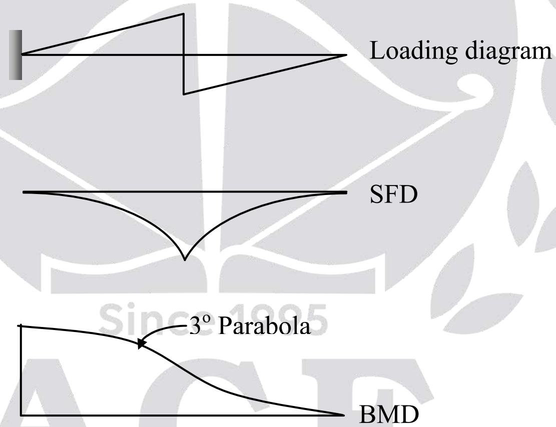
(B)


(C)


(D)


40. Ans: (B)

Sol:



Slope of SFD = Rate of loading and

Slope of BMD = Shear force value on the beam

Distractor Logic:

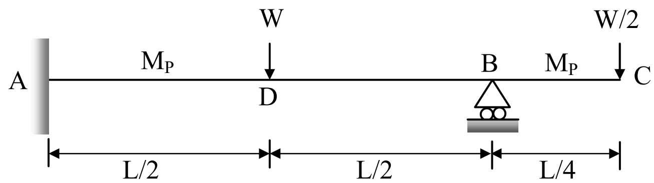
(A) Bending moment value should not change the sign (nature) in the beam.

(B) The appropriate answer.

(C) Slope of BMD can not be zero at the middle of its length

(D) BMD can not change its sign

41. A propped cantilever of uniform M_p is loaded as shown in figure below. Collapse load for the beam will be



(A) $\frac{4M_P}{L}$ (B) $\frac{6M_P}{L}$

(C) $\frac{8M_P}{L}$ (D) $\frac{12M_P}{L}$

41. Ans: (C)

Sol: Number of reaction 'r' = 3

Number of equilibrium equations 'S' = 2

Static indeterminacy 'D_s' = $D_{se} + D_{si}$

$= r - S = 3 - 2 = 1$

Number of possible plastic hinges 'N' = 3[At A, B & D]

Number of plastic hinges required to form a mechanism 'n' = $D_s + 1 = 2$

Number of independent mechanism 'I' = $N - D_s = 3 - 1 = 2$

(Two independent beam mechanisms)

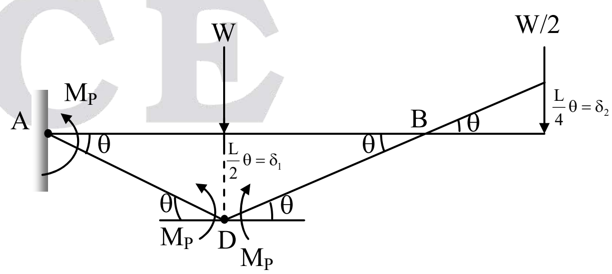
1st beam mechanism:

External work done 'W_e' = load × displacement under the load

$W_e = +W_c\delta_1 - \frac{W_c}{2}.\delta_2$

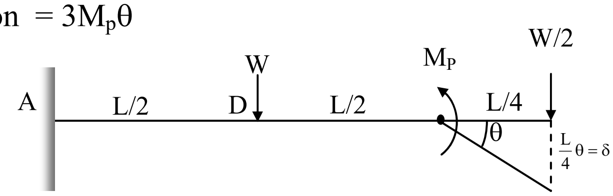
$W_e = W_c \times \frac{L}{2}\theta - \frac{W_c}{2}.\frac{L}{4}\theta$

$= W_C L\theta\left[\frac{1}{2} - \frac{1}{8}\right] = \frac{3W_c L\theta}{8}$



Internal work done (W_i) – Moment × rotation = $3M_p\theta$

External work done = Internal work done



$$\frac{3W_c L\theta}{8} = 3M_p\theta$$

$$W_c = \frac{8M_P}{L}$$

2nd Beam mechanism:

$$W_e = \frac{W_c}{2} \times \delta$$

$$W_e = \frac{W_c}{2} \times \frac{L\theta}{4} = \frac{W_c L\theta}{8}$$

$W_i = M_p\theta$

$W_e = W_i$

$$\frac{W_c L\theta}{8} = M_p\theta$$

$$W_C = \frac{8M_p}{L}$$

True collapse load is $\frac{8M_P}{L}$ [least]

42. For an n×n matrix consisting of all ones, which of the following is true?

(A) the distinct Eigen values are 0 and 1

(B) the distinct Eigen values are 1 and n

(C) the distinct Eigen values are 1, 2, ..., n

(D) the distinct Eigen values are 0 and n

42. Ans: (D)

Sol: Let $A = \begin{bmatrix} 1 & 1 & \ldots\ldots & 1 \\ 1 & 1 & \ldots\ldots & 1 \\ \ldots & \ldots & \ldots\ldots & \ldots \\ 1 & 1 & \ldots\ldots & 1 \end{bmatrix}_{n\times n}$

$|A - \lambda I| = 0$

$$\begin{vmatrix} 1-\lambda & 1 & \ldots\ldots & 1 \\ 1 & 1-\lambda & \ldots\ldots & 1 \\ \ldots & \ldots & \ldots\ldots & \ldots \\ 1 & 1 & \ldots\ldots & 1-\lambda \end{vmatrix} = 0$$

$C_1 \to C_1 + C_2 + \ldots\ldots\ldots\ldots\ldots + C_n$

$$\begin{vmatrix} n-\lambda & 1 & \dots\dots\dots & 1 \\ n-\lambda & 1-\lambda & \dots\dots\dots & 1 \\ \dots & \dots & \dots\dots\dots & \dots \\ n-\lambda & 1 & \dots\dots\dots & 1-\lambda \end{vmatrix} = 0$$

$R_2 - R_1, R_3 - R_1, \dots\dots\dots, R_n - R_1$

$$\begin{vmatrix} n-\lambda & 1 & \dots\dots\dots & 1 \\ 0 & -\lambda & \dots\dots\dots & 0 \\ \dots & \dots & \dots\dots\dots & \dots \\ 0 & 0 & \dots\dots\dots & -\lambda \end{vmatrix} = 0$$

$\Rightarrow \lambda = n, 0, 0, \dots\dots\dots\dots, 0 \quad [(n-1) \text{ zeros}]$

$\therefore$ The distinct Eigen values are 0 and n

43. In a bituminous concrete the following observations are made. The theoretical specific gravity of mix and absolute specific gravity of the aggregate respectively (round upto two decimal places), are

Ingredients	Weights (g)	Specific gravity (G)
C.A	1200	2.63
F.A	836	2.78
Filler	650	2.96
Bitumen	550	1.02

(A) 3.6 & 2.75 (B) 2.13 & 3.6

(C) 2.13 & 2.75 (D) 2.75 & 2.14

43. Ans: (C)

Sol:

Percentage	Weights
$W_{CA} = 37.08$	$W_{FA} = 25.83$
$W_{Fill} = 20.08$	$W_{bit} = 16.99$

Theoretical specific gravity of mix

$$\frac{100}{G_t} = \frac{W_{CA}}{G_{CA}} + \frac{W_{FA}}{G_{FA}} + \frac{W_{Filler}}{G_{Filler}} + \frac{W_{bit}}{G_{bit}}$$

$$\frac{100}{G_t} = \frac{37.08}{2.63} + \frac{25.83}{2.78} + \frac{20.08}{2.96} + \frac{16.99}{1.02}$$

$G_t = 2.14$

Absolute specific gravity of

$$\frac{37.08 + 25.83 + 20.08}{G_{agg}} = \frac{37.08}{2.63} + \frac{25.83}{2.78} + \frac{20.08}{2.96}$$

$G_{agg} = 2.75$

44. The solution of the initial value problem $\frac{dy}{dx} = \left(y + y^2\right)\cot x$, $y\left(\frac{\pi}{2}\right) = 1$, is

(A) y cosx – (1 – y) sinx = 0
(B) y = sinx
(C) y = sinx + cosx
(D) 2y – (1 + y) sinx = 0

44. Ans: (D)

Sol: Given $\frac{dy}{dx} = \left(y + y^2\right)\cot x$

$$\frac{dy}{y + y^2} = \cot x \; dx$$

$$\frac{dy}{y(1+y)} = \cot x \, dx$$

$$\left(\frac{1}{y} - \frac{1}{1+y}\right)dy = \cot x \, dx$$

Integrating both sides, we get

$\ell n\, y - \ell n\,(1 + y) = \ell n\, \sin x + \ell n\, C$

$$\ell n\left(\frac{y}{1+y}\right) = \ell n\left(C \sin x\right)$$

$$\frac{y}{1+y} = C \sin x$$

$\therefore$ y = C(1 + y) sin x .... (1) is the general solution.

$$y\left(\frac{\pi}{2}\right) = 1,\ (1) \Rightarrow 1 = C(1+1)\sin\left(\frac{\pi}{2}\right)$$

$$\Rightarrow 1 = 2C$$

$$\Rightarrow C = \frac{1}{2}$$

$$\therefore\ y = \frac{1}{2}(1+y)\sin x$$

$$2y = (1 + y)\sin x$$

$$2y - (1 + y)\sin x = 0$$

Hence, option (D) is correct.

45. A siphon spillway has the dimensions of cross section 1.5 m × 6 m wide. RL of MFL on U/S is 120.00 m and on D/S 110.00. The surplus discharge to be disposed off is 300 cumec. Number of siphons to be provided in parallel is [C_d = 0.6]

(A) 2 (B) 3 (C) 4 (D) 5

45. Ans: (C)

Sol: Capacity of each siphon = $C_d A \sqrt{2gH}$

$$= 0.6(1.5\times 6)\sqrt{2(9.81)(10)} = 75.6$$

$$\text{No. of siphons} = \frac{\text{Total Q}}{\text{Capacity of each Siphon}} = \frac{300}{75.6} = 3.97 \simeq 4 \text{ siphons}$$

46. A project consists of eight activities with the following details

Activity	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Predecessor	-	-	-	A, B	B, C	B	D, F	D, E, F
Duration (days)	3	5	4	6	3	2	3	5

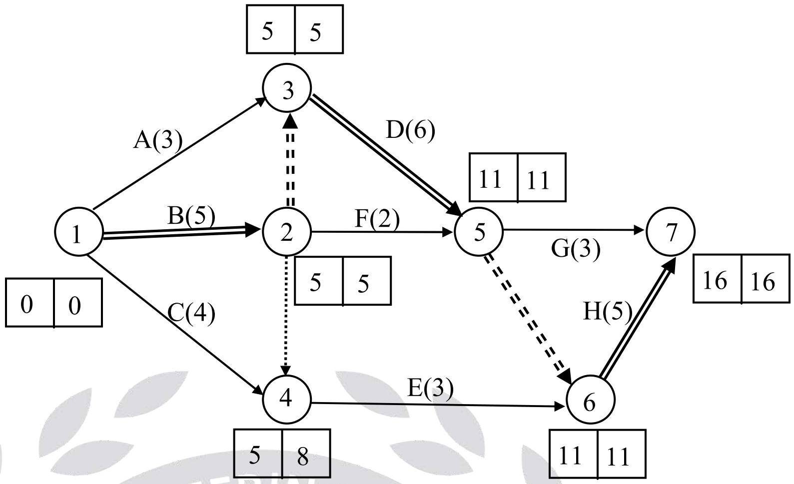
The total float on 'A' and free float on 'E' respectively are _______________.

(A) 0 and 3 (B) 2 and 0

(C) 0 and 0 (D) 2 and 3

46. Ans: (D)

Sol:



TF for A = 5 – 0 – 3 = 2

TF for E = 11 – 5 – 3 = 3

FF for E = TF – Slack @ head event

= 3 – (11 – 11)

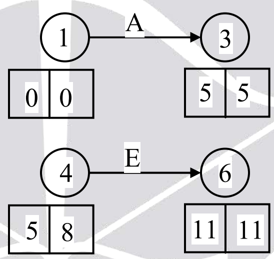
= 3

Distracter Logic:

(A) TF for A = 5 – 5 = 0

TF for E = 8 – 5 = 3

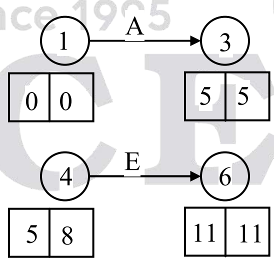
FF for E = 3 – (11– 11) = 3



(B) TF for A = 5 – 0 – 3 = 2

TF for E = 11 – 8 – 3 = 0

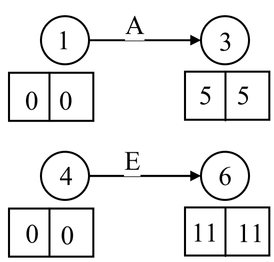
FF for E = 0



(C) TF for A = 5 – 5 = 0

TF for E = 11 – 11 = 0

FF for E = 0



(D) Correct answer

47. A transition curve is required to be introduced between a straight and a circular curve of radius 320 m and the maximum superelevation is restricted to 0.1 m for a gauge of 1.0 metre. If the superelevation of 4 cm is provided on the distance covered by the vehicle in one second, the length of transition curve is __________

(A) 44.30 cm (B) 4.43 m

(C) 44.30 m (D) 4.43 cm

47. Ans: (C)

Sol: $h = \dfrac{Gv^2}{Rg} \Rightarrow 0.1 = \dfrac{1\times v^2}{320\times 9.81}$

$\therefore\ v = 17.72$ m/sec

$L = \dfrac{vh}{x} = \dfrac{17.72\times 0.1}{0.04} = 44.30$ m

Distractor Logic

(A) May be confused with units instead of unit of x = 0.04 m/sec it may be taken as x = 4 cm/sec

(B) May be calculation mistake

(C) Correct

(D) May be units confusion

48. Which of the following statements are true?

P. Warping stresses are tensile on the bottom face of edge (or) interior during day time.

Q. CBR is a relative strength parameter of subgrade soil.

R. Classification of bitumen as per IRC is based on viscosity and VG30 is commonly used bitumen for Indian condition.

(A) P and Q (B) Q and R

(C) P and R (D) P, Q, R

48. Ans: (D)

Sol: Distractor Logic

(A) During day time pavement warps up and it is prevented by self weight causing tension on bottom of edge & interior region.

(B) CBR is a bearing strength parameter which gives relative strength of soil compared to crushed aggregate.

(C) Present IRC grading of bitumen is based on Viscosity test. Previously it was based on penetration test.

(D) All the given options are true.

49. A concrete pile 45 cm diameter is driven through a system of layered cohesive soil. The length of pile is 16 m. Water table is close to ground surface.

Top Layer 1: Thickness = 8 m

Cohesion C = 30 kN/m^2

Adhesion factor α = 0.9

Layer 2: Thickness = 6m

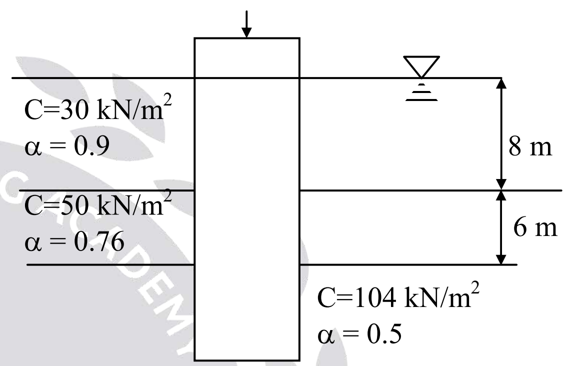
Cohesion C = 50 kN/m^2

Adhesion factor α = 0.76

Layer 3: Thickness = Great depth

Cohesion C = 104 kN/m^2

Adhesion factor α = 0.5



Taking a factor of safety of 2.5, the allowable load on pile (in kN) is ___________.

49. Ans: 369.56 kN **Range : 366 to 374**

Sol: Q_u (ultimate load carried by pile) = CN_c (at base) $A_b + P\sum_{i=1}^{n}\alpha_i C_i L_i$

P = Perimeter of the pile

A_b = Area of base

α_i = Adhesion factor of ith layer

C_i = average cohesion in ith layer

L_i = Length of pile in ith layer

n = no. of layers Take $N_c = 9$

$$Q_u = 9\times104\times\frac{\pi}{4}\times0.45^2 + \pi\times0.45[0.9\times30\times8 + 0.76\times50\times6 + 0.5\times104\times2]$$

$$= 148.92 + 775.03 = 923.95$$

$$Q_a = \frac{923.95}{2.5} = 369.56 \text{ kN}$$

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CENTER	COURSE	BATCH TYPE	DATE
CHENNAI	GATE+PSUs - 2020 & 21	Weekend Batch	19th Jan 2019
CHENNAI	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
BANGALORE	GATE+PSUs - 2020 & 21	Weekend Batch	19th Jan 2019
BANGALORE	GATE+PSUs - 2020	Regular Batch	17th June 2019
BANGALORE	KPSC-AE (CE) – PAPER 1 & PAPER 2	Regular Batch	19th Jan 2019
LUCKNOW	ESE+GATE+PSUs - 2020 & 21	Evening Batch	06th Feb 2019
LUCKNOW	GATE+PSUs - 2020	Regular Batch	Mid - May 2019
PATNA	GATE+PSUs - 2020	Weekend Batch	19th Jan 2019
TIRUPATHI	GATE+PSUs - 2020 & 21	Weekend Batch	19th Jan 2019
KOLKATA	GATE+PSUs - 2020	Weekend Batch	19th Jan 2019
KOLKATA	ESE+GATE+PSUs - 2021	Regular Batch	19th Jan 2019
AHMEDABAD	ESE+GATE+PSUs - 2020&21	Weekend Batch	19th Jan 2019
AHMEDABAD	GATE+PSUs - 2020	Regular Batch	02nd Week of June 2019

50. The diameter of the smallest particle of specific gravity 2.65 removed from sedimentation tank of plan area 100 m^2 treating 8.64 MLD of water with coefficient of dynamic viscosity 1 centipoise is ______$\times 10^{-5}$ m. Assume the flow is laminar. [Rounded upto two decimals]

50. Ans: 3.34 **Range: 3.30 to 3.40**

Sol: Q = 8.64 MLD

A_s =100 m^2, S = 2.65

$\rho_p = S \times \rho_w = 2650$ kg/m^3

$\mu = 1$ cp $= 10^{-3}$ kg/m-sec

$$\nu_o = \frac{Q}{A_s} = \frac{\frac{8.64\times10^6}{10^3\times24\times60\times60}}{100} = 0.001 \text{ m/sec}$$

For 100% removal

$\nu_s = \nu_o = 0.001$ m/sec

$$\nu_s = \frac{g(\rho_p - \rho_w)d^2}{18\mu}$$

$$0.001 = \frac{9.81(2650-1000)d^2}{18\times10^{-3}} \Rightarrow d = 3.335\times10^{-5}\text{ m} = 3.34\times10^{-5}\text{ m}$$

51. A 150mm diameter circular hollow section is welded to a rigid support using fillet weld. It is subjected to vertical eccentric load P and twisting moment T. The vertical shear in weld and stress in weld due to twisting moment are 30 MPa and 40 MPa respectively. The maximum stress in fillet weld due to eccentricity of load is 150 MPa. The fillet welded section should be designed for a stress of ________MPa.

51. Ans: 173.2 MPa **Range: 173 to 174 MPa**

Sol: Vertical shear stress in weld, $q_v = 30$ MPa

Shear stress in weld due to twisting moment, $q_t = 40$ MPa

Resultant shear stress in weld, $q = \sqrt{q_v^2 + q_t^2} = \sqrt{30^2 + 40^2} = 50$ MPa

Maximum bending stress in weld due to eccentricity, f = 150 MPa

Design equivalent stress in weld, $f_e = \sqrt{3q^2 + f^2} = \sqrt{3\times50^2 + 150^2} = 173.2$ MPa

52. A district road has a design speed of 50 kmph. The road is single lane two way traffic. Reaction time of driver is 2.5 sec. Coefficient of longitudinal friction and lateral frictions are 0.37 and 0.15 respectively.

The safe stopping sight distance is ________m.

52. Ans: 122.48 **Range : 121 to 123**

Sol: $\nu = 13.88$ m/s

For single lane two way traffic

$$\text{Safe SSD} = 2(\text{SSD}) = 2\left[\nu t + \frac{v^2}{2gf}\right]$$

$$= 2\left[13.88 \times 2.5 + \frac{13.88^2}{2 \times 9.81 \times 0.37}\right]$$

$$= 122.48 \text{ m}$$

53. The mass curve of an isolated storm in a 500 ha watershed is as follows:

Time from start (hr)	0	2	4	6	8	10	12	14	16	18
Cumulative Rainfall (cm)	0	1.0	2.6	2.8	4.1	7.3	10.8	11.8	12.4	12.6

The direct runoff produced by the storm is measured at the outlet of the watershed as 0.340 Mm^3. The estimated ϕ-index of the storm would be _____ cm/hour (upto 2 decimal places)

53. Ans: 0.40 **Range: 0.40 to 0.42**

Sol:

Time from start (hr)	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18
Rainfall (P cm)	1.0	1.6	0.2	1.3	3.2	3.5	1.0	0.6	0.2
i = P/t, cm/hr	0.5	0.8	0.1	0.65	1.6	1.75	0.5	0.3	0.1

$$R = \frac{\text{Runoff volume}}{\text{C.A}} = \frac{0.340 \times 10^6}{500 \times 10^4} = 0.068 \text{ m} = 6.8 \text{ cm}$$

1st Trial

Assume t_e = 18 hr $\qquad \phi - \text{index} = \dfrac{P_e - R}{t_e}$

P_e = 1.0+1.6 + 0.3 + 1.3 + 3.2+3.5 + 1.0+0.6+0.2 = 12.7 cm

$\phi\text{-index} = \dfrac{12.7 - 6.8}{18} = 0.327$ cm/hr

2nd Trial

P_e = 12.7 – [0.2 + 0.6+0.2] = 11.7 cm

$\phi - \text{index} = \dfrac{11.7 - 6.8}{12} = 0.408\,\text{cm/hr}$

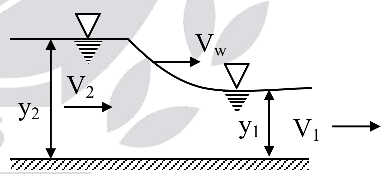
54. A 2.0 m wide rectangular channel has a flow with a velocity of 2.0 m/s and depth of 1.3m. The rate of inflow at the upstream end is suddenly increased to an extent that the depth is doubled in magnitude. The absolute velocity of the resulting surge is ___________ m/s (rounded to two decimals) Assume g = 9.81 m/s^2).

54. Ans: 8.19 **Range: 8.18 to 8.19 m/s**

Sol: Given:

y_1 = 1.30m, V_1 = 2.0m/s

y_2 = 2.60 m



(i) Calculation of surge velocity moving d/s:

By the surge equation obtained from a combination of momentum and continuity equations.

$$V_w - V_1 = \sqrt{\frac{g y_2}{2 y_1}(y_2 + y_1)}$$

Solving V_w = 8.1853m/s $\simeq$ 8.19 m/s

OUR GATE - 2018 TOP RANKERS

	TOP 10	TOP 100
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EE	7	69
CE	7	42
ME	4	54
CSIT	6	31
IN	11	78
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55. A RC slab is to be provided over a room 3 m × 5 m (centre to center) with corners not held down. The ratio of maximum moments at mid span in the shorter span direction to longer span direction (rounded to two decimal places) is __________

55. Ans: 2.78

Sol: Aspect ratio, $\frac{L_y}{L_x} = \frac{5}{3} = 1.6 < 2$

$\therefore$ It is a two way slab

For the condition given in question corners not held down, hence the slab is designed by Rankine Grashoff method

Moment in the shorter span direction, $m_x = \frac{1}{8}\left[\frac{\left(\frac{L_y}{L_x}\right)^4}{1+\left(\frac{L_y}{L_x}\right)^4}\right] wL_x^2$

Moment in the longer span direction, $m_y = \frac{1}{8}\left[\frac{\left(\frac{L_y}{L_x}\right)^2}{1+\left(\frac{L_y}{L_x}\right)^4}\right] wL_x^2$

$$\frac{m_x}{m_y} = \left(\frac{L_y}{L_x}\right)^2 = \left(\frac{5}{3}\right)^2 = 2.78$$

56. The height to which a parcel of polluted air of temperature 40°C rises in vehicle atmosphere is _______(km). ELR is 0.5°C/100 m and temperature of atmosphere at ground is 35°C.

56. Ans: 1

Sol: ELR = – 0.5°C/100 m ALR = –1°C/100 m

$$40 + \left[-\frac{1}{100} \times z\right] = 35 + \left[\frac{-0.5}{100} \times z\right]$$

$$4000 - z = 3500 - 0.5z$$

$$z = \frac{4000 - 3500}{0.5} = 1000 \text{ m} = 1 \text{ km}$$

Air parcel rises 1 km above ground.

57. A simply supported prestressed concrete beam subjected to a load of 15 kN/m has a span of 8 m. A parabolic cable is provided with zero eccentricity at ends and 'h' at mid span. A prestressing force 1000 kN introduced to cable at ends. The eccentricity at 2 m from support when load counteract by prestressing cable is (neglecting self weight) _________ (in mm)

57. Ans: 90

Sol: Dip of cable at mid span, $h = \frac{w\ell^2}{8P} = \frac{15\times 8^2}{8\times 1000}$

$$= 0.12 \text{ m} = 120 \text{ mm}$$

Equation of parabola, $y = \frac{4h}{L^2}x(L-x) = \frac{4\times 0.12}{8^2}\times 2\times(8-2)$

$$= 0.09 \text{ m}$$

Alternatively

At $\frac{L}{4}$, $B.M = \frac{wL}{2}\times\frac{L}{4} - \frac{wL}{4}\frac{L}{8} = \frac{3}{32}wL^2$

$h_1 = \frac{M}{P} = \frac{3}{32}\frac{wL^2}{P} = \frac{3}{32}\times\frac{15\times 8^2}{1000} = 0.09$ m

58. 900 kg of bleaching powder containing 35% of chlorine is consumed per month to treat 15 MLD water to have a chlorine residual of 0.2 mg/*l*. The Cl_2 demand of water is ______ mg/*l*.

58. Ans: 0.5

Sol: Bleaching powder required/month = 900 kg

Bleaching powder required/day $= \frac{900}{30} = 30$ kg

Total bleaching powder required = Q × dose of bleaching powder

30 = 15 × dose of bleaching powder

Dose of bleaching powder $= \frac{30}{15} = 2$ mg/*l*

Cl_2 dose = Bleaching powder dose × % Cl_2 in bleaching powder

$$= 2\times\frac{35}{100} = 0.7 \text{ mg}/l$$

Cl_2 demand = Cl_2 dose – Residual Cl_2 = 0.7 – 0.2 = 0.5 mg/*l*

59. A strata of Normally consolidated clay of thickness 3 m drained on one side only.

Coefficient of permeability, $k = 5\times 10^{-8}$ cm/s

Coefficient of volume compressibility $m_v = 125 \times 10^{-2}$ cm^2/kN

When an uniform surcharge of 250 kN/m^2 was applied on top of ground level, the clay layer consolidated. A timer (with smallest unit hour) was started when soil is consolidated 20%.The reading on timer (round to nearest multiple of 50) when soil is 80% consolidated is _____________.

59. Ans: 3300

Sol: $$C_v = \frac{k}{\gamma_w m_v} = \frac{5\times10^{-8}}{9.81\times10^{-6}\times125\times10^{-2}} = 4.077\times10^{-3}\ \text{cm}^2/\text{sec}$$

$$T_{20} = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 = \frac{\pi}{4}(0.2)^2 = 0.0314$$

$T_{80} = 1.781 - 0.933\log_{10}(100 - U)$

$= 1.781 - 0.933\log_{10}(100 - 80)$

$= 0.567$

d = H (Single drainage) = 300 cm

t_{20} (time for 20% consolidation) $= \dfrac{d^2T_{20}}{C_v}$

$$= \frac{(300)^2\times0.0314}{4.077\times10^{-3}}\text{sec} = \frac{(300)^2\times0.0314}{4.077\times10^{-3}\times60\times60}\text{hrs}$$

$= 192.54$ hrs

t_{80} (time for 80% consolidation) $= \dfrac{d^2T_{80}}{C_v} = \dfrac{(300)^2\times0.567}{4.077\times10^{-3}\times60\times60}$ hrs

$= 3476.82$ hrs

Timer started after 20% consolidation

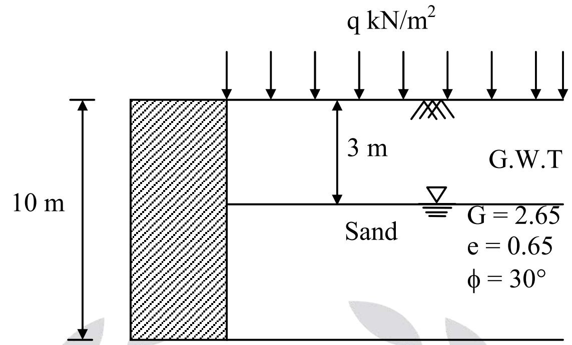
Reading on timer on 80% consolidation

$= t_{80} - t_{20}$

$= 3476.82 - 192.54 = 3284.28$ hrs

(Nearest multiple of 50 is 3300)

60. For the earth retaining structure shown in figure, the total active thrust per unit length of wall is 501 kN/m. The value of surcharge placed (in kPa, rounded to nearest integer) is________



60. Ans: 14

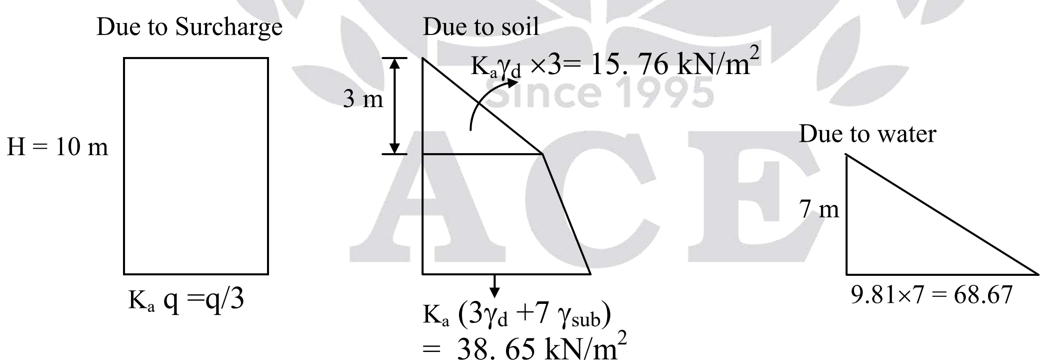
Sol: $\gamma_d = \dfrac{G\gamma_w}{1+e} = 15.76\,\text{kN/m}^3$

$\gamma_{sub} = \dfrac{(G-1)\gamma_w}{1+e} = 9.81\ \text{kN/m}^3$

$K_a = \dfrac{1-\sin\phi}{1+\sin\phi} = \dfrac{1}{3}$

Total thrust = 501 kN/m

Active pressure distribution



$$501 = \frac{q}{3}\times 10 + \frac{1}{2}\times 15.76\times 3 + \frac{1}{2}(15.76+38.65)7 + \frac{1}{2}\times 7\times 68.67$$

$q = 13.97 \simeq 14\ \text{kN/m}^2$

61. An activated sludge process treating waste water in an aeration tank of volume 10000 m^3 is to have an MLSS of 3000 mg/*l*. If the sludge wasted at a rate of 300 m^3/day with a MLSS 10000 mg/*l* then sludge age is ________ days.

61. Ans: 10

Sol: Volume of an aeration tank, V = 10000 m^3

MLSS, X = 3000 mg/*l*

Waste sludge, Q_w = 300 m^3/day

MLSS in sludge, X_u = 10000 mg/*l*

$$\text{Sludge age, } \theta_c = \frac{VX}{Q_w X_u + (Q - Q_w)X_e}$$

$\therefore$ X_e is not given $\therefore$ $X_e = 0$

$$\text{Sludge age, } \frac{VX}{Q_w X_u} = \frac{10000 \times 3000}{300 \times 10000} = 10 \text{ days}$$

62. In an aerial photogrammetry, photographs are taken to cover an area of 600 sq. km, with format size of lens is 250 × 250 mm and scale of the photograph is 1 in 10,000. If the end lap and side laps are 60% and 30% respectively, the number of photographs required are ___________. (Rounded to nearest integer)

62. Ans: 343

Sol:
$$L = (1 - p_\ell)\frac{\ell}{S} = (1 - 0.6) \times \left[\frac{250 \times 10^{-3}}{\frac{1}{10{,}000}}\right] \times 10^{-3} = 1 \text{ km}$$

$$w = (1 - p_w)\frac{w}{S} = (1 - 0.3) \times \left[\frac{250 \times 10^{-3}}{\frac{1}{10{,}000}}\right] \times 10^{-3} = 1.75 \text{ km}$$

a = L.W = 1 × 1.75 = 1.75 km^2

$$N = \frac{A}{a} = \frac{600}{1.75} = 342.87 \simeq 343$$

63. A cylindrical sample of soil having a cohesion of 80 kN/m^2 is subjected to a cell pressure of 100 kN/m^2.

If deviatoric stress at failure was found to be 333 kN/m^2, the angle made by failure plane with axis of the sample is ____________(Rounded to nearest integer) considering soil sample as C –ϕ soil .

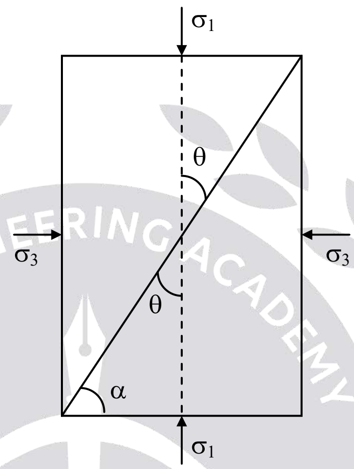
63. Ans: 35°

Sol: $\sigma_3 = \sigma_c = 100$ kN/m^2

$\sigma_1 - \sigma_3 = 333$ kN/m^2

$\sigma_1 = 433$ kN/m^2

C = 80 kN/m^2



$$\sigma_1 = \sigma_3 N_\phi + 2C\sqrt{N_\phi}$$

$$N_\phi = \tan^2\left(45 + \frac{\phi}{2}\right)$$

$$= \tan^2 \alpha$$

$433 = 100 \tan^2\alpha + 160 \tan\alpha$

Solving quadratic equation,

$\tan\alpha = 1.43$

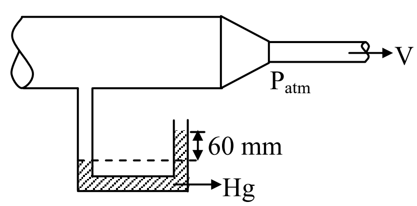
$\alpha = 55°$ (with major principal plane which is horizontal in the present case)

$\theta = 180° - 55° - 90°$

$= 35°$

θ is angle with axis of sample, α is with major principal plane.

64. A pipe of 60 mm diameter is connected to the nozzle of 30 mm exit diameter which discharges water into atmosphere as shown in the figure. If the open ended mercury manometer shows deflection of 60 mm, the jet exit velocity (rounded to first decimal place) is _________ m/s. (Assume g = 10 m/s^2, neglect all losses)



64. Ans: 4

Sol: Applying Bernoulli's equation between inlet (1) and exit of nozzle,

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{\cancelto{P_{atm}}{P_2}}{\rho g}+\frac{V_2^2}{2g}+Z_2$$

$$\frac{P_1-P_{atm}}{\rho g}=\frac{V_2^2-V_1^2}{2g}=\frac{V_2^2}{2g}\left(1-\frac{V_1^2}{V_2^2}\right)$$

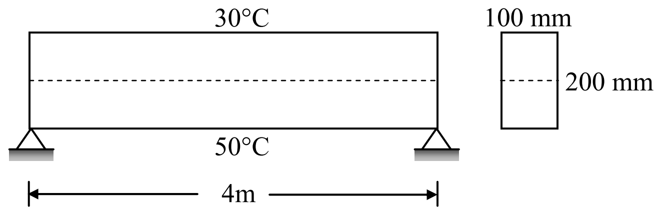
$$h\left(\frac{S_m}{S}-1\right)=\frac{V_2^2}{2g}\left(1-\left(\frac{d_2}{d_1}\right)^4\right)$$

$$0.060\times\left(\frac{13.6}{1}-1\right)=\frac{V_2^2}{2\times 10}\left(1-0.5^4\right)$$

V_2 = 4.02 m/s

= 4.0 m/s (rounded to first decimal)

65. A steel beam of cross section 100 mm × 200 mm is subjected to a differential temperature condition as shown in figure. The flexural stress developed on the bottom fibre of the beam (in MPa) is given by _________



$\alpha_s = 10\times10^{-6}/°C$, $E_s = 200$ GPa

65. Ans: 20

Sol: The temperature of axis $= \dfrac{30+50}{2} = 40°C$

The difference of temperature of bottom fibre from axis of beam, $\Delta T = 50–40 = 10°C$.

The expansion of bottom fibre is completely prevented by the hinges.

$\therefore$ Stress developed at the bottom fibre

$\sigma_t = \alpha(\Delta T)(E)$

$= (10\times10^{-6})(10)(200\times10^3)$

$= 20$ MPa (compressive)