GATE WALLAH

GATE 2025

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QUESTION & SOLUTION

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And Still Counting...

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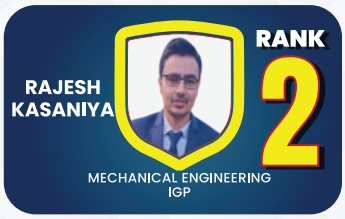
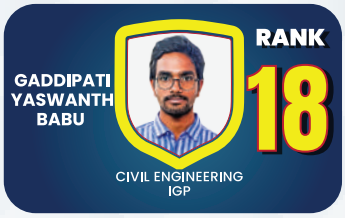




And Still Counting...

QUESTION-1 — MCQ

A circle with centre at (x, y) = (0.5, 0) and radius = 0.5 intersects with another circle with centre $(x, y) = (1, 1)$ and radius = 1 at two point one of the point intersect at (x, y) is_____?

(a) 0, 0 (b) 1, 1

(c) 0, 0.5 (d) 0.5, 0

SOLUTION: (c)

$(x - a)^2 + (y - b)^2 = r^2$

$(x - 0.5)^2 + y^2 = 0.5^2$ …(1)

$(x - 1)^2 + (y - 1)^2 = 1$ …(2)

$x^2 + 1 - 2x + y^2 + 1 - 2y = 1$

$x^2 + y^2 = 2y + 2x - 1$ …(3)

Putting $x^2 + y^2$ in equation (1)

$x^2 + 0.25 - 2.x \times 0.5 + y^2 = 0.5^2$

$2y + 2x - 1 - 0.25 - x = 0.25$

$2y + x = 1$

Option (a): (0, 0)

$2 \times 0 + 0 \neq 1$ (wrong)

Option (b): (1, 1)

$2 \times 1 + 1 \neq 1$ (wrong)

Option (c): (0, 0.5)

$2 \times 0.5 + 0 = 1$ (correct)

QUESTION-2 — NAT

Consider Euler method with step size (h) of 0.5, the value of y at x = 1 is equal to _____?

$$\frac{dy}{dx} = y + 2x - x^2,\ y(0) = 1,\ (0 \le x < \infty)$$

SOLUTION: (2.62)

x_0	x_1	x_2
0	0.5	1
1	—	?
y_0	y_1	y_2

$h = 0.5,\ f(x, y) = y + 2x - x^2$

$y_1 = y_0 + h f(x_0, y_0)$

$= 1 + 0.5f(0, 1) = 1 + \frac{1}{2}(1) = 1.5$

$y_2 = y_1 + h f(x_1, y_1)$

$= 1.5 + 0.5f(0.5, 1.5) = 1.5 + \frac{1}{2}\left[\frac{3}{2} + 1 - \frac{1}{4}\right]$

$= \frac{3}{2} + \frac{1}{2}\left(\frac{9}{4}\right) = \frac{3}{2} + \frac{9}{8} = \frac{21}{8} = 2.62$

QUESTION-3 — NAT

A water resources project with an expected life of 25 years has to be designed for an acceptable risk or 5% against a design flood. The return period for design flood (in years) _____. (roundoff)

SOLUTION: (487.89)

n = 25 years

$p_1 = 5\%$

T = ?

$p_1 = 1 - q^n$

$q = 1 - p$

$0.05 = 1 - q^{25}$

$p = 1/T$

$0.05 = 1 - (1 - p)^{25}$

$$0.05 = 1 - \left(1 - \frac{1}{T}\right)^{25}$$

T = 487.89 years.

QUESTION-4— MCQ

Writes second-order linear, homogeneous partial differential equations.

(a) $\frac{o^2u}{ot^2} = c^2\left(\frac{o^2u}{ox^2} + \frac{o^2u}{o^2y^2}\right) + xy$

(b) $\left(\frac{o^2u}{ot^2}\right)^2 = c^2\frac{d^2u}{ux^2}$

(c) $\frac{\partial u}{\partial t} = c\frac{\partial u}{\partial x}$

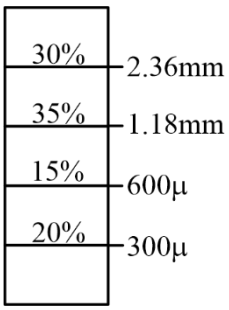
(d) $\frac{\partial^2u}{\partial x^2} + \frac{\partial^2u}{\partial u^2} + \frac{\partial^2u}{\partial z^2} = 0$

SOLUTION: (d)

QUESTION-5 — NAT

If the weights retained on 2.36 mm, 1.18 mm, 600 mm, 300 μm sieves are 30%, 35%, 35%, 20% respectively of total weight of aggregate sample, then fineness modulus of sample is _____.

SOLUTION: (2.75)



Sieve size	% retained	Cumulative % retained
2.36mm	30%	30%
1.18mm	35%	65%
600μ	15%	80%
300μ	20%	100%

$$\text{F.M} = \frac{\text{sum of cumulative \% retained on each sieve}}{100}$$

$$\text{F.M} = \frac{30+65+80+100}{100} = \frac{275}{100} = 2.75$$

QUESTION-6 — MCQ

Horizontal distance between a staff point and the point of observation is d, the error due to curvature of earth is proportional to

(a) $\frac{1}{d^2}$ (b) $1/d$

(c) d (d) d^2

SOLUTION: (d)

Error due to curvature = $0.0785\ d^2$

$Ec \propto d^2$

QUESTION-7 — MCQ

Maximum degree of curve that can be used in railway in a mountainous region is

(a) 20 (b) 50

(c) 10 (d) 40

SOLUTION: (d)

Due to space constraints and difficult topography, sharper curves are allowed, and the maximum degree of curvature can go up to 10° to 40° in mountain region.

Hence, for railway in mountain region is 40°.

QUESTION-8 — MCQ

All vehicle that come during a particular peak hour come during 10 min within the hour, 15 min peak hour factor for this peak hour

(a) 0.75 (b) 0.25

(c) 0.167 (d) 1.0

SOLUTION: (b)

As all vehicles arrive in 10 minutes so, the 15-minute volume is the same as the hourly volume.

Peak 15-min Volume = Hourly Volume

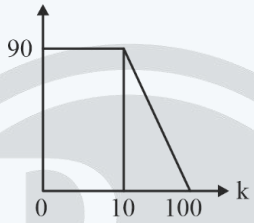
$$PHF = \frac{\text{Hourly Volume}}{4 \times \text{Peak 15-min Volume}}$$

$$PHF = \frac{\text{Hourly Volume}}{4 \times \text{Hourly Volume}}$$

$$PHF = \frac{1}{4} = 0.25$$

QUESTION-9 — MCQ

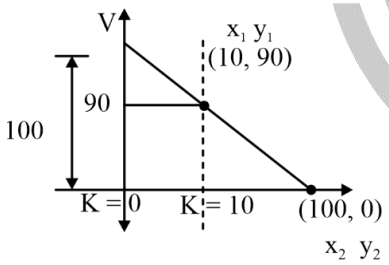
Speed density relation on one way, single lane road shown in figure where u is speed (km/hr), k is density veh/km find max flow (veh/km) on this road



(a) 900 (b) 2500

(c) 2000 (d) 2250

SOLUTION: (b)



$V = mk + C$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 90}{90} = -1$$

$V = -K + 100$ …(1)

$q = KV$

$q = -K^2 + 100\,K$

For maximum flow $\frac{dq}{dk} = 0$

$-2K + 100 = 0$

$K = 50$

Put K = 50 and equation (1) and $V = -50 + 100 = 50$

$q_{max} = 50 \times 50 = 2500$

QUESTION-10 — NAT

During determination of bulk specific gravity of compacted bituminous specimen, the mass in air of specimen is 1260 gm and volume is 525 cm^3, the density of water is 1.0 g/cm^3, maximum theoretical specific gravity of mix is 2.510, percentage air void in compacted specimen is _____ (round off to two decimal place).

SOLUTION: (4.38)

Maximum theoretical specific gravity of mix is 2.510

$M_{sample} = 1260$ g

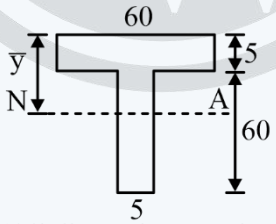
$V_{sample} = 525$ cc

$$G_m = \frac{1260}{525} = 2.4$$

$$V_v\% = \left(1 - \frac{G_m}{G_{th}}\right) \times 100 = 4.38\%$$

QUESTION-11 — NAT

Consider beam shown in figure with $\bar{y}$ to depth of neutral axis. Section only subjected to increasing bending moment, $\bar{y}$ is 18.75 cm, when section has not yielded at top and bottom fibre. Further $\bar{y}$ decrease to 5 mm when entire section has yielded, shape factor is ____ (round off to two decimal place)



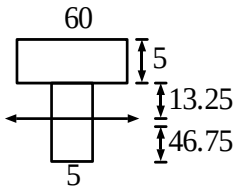
(All dimensions are in mm)

SOLUTION: (1.81)

$$z_e = \frac{I}{y}$$

$$I_{xx} = \frac{5 \times 60^3}{11} + 5 \times 60(30 - 46.25)^2 + \frac{60 \times 5^2}{12} + 5 \times 60(62.5 - 46.25)^2 = 249062.5 \text{ mm}^4$$

$$z_e = \frac{I}{y_{maximum}} = \frac{249062.5}{46.25} \text{mm}^3 = 5385.13 \text{ m}^3$$



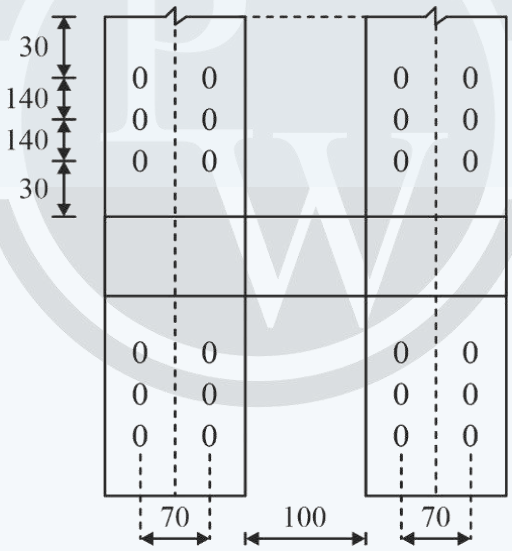
$$z_p = \frac{A}{2}(y_1 + y_2)$$

$$\frac{60 \times 5 \times 2}{2}(2.5 + 30) = 9750 \text{ mm}^3$$

$$\text{Shape Factor} = \frac{9750}{5385.13} = 1.81$$

QUESTION-12 — NAT

Consider buildup column made of two I section. Shown in figure, with each batten plate bolted to component I-section of column through six black bolt. Each connection of batten plate with component section is to be designed for longitudinal shear of 70 kN and moment = 10 kNm, Min bolt value will be___ (round to nearest integer).



All dimensions are in mm

SOLUTION: (22.65)

$$R = \sqrt{35^2 + 140^2} = 144.3 \text{mm}$$

$$\text{Shear force in each bolt } (F_1) = \frac{70}{6} = 11..67 \text{ kN}$$

$$\text{Force due to moment } (F_2) = \frac{10 \times 144.3 \times 10^3}{4 \times 144.3^2 + 2 \times 35^2} = 16.82 \text{ kN}$$

Resultant = $\sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

$\cos\theta = \frac{35}{144.3} = 0.24 = \sqrt{11.69^2 + 16.82^2 + 2\times11.67\times16.82\times0.24} = 22.65$ kN

QUESTION-13 — NAT

Consider a reinforced concrete beam section of 300 mm width and 700 mm depth. The beam is reinforced with the tension steel of 2000 mm^2 area at an effective cover of 50 mm. Concrete in the tension zone is assumed to be cracked. Assume the modular ratio of 12 and Young's modulus of 200 GPa for steel. When the extreme fiber in the compression zone undergoes the strain of 0.0004 due to the applied bending moment, the stress in the steel (in MPa) is _____ . (Round off to the nearest integer).

SOLUTION: (126)

d = 700 – 50 = 650 mm

$\frac{bx_a^2}{2} = mAst(d - x_a)$

$x_a = 252.26$ mm

$\epsilon_{st} = \epsilon_c\left(\frac{d - x_a}{x_a}\right) = 0.0004\left(\frac{650}{252.26} - 1\right)$

$\epsilon_{st} = 6.306\times10^{-4}$

$\sigma_{st} = E_s\times\epsilon_{st} = 6.306\times10^{-4}\times2\times10^5 \simeq 126$ MPa

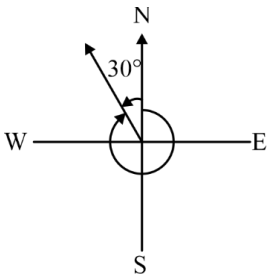
QUESTION-14 — MCQ

The magnetic bearing of line is N 30°W, then what is the whole circle bearing of line.

(a) 30° (b) 210°

(c) 250° (d) 330°

SOLUTION: (d)



WCB = 360 – 30 = 330°

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QUESTION-15 — MCQ

The mean rainfall over a catchment has to be estimated. The data for four rain gauge located in and around catchment in table. Which of following is correct

	Rain	P	Q	R	S
Whether located inside		yes	yes	yes	No
Theissen weight factor		0.25	0.50	0.10	0.15
Rainfall(mm)		100	110	100	125

(a) Estimated data obtained from thiessen polygon method is less than that obtained from Arithmetic method

(b) Estimated data obtained from thiessen polygon method is greater than that obtained from Arithmetic method

(c) Theissen polygon method can not applied in this case

(d) Estimated data obtained from thiessen polygon method is equal to that obtained from Arithmetic method

SOLUTION: (b)

STN	P	Q	R	S
Located inside	Yes	Yes	Yes	No
W	0.25	0.5	0.1	0.15
P	100	110	100	125

Arithmetic Mean Method:

$$P_a = \frac{P_P + P_Q + P_R}{3} = \frac{100+110+100}{3} = 103.33\text{mm}$$

Thiessen Polygon Method:

$P_a = (100 \times 0.25) + (110 \times 0.5) + (100 \times 0.1) + (125 \times 0.15)$

$P_a = 108.75$ mm

QUESTION-16 — MCQ

To drive total flood hydrograph at catchment outlet from an isolated storm. The order in which following method are applied from first to last

P = obtain hyetograph

Q = addition of base flow

R = estimation of initial and infiltration loss

S = Application of unit hydrograph

(a) PQRS (b) PRSQ

(c) RPSQ (d) PSQR

SOLUTION: (b)

QUESTION-17 — MCQ

In an oedometer apparatus, a specimen of fully saturated clay has been consolidated under a vertical pressure of 100kPa and is at the equilibrium state.

Immediately of increasing the vertical pressure to 150 kPa. The σ' & excess pore water pressure ΔU will be,

(a) $\sigma' = 50$ kPa, $\Delta U = 100$ kPa

(b) $\sigma' = 100$ kPa, $\Delta U = 150$ kPa

(c) $\sigma' = 150$ kPa, $\Delta U = 50$ kPa

(d) $\sigma' = 100$ kPa, $\Delta U = 50$ kPa

SOLUTION: (d)

$\sigma = 100$ kPa

As the soil is fully consolidated,

Excess PWP (U) = 0

$\sigma_i' = \sigma - U$

$\sigma_i' = 100 - 0 = 100$ kPa

Increase in vertical ($\Delta\sigma$) = 50 kN/m^2, immediately after load increment.

All the load will be taken by water so excess PWP will develops equal to increase in vertical pressure

$\Delta U = \Delta\sigma = 50$ kN/m^2

Also, $\Delta\sigma' = \Delta\sigma - \Delta U$

$\Delta\sigma' = 50 - 50$

$\boxed{\Delta\sigma' = 0}$

$\sigma'_f - \sigma'_i = 0$

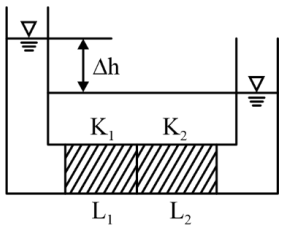
$\sigma'_f - 100 = 0$

$\boxed{\sigma'_f = 100 \text{ kPa}}$

Hence (d) is the correct option.

QUESTION-18 — NAT

Two soils of permeability K_1 & K_2 are placed in a horizontal apparatus as shown in figure. For soil 1, $L_1 = 50$ cm and $K_1 = 0.055$ cm/sec, for soil (2), $L_2 = 30$ cm and $K_2 = 0.035$ cm/sec. The cross-sectional area of horizontal pipe is 100 cm^2 and head difference (Δh) is 150 cm. The discharge (in cm^3/sec) through soil is, _____.



SOLUTION: (8.5)

$L_1 = 50$ cm

$L_2 = 30$ cm

$A = 100\ cm^2$

$K_1 = 0.055$ cm/sec

$K_2 = 0.035$ cm/sec

As it is vertical flow

$$K_{eq} = \frac{L_1 + L_2}{\frac{L_1}{K_1} + \frac{L_2}{K_2}} = \frac{50 + 30}{\frac{50}{0.055} + \frac{30}{0.035}}$$

$K_{eq} = 0.0453$ cm/sec

$Q = K_{eq} \times i \times A$

$$Q = 0.0453 \times \frac{150}{80} \times 100$$

$Q = 8.493\ cm^3/sec$

OR

$Q = 8.5\ cm^3/sec$

QUESTION-19 — NAT

A 6m × 6m square footing constructed in clay is subjected to a vertical load of 2500 kN at its centre, Base of footing is 2 m thick concrete.

GWT is at a great depth considering Terzaghi bearing capacity theory, the FOS against bearing capacity failure is _____ .

$\gamma_{concrete} = 24\ kN/m^3$

$C = 50\ kN/m^3$

$\phi = 0°$

$y = 19\ kN/m^3$

for $\phi = 0°$, $N_c = 5.7$, $N_a = 1$, $N_\gamma = 0$

SOLUTION: (4.66)

Given,

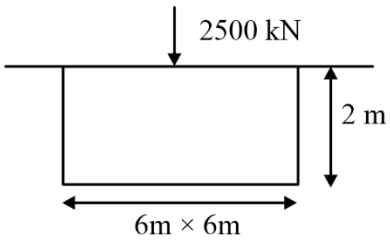
$\gamma_{concrete} = 24\ kN/m^3$

C = 50 kPa

$y = 19\ kN/m^3$

P = 2500 kN

$Nc = 5.70,\ N_q = 1,\ N_y = 0$



FOS = ?

Net bearing pressure (q_n)

$$q_n = \frac{2500 + 24 \times 2 \times 6^2}{6^2} - 19 \times 2$$

$$\boxed{q_n = \frac{715}{9}\text{kPa}}$$

$q_{nu} = 1.3 \times N_c = 1.3 \times 50 \times 5 = 7$

$$\boxed{q_{nu} = \frac{741}{2}\text{kPa}}$$

For safety,

$q_{ns} \geq q_n$

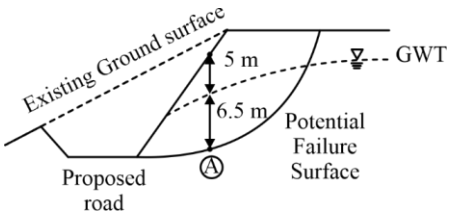
$\frac{q_{nu}}{FOS} \geq q_n$

So, $FOS = \frac{q_{nu}}{q_n}$

$$\boxed{FOS = \frac{\frac{741}{2}}{\frac{715}{9}} = 4.66}$$

QUESTION-20 — NAT

A cut shape is made in a silty clay soil for a new load project as shown in figure. The location of GWT and potential failure surface as shown in figure. After the cut is made the excess PWP is fully dissipated and shear stress at the point 'A' is 60 kN/m^2. The FOS at the point 'A' for long term stability is _____.



SOLUTION: (0.97)

Given

$\tau_A = 60$ kPa

$c' = 15$ kPa

$\phi^1 = 15°$

$c_u = 75$ kPa

$\gamma_t = 19$ kN/m^3

$\gamma_{sat} = 20$ kN/m^3

$\gamma_w = 9.81$ kN/m^3

FOS for long team stability we use effective stress parameters (C^1 & ϕ^1)

$$(\tau_{ff})_A = c' + \bar{\sigma}_A \tan\phi'$$

$$\bar{\sigma}_A = (5\times 19) + (20 - 9.81)\times 6.5$$

$$\boxed{\bar{\sigma}_A = 161.235 \text{ kPa}}$$

So,

$$(\tau_{ff})_A = 15 + 161.235 \tan 15$$

$$\boxed{(\tau_{ff})_A = 58.203 \text{ kPa}}$$

So,

$$\text{FOS} = \frac{\text{Shear stress } ((\tau_{ff})_A)}{\text{Shear stress } (\tau_A)}$$

$$\boxed{\text{FOS} = \frac{58.203}{60} = 0.97}$$

QUESTION-21 — NAT

A clayey soil w/c = 18%, $G_s = 2.74$ and S = 65%. The soil soaks up water during a rain event and 'S' increases to 85.2%. The change is volume during soaking is negligible. The new moisture content of soil will be _____.

SOLUTION: (24)

$W_1 = 1.8\ \%$

$S_1 = 0.65\ \%$

$C_s = 2.74$

As $Se = wG_S$

As change in volume during soaking is negligible

So

e = constant

G_s = constant

$S \propto W$

$W \propto S$

$$\frac{W_2}{W_1} = \frac{S_2}{S_1}$$

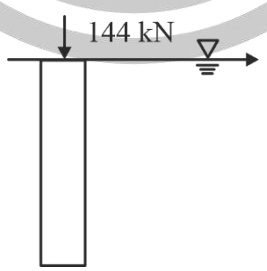
$$W_2 = \frac{0.852}{0.65} \times 18\%$$

$$\boxed{W_2 = 23.59\% = 24\%}$$

QUESTION-22 — NAT

A single pile with 450 mm diameter has been driven into a homogeneous clay, which has a undrained cohesion of 20 Kpa and unit weight of 18 kN/m^3, The GWT is found to be at the surface of clay layer. Adhesion factor (α) of soil is 0.95 and $N_c = 9$. The pile is supporting a column load of 144 kN with FOS of 3 against ultimate axial pile capacity in compression. The required embedment depth of pile (in m) is _____.

SOLUTION: (15.02)



Given :

d = 0.45 m

c = 20 kPa

$\gamma = 18$ kN/m^3

d = 0.95

$N_C = 9$

Q = 144 kN

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FOS = 3

As $Q_u = Q \times FOS$

$Q_u = 144 \times 3 = 432$ kN

As

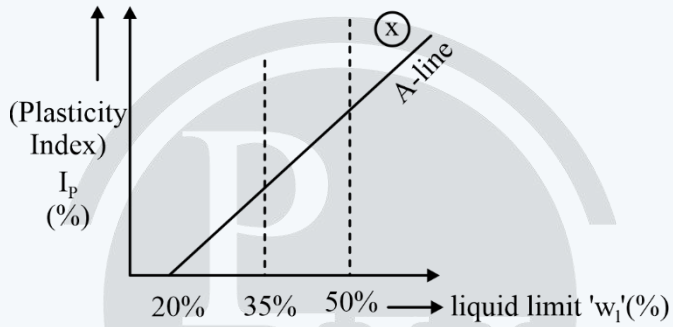
$$Q_u = C_u N_c \frac{\pi d^2}{4} + \propto C_u \pi dl$$

$$432 = 20 \times 9 \times \frac{\pi}{4} \times (0.45)^2 + 0.95 \times 20 \times \pi \times 0.45 \times l$$

$$\boxed{l = 15.02\,\text{m}}$$

QUESTION-23 — MCQ

For the plasticity shown below.



Soil 'X' represents

(a) Inorganic clay with high plasticity

(b) Inorganic clay medium plasticity

(c) Inorganic silt with high plasticity

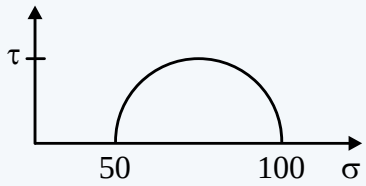
(d) Inorganic silt with medium plasticity

SOLUTION: (a)

As the soil 'X' lies above A live so the soil is inorganic clay of high plasticity and high compressibility.

QUESTION-24 — MCQ

Mohr circle for consolidated drained test on NC clay is shown below.

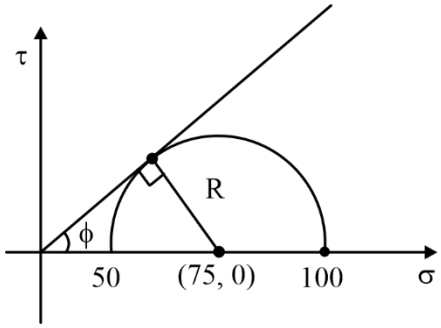


Angle of internal friction is

(a) $\sin^{-1}(1/2)$ (b) $\sin^{-1}(1/3)$

(c) $\sin^{-1}(2/3)$ (d) $\sin^{-1}(3/4)$

SOLUTION: (b)



$$\sin\phi = \frac{25}{75}$$

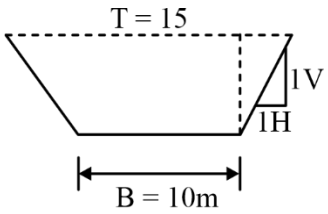
$$\boxed{\phi = \sin^{-1}\left(\frac{1}{3}\right)}$$

QUESTION-25 — NAT

Symmetrical trapezoidal is 100 km long, bottom width is 10m, side slope H 1:1V. Average depth of flow 2.5m throughout month of April. Measurement from class A evaporimeter in vicinity of canal indicated at an average evaporation rate of 0.5 cm/day in a April.

Volume of water evaporation From canal (in m^3) in month of April is ___10^3 (round to one decimal place)

SOLUTION: (157.5)



L = 100 km,

E_p = 0.5 cm/day

C_p = 0.7 (class A pan)

y = 2.5 m, April = 30 days

$V_E = A \times C_p \times E_p$

$$V_E = 100\times10^3\times15\times0.7\times\frac{0.5}{100}\times30$$

$V_E = 157.5 \times 10^3\ m^3$

QUESTION-26 — MCQ

For a flowing fluid, a dimensionless combination of velocity (V), length scale (l), and acceleration due to gravity (g) would be

(a) $\frac{V^2}{gl}$ (b) $\frac{Vg}{l}$

(c) $\frac{l}{V^2 g}$ (d) $\frac{gl^2}{V}$

SOLUTION: (a)

$$\frac{V^2}{gl} \Rightarrow \frac{m^2/s^2}{m/s^2 \times m}$$

Therefore dimensionless.

QUESTION-27 — MSQ

Aeration is employed as a treatment option for the removal of several pollutants from contaminated water. Identify, the pollutants where aeration is employed as a part of their removal.

(a) Zinc (b) Mangenese

(c) Cadmium (d) Iron

SOLUTION: (b, d)

Iron and Manganese are removed during aeration process.

QUESTION-28 — NAT

A hydraulic jump is formed in a 5 m wide rectangular channel which has a horizontal bed and having a discharge of 15 m^3/s. The depth of water upstream of the jump is 0.5 m. Power dissipated by the jump (in kW) is _____ (in nearest integer).

Take, g = 9.81 m/s^2

Density of water = 1000 kg/m^3

Kinetic energy correction factor = 1.0

SOLUTION: (72)

Hydraulic jump

Given,

B = 5 m, Q = 15 m^3/sec

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y_1 = 0.5 m, power dissipated (kW) = ?

g = 9.81 m/sec^2

Density of water = 1000 kg/m^3

α = 1

$$F_1^2 = \frac{q^2}{gy_1^3} = \frac{3^2}{9.81 \times 0.5^3} = 7.34$$

$$y_2 = \frac{0.5}{2}(-1 + \sqrt{1 + 8 \times 7.36})$$

y_2 = 1.682 m

$$E_L = \frac{(y_2 - y_1)^3}{4 \cdot y_1 y_2} m = \frac{(1.682 - 0.5)^3}{4 \times 0.5 \times 3.364} = 0.49 \text{ m}$$

$P_L = \gamma_w \times Q \times E_L$ watts

= (1000 × 9.81) × 15 × 0.49

= 72.1 × 10^3 watts = 72 kW

QUESTION-29 — NAT

A 5 m wide rectangular channel carries a discharge of 10 m^3/s at a depth of 1.5m under a uniform flow. To produce critical flow condition without affecting the upstream condition, the channel bottom elevation should be raised by _____ (m). (Report upto 2 decimal places)

Assume:

No head loss at the raise,

Kinetic energy correction factor = 1.0

Acceleration due to gravity, g = 9.81 m/s^2

SOLUTION: (0.48)

Given,

Q = 10 m^3/s, B = 5 m, q = 10/5 = 2 m^2/s

y_1 = 1.5 m, y_2 = critical depth

α = 1.0, g = 9.81

$$E_1 = 1.5 + \frac{2^2}{2 \times 9.81 \times 1.5^2} = 1.5906 \text{ m}$$

$$E_{min} = 1.5 \times \left(\frac{q^2}{g}\right)^{\frac{1}{3}}$$

$$E_{min} = 1.5 \times \left(\frac{2^2}{9.81}\right)^{\frac{1}{3}} = 1.1120 \text{ m}$$

$\Delta Z_{max} = (E_1 - E_{min}) = 1.5906 - 1.1120 = 0.4786 \text{ m} \simeq 0.48 \text{ m}$

QUESTION-30 — MSQ

The Surface Overflow Rate (SOR) in a rectangular sedimentation tank is 45 $m^3/m^2/d$. Minimum diameter of spherical inorganic and organic particle expected to be completely removed in this tank are calculated. Assume that Stoke's law is applicable. Which of the flowing is/are correct?

Specific gravity of inorganic particle = 2.65

Specific gravity of organic particle = 1.20

Acceleration due to gravity = 9.81 m/s^2

Kinematic viscosity = 1×10^{-6} m^2/s

(a) Minimum diameter of organic particles = 55 μm

(b) Minimum diameter of inorganic particles = 24 μm

(c) Minimum diameter of organic particle = 69 μm

(d) Minimum diameter of inorganic particle = 15μm

SOLUTION: (b, c)

For 100% removal $V_s = V_o$:

$V_o = 45 \text{ m}^3/\text{m}^2/\text{d}$

$V_o = 5.2083 \times 10^{-4}$ m/s

For inorganic particles:

$V_s = V_o$

$$\frac{gd^2}{18\nu}(G-1) = V_o$$

$$\frac{9.81 \times (d)^2 \times (2.65-1)}{18 \times 1 \times 10^{-6}} = 5.2083 \times 10^{-4}$$

$d_{Inorganic} = 24$ μm

For organic particles:

$V_s = V_o$

$$\frac{gd^2}{18\nu}(G-1) = V_o$$

$$\frac{9.81(d)^2 \times (1.2-1)}{18 \times 1 \times 10^{-6}} = 5.2083 \times 10^{-4}$$

$d_{organic} = 69$ μm

QUESTION-31 — MSQ

A facultative pond system is employed for waste water treatment. Which is/are true statement?

(a) The pH will be low during day-time compared to hight-time.

(b) The DO concentration will be low during day-time compared to night-time.

(c) The pH will be high during day-time compared to night-time.

(d) The DO concentration will be high during day-time compared to night-time.

SOLUTION: (c, d)

Facultative Pond

	Day	**Night**
pH	More	Less
DO	More	Less

QUESTION-32 — MSQ

Organic Fraction of Municipal Solid Waste (OFMSW) with bulk density of 315 kg/m^3 and water content of 30% is mixed with municipal sludge of bulk density 700 kg/m^3 and water content of 70% such that the water content of the mixture is 40%. The amount (in kg) of sludge to be mixed per kg of Municipal Solid Waste (up to 2 decimal) and density of the mix (in kg/m^3) (in nearest integer) are calculated. Which of these statement(s) is/are true?

(a) 0.33 kg of sludge added per kg of OFMSW

(b) 0.66 kg of sludge added per kg of OFMSW

(c) Density of the mix is 365 kg/m^3

(d) Density of the mix is 450 kg/m^3

SOLUTION: (a, c)

	MSW	Sludge
Mass	x	1
Moisture content	30%	70%
ρ	315 kg/m^3	700 kg/m^3

$$(M\cdot C)_{mix}=\frac{x\times 0.30+1\times 0.7}{1+x}$$

$$0.4=\frac{x\times 0.30+1\times 0.7}{1+x}$$

$0.4(1 + x) = 0.3x + 0.7$

$x = 3$

3 kg MSW $\rightarrow$ 1 kg sludge

1 kg MSW $\rightarrow$ 1/3 kg sludge = 0.33 kg sludge

$$\rho_{mix} = \frac{m}{V} = \frac{4}{\frac{3}{315} + \frac{1}{700}}$$

$\rho_{mix} = 365.21 \text{ kg/m}^3 \simeq 365 \text{ kg / m}^3$

QUESTION-33 — MCQ

Fecal Coliform (FC) concentration in river water was measured as 10780 cfu/100 ml. The Fecal Coliform concentration after the conventional water treatment but before chlorination was measured as 23 cfu/100 ml. The 'Log kill' (inactivation) of (FC) due to the conventional water treatment is closest to

(a) 3.00 (b) 2.67

(c) 4.00 (d) 2.50

SOLUTION: (b)

$\log (\text{removal}) = \log_{10} (N_o) - \log_{10} (N_t)$

$= \log_{10} (10780) - \log_{10} (23) = 2.67$

QUESTION-34 — MSQ

For Bernoulli's equation to be applicable in a fluid flow situation which of the following condition is/are to be satisfied

(a) Flow should be steady (b) Flow should be rotational

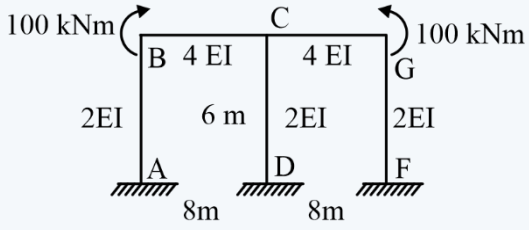
(c) Flow should be frictionless (d) Flow should be incompressible

SOLUTION: (a, c, d)

For Bernoulli's equation to be applicable in a fluid flow situation flow should be steady, inviscid, incompressible, irrotational and flow along the streamline.

QUESTION-35 — MSQ

Consider the frame shown in figure under the loading of 100 kNm couples at the joint B&G. Consider the only effect of flexural deformation, which of following is/are true?



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(a) There is no rotation at joint C

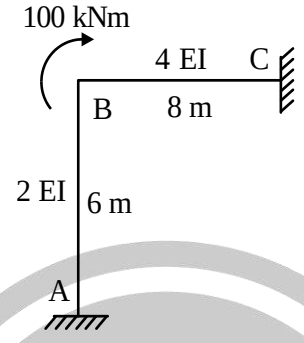
(b) There is zero shear force in member CD

(c) Axial force in member CD is zero

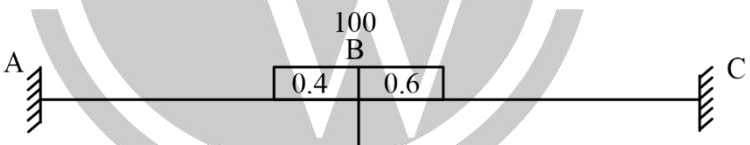
(d) Bending moment developed in BC at end C is more than 50 kNm

SOLUTION: (a, b)

Since member is symmetrical about Column CD, so consider half structure



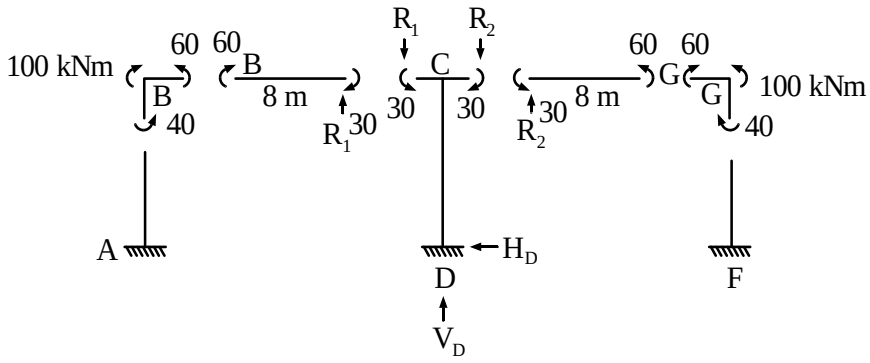
Point	Member	Stiffness	Total stiffness	DF
B	BA	$\frac{8EI}{6}$	$\frac{10EI}{3}$	0.4
	BC	$\frac{16EI}{8}$		0.6



Balance		–40	– 60	
COM	– 20			– 30
Final moment	– 20	– 40	– 60	– 30

• So Bending moment developed in BC at C is less than 50 kNm.

• Since structure is symmetrical about column CD so rotation at C is zero and CD member carries only axial forces & shear force is zero.



$\sum M_C = 0 \quad -H_D \times 6 + 30 - 30 = 0$

$H_D = 0$ (i.e. SF is zero in member AB)

$\sum M_B = 0 \quad -R_1 \times 8 + 30 + 60 = 0 \quad R_1 = 11.25$ kN

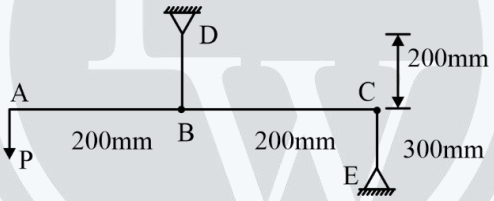
$\sum M_G = 0 \quad R_2 \times 8 - 30 - 60 = 0 \quad R_2 = 11.25$ kN

$\sum F_y = 0 \quad V_D - R_1 - R_2 = 0 \quad V_D = 22.5$ kN

(i.e. AF ≠ 0 in member DC)

QUESTION-36 — NAT

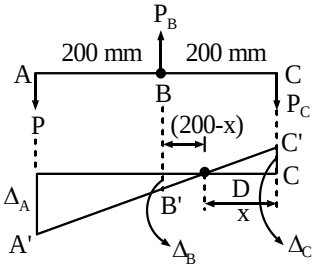
Consider the rigid bar ABC supported by pin jointed links BD & CE and subjected to a load P at the end A as shown in figure. The axial rigidity of BD & CE are 22500 kN & 15000 kN respectively.



IF CE elongates by 5mm due to load P, magnitude of down ward deflection at end A would be ____ mm.

SOLUTION: (30)

The FBD of rigid bar ABC is shown below,



Deflected shape of ABC

Using equilibrium equations

$\sum F_V = 0$

$P + P_C = P_B$

$P_B - P_C = P$ …(i)

$\sum M_C = 0$

$P(400) = P_B \times 200$

$P_B = 2P$

So

$2P - P_C = P$

$P_C = P$ and $P_B = 2P$

Now, $\frac{\Delta_B}{\Delta_C} = \frac{P_B L_B / (AE)_B}{P_C L_C / (AE)_C}$

$\frac{\Delta_B}{\Delta_C} = \frac{(2P)(300)/15000}{P(200)/22500}$

$\frac{\Delta_B}{\Delta_C} = 4.5$

$\Delta_B = 22.5$ m

Using similar triangles, ΔDCC' & DBB'

$\frac{\Delta_B}{\Delta_C} = \frac{200 - x}{x}$

$4.5 = \frac{200 - x}{x}$

$4.5x = 200 - x$

$3.5x = 200$

$x = 57.143$ mm

Using similar triangles, ΔDCC' & DAA'

$\frac{\Delta_A}{\Delta_C} = \frac{AD}{CD}$

$\frac{\Delta_A}{5\text{mm}} = \frac{400 - x}{x}$

$\frac{\Delta_A}{5} = \frac{400 - 57.143}{57.143}$

$\Delta_A = 29.95$ mm

($\Delta_A \simeq 30$ mm)

QUESTION-37 — MSQ

Which of the following are correct answers?

$f = 1.76\sqrt{d}$

$$P = 4.75\sqrt{Q}$$

$$D = 0.47\left(\frac{Q}{f}\right)^{\frac{1}{3}}$$

(a) D is scour depth below bed level

(b) D is scour depth from the maximum flood level in the river

(c) d is grain size in mm

(d) P is water way width

SOLUTION: (b, c, d)

d is used to represent grain size in mm in sediment transport equations.

In hydraulic engineering, P represents the waterway width, which is a function of discharge.

QUESTION-38 — MCQ

$$\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\frac{1}{5!}.....$$

(a) e – 1

(b) e + 1

(c) e

(d) π

SOLUTION: (a)

$$e^n = 1+n+\frac{n^2}{2!}+\frac{n^3}{3!}+\ldots$$

$$e^1 = 1+1+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\ldots$$

i.e. $\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\ldots = e-1$

QUESTION-39 — MCQ

X is the random variable taking values 0, 1, 7, 11, 12. The probability mass function for X is P (X = 0) = 0.4, P (X = 1) = 0.3, P (X = 7) = 0.1, P (X = 11) = 0.1, P (X = 12) = 0.1 then Find variance of X = ?

(a) 28.4

(b) 10.89

(c) 31.7

(d) 20.81

SOLUTION: (d)

X:	0	1	7	11	12
P(X):	0.4	0.3	0.1	0.1	0.1

$E(X) = \sum p_i \times x_i = 0 \times 0.4 + 1 \times 0.3 + 7 \times 0.1 + 11 \times 0.1 + 12 \times 0.1$

$= 0.3 + 0.7 + 1.1 + 1.2 = 3.3$

$E(X^2) = \sum p_i \times x_i^2 = 0.4\,(0)^2 + 0.3\,(1)^2 + 0.1\,(7)^2 + 0.1\,(11)^2 + 0.1\,(12)^2$

$= 0 + 0.3 + 4.9 + 12.1 + 14.4 = 31.7$

$\text{Var}(X) = E(X^2) - E^2(X) = 31.7 - (3.3)^2 = 31.7 - 10.29 = 20.81$

QUESTION-40 — MCQ

Suppose λ is an Eigen value of matrix A and X is the corresponding Eigen vector. Let X is also be an Eigen Vector of the matrix B = A – 2I, where I is the identity matrix. Then eigen value of B corresponding to the Eigen vector X is equal to_____.

(a) $\lambda + 2$ (b) λ

(c) 2λ (d) $\lambda - 2$

SOLUTION: (d)

By using direct property of Eigen value, we can find value of B by replacing A with λ in B. So, eigen value of B will be = $\lambda - 2\,(1) = \lambda - 2$.

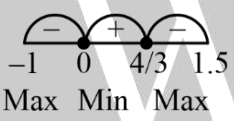
QUESTION-41 — NAT

Maximum value of function $h(x) = -x^3 + 2x^2$ in the interval [–1, 1.5] is equal to _____.

SOLUTION: (3)

$h'(x) = -3x^2 + 4x = x\,(4 - 3x) = 3x\left(\frac{4}{3} - x\right) = -3x\,(x - 1.33)$

Turing points are $h'(x) = 0 \Rightarrow x = 0$ & $\frac{4}{3}$



$x = -1$ and $\frac{4}{3}$ are points of Maxima

$$h(-1) = \left[x^2(2-x)\right]_{x=-1} = 3$$

$$h\left(\frac{4}{3}\right) = \left[x^2(2-x)\right]_{n=\frac{4}{3}} = \frac{16}{9}\left(2 - \frac{4}{3}\right)$$

$$= \frac{16}{9} \times \frac{2}{3} = \frac{32}{27} = 1.18$$

Hence maxima value of h(x) = 3

QUESTION-42 — NAT

The value of $\lim_{x \to \infty}\left[x - \sqrt{x^2 + x}\right]$ is equal to _____.

SOLUTION: (– 0.5)

$$\lim_{x\to\infty}\left(x-\sqrt{x^2+x}\right)\left(\frac{x+\sqrt{x^2+x}}{x+\sqrt{x^2+x}}\right)$$

$$=\lim_{x\to\infty}\frac{x^2-(x^2+x)}{x+\sqrt{x^2+x}}=\lim_{x\to\infty}.\frac{-1}{1+\sqrt{1+\frac{1}{x}}}=\frac{-1}{1+1}=-0.50$$

QUESTION-43 — MCQ

$A=\begin{bmatrix}1 & 1\\ 1 & 3\\ -2 & -3\end{bmatrix}$ & $B=\begin{bmatrix}b_1\\ b_2\\ b_3\end{bmatrix}$ then for Ax = B to be solved, which one of the following option is correct condition?

(a) $3b_1 + b_2 + 2b_3 = 0$

(b) $b_1 + 3b_2 + b_3 = 2$

(c) $b_1 + b_2 + b_3 = 2$

(d) $b_1 + b_2 + b_3 = 0$

SOLUTION: (a)

$$[A:B]=\begin{bmatrix}1 & 1 & : & b_1\\ 1 & 3 & : & b_2\\ -2 & -3 & : & b_3\end{bmatrix}\xrightarrow[R_3\to R_3-2R_1]{R_2\to R_2-R_1}\begin{bmatrix}1 & 1 & : & b_1\\ 0 & 2 & : & b_2-b_1\\ 0 & -1 & : & b_3+2b_1\end{bmatrix}$$

$$\xrightarrow{R_3\to R_3+\frac{1}{2}R_2}\begin{bmatrix}1 & 1 & : & b_1\\ 0 & 2 & : & b_2-b_1\\ 0 & 0 & : & \left(b_3+2b_1+\frac{1}{2}b_2-\frac{1}{2}b_1\right)\end{bmatrix}$$

$$=\begin{bmatrix}1 & 1 & : & b_1\\ 0 & 2 & : & b_2-b_2\\ 0 & 0 & : & (3b_1+b_2+2b_3)\end{bmatrix}$$

i.e., a is correct

QUESTION-44 — NAT

One-way, single lane road has traffic that consist of 30% truck and 70% car. Speed (km/hr) of truck is a uniform random variable on interval (30, 60) and speed of car is uniform random variable on interval (40, 80). Speed limit on road = 50 km/hr of vehicle. Percentage of vehicle that exceeded speed limit _____ (round off to one decimal place).

Note X is uniform random variable on interval (α, β) if it probability density function is given then

$$f(x)=\begin{cases}\frac{1}{\beta-\alpha} & \alpha<x<\beta\\ \text{otherwise } 0\end{cases}$$

SOLUTION: (62.5)

x = (Speed of Truck), x ∈ (30, 60) so pdf is f(x) = $\frac{1}{60-30}=\frac{1}{30}$

x = (Speed of Car), y ∈ (40, 80) so pdf is f(y) = $\frac{1}{80-40}=\frac{1}{40}$

(Truck crosses speed limit) = P (50 < x < 60) = $\int_{50}^{60} f(x)dx = \frac{1}{30}(60-50)=\frac{1}{3}$

P (Car crosses speed limit) = P (50 < y < 80) = $\int_{50}^{80} f(y)dy = \frac{1}{40}(80-50)=\frac{3}{4}$

So, % of vehicles crosses speed limit = 30% × $\frac{1}{3}$ for Truck

+ 70% × $\frac{3}{4}$ For Car

= 10% + 52.5% = 62.5%

QUESTION-45 — NAT

Let y be the initial value problem y" + 0.8 y' + 0.16 y = 0

Where, y(0) = 3, y'(0) = 4.5, then y (1) is equal to _____.

SOLUTION: (5.83)

y' + 0.8 y' + 0.16y = 0

$(D^2 + 0.8\ D + 0.16)\ y = 0$ where $D = \frac{d}{dx}$

Auxillary Equation is $m^2 + 0.8\ m + 0.16 = 0 = (m + 0.4)^2 = 0$

m = –0.4, –0.4

CF = $(C_1 + C_2x)e^{-0.4x}$, & PI = 0

Solution of (1) is y = CF + PI

$y = C_1e^{-0.4x} + C_2\ x\ e^{-0.4x} + 0$

$y' = -0.4\ C_1e^{-0.4x} - 0.4C_2x\ e^{-0.4x} + C_2\ e^{-0.4x}$

using y(0) = 3 ⇒ $3 = C_1 + 0 \Rightarrow C_1 = 3$

using y'(0) = 4.5 ⇒ $4.5 = -0.4C_1 + C_2 \Rightarrow C_2 = 4.5 + 1.2 = 5.7$

Hence solution is $y = 3e^{-0.4x} + 5.7x\ e^{-0.4x}$

So $y(1) = 3e^{-0.4} + 5.7x\ e^{-0.4x} = 8.7 \times e^{-0.4} = 5.83$

QUESTION-46 — NAT

The Fourier series of the probability function

$$f(x)=\begin{cases}0; & -2<x^2-1\\ 2k; & -1\le x<1\\ 0; & -1<x<2\end{cases};\qquad \text{period} = 4$$

Then Fourier series expansion will be?

(a) $f(x)=k+\frac{4k}{\pi}.\left\{\cos\frac{\pi x}{2}-\frac{1}{3}\cos\left(\frac{3\pi x}{2}\right)+\frac{1}{5}.\cos\left(\frac{5\pi x}{2}\right)\right\}$

(b) $f(x)=k+\frac{3k}{\pi}.\left\{\cos\frac{\pi x}{2}-\frac{1}{3}\cos\left(\frac{3\pi x}{2}\right)+\frac{1}{5}.\cos\left(\frac{5\pi x}{2}\right)\right\}$

(c) $f(x)=k+\frac{5k}{\pi}.\left\{\cos\frac{\pi x}{2}-\frac{1}{3}\cos\left(\frac{3\pi x}{2}\right)+\frac{1}{5}.\cos\left(\frac{5\pi x}{2}\right)\right\}$

(d) $f(x)=k+\frac{4k}{\pi}.\left\{\cos\frac{\pi x}{2}-\frac{1}{3}\cos\left(\frac{2\pi x}{4}\right)+\frac{1}{5}.\cos\left(\frac{5\pi x}{2}\right)\right\}$

SOLUTION: (a)

$$f(x)=\frac{a_0}{2}+\sum_{n=1}^{\infty}a_n.\cos\left(\frac{n\pi x}{2}\right)+\sum_{n=1}^{\infty}b_n.\sin\left(\frac{n\pi x}{2}\right).$$

$$a_0=\frac{1}{2}.\int_{-2}^{2}f(x)dx=\frac{1}{2}.\int_{1}^{1}2k.dx=k(2)$$

$$\Rightarrow\frac{a_0}{2}=k\,.$$

$$a_n=\frac{1}{2}.\int_{-2}^{2}f(x).\cos\left(\frac{n\pi x}{2}\right)dx;\ b_n=\frac{1}{2}.\int_{-2}^{2}f(x).\sin\left(\frac{n\pi x}{2}\right)dx\ ,\ (\because\ f(x)\text{ is even function}).$$

$$a_n=\frac{1}{2}.2k.\cos\left(\frac{n\pi x}{2}\right)dx.$$

$$\Rightarrow a_n=2k.\int_{0}^{1}\cos\left(\frac{n\pi x}{2}\right)dx.$$

$$=2k.\left\{\frac{\sin\left(\frac{n\pi x}{2}\right)}{\left(\frac{nx}{2}\right)}\ ]\right\}=2k.\frac{2}{n\pi}\left\{\sin\left(\frac{n\pi}{2}\right)\right\}$$

$$=\frac{4k}{n\pi}.\sin\left(\frac{n\pi}{2}\right).$$

$$\therefore f(x) = k + \sum_{n=1}^{\infty} \frac{4k}{n\pi}.\sin\left(\frac{n\pi}{2}\right).\cos\left(\frac{n\pi x}{2}\right)$$

$$\Rightarrow f(x) = k + \frac{4k}{\pi}.\left\{\cos\frac{\pi x}{2} - \frac{1}{3}\cos\left(\frac{3\pi x}{2}\right) + \frac{1}{5}.\cos\left(\frac{5\pi x}{2}\right)\right\}$$

QUESTION-47 — MCQ

Rohit goes to a restaurant for lunch 19 m. He enters the restaurant e notices that the hour hand and minute hand on the wall clock are exactly coinciding, after 1 hr. when he cleans the restaurant, he notices the clock hands are again exactly coinciding. How much time (in minutes) did Rohit spend at restaurant?

(a) $60\frac{5}{13}$ (b) $65\frac{5}{11}$

(c) $66\frac{6}{13}$ (d) $64\frac{6}{11}$

SOLUTION: (b)

To coincide again minute hand has to cover 360° with the relative spend of 5.5°/minute.

$\therefore \quad \frac{360}{5.5} = \frac{720}{11} = 65\frac{5}{11}$ minutes

QUESTION-48 — MCQ

Is there any good show _____ television tonight

(a) In (b) on

(c) at (d) within

SOLUTION: (b)

Is there any good show on television tonight

QUESTION-49 — MCQ

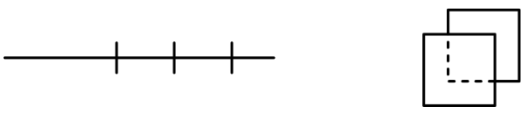
Thin wire is used to construct all edges of a cube of 1 m side by bending, cutting and soldering the wire. If the wire 12 m long, what is minimum number of cuts required to construct the wire frame to form the cube

(a) 4 (b) 6

(c) 12 (d) 3

SOLUTION: (d)

The cube two forces of each four edges can be formed by bending a single piece including one outer edge. i.e



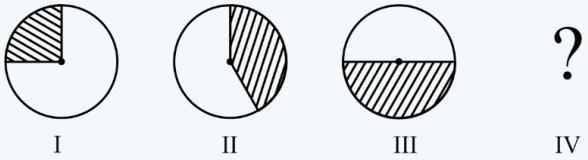
Here already 4 + 4 + 1 = 9 edges are formed, to complete remaining 3 edges more 3 pieces are required

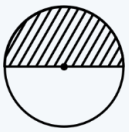
∴ Number of pieces required = 4

And No. of cuts to form 4 pieces = 3

QUESTION-50 — MCQ

Find the next figure in the sequence



(a) 

(b) 

(c) 

(d) 

SOLUTION: (d)

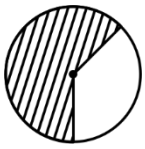
If we consider the given figure shaded portion, sequence is 90°, 135°, 180°.

That means 90° + 45° = 135°

135° + 45° = 180°

∴ 180° + 45° = 225° (Shaded should be there)

Also the rotation of clockwise 90° of the shaded portion is followed.



QUESTION-51 — MCQ

As the police officer was found guilty of embezzlement, he was _____ dismissed from the service in accordance with the service rules.

(a) Sumptuously
(b) Unintentionally
(c) Brazenly
(d) Summarily

SOLUTION: (d)

Sumptuously : In a way that is rich or luxurious

Unintentionally : Without intention OR without deliberate effort

Brazenly : In bold shameless manner

Summarily : Direct or without using formalities.

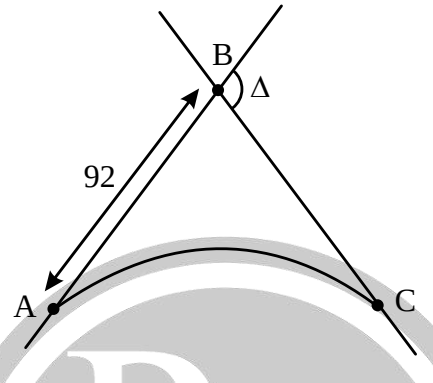
QUESTION-52 — NAT

R = 200 m,

L of curve = 92 m

Find the deflection angle in degree.

SOLUTION: (49.40)



R = 200 m

AB = 92 m

$T = R \tan \frac{\Delta}{2}$

$92 = 200 \tan \frac{\Delta}{2}$

$\frac{\Delta}{2} = \tan^{-1}\left(\frac{92}{200}\right)$

$\Delta = 49.40°$

QUESTION-53 — NAT

Deta of reciprocal leveling is given below find the R.L. of B? (Round off to 3 decimal places)

Level	A	B
(A)	1.8	1.35
(B)	1.45	0.95

RL of A = 150 m

SOLUTION: (150.475)

$$\Delta h = \frac{(1.8-1.35)+(1.45-0.95)}{2}$$

$\Delta h = 0.475$ m

R.L. of B = 150.475 m

QUESTION-54 — MSQ

Find the correct statements:

(a) GANT charts is used to find out critical activities of a project.

(b) PERT is used in large projects with high uncertainty.

(c) Free float is the amount of time by which the start of an activity may be delayed without delaying the start of a following activity.

(d) Dummy activity consumes resource and time.

SOLUTION: (b and c)

Free float is the amount of time by which the start of an activity may be delayed without delaying the start of a following activity.

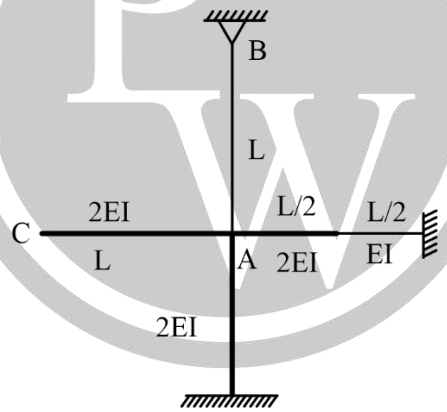
PERT is used in large projects with high uncertainty.

Dummy activity does not consumes resource and time.

QUESTION-55 — MCQ

Consider the structure shown in figure.

The distribution factor of member AD will be?



(a) 0.267

(b) 0.398

(c) 0.421

(d) 0.254

SOLUTION: (b)

Distribution factor of member AD when stiffness is 2EI for complete member-

$$DF_{AD} = \frac{K_{AD}}{K_{AD} + K_{AB} + K_{AC} + K_{AF}}$$

$$= \frac{\frac{4(2EI)}{L}}{\frac{4(2EI)}{L} + \frac{3EI}{L} + 0 + \frac{4(2EI)}{L}} = 0.421$$

Distribution factor when whole member AD have EI stiffness-

$$K'_{AD} = \frac{\frac{4EI}{L}}{\frac{4EI}{L} + \frac{3EI}{L} + 0 + \frac{8EI}{L}} = 0.267$$

Since member AD have varying stiffness between EI & 2EI, so distribution factor will lies between 0.267 and 0.421, i.e. 0.398.

❐❐❐

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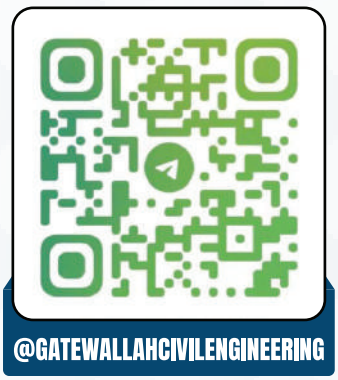

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