GATE WALLAH

CIVIL ENGINEERING

EXAM HELD ON

4th FEBRUARY 2024

EVENING SESSION

DETAILED SOLUTION BY TEAM

[MCQ]

Q.1. For a reconnaissance survey, it is necessary to obtain vertical aerial photographs of a terrain at an average scale of 1:13000 using a camera. If the permissible flying height is assigned as 3000 m above a datum and the average terrain elevation is 1050 m above the datum, the required focal length (in mm) of the camera is:

(a) 100 (b) 150

(c) 200 (d) 125

Sol. **(b)**

$S = 1/13000$, $H = 3000$, $h_1 = 1050$

$$S = \frac{f}{H - h_1}$$

$$\frac{1}{3000} = \frac{f}{3000 - 1050}$$

$f = 150$ mm

[MCQ]

Q.2. The longitudinal sections of a runway have gradients as shown in the table.

End to end for sections of runway (m)	Gradient (%)
0 to 200	+1.0
200 to 600	–1.0
600 to 1200	+0.8
1200 to 1600	+0.2
1600 to 2000	–0.5

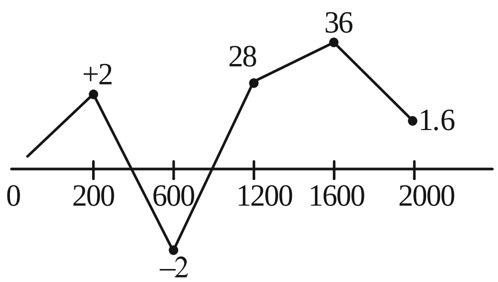
Consider the reduced level (RL) at the starting point of the runway as 100 m.

(a) 0.28% (b) 0.18%

(c) 0.35% (d) 0.02%

Sol. **(a)**

Airport : effective gradient



$$= \frac{3.6 - (-2)}{2000} \times 100 = 0.28\%$$

[MCQ]

Q.3. Which one of the following saturated fine-grained soils can attain a negative Skempton's pore pressure coefficient (A)?

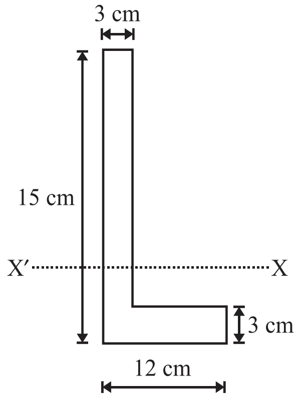
(a) Quick clays
(b) Normally-consolidated clays
(c) Lightly-consolidated clays
(d) Over-consolidated clays

Sol. **(d)**

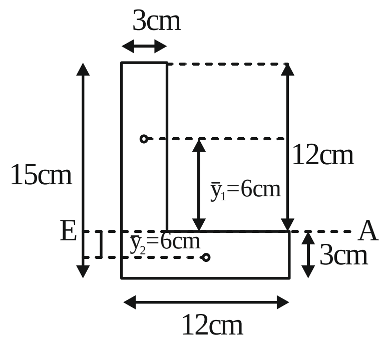
Over consolidated clay.

[NAT]

Q.4. The steel angle section shown in the figure has elastic section modulus of 150.92 cm^3 about the horizontal X – X axis, which passes through the centroid of the section.



Sol. **(1.789)**



$Z_e = 150 \cdot 92\ cm^3$

S.F. = ?

$A = 72\ cm^2,\ A/2 = 36\ cm^2$

$$Z_p = \frac{A}{2}(\bar{y}_1 + \bar{y}_2)$$

$$= 36(6 + 1.5) = 270 cm^3$$

$$S.F = \frac{Z_p}{Z_e} = \frac{270}{150.92} = 1.789$$

Civil Engineering

[NAT]

Q.5. A horizontal curve of radius 108 m (with transition curves on either side) in a board gauge railway track is designed and constructed for an equilibrium speed of 70 kmph. However, a few year construction the railway authorities decided to run express trains on this track. The Maximum allowable cant deficiency is 10 cm.
The maximum restricted speed (in kmph) of the express train running on this track is _____ (round off to the nearest integer).

Sol. **(27.8)**

V_{avg} = 70 kmph

(BG) G = 1.676 m

CD = 10 cm

R = 108m

$$e_{act} = \frac{GV_{avg}^2}{127R}$$

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

$$V_{max} = 106.49\text{kmp}$$

Restricted

As per martin

$$V_{max} = 4.35\sqrt{R-67}$$

$$V_{max} = 27.85\text{kmph}$$

[MCQ]

Q.6. **P:** Compacted fine-grained soils with flocculated structure have isotropic permeability.
Q: Phreatic surface line is the line along which the pore water pressure is always maximum.
R: The piping phenomenon occurring below the drum foundation is typically known as blowout piping.
Which of the following option(s) is/are **correct**?

(a) Both P and R are TRUE
(b) Both Q and R are FALSE
(c) P is FALSE and Q is TRUE
(d) P is TURE and R is FALSE

Sol. **(d)**

P → compacted fine-grained soils with flocculated structure have isotropic permeability

Q → Phreatic surface line is the line along which the pore water pressure is always maximum.

R → The piping phenomenon occurring below the dan foundation is typically knowns as blow not piping.

[NAT]

Q.7. A rectangular channel is 4.0 m wide and carries a discharge of 2.0 m^3/s with a depth of 0.4 m. The channel transitions to a maximin width contraction at a downstream location. without influencing the upstream flow conditions. The width (in meters) at the maximum contraction is _______ (rounded off to 2 decimal places)

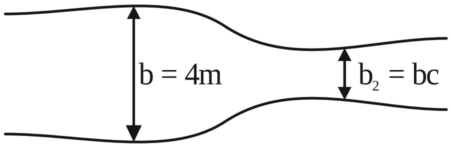
Sol. **(3.55)**

b = 4 m

Q = 2 m^3/s

y = 0.4 m

$b_2 = bc$



$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = 0.294 \text{ m}$$

$E_1 = E_2$

= 0.2 g

$E_1 = E_2$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g}$$

$$0.4 + \frac{1}{2g}\left(\frac{4}{(4\times 04)^2}\right) = y_c + \frac{1}{2g}\left(\frac{4}{b_c^2 \times y_c^2}\right)$$

$$0.4 + \frac{1}{2g}\left(\frac{4}{(4\times 0.4)^2}\right) = 0.294 + \frac{1}{2g}\left(\frac{4}{b_c^2 \times (0.294)^2}\right)$$

$b_c = 3.55$ m

[MCQ]

Q.8. If the sum of the first 20 consecutive positive odd numbers is divided by 20^2, the result is

(a) 1 (b) 1/2

(c) 20 (d) 2

Sol. **(a)**

$1 + 3 = 4 = 2^2$

$1 + 3 + 5 = 9 = 3^2$

$$\frac{1+3+5+\ldots}{20^2} = \frac{20^2}{20^2} = 1$$

[MCQ]

Q.9. A student was supposed to multiply a positive real number p with another positive real number q. Instead, the student divided p by q. If the percentage error in the student's answer is 80%, the value of q is

(a) 5 (b) sqrt 5
(c) 2 (d) sqrt 2

Sol. **(b)**

P·q

$$\Rightarrow \frac{pq - \frac{p}{q}}{pq} \times 100 = 80.$$

$$\Rightarrow \frac{q\left(1-\frac{1}{q^r}\right)}{q} = \frac{8}{10}$$

$$\Rightarrow 1 - \frac{1}{q^2} = \frac{8}{10}$$

$$\Rightarrow \frac{1}{q^2} = \frac{1}{5}$$

$$\Rightarrow q = \sqrt{5}$$

[MCQ]

Q.10. If '→' denotes increasing order of intensity, then the meaning of the words [drizzle → rain → downpour] is analogous to [_____ → quarrel → feud] Which one of the given options is appropriate to fill the blank?

(a) dodge (b) bicker
(c) bog (d) dither

Sol. **(b)**

Drizzle → rain → downpour
Bicker → quarrel → fuel
(1) Dogde (2) bicker
(3) bog → wet regular load (4) other → confused to total any decision

[MCQ]

Q.11. The ration of the number of girls to boys in class VIII is the same as the ration of the number of boys to girls in class IX. The total number of students (boys and girls) in classes VIII and IX is 450 and 360, respectively. If the number of girls in classes VIII and IX is the same, then the number of girls in each class is

(a) 200 (b) 250

(c) 150 (d) 175

Sol. **(a)**

$$\frac{G_8}{B_8}=\frac{B_9}{G_9}$$

$B_8 + G_8 = 450$

$B_9 + G_9 = 360$

$G_8 = G_9$

$$\Rightarrow \frac{G_8}{B_8}+1=\frac{B_9}{G_9}+1$$

$$\Rightarrow \frac{G_8+B_8}{B_8}=\frac{G_9+B_9}{G_9}$$

$$\boxed{\Rightarrow B_8=\frac{5}{4}.G_9}$$

$\Rightarrow B_8 + G_8 = 450.$

$$\Rightarrow \left(\frac{5}{4}+1\right)G_8=450$$

$$\Rightarrow \frac{9}{4}G_8=450$$

$\Rightarrow G_8 = G_9 = 200$

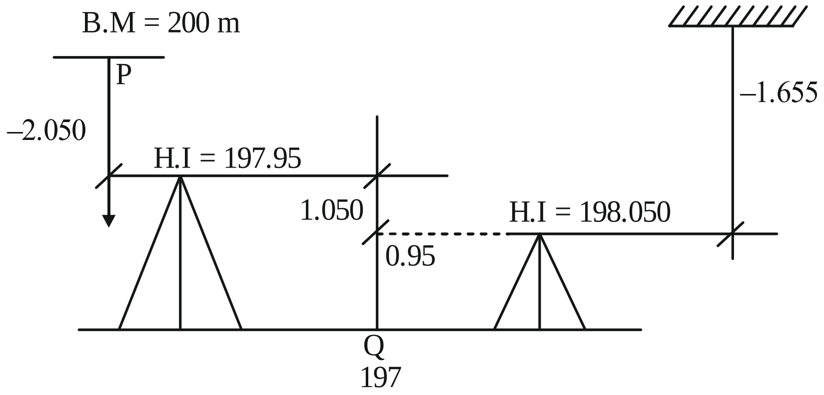
[NAT]

Q.12. Differential levelling is carried out from point P (BM: +200.00 m) to point R. the reading taken are given in the table.

Points	Staff readings (m)		Remarks
	Back Sight	Fore Sight	
P	(–)2.050		BM: +200.000 m
Q	1.050	0.950	Q is change point
R		(–)1.655	

Reduced Level in (in meters) of point R is _____ (rounded off to 3 decimal places)

Sol. **(199.705)**



$198.050 + 1.655 = 199.705$

[NAT]

Q.13. A drained triaxial test was conducted on a saturated send specimen using a stress-path triaxial testing system. The specimen failed when the axial stress reached a value of 100 kN/m^2 from an initial confining pressure of 300 kN/m^2.
The angle of shearing plane (in degrees) with respect to horizontal is _____ (rounded off to the nearest integer)

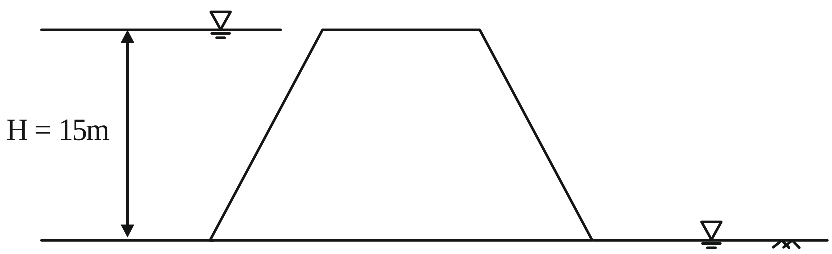
Sol. **(49)**

$\sigma_1 = \sigma_d + \sigma_c = 400$ kN/m^2
$\sigma_3 = \sigma_c = 300$ kN/m^2
$\sigma_1 = \sigma_3 \tan^2(45 + \phi/2)$
$45 + \phi/2 = \tan^{-1}\sqrt{4/3}$
$= 49.10°$

[NAT]

Q.14. A homogeneous earth dam has maximum water head difference of 15 m between the upstream and downstream sides. A flow net was drawn with the number of potential drops as 10 and the average length of the element as 3 m. Specific gravity of the soil is 2.65. For a factor of safety of 2.0 against piping failure, void ratio of the soil is ____ (rounded off to 2 decimal places).

Sol. **(0.65)**



$N_D = 10, l = 3m$

$G_s = 2.65$, FOS = 2.0

e = ?

$$i_c = \frac{h_l}{l} = \frac{\frac{15}{10}}{3} = 0.5$$

$$FOS = \frac{i_{cr}}{i_e}$$

$$i_{cr} = 2 \times 0.5 = 1 = \frac{G_s - 1}{1+e}$$

e = 2.65 – 1 – 1

= 0.65

[NAT]

Q.15. The in-situ percentage of voids of a and deposit is 50%. The maximum and minimum densities of sand determined from the laboratory tests are 1.8 g/cm^3 and 1.3 g/cm^3, respectively. Assume the specific gravity of and as 2.7.
The relative density index of the situ sand is _____. (rounded off to 2 decimal places).

Sol. **(13.33)**

$$P_r = \frac{\frac{1}{\gamma_{d,\min}} - \frac{1}{\gamma_d}}{\frac{1}{\gamma_{d,\min}} - \frac{1}{\gamma_{d,\max}}}$$

$$e = \frac{n}{1-n} = \frac{0.5}{1-0.5} = 1$$

$$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.7 \times 1}{1+1} = \frac{2.7}{2}$$

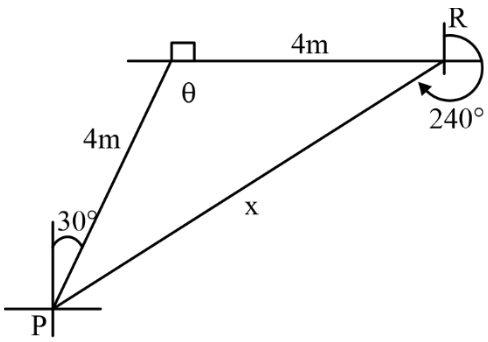
$$P_r = \frac{\frac{1}{1.3} - \frac{1}{1.35}}{\frac{1}{1.3} - \frac{1}{1.8}} \times 100\% = 13.33\%$$

[NAT]

Q.16. A child walks on a level surface from point P to point Q at a bearing of 30°, from point Q to point R at a bearing of 90° and then directly returns to the starting point P at a bearing of 240°. The straight-line paths PQ and QR are 4 m each. Assuming that all bearings are measured from the magnetic north in degrees. The straight-line path length RP (in meters) is _____ (rounded off to 2 decimal places).

Civil Engineering

Sol. **(6.298)**



4 cos 30° + 4 cos 90° + x cos 240° = 0

x = 6.928 m

[NAT]

Q.17. A 2 m wide rectangular channel is carrying a discharge of 30 m3/s at a bed slope of 1 in 300. Assuming the energy correction factor as 1:1 and acceleration due to gravity as 10 m/s^2, the critical depth of flow (in meters) is ____ (rounded off to 2 decimal places)

Sol. **(2.914)**

$$E = y + \frac{\alpha V^2}{2g}$$

$$E = y + \frac{\alpha q^2}{y^2 \times 2g}$$

$$\frac{dE}{dy} = 0 = 1 + \frac{\alpha q^2}{2g}\frac{(-2)}{y^3} = 0$$

$$y^3 = \frac{\alpha q^2}{g}$$

$$y_c = \left(\frac{\alpha q^2}{g}\right)^{1/3}$$

$$y_c = \left(\frac{1.1 \times 15^2}{10}\right)^{1/3} \qquad \left[q = \frac{Q}{B} = \frac{30}{2} = 15\text{m}^3/\text{sec/m}\right]$$

$y_c = 2.914$ m

Civil Engineering

[MCQ]

Q.18. The longitudinal sections of a runway have gradients as shown in the table.

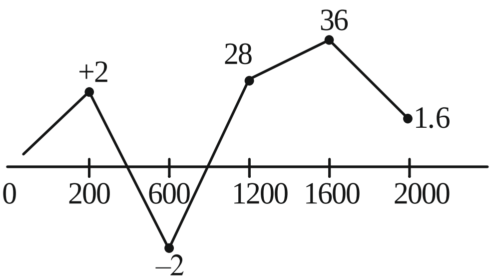
End to end for sections of runway (m)	Gradient (%)
0 to 200	+1.0
200 to 600	–1.0
600 to 1200	+0.8
1200 to 1600	+0.2
1600 to 2000	–0.5

Consider the reduced level (RL) at the staring point of the runway as 100 m. The effective gradient of the runway is

(a) 0.28%
(b) 0.18%
(c) 0.35%
(d) 0.02%

Sol. **(0.28)**

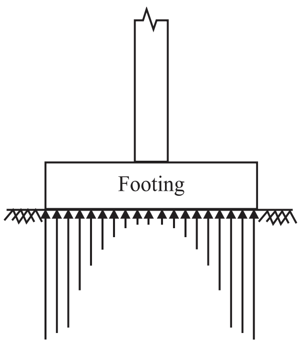
Airport : effective gradient



$$= \frac{3.6-(-2)}{2000} \times 100 = 0.28\%$$

[MCQ]

Q.19. The contact pressure distribution shown in the figure belongs to a



(a) flexible footing resting on a cohesive soil
(b) rigid footing resting on a cohesive soil
(c) rigid footing resting on a cohesive soil
(d) flexible footing resting on a cohesive soil

Sol. **(c)**

Rigid footing on cohesive soil

Civil Engineering

[NAT]

Q.20. A RC pile of 10 m length & 0.7 m diameter is embeded in a saturated pure clay with unit cohesion of 50 kpa. If ∝ = 0.5, the net ultimate pullout capacity (in kN) of the pile is ________

Sol. **(1099)**

$$q_{np} = \alpha \bar{c} A_s + W_p$$

$$\alpha \bar{c} A_s = 0.5 \times 50 \times \pi \times 0.7 \times 10 = 549.5 \text{ kN}$$

$W_p = [25 \times \pi \times 0.7 \times 10] = 549.5$ kN

$q_{np} = 549.5 + 549.5 = 1099$ kN

[MCQ]

Q.21. The function $f(x) = x^3 - 27x + 4$, $1 \le x \le 6$ has

(a) minima (b) inflection
(c) maxima (d) saddle

Sol. **(c)**

$f(x) = x^3 - 27x + 4$

$x(x^2 - 27) + 4$

$\Rightarrow f'(x) = 3x^2 - 27 = 0$

$f''(x) = 6x = 6(3) = 1870.$

$\therefore$ f(x) has Minima in $1 \le x \le 6$.

[MCQ]

Q.22. Structural design mtd that doesn't take into accounts the safety factors on the design load is

(a) load factor mtd (b) WSM
(c) ULM (d) LSM

Sol. **(b)**

WSM

[MCQ]

Q.23.

Air pollutant	Treatment technique
P – NO_2	(i) Flaring
Q – SO_2	(ii) Cyclonic separator
R – CO	(iii) Lime scrubbing
S – Particles	(iv) NH_3 injection

(a) P–IV, Q–III, R–I, S–II
(b) P–II, Q–III, R–I, S–IV
(c) P–IV, Q–I, R–III, S–II
(d) P–I, Q–III, R–IV, S–II

Sol. **(a)**

NO_2	NH_3 Injection
SO_2	lime scrubbing
CO	Flaring
Particulate	Cyclonic seperator

[NAT]

Q.24. An organic waste is represented as $C_{240}O_{220}H_{180}N_5S$. Assume complete conversion of S to SO_2 while burning. SO_2 generated (in gm) per kg of this waste is ________

Sol. **(10.06)**

$C_{200}O_{200}H_{180}N_5S + O_2 \rightarrow 200\ CO_2 + \ldots + /SO_2$

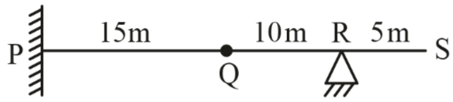
$200 \times 12 + 200 \times 10 + 180 + 5 \times 14 + 32 = 6362$ gm

6362gm of SW $\rightarrow$ 64 gm of SO_2

$1000 \text{ gm} \rightarrow \frac{64}{6362} \times 1000 = 10.06$ gm of SO_2

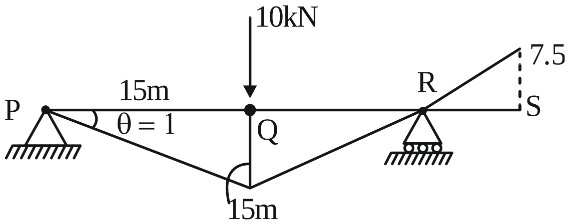
[NAT]

Q.25. A concentrated vertically downward load (V) of 10 kN can act at any point over entire length of beam.



The maximum magnitude of moment reaction (kN.m) that can be at support p due to V is __________.

Sol. **(150)**



$\frac{15}{10} \times 5$

$(M_P)_{max} = 10 \times 15$

$= 150$ kNm

[MCQ]

Q.26. If

$$A=\begin{bmatrix}2 & 1 & 4\\1 & 0 & 3\end{bmatrix}, B=\begin{bmatrix}-1 & 0\\2 & 3\\1 & 4\end{bmatrix}$$

Det (AB) = ?

Sol. **(10)**

$$A=\begin{bmatrix}2 & 1 & 4\\1 & 0 & 3\end{bmatrix} B=\begin{bmatrix}-1 & 0\\2 & 3\\1 & 4\end{bmatrix}$$

Def (AB) = ________

$$AB=\begin{bmatrix}-2+2+4 & 0+3+16\\-1+0+3 & 0+0+12\end{bmatrix}=\begin{bmatrix}4 & 19\\2 & 12\end{bmatrix}$$

|AB| = 48 – 38 = 10

[NAT]

Q.27. A storm with a recorded precipitation of 11.0 cm, as shown in the table, produced a direct run-off of 6.0 cm.

Time from start(hours)	0	1	2	3	4	5	6	7	8
Recorded cumulative precipitation (cm)	0	0.5	1.5	3.1	5.5	7.3	8.9	10.2	11.0

The ϕ - index of the storm is ________ cm/hr (rounded off to 2 decimal places)

Sol. **(0.642)**

P = 1 cm, R = 6 cm, t = 8 hrs

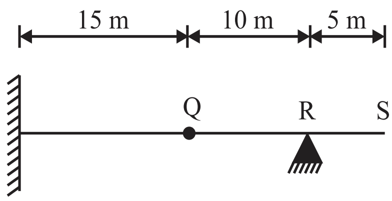
t	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8
p	0.5	1	1.6	2.4	1.8	1.6	1.3	0.8
q	0.5	1	1.6	2.4	1.8	1.6	1.3	0.8

1. $\phi-\text{index}=\frac{11-6}{8}=0.625$

2. $\phi-\text{index}=\frac{(11-0.5)-6}{7}$ = 0.642/cm/hr

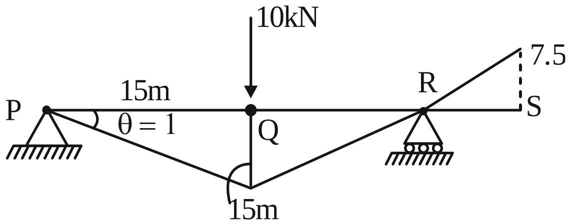
[NAT]

Q.28. The horizontal beam PQRS shown in the figure has a fixed support at point P, an internal hinge at point Q, and a pin support at point R. A concentrated vertically downward load (V) of 10 kN can act at any point over the entire length of the beam.



The maximum magnitude of the moment reaction (in kN. m) that can act at the support P due to V is ___________ (in integer)

Sol. **(150)**



$\frac{15}{10}\times 5$

$(M_P)_{max} = 10 \times 15$

$= 150$ kNm

[NAT]

Q.29. A circular settling tank is to designed for primary treatment of sewage at a flow rate of 10 million litres / day. Assume a detention period of 2.0 hours and surface loading rate of 40000 litres/m^2/day. The height (in meters) of the water column in the tank is __________ (rounded off to 2 decimal places.)

Sol. **(3.33)**

Q = 10 MLD

DT = 2 hr

SLR = 40,000 l/m^2/d

$$SA = \frac{Q}{SLR} = \frac{10\times10^6}{40000}$$

$$\boxed{SA = 25000^2}$$

$Vol^m = Q \times T$

$$= \frac{10\times10^6\times10^{-3}}{24}\times 2$$

$Vol^m = 833.33\ m^3$

$$\text{depth} = \frac{Vol^m}{SA} = \frac{833.33}{25u} = 3.33\text{ m}$$

[MCQ]

Q.30. The consolidated data of a spot speed study for a certain stretch of a highway is given in the table:

Speed range (kmph)	**Number of observations**
0 – 10	7
10 – 20	31
20 – 30	76
30 – 40	129
40 – 50	104
50 – 60	78
60 – 70	29
70 – 80	24
80 – 90	13
90 – 100	9

The "upper speed limit" (in kmph) for the traffic sign is

(a) 70
(b) 65
(c) 55
(d) 50

Sol. **(c)**

Cumulative

Average speed	No. of observation	Percentile
5	7	7
15	31	38
25	76	114
35	129	243
45	104	347
55	78	425
65	29	454
75	24	478
85	13	491
95	9	500

Percentile

7/500 × 100 = 1.4

7.6

22.8

48.6

69.4

85

At 85 speed the upper limit is 55 kmph

[NAT]

Q.31. A drained triaxial test was conducted on a saturated sand specimen using a stress-path triaxial testing system. The specimen failed when the axial stress reached a value of 100 kN/m^2 from an initial confining pressure of 300 kN/m^2.
The angle of shearing plane (in degrees) with respect to horizontal is ____________ (rounded off to the nearest integer).

Sol. **(49.10)**

$\sigma_{1g} = \sigma_a + \sigma_c = 400$ kN/m^2

$\sigma_{3g} = \sigma_c = 300$ kN/m^2

$\sigma_{1g} = \sigma_{3g} \tan^2 (45 + \phi/2)$

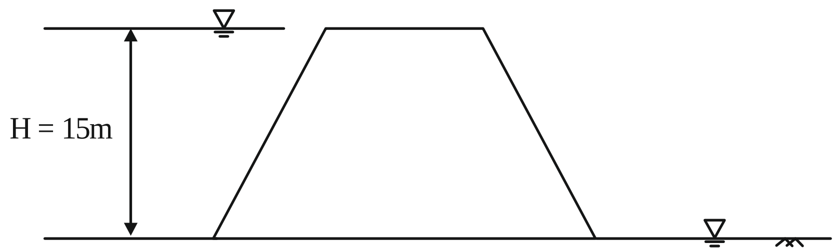
$$45 + \frac{\phi}{2} = \tan^{-1}\sqrt{4/3}$$

$= 49.10°$

[NAT]

Q.32. A homogeneous earth dam has a maximum water head difference of 15 m between the upstream and downstream sides. A flownet was drawn with the number of potential drops as 10 and the average length of the element as 3 m. Specific gravity of the soil is 2.65. For a factor of safety of 2.0 against piping failure, void ration of the soil is ____________ (rounded off to 2 decimal places).

Sol. **(0.65)**



$N_D = 10, l = 3$m

$G_s = 2.65$, FOS = 2.0

e = ?

$$i_c = \frac{h_l}{l} = \frac{\frac{15}{10}}{3} = 0.5$$

$$FOS = \frac{i_{cr}}{i_e}$$

$$i_{cr} = 2 \times 0.5 = 1 = \frac{G_s - 1}{1 + e}$$

e = 2.65 – 1 – 1

= 0.65

[NAT]

Q.33. An organic waste is represented as $C_{200}O_{200}H_{180}N_5S$.
(Atomic weights: S – 32, H – 1, C- 12, O – 16, N- 14)
Assume complete conversion of S to SO2 while burning.
SO_2 generated (in grams) per kg of this waste is ___________ (rounded off to 1 decimal place.)

Sol. **(10.06)**

$C_{200}\ O_{200}\ H_{180}\ N_5\ S + O_2 \rightarrow 200\ CO_2 + \ldots + /SO_2$

$200 \times 12 + 200 \times 10 + 180 + 5 \times 14 + 32 = 6362$ gm

6362gm of SW $\rightarrow$ 64 gm of SO_2

$$1000 \text{ gm} \rightarrow \frac{64}{6362} \times 1000 = 10.06 \text{ gm of } SO_2$$

[MCQ]

Q.34. A hypothetical multimedia filter, consisting of anthracite particles (specific gravity: 1.50), silica sand (specific gravity: 2.60) and ilmenite sand (specific gravity: 4.20), is to be designed for treating water/ wastewater. After backwashing, the particles should settle forming three layers: coarse anthracite particles at the top of the bed, silica sand in the middle, and small ilmenite sand particles at the bottom of the bed.

Assume

(i) Slow discrete settling (Stoke's law is applicable)

(ii) All particles are spherical.

(iii) Diameter of silica sand particles is 0.20 mm.

The **correct** option fulfilling the diameter requirements for this filter media is

(a) diameter of anthracite particles is slightly greater than 0.35 mm and diameter of ilmenite particles is slightly less than 0.141 mm.

(b) diameter of anthracite particles is slightly less than 0.64 mm and diameter of ilmenite particles is slightly less than 0.10 mm

(c) diameter of anthracite particles is slightly less than 0.35 mm and diameter of ilmenite particles is slightly less than 0.141 mm.

(d) diameter of anthracite particles is slightly greater than 0.64 mm and diameter of ilmenite particles is slightly less than 0.10 mm.

Sol. **(?)**

MMF

Anthracite, $D_{10} = 0.9$ to 1 mm, S = 1.4 to 1.5

Silica sand, $D_{10} = 0.5$ mm, S = 2.67

Garnet, d = 0.15 mm, S = 4.2

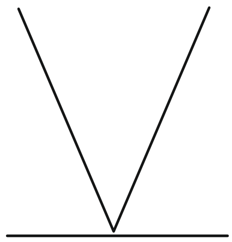
[MCQ]

Q.35. A round-bottom triangular lined canal is to be laid at a slope of 1 in 1500, to carry a discharge of 25 m3/s. The side slopes of the canal cross-section are to be kept at 1.25H :1V. If Manning's roughness coefficient is 0.013, the flow depth (in meters) will be in the range of

(a) 2.61 to 2.64 (b) 2.24 to 2.27

(c) 1.94 to 1.97 (d) 2.39 to 2.42

Sol. **(d)**



$$\tan\theta = \frac{1}{1.25} \Rightarrow \theta = \tan^{-1}\left(\frac{1}{1.25}\right)$$

= 0.6747 radian

And,

Cot θ = 1.25

$A = y^2 (\theta + \cot\theta) = y^2 \times 1.9247$

Welted perimeter (P) = $2y(\theta + \cot\theta) = 3.8494\ y$

$$\therefore\ R = \left(\frac{A}{P}\right) = \frac{y}{2}$$

And, As per Manning's Formula,

$$Q = \frac{1}{n} A R^{2/3} (S)^{1/2}$$

$$25 = \frac{1}{0.013} \times 1.9247 y^2 \times \left(\frac{y}{2}\right)^{2/3} \times \sqrt{\frac{1}{150}}$$

$$y = \left[\frac{25 \times 0.013 \times (2)^{2/3} \times \sqrt{1500}}{1.9247}\right]^{3/8}$$

= 2.40488 m

Civil Engineering

[MCQ]

Q.36. What is the **correct** match between the air pollutants and treatment techniques given in the table?

Air pollutants	Treatment techniques
P. NO_2	i. Flaring
Q. SO_2	ii. Cyclonic separator
R. CO	iii. Lime scrubbing
S. Particles	iv. NH_3 injection

(a) P – i, Q – ii, R – iii, S – iv
(b) P – iv, Q – iii, R – i, S – ii
(c) P – ii, Q – iii, R – iv, S – i
(d) P – ii, Q – i, R – iv, S – iii

Sol. **(b)**

NO_2	NH_3 Injection
SO_2	lime scrubbing
CO	Flaring
Particulate	Cyclonic separator

[MCQ]

Q.37 The function

$f(x) = x^3 - 27x4, 1 \le x \le 6$ has

(1) Minima point
(2) Maxima point
(3) Saddle point
(4) Inflection point

Sol. **(b)**

$f(x) = x^3 - 27x + 4$

$x(x2 - 27) + 4$

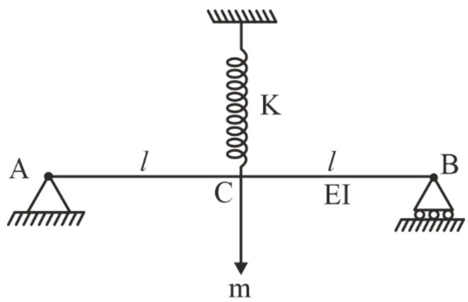
$\Rightarrow f'(x) = 3x^2 - 27 = 0$

$f''(x) = 6x = 6(3) = 1870.$

$\therefore$ f(x) has Minima in $1 \le x \le 6$.

[MCQ]

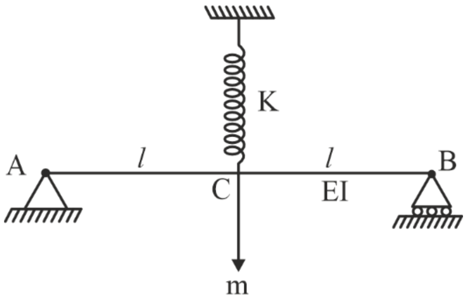
Q.38 Angular velocity of given system



(a) $W = \sqrt{\dfrac{K + \dfrac{6EI}{l^3}}{m}}$ (a) $W = \sqrt{\dfrac{K - \dfrac{6EI}{l^3}}{m}}$

(d) $W = \sqrt{\dfrac{K + \dfrac{4EI}{l^3}}{m}}$ (d) $W = \sqrt{\dfrac{K - \dfrac{4EI}{l^3}}{m}}$

Sol. **(a)**



$F = K\Delta$

$$\Delta = \frac{P(3l)^3}{48EI} = \frac{Pl^3}{6EI}$$

$$P = \left(\frac{6EI}{l^3}\right)\Delta$$

K_B

$$W = \sqrt{\frac{K_{eq}}{m}}$$

$K_{eq} = K_{SP} + K_B$

$$K_{eq} = K + \frac{6EI}{l^3}$$

$$\boxed{W = \sqrt{\frac{K + \frac{6EI}{l^3}}{m}}}$$

[NAT]

Q.39. A vertical summit curve on a freight corridor at the intersection of two gradients +3.0% and + -5.0%.

Assume the following:

Only large sized trucks are allowed on this corridor

Design speed = 80 kmph

Eye height of truck drivers above the road surface = 2.30 m

Height of object above the road surface for which trucks need to stop = 0.35 m

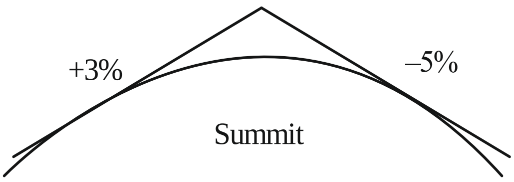
Total reaction time of the truck drivers = 2.0s

Coefficient of longitudinal friction of the road = 0.36

Stopping sight distance gets compensated on the gradient

The design length of the summit curve (in meters) to accommodate the stopping sight distance is ________ (rounded off to 2 decimal places)

Sol. **(142)**



N = 8%

H = 2.3 m

h = 0.35 m

$t_r = 2.5$ sec

f = 0.36

V = 80 kmph

(1) l > 80

$$SSD = vtr + \frac{v^2}{2gf}$$

$$= \left(80 \times \frac{5}{18}\right) \times 2.5 + \frac{\left(80 \times \frac{5}{18}\right)^2}{2 \times 9.81 \times 0.36}$$

SSD = 125.45 m

$$l = \frac{NS^2}{\left(\sqrt{2H} + \sqrt{2h}\right)^2}$$

l = 142.10 m

[NAT]

Q.40. If $\vec{p} = \hat{i} + j + k, \bar{q} = \hat{i} + 2j + 3k, \vec{r} = 2\hat{i} + 3j + 4k$, then which of the following is/are correct.

(a) $\vec{P} \times (\vec{q} \times \vec{r}) + \vec{q} \times (\vec{r} \times \vec{p}) + \vec{r} \times (\vec{p} \times \vec{q}) = 0$

(b) $\vec{p} \times (\vec{q} \times \vec{r}) = (\vec{p} \cdot \vec{r})\vec{q} - (\vec{p} \cdot \vec{q})\vec{r}.$

(c) $\vec{r}(\vec{p} \times \vec{q}) = 0 = (\vec{q} \times \vec{p}) \cdot \vec{r}$

(d) $\vec{p} \times (\vec{q} \times \vec{r}) \neq (\vec{p} \times \vec{q}) \times \vec{r}$

Sol. **(c)**

$\vec{P} = \hat{i} + \hat{j} + \hat{k};\ \vec{q} = \hat{i} + 2\hat{j} + 3\hat{k};\ \vec{r} = 2\hat{i} + 3\hat{j} + 4\hat{k}$

(a) $\vec{P} \times (\vec{q} \times \vec{r}) + \vec{q} \times (\vec{r} \times \vec{p}) + \vec{r} \times (\vec{p} \times \vec{q}) = 0$

$$= \vec{p} \times \underbrace{\left(\vec{q} \times (\vec{p} + \vec{q})\right)}_{\vec{q} \times \vec{p}} + \vec{q} \times \underbrace{\left((\vec{p} + \vec{q}) \times \vec{p}\right)}_{\vec{q} \times \vec{p}} + \vec{r} \times (\vec{p} \times \vec{q})$$

$$= \vec{p} \times (\vec{q} \times \vec{p}) + \vec{q} \times (\vec{q} \times \vec{p}) - \vec{r} \times (\vec{q} \times \vec{p}) = \vec{0}.$$

(b) $\vec{p} \times (\vec{q} \times \vec{r}) = (\vec{p} \cdot \vec{r})\vec{q} - (\vec{p} \cdot \vec{q})\vec{r}.$

(c) $\vec{r}(\vec{p} \times \vec{q}) = 0 = (\vec{q} \times \vec{p}) \cdot \vec{r}$

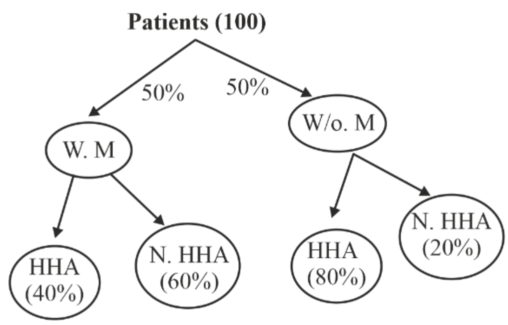
(d) $\vec{p} \times (\vec{q} \times \vec{r}) \neq (\vec{p} \times \vec{q}) \times \vec{r}$

[MCQ]

Q.41. In a sample of 100 heart patients, each patient has 80% chance of having a heart attack without medicine X. It is clinically known that medicine X reduces the probability of having a heart attack by 50 %. Medicine X is taken by 50 of these 100 patients. The probability that a randomly selected patient, out of the 100 patients, takes medicine X and has a heart attack is

(a) 30 % (b) 20 %
(c) 40 % (d) 60 %

Sol. **(b)**



Required Probability = 50 × 40% $= \frac{50}{100} \times \frac{40}{100}$

$= \frac{20}{100} \times 100 = 20\%$

[MCQ]

Q.42. Consider the following data for a project of 300 days duration. Budgeted cost of work scheduled (BCWS) = Rs 200, Budgeted cost of work performed = Rs 150, Actual cost of work performed (ACWP) = Rs 190. The schedule variance for the project is.

(a) + 50 Rs
(b) – 50 days
(c) – 50 Rs
(d) + 50 days]

Sol. **(c)**

Schedule variance (SV) = (BCWP – BCWS)

= (150 – 200)

= – Rs 50

[NAT]

Q.43. A circular settling tank is to be designed for primary treatment of sewage at a flow rate of 10 million *l*/day. Assume detention period of 2 hr and surface loading rate of 40,000 *l*/m^2/day. The ht. (in meter) of water column in tank is __________.

Sol. **(3.333)**

Q = 10 × 10^6 lt/day = 10 × 10^3 m^3/day

Surface Loading Rate = 40, 000 lt/m^2/day = 14 m^3/m^2/day

Let, diameter of circular settling tank = D metre and its height is H m

We know that,

$$\text{Surface loading rate } = \left(\frac{Q}{\text{Surface Area}}\right) = \left(\frac{Q}{\frac{\pi}{4} \times D^2}\right) = 40 \text{ m}^3/\text{m}^2/\text{day}$$

$$\Rightarrow \left(\frac{\pi}{4} \times D^2\right) = \left(\frac{10 \times 10^3}{40}\right) = 250 \text{ m}^2$$

$\Rightarrow$ D = 17.84 m

Also,

$$\text{Detention time (td) } = \left[\frac{\text{Volume}}{\text{Discharge}}\right] = \left[\frac{D^2(0.785H + 0.011D)}{Q}\right] = \frac{2}{24} \text{day}$$

H = 3.333 m

[MCQ]

Q.44. Various stresses in jointed plain concrete pavement with slab size of 3.5 × 4.5 m are deleted as follows. Wheel loads stress at interior = S_{wl}^{i} wls at edge = S_{wl}^{e} wls at corner = S_{wl}^{c}, warping stress at interim = S_{t}^{i}. Ws at edge = S_{t}^{e}, Ws at corner = S_{t}^{c}. Frictional stress between slab & supporting layer = S_f. The critical combination at the concrete slab during a summer midnight is

(a) $S_{wl}^{e}+S_{t}^{e}+S_{f}$ (b) $S_{wl}^{c}+S_{t}^{c}$

(c) $S_{wl}^{e}+S_{t}^{e}-S_{f}$ (d) $S_{wl}^{c}+S_{t}^{c}+S_{f}$

Sol. (c)

Critical Combination at the Concrete slab during Summer mid-night

Warping Stress:

- In right time, the slab tries to contract at the top but it is restrained by the weight, hence tension is developed at the top and compression is developed at the bottom. It is higher in interior region.

Load Stress:

- The load stress in edge region is higher than interior. Note it is maximum at corners.

Frictional Stress:

- During summer, frictional stress are compressive during expansion.

Thus, the critical combination is:

(Loading Stress + Warping Stress – Frictional Stress)$_{\text{at edge region}}$

$$=S_{wl}^{e}+S_{t}^{e}-S_{f}$$

[MCQ]

Q.45. Consider the settlements P and Q related to the analysis/design of retaining walls.

P: When a rough retaining wall moves toward the backfill. The wall friction force/ resistance mobilizes in upward direction along the wall.

Q: Most of the earth pressure theories calculate the earth pressure due to surcharge by neglecting the actual distribution of stresses due to surcharge

Which one of the following options is CORRECT?

(a) P is True and Q is false (b) Both P and Q are true

(c) P is false and Q is true (d) Both P and Q are false

Sol. **(c)**

When a rough retaining wall moves toward the backfill, the soil will try to move inward and upward and thus the friction and shearing resistance mobilizes in downward direction along the wall.

Most of the earth pressure theories calculate the earth pressure due to surcharge by neglecting the actual distribution of stresses due to surcharge

---

[NAT]

Q.46. A 500 m long water distribution pipeline P with diameter 1.0 m. is used to convey 0.1 m^3/s of flow. A new pipeline Q, with the same length and flow rate, is to replace P. The friction factors for p and Q are 0.04 and 0.01 respectively, the diameter of the pipeline Q (in meters) is _________ (rounded off to 2 decimal)

Sol. **(0.76)**

In both pipes, head loss are equal,

$$(h_L)_P = (h_L)_Q$$

$$\Rightarrow \frac{f_p l\, Q^2}{12.1 D_p^5} = \frac{f_Q\, l Q^2}{12.1\, D_Q^5}$$

$$\Rightarrow D_Q^5 = \frac{f_Q}{f_P} \times D_P^5 -$$

$$\Rightarrow D_Q = \left[\frac{0.01}{0.04} \times (1)^5\right]^{1/5}$$

= 0.7578 m

Civil Engineering

PW GATE WALLAH

SOLDIERS

THANK YOU