## Solutions

## General Aptitude

1. Ans. D.

Not is already embedded in until. So, A and B are incorrect.
Also, the minister is a single person, and with a singular subject, singular verb follows(ending in 's').
Thus, $C$ is incorrect and $D$ is the right answer.
2. Ans. A.

Paraphrase - To express something in different words so that it becomes easy for the listener to understand. Paradox - A statement which sounds logical, but proves to be illogical when investigated.
Paradigm - A way of looking or thinking (perception) about something.
Paraffin - A flammable substance used in candles, polishes, etc.
So, A is the correct choice.

## 3. Ans. A.

Here, we are talking about figure of speech So, figurative is figure of speech meaning: Use of metamorphic meaning of words to explain your thoughts instead of literal use of them.
4. Ans. C.
'taga' and 'care' are a matching pair in every combination.
So, 'taga' surely represents 'care'.
Also, note here that the second half of the word in encoded value refers to the first half of the word in the decoded value.
So, 'fer' represents 'less', 'relf' represents 'free' and 'o' represents 'full'.
Going by the same logic, the answer would be tagazen, i.e., C.
5. Ans. D.

Four blocks are needed for each direction (totally 3 directions) to build a bigger cube containing 64 blocks. So area of one side of the bigger cube $=4 \times 4=16$ units There are 6 faces so total area $\mathbf{= 6 \times 1 6 = 9 6}$ units
When cubes at the corners are removed they introduce new surfaces equal to exposes surfaces so the area of the bigger cube does not change from 96
6. Ans. B.

Revenue from Elegance $=$
$(27300+25222+28976+21012) *$ Rs. $48=$ Rs. 4920480
Revenue from Smooth $=(20009+19392+22429+18229)$

* Rs. 63 = Rs. 5043717

Revenue from Soft $=(17602+18445+19544+16595) *$
Rs. 78 = Rs. 5630508
Revenue from Executive $=(9999+8942+10234+10109)$

* Rs. 173 = Rs. 6796132

Total Revenue = Rs. 22390837
Fraction of Revenue for Elegance $=0.219$
Fraction of Revenue for Smooth $=0.225$
Fraction of Revenue for Soft $=0.251$
Fraction of Revenue for Executive $=0.303$
Thus, $B$ (Executive) is the correct answer.
7. Ans. D.

A is incorrect as it cannot be inferred that exactly 17 languages are there, because the statement says that there are atleast 17 languages on the currency note. $B$ is incorrect because of the word 'only' in the option, which is too strong to be inferred.
C is incorrect as it says 'space for all Indian languages', but the number of languages in India is not mentioned in the question.
$D$ is correct as it can be easily inferred from the statement.
8. Ans. D.

All three can Beat S, but S loses to P only sometimes. So, (ii) can not be inferred from the given statements.

Defeating in Poker is not transitive. P beats Q. Q beats R and $R$ beats $S$. Yet $S$ loses to $P$ only sometimes, meaning that $S$ mostly wins against $P$. So we can not logically infer that $P$ is likely to beat $R$.
9. Ans. B.
from the option (b)
$2 x^{7}+3 x-5=0$
substitute $x=1$ in $2(1)^{7}+\mathbf{3 ( 1 )}-5=0$; So $(x-1)$ is a
$5-5=0$
factor of $f(x)$
10. Ans. B.

From the data given we assume

## load $=\frac{\exp \text { onent }}{\log (\text { cycles })}$

$80=\frac{x}{\log (10000)} \Rightarrow x=160$
$40=\frac{x}{\log (10000)} \Rightarrow x=160$
$\operatorname{load}=\frac{160}{\log 5000}=43.25$

## Civil Engineering

1. Ans. C.

Let $f(x)=3 x-e^{x}+\sin x$ and $x_{0}=0.333 \approx \frac{1}{3}$
$\Rightarrow f^{\prime}(x)=3-e^{x}+\cos x$
$f\left(x_{b}\right)=-0.069$ and $f^{\prime}\left(x_{b}\right)=2.55$
$\therefore \mathrm{x}_{1}=\mathrm{x}_{\mathrm{b}}-\frac{\mathrm{f}\left(\mathrm{x}_{\mathrm{o}}\right)}{\mathrm{f}^{\prime}\left(\mathrm{x}_{0}\right)}$
(Using Newton - Rapshon method)
$=0.333+\frac{\mathbf{0 . 0 6 9}}{2.55}=\mathbf{0 . 3 6 0}$ is the required next
approximation
2. Ans. C.

Comparing the given equation with the general form of second order partial differential equation, we have $A=1, B=3, C=1 \Rightarrow B^{2}-4 A C=5>0$
$\therefore$ P.D.E is Hyperbola.
3. Ans. D.

Consider the ${ }^{*} 2 \mathrm{x}^{2+}$ square matrix $M=\left[\begin{array}{ll}a & b \\ c & d\end{array}\right]$ Characteristic equation of $M$ is $\lambda^{1}-(a+d) \lambda+(a d-b c)=0$
Put $\boldsymbol{\lambda}=\mathbf{1}$, we get
$1-(a+d)+a d-b c=0$
$1-a-d+a d-(1-d)(1-a)=0$
$1-a-d+a d-1+a+d-a d=0$
$0=0$,
which is true
$\therefore \lambda=1$ Satisfies the equation (1) but $\lambda=\mathbf{2 , 3 , 4}$ does not satisfy the equation (1). For all possible values of $a, d$ Alternate Method: If sum of the elements in each row/column of a square matrix is equal to ' $S$ ' then ' $S$ ' is an eigen value of that matrix.
4. Ans. A.

Type II Errors means acceptance of the null hypothesis when it is false and should be rejected.

## 5. Ans. B.

The P.D.E $\frac{\partial u}{\partial t}=\alpha \frac{\partial^{2} u}{\partial x^{2}} \ldots(1)$ is called 1-D heat equations.
Then the solution of (1) is
$u(x, t)=(A \cos p x+B \sin p x) C e^{-\theta^{2}=t}$
Put
$-p^{2} \alpha=k \Rightarrow p=\sqrt{\frac{-k}{\alpha}}=\sqrt{\frac{\sqrt{k}}{\alpha}} \hat{d}$
$\therefore$ (1) becomes
$u(x, t)=(A \cosh \sqrt{k / \alpha} x+B \sinh \sqrt{k / \alpha}, x), C \sigma^{k}$

$=C \theta^{1 *}\left[\theta^{(\sqrt{4 / a}) x},\left\{\frac{A+B}{2}\right\}+\theta^{(\sqrt{/ / a}) \times},\left\{\frac{A-B}{2}\right\}\right]$
$=C \sigma^{2 *}\left[C_{1} e^{(\sqrt{7 / a}) x}+C_{2} s^{-(\sqrt{2 / a}) x}\right]$
6. Ans. A.

$B F_{W}=0 \Rightarrow H_{1}=0$
$\Sigma M_{c}=0 \Rightarrow V_{0} \times 2 L=0 \Rightarrow V_{0}=0$
$\mathrm{ZV}=0 \Rightarrow V_{G}=P$
7. Ans. D.

If $\tau_{\nabla}>\tau_{c . \pi m}$,
Diagonal compression failure occurs in concrete
8. Ans. B.

As per IS 800, the design bending strength of laterally unsupported beam as governed by lateral torsional buckling is:
$M_{d}=A_{B} Z_{B} F_{\text {de }}$
$A=\frac{Z_{E}}{Z_{B}}$ for semi compact section,
So,

$$
\begin{aligned}
M_{d} & =\frac{Z_{a}}{Z_{p}} Z_{p} f_{b s}=Z_{e} f_{b e}=500 \times 10^{y} \times 200 \times 10^{-s} \\
& =100 \mathrm{kN}-\mathrm{m}
\end{aligned}
$$

9. Ans. C.

Bulls Trench kiln is used for manufacturing bricks
10. Ans. B.

Tri-Calcium Silicate (3CaO.SiO2 or C3S)

- Formed within week
- Responsible for initial strength of cement
- Contribute about 50-60\% of strength
- Content increase for the pre fabricated concrete construction, Cold weathering construction.
The compound responsible for initial setting and early strength gain in OPC is $\mathrm{C}_{3} \mathrm{~S}$

11. Ans. B.

In consolidated undrained triaxial test - Pore Water Pressure is zero at the end of consolidation stage.
12. Ans. D.

Soil is plastic in range of $26 \%$ to $48 \%$. So, plastic limit $=26 \%$, liquid limit $=48 \%$
Since 35\% <LL<50\% So, CI
13. Ans. D.
$P_{\mathrm{I}}=\mathrm{k}_{\mathrm{A}} \sigma_{z}-2 \mathrm{C}_{\mathrm{y}} \sqrt{\mathrm{k}_{\mathrm{A}}}$
at $\mathbf{Z}=Z_{8} P_{10}=0$
$K_{A}\left(y z_{\mathrm{b}}\right)-2 C \sqrt{K_{A}}=0$
$K_{A}\left(y z_{b}\right)=2 C \sqrt{K_{A}}$
$z_{0}=\frac{2 C_{\gamma} \sqrt{K_{A}}}{\gamma \cdot K_{A}}=\frac{2 C}{\gamma \sqrt{K_{A}}}$
$z_{a r a c}=2 z_{b}=\frac{2 \times 2 C}{y \sqrt{k_{A}}}=\frac{4 C}{y \sqrt{k_{A}}}$
14. Ans. A.

Area under hydrograph $=$ direct runoff volume
$\frac{1}{2} \times 1 \times 6 \times 60 \times 60=5 \times \frac{1}{100} \times A$
$A=\frac{1}{2} \times \frac{6 \times 60 \times 60 \times 100}{5}=\frac{2160000}{10}$
$=21600 \mathrm{~m}^{2}=21.6 \times 10^{4} \mathrm{~m}^{2}$
$A=21.6$ hectares

## 15. Ans. B.

Hydrologic flood routing - based on Continuity equation only
Hydraulic flood routing - - based on both Continuity equation \& Momentum equation
16. Ans. A.

Consider
Pre-jump depth $=y_{1}$
Post-jump depth $=y_{2}$
$F_{r(i)}=10$
We now that
$\frac{\text { Post jump depth }}{\text { Pre jump depth }}=\frac{y_{2}}{y_{1}}=\frac{1}{2}\left[\sqrt{1+8 F_{1}^{2}}-1\right]$
$=\frac{1}{2}\left[\sqrt{1+8 \times(10)^{2}}-1\right]$
$=\frac{1}{2}[27.3]=13.65$

## 17. Ans. A.

Photochemical oxidants are the products of reactions between NOx and a wide variety of volatile organic compounds (VOCs). The most well-known 'oxidants' are ozone $\left(\mathrm{O}_{3}\right)$, peroxyacetyle nitrate (PAN) and hydrogen peroxide ( H 2 O 2 )
18. Ans. A.

The corrosion often present in the crown (top)
of concrete sewers is caused by $\mathrm{H}_{2} \mathrm{~S}$
19. Ans. B.

Given, $D=0.45 \mathrm{~m}, \mathrm{~L}=7.5 \mathrm{~m}$
No. of fabric filter bags, $N=\frac{\mathbf{A}_{\mathbf{i}}}{\mathbf{A}_{\mathrm{b}}}$
Total area of filter
$\left(A_{f}\right)=\frac{10 \times 60}{2}=300 \mathrm{~m}^{x}$
Area of one bag
$\left(A_{8}\right)=\pi \mathrm{dL}=\pi \times 0.45 \times 7.5=10.60 \mathrm{~m}^{2}$
$\mathrm{N}=\frac{300}{10.60}=28.28=29$
20. Ans. A.

Activated sludge process - Heterotrophic bacteria Rising of sludge - Denitrifies
Conventional nitrification - Autotrophic bacteria
Biological nitrogen removal - Nitrifies and denitrifies

## 21. Ans. B.

The graph wrong among the given is ' R ' The correct graph should be

22. Ans. C.

Maximum theoretical capacity,
$=\frac{3600}{H_{z}}$
$=\frac{3600}{3}$
$=1200 \mathrm{veh} / \mathrm{hr}$.

## 23. Ans. C.

Minimum number of satellites needed for a GPS to determine its position precisely is 4
24. Ans. C.

There are two types of remote sensing instrumentspassive and active.
Passive instruments detect natural energy that is reflected or emitted from the observed
scene. Passive instruments sense only radiation emitted by the object being viewed or reflected by the object from a source other than the instrument
25. Ans. A.

RL of bottom of beam
$=40.5+2.96+0.645=44.105 \mathrm{~m}$
26. Ans. A.
$P(x \leq 4)=\int_{-\infty}^{4} f(x) d x=\int_{-\infty}^{1}(0) d x+\int_{4}^{4}(0.25) d x$
$+\int_{4}^{w}(0) d x$

$$
=\frac{1}{4}(x)_{1}^{4}=\frac{1}{4}(4-1)=\frac{3}{4}
$$

27. Ans. B.
$\int_{8}^{\infty} \frac{1}{1+x^{2}} d x=\left[\tan ^{-1} x\right]_{0}^{m}=\tan ^{-1} \infty-\tan ^{-1} 0=\frac{\pi}{2}$
and $L(\sin x)=\frac{1}{g^{2}+1} \Rightarrow L\left(\frac{\sin x}{x}\right)=\int_{0}^{\sin } \frac{1}{g^{2}+1} d x$
(Using" Division by $\mathrm{x}^{\prime \prime}$ )
$=\left[\tan ^{-1} s\right]_{0}^{3}=\tan ^{-1} \infty-\tan ^{-1}(s)=\cot ^{-1}(s)$
$\Rightarrow \int_{a}^{m} e^{-m} \cdot \frac{\sin 3}{x} d x=\cot ^{-1}(3)$
(Using definition of Laplace transform)
Put $s=0$, we get 1
$\int_{s}^{\pi} \frac{\sin x}{x} d x=\cot ^{-1}(0)=\frac{\pi}{2}$
$\infty \int_{s}^{m} \frac{1}{1+x^{2}} d x+\int_{s}^{\infty} \frac{\sin x}{x} d x=\pi$
28. Ans. B.

At the point of intersection of the curves, $y=x^{7}+1$ and $x+y=3$ i.e., $y=3-x$, we have $x^{2}+1=3-x \Rightarrow x^{2}+x-2=0$
$\Rightarrow x=-2,1$ and $3-x \geq x^{1}+1$
$\therefore$ Required area is $\iint_{\pi} d y d x$
$=\int_{u=x}^{1}\left[\int_{y=x^{2}+1}^{y-x} d y\right] d x$
$=\int_{-1}^{1}\left\{(3-x)-\left(x^{1}+1\right)\right\} d x$
$=\left(\frac{-x^{y}}{3}-\frac{x^{2}}{2}+2 x\right)_{-2}^{1}=\frac{9}{2}$
29. Ans. C.

Resolving components w.r.t x-axis

$\mathrm{EF} \mathrm{r}_{u} \Rightarrow \mathrm{P} \cos 60^{\circ}+\cos (60+45)+\mathrm{R}$
$\cos (90+45+60)$
$\Sigma F_{u}=100 \cos 60^{\circ}+250 \cos (95)+100 \cos$
(195)
$z F_{u}=-159.6 \mathrm{kN}$
$\Sigma F_{u}=P \sin 60+Q \sin (60+45)+R \sin$
$(90+45+60)=100 \sin 60+250 \sin (95)+$
$100 \sin (195)$
$\Sigma F_{u}=289.3 \mathrm{kN}$
$|F|=\sqrt{F_{u}^{2}+F_{v}^{2}}=\sqrt{(-159.6)^{2}+(289.3)^{2}}$
$=330.4 \mathrm{kN}$
$\tan \theta=\frac{F_{y}}{F_{u}}=\frac{289.3}{-159.6} \Rightarrow \theta=-61.1^{*}$
0. w.r.t $x-a x i s=180-61.1=118.9^{\circ}$
30. Ans. A.

$$
\begin{aligned}
& D E \operatorname{is}\left(D^{4}+3 D^{2}\right) \cdot y=108 x^{2}, D=\frac{d}{d x} \\
& A E E:-m^{4}+3 m^{2}=0 \Rightarrow m^{2}\left(m^{2}+3\right)=0 \\
& \Rightarrow m=0,0, \pm \sqrt{3} \\
& \therefore C F=\left(C_{1}+C_{2} x\right)+C_{2} \sin (\sqrt{3 x}) \\
& +C_{4} \cos (\sqrt{3 x}) \\
& \text { and } P I=\frac{1}{D^{4}+3 D^{2}}\left(108 x^{2}\right) \\
& \qquad=\frac{36}{D^{2}}\left[1+\frac{D^{2}}{3}\right]^{-1}\left(x^{2}\right) \\
& =\frac{36}{D^{2}}\left[1-\frac{D^{2}}{3}+\ldots\right]\left(x^{2}\right)=\frac{36}{D^{2}}\left[x^{z}-\frac{1}{3}(2)+0\right] \\
& =\left[\int\left(36 x^{2}-\frac{2}{3}\right) d x d x=36\left(\frac{x^{4}}{(4)(3)}-\frac{2}{3} \frac{x^{z}}{(2)(1)}\right)\right. \\
& =3 x^{4}-12 x^{2}
\end{aligned}
$$

31. Ans. D.
$20 \mathrm{kN} / \mathrm{m}$

$E I=30 \times 10^{8} \mathrm{~N}-\mathrm{m}^{2}$
$R_{p}=R_{4}=10 \mathrm{kN}$

$$
\begin{aligned}
& M(x)=-E L \frac{d^{\prime} y}{d x^{2}}=10 x \quad(0 \leq x \leq 1) \\
& =10(1+y)-20 y(0.5-y / 2)(0 \leq y \leq 0.5)
\end{aligned}
$$


$\frac{d y}{d x}$. $\left.\frac{d y}{d x \mid} \right\rvert\,$
$\Rightarrow 5+C_{1}=-4.583$
$\Rightarrow C_{1}=-9.583$
So,
$\left.\frac{d y}{d x}\right|_{\max }=\frac{C_{1}}{E I}=\frac{-9.583}{30 \times 10^{4}}=-3.19 \times 10^{-7}$
32. Ans. D.

By principal of superposition,
$\delta_{\text {max } 1}=\delta_{\text {maxy }}$ and $\theta_{\text {max } 1}=\theta_{\text {max }}$
33. Ans. A.

Conditions for zero force members are
(i) The member meets at a joint and they are noncollinear and no external force acts at that joint. Both the members will be the zero force members.
(ii) When the members meet at joint and two are collinear and no external force acts at the joint then third member will be zero force member.
According to the above statements
We can say that
FT, TG, HU, MP and PL members are zero force members.
34. Ans. D.


Taking moments about $A=0$
$\Rightarrow R_{\mathrm{gn}} \times 8+\mathrm{P} \times 1.5=0$
$\Rightarrow R_{\mathrm{gn}}=\frac{-1.5 P}{8}$
$\Sigma F_{W}=0$
$\Rightarrow R_{m n}=R_{m i n}=\frac{1.5 P}{8}$
$\Sigma F_{v}=0$
$\Rightarrow R_{w}=P$
35. Ans. B.

Given: Width of beam (b) $=250 \mathrm{~mm}$
Effective depth (d) $=400 \mathrm{~mm}$
As per IS-456:200
From clause 26.5.1.1 (a)
Minimum tension reinforcement
$\frac{A_{a}}{b d}=\frac{0.85}{f_{v}}$


From clause 26.5.1.2(b)
Maximum tension reinforcement
$=0.04 \mathrm{bd}=0.04 \times 250 \times 400=4000 \mathrm{~mm}^{2}$
36. Ans. B.

Long term elasticity


$$
E_{c}=5000 \sqrt{t_{\alpha}}
$$

$$
=5000 \sqrt{25}
$$

$=500 \times 5$
$=25000$
Creep coefficient
$(\theta)=1.5$
long term elasticity
$=\frac{25000}{1+1.5}=10,000$
37. Ans. B.
$-M_{B} \theta-M_{B} \theta-M_{\nabla} \theta+\mathrm{P} \times \frac{\mathrm{L}}{2} \theta=0$
$3 M_{B} \theta=\frac{P L \theta}{2}$
$P=\frac{8 M_{\mathrm{F}}}{\mathrm{L}}$
38. Ans. B.

Maximum force carried by plates,
$\mathrm{P}=\frac{\mathrm{A}_{\mathrm{g}} \mathrm{F}_{\mathrm{v}}}{y_{\mathrm{m}_{b}}}=\frac{100 \times 12 \times 250}{1.1}=272.73 \mathrm{kN}$
Load carried by each weld
$=\frac{\mathrm{P}}{\mathbf{2}}=\mathbf{1 3 6 . 3 6 \mathrm { kN }}$
For minimum length of weld,
Strength of weld=Load carried by weld

$\mathrm{I}_{n}=102.9 \mathrm{~mm}$ next multiple of 5 is w 105 mm
39. Ans. B.

$$
\begin{aligned}
& t_{e}=\frac{8+4 \times 10+14}{6}+\frac{6+8 \times 4+11}{6}+ \\
& \frac{5+7 \times 4+10}{6}+\frac{7+4 \times 12+18}{6} \\
&=10.333+8.1666+7.1666+12.166 \\
&=37.8328
\end{aligned}
$$

40. Ans. A.
$\boldsymbol{\eta}=0.7=\frac{V_{v}}{V}$
$\mathrm{S}=40 \%=0.40=\frac{\mathrm{V}_{\mathrm{v}}}{\mathrm{V}_{\mathrm{v}}}$
$V=V_{\mathrm{v}}+V_{\mathrm{w}}+V_{\mathrm{v}} \Rightarrow V_{\mathrm{v}}+V_{\mathrm{E}} \mathrm{V}=\frac{V_{v}}{0.7}$,
$V_{v}=0.7 \mathrm{~V}$
$0.40=\frac{V_{\mathrm{ve}}}{\mathrm{V}_{\mathrm{w}}}$
$V_{w}=0.4 V_{v}$
$V_{v}-V_{v}=0.4 V_{v}$
$V_{v}-0.4 V_{v}=V_{v}$
$V_{u}=0.6 V_{v}$
$V_{\mathrm{m}}=0.6 \times 0.7 \mathrm{~V}=0.6 \times 0.7 \times 100$
$V_{\mathrm{a}}=42 \mathrm{~m}^{2}$
41. Ans. A.

$\because K_{8} y H=40 \Rightarrow K_{5} y=\frac{40}{H}$
So, $P_{\mathrm{I}}=\frac{1}{\mathbf{2}} \mathrm{~K}_{5} \mathrm{yH}^{\prime 2}=\mathbf{2 0 H}=120 \mathrm{kN}$
Taking moment about $\mathbf{P}=\mathbf{0}$
$\Rightarrow P_{\pi} \times 2=W \times 2$
$\Rightarrow \mathrm{P}_{\mathrm{B}}=\mathrm{W}=120 \mathrm{kN}$
42. Ans. D.


For clay:
$\mathrm{w}=25 \%=0.25$
$e g=W G$
$e=\frac{W G}{8}=\frac{0.25 \times 2.7}{1}=0.675$
$y_{\text {mic }}=y_{m 0}-y_{m}$
$=\left(\frac{\mathrm{G}+\mathrm{e}}{1+e}\right) y_{m}-y_{m}$
$=\left(\frac{G+e}{1+e}\right) y_{1 m}=\left(\frac{2.7-1}{1+0.675}\right) \times 10$
$=10.15 \mathrm{kN} / \mathrm{m}^{\mathrm{I}}$
$\bar{\sigma}($ Before Compaction $)=17 \times 1+0.5 \times 10.15$
$=17+5.075$
$=22.075 \mathrm{kN} / \mathrm{m}^{\mathrm{I}}$
<Pre consolidation pressure ( 60 KPa )
Hence Over consolidation stage
$\bar{\sigma}$ (After Compaction)
$=2.5 \times 20+17 \times 1+0.5 \times 10.15$
$=50+17+5.075$
$=72.075 \mathrm{kN} / \mathrm{m}^{2}>60 \mathrm{kPa}$
Hence Normal consolidation stage
Total settlement
$=\frac{\mathrm{C}_{\mathrm{R}} \mathrm{H}_{\mathrm{B}}}{1+\mathrm{e}_{\mathrm{B}}} \log \left(\frac{\bar{\sigma}_{c}}{\sigma_{\mathrm{B}}}\right)+\frac{\mathrm{C}_{\mathrm{B}} \mathrm{H}}{1+\mathrm{C}_{\mathrm{B}}} \log \left(\frac{\bar{\sigma}_{\mathrm{B}}+\Delta \bar{\sigma}}{\bar{\sigma}_{c}}\right)$
$C_{h}=0.05$
$\left.C_{k}=\frac{\Delta e}{\log \left(\overline{\sigma_{2}}\right.} \overline{\sigma_{1}}\right) \quad 0.05$
$\Delta e=0.05 \log \left(\frac{60}{22.075}\right)$
$\Delta e=0.0217$
$0.6750-e_{6}=0.0217$
$\Theta_{\mathrm{s}}=\mathbf{0 . 6 5 3} \Rightarrow$ For over consolidation stage
$\Delta \mathrm{H}=\frac{0.05 \times 1000}{1+0.653} \log \left(\frac{60}{22.075}\right)+$
$\frac{0.05 \times 1000}{1+0.675} \log \left(\frac{72.075}{60}\right)$
$=30.25 \times \log \left(\frac{60}{22.075}\right)+298.5 \log \left(\frac{72.075}{80}\right)$
$=30.25 \times 0.434+298.5 \times 0.0796$
$=13.13+23.76$
$=36.89 \mathrm{~mm}$
43. Ans. C.

Effective stress at $\mathrm{x}-\mathrm{x}, \boldsymbol{\sigma}-\mathrm{u}$
$=5 \times y_{\text {mus }}+\frac{3}{6} \times 5 y_{m}$
$=5 \times(18-9.81)+2.5 \times 9.81$
$=40.95+24.5=65.475 \mathrm{kN} / \mathrm{m}^{2}$
44. Ans. A.

Given effective shear strength parameters are effective are
$C^{\prime}=15 \mathrm{KPa}, \quad \sigma_{6}=200 \mathrm{KPa}$
$\psi^{\prime}=22^{\circ}, \quad \mathrm{U}=150 \mathrm{KPa}$
$\sigma_{c}^{\prime}=\sigma_{c}-\mathrm{U}=\mathbf{2 0 0}-\mathbf{1 5 0}=\mathbf{5 0 K P a}$
We know that
$\sigma_{1 f}^{\prime}=\sigma_{c}^{\prime}+\sigma_{d}^{\prime}$
$\sigma_{\text {䃴 }}^{\prime}=\sigma_{c}^{\prime}=50 \mathrm{KPa}$
$\sigma_{1 f}^{\prime}=\sigma_{\mathrm{id}}^{\prime} \mathrm{N}_{4}+2 \mathrm{C} \sqrt{\mathbb{N}_{1}}$
$N_{1}=\tan ^{2}\left(45+\frac{\phi^{\prime}}{2}\right)=\tan ^{2}\left(45+\frac{22}{2}\right)$
$=\tan ^{2}(45+11)=\tan ^{2}(56)=2.198$
$\sigma_{1 f}^{\prime}=50 \times 2.198+2 \times 15 \times \sqrt{2198}$
$=109.9+30 \times(1.483)$
$=109.9+44.49=154.39$
$\sigma_{1 f}^{\prime}=154.39$
$\sigma_{c}^{\prime}+\sigma_{d}^{\prime}=154.39$
$\sigma_{d}^{\prime}=154.39-\sigma_{c}^{\prime}$
$=154.39-50$

## Deviator atress $\left(\sigma_{t}^{\prime}\right)=104.39$

45. Ans. A.

$y_{w} \times \mathrm{H}_{1}$
$=10 \times 65=650 \mathrm{kN} / \mathrm{m}^{2}$
$y_{n 1} \mathrm{H}_{2}+\frac{1}{3} y_{m}\left(\mathrm{H}_{2}-\mathrm{H}_{1}\right)$
$=50+\frac{1}{3} \times 10 \times 60=250 \mathrm{kN} / \mathrm{m}^{2}$
$P=\frac{1}{2} \times(650+250) \times 10+\frac{1}{2} \times(250+50) \times 40$
$=45000+6000$
$=10500 \mathrm{kN} / \mathrm{m}$
46. Ans. B.

Flow is normal to bedding flame
$K_{\mathrm{ovi}}=\frac{\Sigma_{z_{1}}}{\Sigma_{\mathrm{K}_{1}}}=\frac{20+30+10}{\frac{20}{3}+\frac{30}{3}+\frac{10}{1}}=2 \mathrm{~m} /$ day
$i=\frac{\text { Head difference }}{\text { Length }}=\frac{15-10}{60}=\frac{5}{60}=\frac{1}{12}$

## Seepage diacharge

$q=K_{\mathrm{swa}} \times i \times A=2 \times \frac{1}{12} \times 3 \times 1$
$=0.5 \mathrm{~m}^{1} / \mathrm{day} / \mathrm{m}$
47. Ans. B.

Given discharge $(Q)=16 \mathrm{~m}^{1} / \mathrm{gec}$.
Bed slope ( S ) $=0.001$
Manning"s roughness coefficients ( $n$ ) $=0.012$

## $g=10 \mathrm{~m} / \mathrm{s}^{7}$

Width $(B)=4 \mathrm{~m}$
Channel is wide rectangular


Area $(A)=B . y$
Perimeter $(P)=B$
Hydraulic Radius (R)
$=\frac{A}{P}=\frac{B y}{B}=y$
$Q=\frac{1}{n}=A R^{2 / 1} S^{1 / 2}$
$16=\frac{1}{0.02}(4 \times y) \cdot y^{2 / 1} s^{1 / 2}$
For meanings equation
$16 \times 0.012$
$\frac{16 \times 0.012}{4 \times \sqrt{0.001}}=y^{3 / 4}$
$y=2.95 \mathrm{~m}$
$y_{c}=\left(\frac{q^{2}}{g}\right)^{1 / 1}$
$=\left(\frac{4^{2}}{10}\right)^{1 / 1} \quad q=\frac{Q}{B}=\frac{16}{4}=4$
$y_{c}=1.189 \mathrm{~m}$
$\mathrm{y}>\mathrm{y}_{G} \Rightarrow$ Channel is mild slope
48. Ans. A.

$F_{\mathrm{H}}=\frac{1}{2} \times \frac{1000 \times 10 \times(5)^{2}}{1000} \mathrm{KN}=125 \mathrm{kN}$
$F_{H}$ acts at a distance $\frac{\mathbf{5}}{\mathbf{3}}=\mathbf{1 . 6 7} \mathrm{m}$ from the base.
$F_{V}=$ Weight of water enclosed or supported (actual or imaginary) by the curved surface
$=\rho g \times$ Vaccum of portion ABC
$=1000 \times 10 \times\left[\frac{1}{2} \times 25 \times \frac{60}{180} \times \pi-2 \times \frac{1}{2} \times \frac{5}{2} \times \frac{5 \sqrt{3}}{2}\right]$
$=1000 \times 10 \times\left[\frac{25}{6} \times \pi-1.25 \times 5 \sqrt{3}\right]$
$=1000 \times 10 \times 2.27 \times 1 \mathrm{~N}$
$=22.7 \mathrm{kN}$
$F_{\mathrm{R}}=\sqrt{F_{\mathrm{N}}^{2}+\mathrm{F}_{\mathrm{k}}^{2}}=\sqrt{(125)^{2}+(22.7)^{2}}=127 \mathrm{kN}$
49. Ans. B.


For Hydraulically efficient channel,
$B=\frac{2}{\sqrt{3}}, y=\frac{2}{\sqrt{3}} \times 2=\frac{4}{\sqrt{3}}=2.3 \mathrm{im}$
50. Ans. B.

A
$P^{H}=4.2, P^{0 H}=9.8$,
$\Rightarrow\left[\mathrm{OH}^{-}\right]=10^{-3.4} \mathrm{~mol} / \mathrm{L}$
B
$\left[\mathrm{OH}^{-}\right]=2 \times 10^{-3.4} \mathrm{~mol} / \mathrm{L}$
$\Rightarrow \mathrm{P}^{\mathrm{CN}}=9.8-\log _{18} 2=9.5$
$\Rightarrow P^{H}=4.5$
51. Ans. C.
$A=\frac{-Q}{W e} \ln \left(1-\%_{B}\right)$
So,
$\frac{A_{1}}{\operatorname{In}\left(1-\eta_{1}\right)}=\frac{A_{2}}{\operatorname{In}\left(1-\eta_{2}\right)}$
$\Rightarrow \frac{5600}{\ln (1-9.6)}=\frac{A}{\ln (1-0.99)}$
$\Rightarrow A=8011.8 \mathrm{~m}^{2}$
52. Ans. C.

$$
\begin{align*}
& B O D_{2}=L_{8} \times\left(1-e^{-k v i z}\right) \\
& \Rightarrow 100=L_{0} \times\left(1-e^{-2 k}\right) \tag{1}
\end{align*}
$$

Also, $155=\mathrm{L}_{8} \times\left(1-\mathrm{e}^{-\mathrm{s}}\right)$
(i) / (ii)

## $\Delta$ TST $^{\prime} ; \tan 16.5^{s}=\frac{T^{\prime} T}{X}$

$\Delta T R T^{\circ}, \tan \left(10.5^{\circ}\right)=\frac{T^{\circ}}{x+80}=\frac{T^{\prime} T+2}{x+80}$
From (i) and (ii)
$x \times 0.296=(x+10) \times \tan \left(10.5^{\circ}\right)-2$
$\Rightarrow x \times 0.296=(x+10) \times 0.185-2$
$\Rightarrow x=82.25 \mathrm{~m}$
So,
$T^{*} T=82.25 \times 0.296=24.35 \mathrm{~m}$
So, RL of top of tower
$=450+2.555+24.35=476.05 \mathrm{~m}$

