1. The parameters in Horton's infiltration equation $\left[f(t)=f_{c}+\right.$ $\left.\left(f_{0}-f_{c}\right) e^{-k t}\right]$ are given as, $f_{0}=7.62 \mathrm{~cm} /$ hour, $\mathrm{f}_{c}=1.34 \mathrm{~cm} /$ hour and k $=4.182 /$ hour. For assumed continuous ponding the cumulative infiltration at the end of 2 hours is
(A) 2.68 cm
(B) 1.50 cm
(C) 1.34 cm
(D) 4.18 cm

Ans:

$$
\begin{aligned}
\mathrm{f}(\mathrm{t})= & \mathrm{f}_{\mathrm{c}}+\left(\mathrm{f}_{0}-\mathrm{f}_{\mathrm{c}}\right) \mathrm{e}^{-\mathrm{kt}} \\
& \mathrm{f}_{\mathrm{o}}=7.62 \mathrm{~cm} / \mathrm{h} \\
& \mathrm{f}_{\mathrm{c}}=1.34 \mathrm{~cm} / \mathrm{h} \\
\mathrm{~K} & =4.182 / \mathrm{h} \\
& \int_{0}^{2} \mathrm{f}(t) d t \\
& =\int_{0}^{2} 1.34+(7.62-1.34) \mathrm{e}^{-4.182 \mathrm{t}} \mathrm{dt} \\
& \left.=1.34 t+6.28 \frac{\mathrm{e}^{-4.182 \mathrm{t}}{ }^{2}}{-4.182}\right]_{0} \\
& =\left(1.34 \times 2+6.28 \frac{e^{-4.182 \times 2}}{-4.182}\right)-\underbrace{(6.28}_{-4.182})
\end{aligned}
$$

$$
=4.18 \mathrm{~cm}
$$

2. The direct runoff hydrograph of a storm obtained from a catchment is triangular in shape and has a base period of 80 hours. The peak flow rate is $30 \mathrm{~m}^{3} / \mathrm{s}$ and catchment area is $86.4 \mathrm{~km}^{2}$. The rainfall excess that has resulted the above hydrograph is
(A) $5 \mathrm{~cm} \quad$ (B) 8 cm
(C) 10 cm (D) 16 cm

Ans:

$$
\begin{aligned}
& \frac{1}{2} \times 80 \times 3600 \times 30=86.4 \times 10^{6} \times \frac{h}{100} \\
& h=5 \mathrm{~cm}
\end{aligned}
$$

3. The rainfall on five successive days in a catchment were measured as 3, $8,12,6$, and 2 cms . If the total runoff at the outlet from the catchment was 15 cm , the value of the $\phi$-index (in $\mathrm{mm} /$ hour) is
(A) 0.0
(B) 1.04
(C) 1.53
(D) Sufficient information not available

Ans:


$$
\begin{aligned}
& \text { Total runoff }=15 \mathrm{~cm} \\
& \text { By observation, } \\
& \text { Runoff above } 6 \mathrm{~cm}=8 \mathrm{~cm} \\
& \text { Runoff above } 3 \mathrm{~cm}=17 \mathrm{~cm} \\
& \text { So } 15 \text { is in between } 3 \text { and } 6 \\
& 8+(6-\emptyset) 3=15 \\
& \begin{array}{r}
\therefore \emptyset=3.667 \mathrm{~cm} / \text { day } \\
\quad=0.153 \frac{\mathrm{~cm}}{\mathrm{hr}}=1.53 \mathrm{~mm} / \mathrm{hr}
\end{array}
\end{aligned}
$$

4. During a 6 -hour storm, the rainfall intensity was $0.8 \mathrm{~cm} /$ hour on a catchment of area $8.6 \mathrm{~km}^{2}$. The measured runoff volume during this period was $2,56,000 \mathrm{~m}^{3}$. The total rainfall was lost due to infiltration, evaporation, and transpiration (in $\mathrm{cm} /$ hour) is
(A) 0.80
(B) 0.304
(C) 0.496
(D) Sufficient information not available

Ans:

$$
\begin{aligned}
\text { Volume of water } & =\text { Area } \times \text { depth } \\
& =8.6 \times 10^{6} \times \frac{0.8 \times 6}{100}=412800 \mathrm{~m}^{3} \\
\text { Run off volume } & =2,56,000 \mathrm{~m}^{3} \\
\text { Loss of water } & =412800-256000 \\
& =156,800 \mathrm{~m}^{3}
\end{aligned}
$$

$$
\begin{aligned}
\hline \text { In terms of depth }=\frac{\text { volume lost }}{\text { area }} & =\frac{156,800}{8.6 \times 10^{6}} \\
& =0.0182 \mathrm{~m}=1.82 \mathrm{~cm} \\
\text { Per hour } & =\frac{1.82}{6}=0.304 \mathrm{~cm} / \mathrm{hr}
\end{aligned}
$$

5. The vertical hydraulic conductivity of the top soil at certain is 0.2 $\mathrm{cm} / \mathrm{hr}$. A storm of intensity $0.5 \mathrm{~cm} / \mathrm{hr}$ occurs over the soil for an indefinite period. Assuming the surface drainage to be adequate, the infiltration rate after the storm has lasted for a very long time, shall be
(a) Smaller than $0.2 \mathrm{~cm} / \mathrm{hr}$
(b) $0.2 \mathrm{~cm} / \mathrm{hr}$
(c) Between 0.2 and $0.5 \mathrm{~cm} / \mathrm{hr}$
(d) $0.5 \mathrm{~cm} / \mathrm{hr}$

Ans: (a)
6. The plan area of a reservoir is $1 \mathrm{~km}^{2}$. The water level in the reservoir is observed to decline by 20 cm in a certain period. During this period the reservoir receives a surface inflow of 10 hectare-meters, and 20 hectaremeters are subtracted from the reservoir for irrigation and power. The pan evaporation and rainfall recorded during the same period at a nearby meteorological station are 12 cm and 3 cm respectively. The calibrated pan factor is 0.7 . The seepage has from the reservoir during this period in hectare-meters is
(a)
0.0
(b) 1.0
(c) 2.4
(d) 4.6
Ans:

| Inflow of water | $=10 \times 10^{4} \mathrm{~m}^{3}$ |
| :--- | :--- |
| Out flow | $=20 \times 10^{4} \mathrm{~m}^{3}$ |
| Rainfall | $=3 \mathrm{~cm}$ |
| Volume of rain fall | $=1 \times 10^{6} \times \frac{3}{100}=3 * 10^{4} \mathrm{~m}^{3}$ |
| Evaporation | $=0.7 \times 12=8.4 \mathrm{~cm}$ |
| Volume of evaporation | $=\frac{8.4}{100} \times 1 \times 10^{6}=8.4 \times 10^{4} \mathrm{~m}^{3}$ |
| Net decrease of volume | $=(10-20+3-8.4) \times 10^{4} \mathrm{~m}^{3}$ |
|  | $=-15.4 \times 10^{4} \mathrm{~m}^{3}$ |
| In term of depth | $=\frac{-15.4 \times 10^{4}}{10^{6}}=-0.154 \mathrm{~m}$ |
|  | $=-15.4 \mathrm{~cm}$ |

Observed decrease of level $=20 \mathrm{~cm}$
Seepage $=20-15.4=4.6 \mathrm{~cm}$
7. An average rainfall of 16 cm occurs over a catchment during a period of 12 hours with uniform intensity. The unit hydrograph (unit depth $=1$ cm , duration $=6$ hours) of the catchment rises linearly from 0 to 30 cumecs in six hours and then falls linearly from 30 to 0 cumecs in the next 12 hours. $\varphi$ index of the catchment is known to be $0.5 \mathrm{~cm} / \mathrm{hr}$. Base flow in the river is known to be 5 cumecs. Peak discharge of the resulting direct runoff hydrograph shall be
(a) 150 cumecs
(b) 225 cumecs
(c) 230 cumecs
(d) 360 cumecs

Ans:
The rainfall in first 6 hours $=8 \mathrm{~cm}$
The rainfall in second 6 hours $=8 \mathrm{~cm}$

$\varphi$ - index $=0.5 \mathrm{~cm} / \mathrm{hr}$
in $6 \mathrm{hr}=$ loss $=6 \times 0.5=3 \mathrm{~cm}$
Net $=8-3=5 \mathrm{~cm}$
The direct runoff hydrograph


Total at $12^{\text {th }}$ hour $=75+150=225 \mathrm{~m}^{3} / \mathrm{s}$
Base flow $=5 \mathrm{~m}^{3} / \mathrm{s}$
The total flow $=225+5=230 \mathrm{~m}^{3} / \mathrm{s}$
8. An average rainfall of 16 cm occurs over a catchment during a period of 12 hours with uniform intensity. The unit hydrograph (unit depth $=1$ cm , duration $=6$ hours) of the catchment rises linearly from 0 to 30 cumecs in six hours and then falls linearly from 30 to 0 cumecs in the next 12 hours. $\varphi$ index of the catchment is known to be $0.5 \mathrm{~cm} / \mathrm{hr}$. Base flow in the river is known to be 5 cumecs. Area of the catchment in hectares is
(a) 97.20
(b) 270
(c) 9720
(d) 2700
Ans:
$\mathrm{A} \times 10^{4} \frac{5}{100}=1 / 2 \times 18 \times 3600 \times 150$
$\therefore \mathrm{A}=9720$ ha.
9. The rainfall during three successive 2 hour periods is $0.5,2.8$ and 1.6 cm . The surface runoff resulting from this storm in 3.2 cm . The $\emptyset$ index value of the storm is
(a) $0.20 \mathrm{~cm} / \mathrm{hr}$
(b) $0.27 \mathrm{~cm} / \mathrm{hr}$
(c) $0.30 \mathrm{~cm} / \mathrm{hr}$
(d) $0.80 \mathrm{~cm} / \mathrm{hr}$

Ans:
Total rainfall in $6 \mathrm{hr}=0.5+2.8+1.6=4.9 \mathrm{~cm}$ Surface runoff $=3.2 \mathrm{~cm}$


The $\emptyset$ - index is above 0.5 cm

$$
\begin{aligned}
\therefore 1.2+(\emptyset-0.5) 2 & =3.2 \\
\emptyset-0.5 & =1 \\
\emptyset=1+0.5 & =0.6 \mathrm{~cm} / 2 \mathrm{hr}=0.3 \mathrm{~cm} / \mathrm{hr}
\end{aligned}
$$

10. The intensity of rain fall and time interval of a typical storm are

| Time interval <br> (minutes) | Intensity of rainfall <br> $(\mathbf{m m} /$ minute $)$ |
| :--- | :---: |
| $0-10$ | 0.7 |
| $10-20$ | 1.1 |
| $20-30$ | 2.2 |
| $30-40$ | 1.5 |
| $40-50$ | 1.2 |
| $50-60$ | 1.3 |
| $60-70$ | 0.9 |
| $70-80$ | 0.4 |

The maximum intensity of rainfall for 20 minutes duration of the storm is
(a) $1.5 \mathrm{~mm} /$ minute
(b) $1.85 \mathrm{~mm} /$ minute
(c) $2.2 \mathrm{~mm} /$ minute
(d) $3.7 \mathrm{~mm} /$ minute

Ans:
Maximum rainfall for 20 minutes
Maximum of $0.7+1.1=1.8 \times 10=18$
$1.1+2.2=3.3 \times 10=33$
$2.2+1.5=3.7 \times 10=37$
$1.5+1.2=2.7 \times 10=27$
$1.2+1.3=2.5 \times 10=25$
$1.3+0.9=2.2 \times 10=22$
$0.9+0.4=1.3 \times 10=13$
Maximum is 37 mm in 20 min
$37 / 20=1.85 \mathrm{~mm} /$ minute
11. During a 3 hour storm event, it was observed that all abstractions other than infiltration are negligible. The rainfall was idealized as 3 one hour storms of intensity $10 \mathrm{~mm} / \mathrm{hr}, 20 \mathrm{~mm} / \mathrm{hr}$ and $10 \mathrm{~mm} / \mathrm{hr}$ respectively and the infiltration was idealized as a Horton curve, $\mathrm{f}=6.8+8.7$ exp ( -t ) ( f in $\mathrm{mm} / \mathrm{hr}$ and t in hr ). What is the effective rainfall?
(a) 10.00 mm (b) 11.33 mm
(c) 12.43 mm (d) 13.63 mm

```
Ans:
Total rainfall \(=10+20+10=40 \mathrm{~mm}\)
Infiltration \(\int_{0}^{3} f(t) d t\)
                    \(=\int_{0}^{3}\left(6.8+8.7_{-t} e^{-t}\right) d t\)
                    \(=6.8 \mathrm{t}+8.7 \frac{\left.e^{-t}-\right]^{3}}{-1} \underline{0}_{3}\)
                    \(=\left(6.8 \times 3+8.7 \frac{e}{-1}\right)-\left(\frac{(8.7}{-1}\right)\)
                    \(=28.67 \mathrm{~mm}\)
Effective rainfall \(=40-28.67=11.33 \mathrm{~mm}\)
```

12. An isolated 4-hour storm occurred over a catchment as follows
Time $\quad 1$ st hr $\quad 2 \mathrm{ndhr} \quad 3 \mathrm{rdhr} \quad 4$ th hr

| Rainfall (mm) | 9 | 28 | 12 | 7 |
| :--- | :--- | :--- | :--- | :--- |

The $\varphi$ index for the catchment is $10 \mathrm{~mm} / \mathrm{h}$. The estimated runoff depth from the catchment due tothe above storm is
(a) 10 mm
(b) 16 mm
(c) 20 mm
(d) 23 mm

Ans:

$$
\begin{aligned}
\text { Run off } & =(28-10)+(12-10) \\
& =18+2=20 \mathrm{~mm}
\end{aligned}
$$

13. The ordinates of a 3-h unit hydrograph at 1 hour intervals starting from time $\mathrm{t}=0$, are $0,3,8,6,3,2$ and $0 \mathrm{~m}^{3} / \mathrm{s}$. Use trapezoidal rule for numerical integration, if required. What is the catchment area represented by the unit hydrograph?
(A) $1.00 \mathrm{~km}^{2}$
(B) $2.00 \mathrm{~km}^{2}$
(C) $7.92 \mathrm{~km}^{2}$
(D) $8.64 \mathrm{~km}^{2}$

Ans:

$$
\begin{aligned}
& \text { volume }=\frac{0+3}{2}+\frac{3+8}{2}+\frac{8+6}{2}+\frac{6+3}{2}+\frac{3+2}{2}+\frac{2+0}{2}=22 \\
& 3600 \times 22=1 \times 10^{-2} \times \frac{A}{106} \\
& A=7.92 \mathrm{~km}^{2}
\end{aligned}
$$

14. The ordinates of a 3-h unit hydrograph at 1 hour intervals starting from time $\mathrm{t}=0$, are $0,3,8,6,3,2$ and $0 \mathrm{~m}^{3} / \mathrm{s}$. Use trapezoidal rule for numerical integration, if required. A storm of 6.6 cm occurs uniformly over the catchment in 3 hours. If $\emptyset$ index is equal to $2 \mathrm{~mm} / \mathrm{hand}$ base flow is $5 \mathrm{~m}^{3} / \mathrm{s}$, what is the peak flow due to the storm?
(A) $41 \mathrm{~m}^{3} / \mathrm{s}$
(B) $43.4 \mathrm{~m}^{3} / \mathrm{s}$
(C) $53.0 \mathrm{~m}^{3} / \mathrm{s}$
(D) $56.2 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { Maximum ordinate of } U H=8 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { Effective rainfall in } 3 \text { hours }=6.6-0.2 \times 3=6 \mathrm{~cm} \\
& \text { Peak flow of } S H=8 \times 6+5=53 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

15. The annual precipitation data of a city is normally distributed with mean and standard deviation as 1000 mm and 200 mm , respectively. The probability that the annual precipitation will be more than 1200 mm is
(A) $<50 \%$
(B) $50 \%$
(C) $75 \%$ (D) $100 \%$

Ans: < $50 \%$
16. The ratio of actual evapo-transpiration to potential evapo-transpiration is in the range
(A) 0.0 to 0.4
(B) 0.6 to 0.9
(C) 0.0 to 1.0
(D) 1.0 to 2.0

Ans: (C)
17. The top width and the depth of flow in a triangular channel were measured as 4 m and 1 m , respectively. The measured velocities on the Centre line at the water surface, 0.2 m and 0.8 m below the surface are $0.7 \mathrm{~m} / \mathrm{s}, 0.6 \mathrm{~m} / \mathrm{s}$ and $0.4 \mathrm{~m} / \mathrm{s}$, respectively. Using two-point method of velocity measurement, the discharge (in $\mathrm{m} 3 / \mathrm{s}$ ) in the channel is
(A) 1.4 (B) 1.2 (C) 1.0 (D) 0.8

Ans:

$$
\begin{aligned}
& \text { Average velocity }=\frac{0.6+0.4}{2}=0.5 \mathrm{~m} / \mathrm{s} \\
& -v_{0.2}+v_{0.8}^{2} \\
& \text { Area }=1 / 2 \times 1 \times 4=2 \mathrm{~m}^{2} \\
& \text { Discharge }=0.5 \times 2= \\
& 1 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

Group I contains parameters and Group II lists methods/instruments. Group I Group II
P. Streamflow velocity 1. Anemometer
Q. Evapo-transpiration rate 2. Penman'smethod
R. Infiltration rate 3. Horton's method
S. Wind velocity 4. Current meter

The CORRECT match of Group I with Group II is
(A) $\mathrm{P}-1, \mathrm{Q}-2, \mathrm{R}-3, \mathrm{~S}-4$
(B) $\mathrm{P}-4, \mathrm{Q}-3, \mathrm{R}-2, \mathrm{~S}-1$
(C) $P-4, Q-2, R-3, S-1$
(D) $\mathrm{P}-1, \mathrm{Q}-3, \mathrm{R}-2, \mathrm{~S}-4$

Ans: (C)
19. A 1-h rainfall of 10 cm magnitude at a station has a return period of 50 years. The probability that a 1-h rainfall of magnitude 10 cm or more will occur in each of two successive years is:
A) 0.04 (B) 0.2 (C) 0.02 (D) 0.0004

Ans:

$$
\begin{aligned}
& \overline{1} \times \overline{1}=0.0004 \\
& 50
\end{aligned}
$$

20. An isohyet is a line joining points of
(A) Equal temperature
(B) Equal humidity
(C) Equal rainfall depth
(D) Equal evaporation

Ans: (C)
21. A lake had a water surface elevation of 103.2 m above datum at the beginning of a certain month. In that month the lake received an average inflow of $6.0 \mathrm{~m}^{3} / \mathrm{s}$ from surface runoff sources. In the same period the out flow from the lake had an average value of $6.5 \mathrm{~m}^{3} / \mathrm{s}$. Further, in that month, the lake received a rainfall of 145 mm and evaporation from the lake surface was estimated 6.10 cm . The average lake surface area can be taken as 5000ha. What is the elevation of water at the end of month
a) 103.58 b) 103.258 c) 103.058 d) 103.508

Ans:

$$
\begin{aligned}
& \text { Inflow volume }=6 \times 86400 \times 30=15.552 \times 10^{6} \mathrm{~m}^{3} \\
& \text { out flow volume }=6.5 \times 86400 \times 30=16.848 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Rainfall } \quad=0.145 \times 5000 \times 10^{4}=7.25 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Evaporation } \quad=\frac{6.1}{100} \times 500 \times 10^{4}=3.05 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Net } \quad(15.552+7.25-16.848-3.05) \times 10^{6}=2.904 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Depth of increase }=\frac{2.90410^{6}}{5000 \times 10^{4}}=0.058 \\
& \text { Present elevation }=103.2+0.058=103.258 \mathrm{~m}
\end{aligned}
$$

22. A small catchment of area 150 ha received a rainfall of 10.5 cm in 90 min . due to a storm. At the outlet of the catchment. The stream draining the catchment was dry before the storm and experienced a runoff lasting for 10 hours within an average discharge of $1.5 \mathrm{~m}^{3} / \mathrm{s}$. The stream of again dry after the runoff event. The ratio of runoff to precipitation is?
a) 0.29 b) 0.30 c) 3.43 d) 0.343

Ans:

$$
\begin{aligned}
& \text { Run off }=1.5 \times 10 \times 3600=54000 \mathrm{~m}^{3} \\
& \text { Precipitation }=150 \times 10^{4} \times \frac{10.5}{100}=157500 \mathrm{~m}^{3} \\
& \text { Ratio of runoff to precipitation }=\frac{540000}{157500}=0.343
\end{aligned}
$$

23. Two and half centimeters of rain per day over an area $200 \mathrm{~km}^{2}$ is equivalent to average rate of input of how many cubic meters per second of water to that area?
a) 57.87 b) 5.787 c) 0.57 d) 0.057

Ans:

$$
\begin{aligned}
& \frac{2.5}{100} \times 200 \times 10^{6}=5 \times 10^{6} \mathrm{~m}^{3} \\
& \frac{5000000}{86400}=57.87 \mathrm{~m}^{3}
\end{aligned}
$$

24. A catchment area of $140 \mathrm{~km}^{2}$ received 120 cm of rainfall in a year. At the outlet of the catchment the flow in the stream draining the catchment was found to have an average rate of $2.0 \mathrm{~m}^{3} / \mathrm{s}$ for 3 months, $3 \mathrm{~m}^{3} / \mathrm{s}$ for 6 months and $5 \mathrm{~m}^{3} / s$ for 3 months. What is the runoff coefficient?
a) 0.602
b) 0.301
c) 0.903 d$) 1.00$

Ans:

$$
\begin{aligned}
& \text { Runoff }=2 \times 86400 \times 90 \times+3 \times 86400 \times 180+5 \times 86400 \times 90 \\
& =101.088 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Precipitation }=140 \times 10^{6} \times 1.2 \\
& \quad=168 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Run off coefficient }=\frac{101.088 \times 10^{6}}{168 \times 10^{6}}=0.602
\end{aligned}
$$

25. Estimate the constant rate of withdrawal from a 1375 ha reservoir in a month of 30days during which the reservoir level dropped by 0.75 m in spite of an average inflow into the reservoir of $0.5 \mathrm{M} \frac{m^{3}}{d a y}$. during the month the average seepage loss from the reservoir was 2.5 cm , total precipitation on the reservoir was 18.5 cm and total evaporation was 9.5 cm
a) $10.11 \mathrm{~m}^{3} / \mathrm{s}$
b) $10.30 \mathrm{~m}^{3} / \mathrm{s}$
c) $10.93 \mathrm{~m}^{3} / \mathrm{s}$
d) $11.00 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { Inflow }=0.5 \times 10^{6} \times 30=15 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Seepage }=\frac{2.5}{100} \times 1375 \times 10^{4}=0.34375 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Rain fall }=\frac{18.5}{100} \times 1375 \times 10^{4}=2.544 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Evaporation }=\frac{9.5}{100} \times 1375 \times 10^{4}=1.306 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Net drop }=1375 \times 10^{4} \times 0.75=10.31 \times 10^{6} \mathrm{~m}^{3} \\
& \text { Out flow }=(10.31+(15+2.544-0.34375)-1.306) \times 10^{6} \\
& =26.204 \times 10^{6} \mathrm{~m}^{3} \text { for } 30 \text { days } \\
& \text { i.e. } \frac{26.204 \times 106}{30 \times 86400}=10.109 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

26. A river reach had a flood wave passing through it. At a given instant the storage of water in the reach was estimated as 15.5 ha.m. What would be the storage in the reach after an interval of 3 hours if the average inflow and outflow during the time period are $14.2 \mathrm{~m}^{3} / \mathrm{s}$ and $10.6 \mathrm{~m}^{3} /$ $s$ respectively.
a) 19.388 ha-m
b) $3.88 \mathrm{ha}-\mathrm{m}$
c) $15.88 \mathrm{ha}-\mathrm{m}$
d) 18.88 ha-m

Ans:

$$
\begin{aligned}
& (14.2-10.6) \times 3600 \times 3=3,88,800 \mathrm{~m}^{3}=3.888 \text { ham } \\
& \text { Total storage }=15.5+3.888=19.388 \mathrm{ha}-\mathrm{m}
\end{aligned}
$$

27. A watershed has an area of 300 ha . Due to a 10 cm rainfall event over the watershed a stream flow is generated and at the outlet of the watershed it lasts for 10 hours. Assuming a runoff/rainfall ratio of 0.2 for this event, the average stream flow rate at the outlet in this period of 10hours is
a) $1.33 \mathrm{~m}^{3} / \mathrm{s}$
b) $16.7 \mathrm{~m}^{3} / \mathrm{s}$
c) $100 \mathrm{~m}^{3} / \mathrm{min}$
d) $60,000 \mathrm{~m}^{3} / \mathrm{h}$

Ans:

$$
300 \times 10^{4} \times \frac{10}{100}=3,00,000 \mathrm{~m}^{3} \text { Rainfall }
$$

Runoff $0.2 \times 3,00,000=60,000 \mathrm{~m}^{3}$

$$
\text { i.e. } \frac{60000}{10 \times 3600}=16.7 \mathrm{~m}^{3} / \mathrm{s}
$$

28. Rainfall of intensity of $20 \mathrm{~mm} / \mathrm{h}$ occurred over a watershed of area 100ha for a duration of 6 h . Measured direct runoff volume in the stream draining the watershed was found to be $30,000 \mathrm{~m}^{3}$. The precipitation not available to runoff in this case is
a) 9 cm
b) 3 cm
c) 17.5 mm
d) 5 mm

Ans:

$$
\begin{aligned}
& \text { Rainfall }=\frac{20}{1000} \times 6 \times 100 \times 10^{4}=120,000 \mathrm{~m}^{3} \\
& \text { Runoff }=30,000 \mathrm{~m}^{3} \\
& \text { Infiltration }=120,000-30,000=90,000 \mathrm{~m}^{3} \\
& \text { Depth of infiltration }=\frac{90,000}{100 \times 10^{4}}=0.09 \mathrm{~m}=9 \mathrm{~cm}
\end{aligned}
$$

29. A catchment of area $120 \mathrm{~km}^{2}$ has three distinct zones as below.

| Zone | area $\left(\mathrm{km}^{2}\right)$ | annual r |
| :--- | :---: | ---: |
| A | 61 | 52 |
| B | 39 | 42 |
| C | 20 | 32 |

The annual runoff from the catchment, is
a) 126.0 cm
b) 42.0 cm
c) 45.42 cm
d) 47.3 cm

Ans:

$$
\frac{52 \times 61+42 \times 39+32 \times 20}{61+39+20}=45.42 \mathrm{~cm}
$$

30. The percentage of total quantity of water in the world that is saline is about
a) $71 \%$
b) $33 \%$
c) $67 \%$
d) $97 \%$

Ans: (d)
31. A catchment has six rain gauge stations. In a year, the annual rainfall recorded by the gauges is as follows. $82.6 \mathrm{~cm}, 102.9 \mathrm{~cm}, 180.3 \mathrm{~cm}$, $110.3 \mathrm{~cm}, 98.8 \mathrm{~cm}$ and 136.7 cm . For a $10 \%$ error in the estimation of the mean rainfall, calculate the optimum number of stations in the catchment?
a) 9 b) 10 c) 8 d)

Ans:

$$
\begin{aligned}
& \bar{p}=\frac{82.6+102.9+180.3+110.3+98.8+136.7}{6}=118.6 \\
& \sigma_{m-1}=\sqrt{\frac{36^{2}+15.7^{2}+61.7^{2}+8.3^{2}+19.8^{2}+18.1^{2}}{5}}=35.04 \\
& C_{v}=100 \times \frac{\sigma m-1}{D}=\frac{100 \times 35.04}{118.6}=29.54 \\
& \text { Optimum number of reengages }=\left(\frac{\left(C_{0}\right)}{\mathrm{s}}\right)^{2} \\
& \qquad=\left(\frac{(29.54}{10}\right)^{2}=8.7 \text { say } 9
\end{aligned}
$$

32. Analysis of data on maximum one-day rainfall depth at madras indicated that a depth of 280 mm had a return period of 50 years. Determine the probability of a one-day rainfall depth equal to or greater than 280 mm at madras occurring (a) once in 20 successive years (b) two times in 15 successive years (c) at least once in 20 successive years.
a) $0.272,0.0323$ and 0.332
b) $0.272,0.323$ and 0.332
c) $0.332,0.323$ and 0.272
d) $0.372,0.323$ and 0.232

Ans:
$\mathrm{P}=\frac{1}{50}=0.02$
$\mathrm{Q}=0.98$
a) $20_{c_{1}} 0.02^{1} 0.98^{19}=0.272$
b) $15 c_{2} \times 0.02^{2} 0.98^{13}=0.0323$
c) $1-0.98^{20}=0.332$
33. A catchment area has seen rain gauge stations. In a year the annual rainfall recorded by the gauges are as follows. 130.0, 142.1, 118.2, $108.5,165.2,102.1,146.9 \mathrm{~cm}$. For a $5 \%$ error in the estimation of the mean rainfall, calculate the number of additional stations required to be established in the catchment.
a) 5 b) 4 c) 3 d) 6

Ans:
$\bar{P} P=130.43$
$\sigma_{m-1}=\sqrt{ } \frac{0.43+11.67+12.23+21.93+34.77+28.33+16.47}{6}$
$C_{v}=100 \times \frac{\sigma m-1}{p}=\frac{100 \times 22.55}{130.43}=17.28$
Optimum no. of rain gauges required $=\left(\frac{\mathrm{cv}}{\mathrm{s}}\right)^{2}=\left(\frac{17.28}{5}\right)^{2}=12$
Additional rain gauges required $=12-7=5$
34. The normal annual precipitation of five rain gauge stations $P, Q, R, S$ and T are respectively $125,102,76,113$ and 137 cm .during a particular storm the precipitation recorded by stations $\mathrm{P}, \mathrm{Q}, \mathrm{R}$ and S are $13.2,9.2,6.8$ and 10.2 cm respectively. The instrument at station T was inoperative during that storm. Estimate the rainfall at station T during that storm.
a) 12.86
b) 10.76 c) 11.80
d) 13.24

$$
\text { Ans: } \begin{aligned}
\frac{P_{T}}{N_{T}} & =\frac{1}{4}\left[\frac{P_{P}}{P_{P}}+\frac{P_{\mathrm{Q}}}{N_{\mathrm{Q}}}+\underset{{ }^{P_{R}}}{N_{R}}+\frac{P_{S}}{N_{S}}\right] \\
& \frac{P_{T}}{137}=\frac{1}{4} * \frac{13.2}{125}+\frac{9.2}{102}+\frac{6.8}{76}+\frac{10.2}{113}+ \\
P_{T} & =12.86
\end{aligned}
$$

35. For a drainage basin of $600 \mathrm{~km}^{2}$, Isohyetal drawn for a storm gave the following data:

| Isohyetal (interval)(cm) | $15-12$ | $12-9$ | $9-6$ | $6-3$ | $3-1$ |  |
| :--- | ---: | :---: | :---: | :---: | :---: | :--- |
| Inter Isohyetal area $\mathrm{km}^{2}$ | 92 | 128 | 120 | 175 | 85 |  |

Estimate the average depth of precipitation $(\mathrm{cm})$ over the catchment?
a) 7.41 b) 8.50 c) 9.80 d) 10.90

Ans:

36. On the basis of Iso pluvial maps the 50 year-24hour maximum rainfall at Bangalore is found to be 16.0 cm . Determine the probability of a 24 h rainfall of magnitude 16.0 cm occurring at bangalore (a) once in 10 successive years (b) twice in 10succesive years (c) all least once in ten successive years.
a) $0.167,0.0153$ and 0.183
b) $0.187,0.0153$ and 0.183
c) $0.167,0.0153$ and 0.193
d) $0.167,0.0163$ and 0.183

Ans:

$$
\mathrm{P}=1 / 50=0.02 \mathrm{q}=0.98
$$

a) $10_{c_{1}} \times 0.02^{1} \times 0.98^{9}=0.167$
b) $10 c_{c_{2}} \times 0.02^{2} \times 0.98{ }^{9}=0.0153$
c) $1-0.98^{10}=0.183$
37. A one day rainfall of 20.0 cm at a place x was found to have a period of 100years. Calculate the probability that a one day rainfall of magnitude equal to or larger than 20 cm (a) will not occur at station $x$ during next $50 y e r a s(b)$ will occur in the next year
a) 0.605 and 0.01
b) 0.395 and 0.1
c) 0.01 and 0.605
d0 0.001 and 0.1
Ans:

$$
\begin{aligned}
& \mathrm{P}=\frac{1}{100}=0.01 \quad \mathrm{q}=0.99 \\
& \text { a) } 50_{c_{0}} 0.01^{0} \quad 0.99^{50}=0.605 \\
& \text { b) } \frac{1}{100}=0.01
\end{aligned}
$$

38. The normal annual rainfall at stations $A, B$, and $C$ situated in meteorologically homogeneous region are $175 \mathrm{~cm}, 180 \mathrm{~cm}$, and 150 cm respectively. In the year 2000, station B was inoperative and stations A and $C$ recorded annual precipitation of 150 cm and 135 cm respectively. The annual rainfall at station $B$ in that year could be estimated.
a) 150 cm
b) 143 cm
c) 158 cm
d) 168 cm

Ans:

$$
\begin{aligned}
& \underline{P}_{N_{B}}=\frac{1}{2} * \frac{P_{A}}{N_{A}}+\frac{P_{c}}{N_{C}}+ \\
& \underline{P_{B}}=\frac{1}{2} * \frac{150}{175}+\frac{135}{150}+ \\
& 180 \\
& P_{B}=158 \mathrm{~cm}
\end{aligned}
$$

39. A study of the iso pluvial maps reveled that at Calcutta a maximum rainfall depth of 200 mm in 12 h has a return period of 50 years. The probability of a 12 h rainfall equal to or greater than 200 mm occurring at Calcutta at least once in 30 years is
a) 0.45
b) 0.60
c) 0.56
d) 1.0

Ans:

$$
\begin{aligned}
& P=\frac{1}{50}=0.02 \quad q=0.98 \\
& 1-0.98^{30}=0.45
\end{aligned}
$$

40. A 6 h rainfall of 6 cm at a place A was found to have a return period of $40 y e a r s$. The probability that at A 6-h rainfall of this or larger magnitude will occur at least once in 20 successive years is
a) 0.397
b) 0.603
c) 0.309
d) 0.025

Ans:

$$
\begin{array}{ll}
\mathrm{P}=\frac{1}{40}=0.025 & \mathrm{q}=0.975 \\
1-0.975^{20}=0.397 &
\end{array}
$$

41. The probability of a 10 cm rain in 1 hour occurring at a station B is found to be $1 / 60$. What is the probability that a 1 hour rain of magnitude 10 cm or larger will occur in station B once in 30 successive years in
a) 0.396
b) 0.307
c) 0.604
d) 0.5

Ans:

$$
\begin{aligned}
& { }^{30}\left(1 /{ }_{C_{1}}\right)^{1}\left(1-1 /{ }_{60}\right)^{29} \\
& =0.307
\end{aligned}
$$

42. A one day rainfall of 18 hours at station C was found to have a return period of 50 years. The probability that a one day rainfall of this or larger magnitude will not occur at station c during next 50years is
a) 0.636
b) 0.020
c) 0.364
d) 0.371

Ans:

$$
\begin{array}{ll}
P=1 / 50=0.02 & \mathrm{q}=0.98 \\
q^{50}=0.98^{50}=0.364 &
\end{array}
$$

43. At a station, Storm I of 5 hour duration with intensity $2 \mathrm{~cm} / \mathrm{h}$ resulted in a runoff of 4 cm and Storm II of 8hour duration resulted in a runoff of 8.4 cm . Assume that the $\phi$-index is the same for both the storms. The $\phi$ index (in $\mathrm{cm} / \mathrm{h}$ ) is:
(A) 1.2 (B) 1.0 (C) 1.6 (D) 1.4

Ans:
Total rainfall due to storm $\mathrm{I}=2 \times 5=10 \mathrm{~cm}$
Runoff $=4 \mathrm{~cm}$
$\varphi=\frac{10-4}{5}=\frac{6}{5}=1.2 \mathrm{~cm}$
44. At a station, Storm I of 5 hour duration with intensity $2 \mathrm{~cm} / \mathrm{h}$ resulted in a runoff of 4 cm and Storm II of 8hour duration resulted in a runoff of 8.4 cm . Assume that the $\phi$-index is the same for both the storms. The intensity of storm II (in $\mathrm{cm} / \mathrm{h}$ ) is:
(A) 2.00 (B) 1.75 (C) 1.50 (D) 2.25

Ans:

$$
\begin{aligned}
& 8.4+1.2 \times 8=18 \mathrm{~cm} \\
& \text { Intensity }=\frac{18}{8}=2.25 \mathrm{~cm}
\end{aligned}
$$

45. In to a stream, with no trace of salt initially, a salt solution with a concentration of $20 \mathrm{mg} / \mathrm{cc}$ is introduced at a constant rate of 2 litres per minute. The samples collected at a downstream section sufficiently far away indicated an equilibrium salt concentration of 0.05 ppm . Determine the discharge $\left(\mathrm{m}^{3} / \mathrm{s}\right)$ in the stream from this data.
(A) 13.33 (B) 11.75 (C) 11.50 (D) 12.25

Ans:

$$
\begin{aligned}
& Q_{1} C_{1}+Q_{2} C_{2}=\left(Q_{1}+Q_{2}\right) \mathrm{C} \\
& Q_{1} .0+2 \times 0.02=\left(Q_{1}+Q_{2}\right) \times \frac{0.05}{10^{6}} \\
& \text { As } 20 \frac{\mathrm{mg}}{\mathrm{cc}}=0.02 \mathrm{ppm} \\
& \therefore Q_{1}+Q_{2}=\frac{2 \times 0.02}{\frac{0.05}{10^{6}}}=0.8 \times 10^{6} \mathrm{lit} / \mathrm{minute} \\
& Q_{1}=0.8 \times 10^{6}-2=0.8 \times 10^{6} \mathrm{lit} / \mathrm{min} \\
& \quad=\frac{0.8 \times 10^{6}}{60 \times 1000}=13.33 \mathrm{~m}^{3} / \mathrm{sec}
\end{aligned}
$$

46. The chemical compound which is generally used to reduce the evaporation from water surface is
a) DDT
b) Alum
c) Cetyl alcohol
d) Potassium dichromate

Ans: (c)
47. Lysimeter is an instrument used to measure
a) Evaporation
b) Infiltration
c) Evapotranspiration
d) Transpiration

Ans: (c)
48. In a triangular channel the top width and depth of flow were 2.0 m and 0.9 m respectively. Velocity measurements on the centre line at 18 cm and 72 cm below water surface indicated velocities of $0.6 \mathrm{~m} / \mathrm{s}$ and 0.4 $\mathrm{m} / \mathrm{s}$ respectively. The discharge in the channel (in $\mathrm{m}^{3} / \mathrm{s}$ ) is
a) 0.9 b) 1.8 c) 0.45
d) None

Ans:

$$
\begin{aligned}
& \text { Velocity }=\frac{0.6+0.4}{2}=0.5 \mathrm{~m} / \mathrm{s} \\
& \text { Area }=1 / 2 \times 2^{2} \times 0.9=0.9 \\
& \text { Discharge }=0.5 \times 0.9=0.45 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

49. The total rainfall in a catchment area $1200 \mathrm{~km}^{2}$ during a 6 -h storm is 16 cm while the surface runoff due to the storm is $1.2 \times 10^{8} \mathrm{~m}^{3}$. The $\emptyset$ index is
a) $0.1 \mathrm{~cm} / \mathrm{h}$
b) $1.0 \mathrm{~cm} / \mathrm{h}$
c) $0.2 \mathrm{~cm} / \mathrm{h}$
d) $2 \mathrm{~cm} / \mathrm{h}$

Ans:

$$
\begin{aligned}
& 1200 \times 10^{6} \times \frac{16}{100}-1.2 \times 10^{8}=72 \times 10^{6} \mathrm{~m}^{3} \\
& \emptyset \text { index }=\frac{72 \times 10^{6}}{1200 \times 16^{6}}=0.06 \mathrm{~m} \\
& =\frac{0.06}{6}=0.01 \mathrm{~m} / \mathrm{h}=1 \mathrm{~cm} / \mathrm{h}
\end{aligned}
$$

A mean annual runoff of $1 \mathrm{~m}^{3} / \mathrm{s}$ from a catchment of area $31.54 \mathrm{~km}^{2}$ represents an effective rainfall of
a) 100 cm b) $10 \mathrm{~cm} \mathrm{c)} 100 \mathrm{~mm} \mathrm{d)} 3.17 \mathrm{~cm}$

Ans:

$$
\frac{1 \times 86400 \times 365}{31.54 \times 10^{6}}=1 \mathrm{~m}=100 \mathrm{~cm}
$$

51. An isohyets is a line joining points having
a) Equal evaporation value
b) Equal barometric pressure
c) Equal height above the MSL
d) Equal rainfall depth in a given duration

Ans: (d)
52. An isopleth is a line joining points having
a) Equal evapotranspiration value
b) Equal barometric pressure
c) Equal height above the MSL
d) Equal rainfall depth in a given duration

Ans: (a)
53. An isopluvial line is a line joining points having
a) Equal evapotranspiration value
b) Equal barometric pressure
c) Equal height above the MSL
d) Equal rainfall depths

Ans: (d)

## Unit hydrographs

1. A 9-hour Unit Hydrograph (UH) of a catchment is triangular in shape with a total time base of 36 hours and a peak discharge of $18 \mathrm{~m}^{3} / \mathrm{s}$. The area of the catchment (in sq. km) is
(A) 233 (B) 117 (C) 1.2
(D) Sufficient information not available

Ans:

$$
\begin{aligned}
& A \times 10^{6} \times \frac{1}{100}=\frac{1}{2} \times 36 \times 3600 \times 18 \\
& A=117 \mathrm{~km}^{2}
\end{aligned}
$$

2. Match the following:

## Group I

P Rainfall intensity
Q Rainfall excess
R Rainfall Averaging
S Mass curve

## Group II

1. Isohyets
2. Cumulative rainfall
3. Hyetograph
4. Direct runoff hydrograph

## Codes:

(a) $\begin{array}{lll}1 & 3 & 2\end{array}$
(b) $\begin{array}{llll}3 & 4 & 1 & 2\end{array}$
(c) $\begin{array}{llll}1 & 2 & 4\end{array}$
(d) $3 \quad 4 \quad 2 \quad 2 \quad 1$

Ans: (b)
3. The average rainfall for a 3 hour duration storm is 2.7 cm and the loss rate is $0.3 \mathrm{~cm} / \mathrm{hr}$. The flood hydrograph has a base flow of $20 \mathrm{~m}^{3} / \mathrm{s}$ and produces a peak flow of $210 \mathrm{~m}^{3} / \mathrm{s}$. The peak of a 3-h unit hydrograph is
(a) $125.50 \mathrm{~m}^{3} / \mathrm{s}$
(b) $105.50 \mathrm{~m}^{3} / \mathrm{s}$
(c) $77.77 \mathrm{~m}^{3} / \mathrm{s}$
(d) $\quad 70.37 \mathrm{~m}^{3} / \mathrm{s}$

Ans:
Rainfall depth in 3 hours $=2.7 \mathrm{~cm}$
Loss rate $=0.3 \mathrm{~cm} / \mathrm{h}$
Total loss in 3 hours $=0.3 \times 3=0.9 \mathrm{~cm}$
Rainfall excess $=2.7-0.9=1.8 \mathrm{~cm}$ in 3 hours
Flood hydrograph peak flow $=210 \mathrm{~m}^{3} / \mathrm{s}$
Base flow $=20 \mathrm{~m}^{3} / \mathrm{s}$
Net peak $=210-20=190 \mathrm{~m}^{3} / \mathrm{s}$
$190 \mathrm{~m}^{3} / \mathrm{s}$ is due to 1.8 cm rainfall excess.
The peak due to $1 \mathrm{~cm}=\frac{190}{1.8}=105.6 \mathrm{~m}^{3} / \mathrm{s}$
4. When the outflow from a storage reservoir is uncontrolled as in a freely operating spillway, the peak of outflow hydrograph occurs at
(a) At point of inter-section of the inflow and outflow hydrographs
(b) A point, after the inter-section of the inflow and outflow hydrographs
(c) The tail of inflow hydrographs
(d) A point, before the inter-section of the inflow and outflow hydrographs
Ans: (b)
5. A four hour unit hydrograph of a catchment is triangular in shape with base of 80 hours. The area of the catchment is $720 \mathrm{~km}^{2}$. The base flow and $\emptyset$-index are $30 \mathrm{~m}^{3} / \mathrm{s}$ and $1 \mathrm{~mm} / \mathrm{h}$, respectively. A storm of a 4 cm occurs uniformly in 4 hours over the catchment.

The peak discharge of four hour unit hydrograph is
(a) $40 \mathrm{~m}^{3} / \mathrm{s}$
(b) $50 \mathrm{~m}^{3} / \mathrm{s}$
(c) $\quad 60 \mathrm{~m}^{3} / \mathrm{s}$
(d) $70 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { A= } 720 \mathrm{~km}^{2} \\
& \text { Base flow }=30 \mathrm{~m}^{3} / \mathrm{s} \\
& \varphi \text { - Index }=1 \mathrm{~mm} / \mathrm{h} \\
& \text { Base of triangle of unit hydrograph }=80 \text { hours } \\
& 720 \times 10^{6} \times \frac{1}{100}=1 / 2 \times 80 \times 3600 \times \text { peak } \\
& \text { Peak }=50 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

6. A four hour unit hydrograph of a catchment is triangular in shape with base of 80 hours. The area of the catchment is $720 \mathrm{~km}^{2}$. The base flow and $\emptyset$-index are $30 \mathrm{~m}^{3} / \mathrm{s}$ and $1 \mathrm{~mm} / \mathrm{h}$, respectively. A storm of a 4 cm occurs uniformly in 4 hours over the catchment. The peak flood discharge due to the storm is
(a) $210 \mathrm{~m}^{3} / \mathrm{s}$
(b) $230 \mathrm{~m}^{3} / \mathrm{s}$
(c) $260 \mathrm{~m}^{3} / \mathrm{s}$
(d) $720 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { Depth due to storm }=4 \mathrm{~cm} \\
& \text { Loss }=1 \mathrm{~mm} / \mathrm{h} \times 4=4 \mathrm{~mm}=0.4 \mathrm{~cm} \\
& \text { Rainfall excess }=4-0.4=3.6 \mathrm{~cm} \\
& \text { Peak of flood }=3.6 \times 50+30=210 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

7. For a catchment, the S-curve (or S-hydrograph) due to a rainfall of intensity $1 \mathrm{~cm} / \mathrm{hr}$ is given by $\mathrm{Q}=1-(1+\mathrm{t}) \exp (-\mathrm{t})(\mathrm{t}$ in hr and Q in $\mathrm{m}^{3} / \mathrm{s}$ ). What is the area of the catchment?
(a) $0.01 \mathrm{~km}^{2}$
(b) $0.36 \mathrm{~km}^{2}$
(c) $1.00 \mathrm{~km}^{2}$
(d) $1.28 \mathrm{~km}^{2}$

Ans:

$$
\begin{aligned}
& \text { For long time of } \mathrm{t} \mathrm{Q}=1 \frac{\mathrm{~m}^{3}}{\mathrm{~s}} \mathrm{i} n \text { S-curve } \\
&=3600 \mathrm{~m}^{3} / \mathrm{hr} \\
& \mathrm{~A} \times 10^{6} \times \frac{1}{100}=3600 \\
& \mathrm{~A}=3600 \times \frac{100}{10^{6}}= 0.36 \mathrm{~km}^{2}
\end{aligned}
$$

8. For a catchment, the S-curve (or S-hydrograph) due to a rainfall of intensity $1 \mathrm{~cm} / \mathrm{hr}$ is given by $\mathrm{Q}=1-(1+\mathrm{t}) \exp (-\mathrm{t})(\mathrm{t}$ in hr and Q in $\mathrm{m}^{3} / \mathrm{s}$ ). What will be the ordinate of a 2 -hour unit hydrograph for this catchment at $\mathrm{t}=3$ hour ?
(a) $0.13 \mathrm{~m}^{3} / \mathrm{s}$
(b) $0.20 \mathrm{~m}^{3} / \mathrm{s}$
(c) $0.27 \mathrm{~m}^{3} / \mathrm{s}$
(d) $\quad 0.54 \mathrm{~m}^{3} / \mathrm{s}$

Ans:
Ordinate of a 2 h UH at $\mathrm{t}=3$ is
S - Curve ordinate at $\mathrm{t}=3-2 \mathrm{~h}$ lagged
S- Curve ordinate at $\mathrm{t}=3$
$\left[1-(1+3) e^{-3}\right]-\left[1-(1+1) e^{-1}\right]$
$=0.54 \mathrm{~m}^{3} / \mathrm{s}$
9. Ordinates of a 1-hour unit hydrograph at 1 hour intervals, starting from time $\mathrm{t}=0$, are $0,2,6,4,2,1$ and $0 \mathrm{~m}^{3} / \mathrm{s}$. Catchment area represented by this unit hydrograph is
(a) $1.0 \mathrm{~km}^{2}$
(b) $2.0 \mathrm{~km}^{2}$
(c) $3.2 \mathrm{~km}^{2}$
(d) $5.4 \mathrm{~km}^{2}$

Ans:

$$
\begin{aligned}
& \mathrm{A} \times 10^{6} \times \frac{1}{100}=3600\left[\frac{0+0}{2}+2+6+4+2+1\right] \\
& \mathrm{A}=\frac{3600}{10^{4}}[15]=5.4 \mathrm{~km}^{2}
\end{aligned}
$$

10. Ordinates of a 1-hour unit hydrograph at 1 hour intervals, starting from time $\mathrm{t}=0$, are $0,2,6,4,2,1$ and $0 \mathrm{~m}^{3} / \mathrm{s}$. Ordinate of a 3-hour unit hydrograph for the catchment at $t=3$ hours is
(a) $2.0 \mathrm{~m}^{3} / \mathrm{s}$.
(b) $3.0 \mathrm{~m}^{3} / \mathrm{s}$.
(c) $4.0 \mathrm{~m}^{3} / \mathrm{s}$.
(d) $5.0 \mathrm{~m}^{3} / \mathrm{s}$.

Ans:

| Time | 1h | - ordinate |  | sum | $1 / 3$ sum |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 0 | 0 |  |  | 0 | 0 |
| 1 | 2 | 0 |  | 2 | $2 / 3$ |
| 2 | 6 | 2 | 0 | 8 | $8 / 3$ |
| 3 | 4 | 6 | 2 | 12 | 4 |
| 4 | 2 | 4 | 6 | 12 | 4 |
| 5 | 1 | 2 | 4 | 7 | $7 / 3$ |
| 6 | 0 | 1 | 2 | 3 | 1 |
|  |  | 0 | 1 | 1 | $1 / 3$ |
|  |  |  | 0 | 0 | 0 |

Ordinate of 3-h UH of $\mathrm{t}=3 \mathrm{~h}$ is $4 \mathrm{~m}^{3} / \mathrm{s}$
11. One hour triangular unit hydrograph of a watershed has the peak discharge of $60 \mathrm{~m}^{3} / \mathrm{sec} . \mathrm{cm}$ at 10hours and time base of 30 hours. The Øindex is 0.4 cm per hour and base flow is $15 \mathrm{~m}^{3} / \mathrm{sec}$. The catchment area of the watershed is
(A) $3.24 \mathrm{~km}^{2}$
(B) $32.4 \mathrm{~km}^{2}$
(C) $324 \mathrm{~km}^{2}$
(D) 3240 km

Ans:

$$
\begin{aligned}
& \mathrm{A} \times 10^{6} \times \frac{1}{100}=\frac{1}{2} \times 30 \times 3600 \times 60 \\
& \mathrm{~A}=324 \mathrm{~km}^{2}
\end{aligned}
$$

12. One hour triangular unit hydrograph of a watershed has the peak discharge of $60 \mathrm{~m}^{3} / \mathrm{sec} . \mathrm{cm}$ at 10 hours and time base of 30 hours. The Øindex is 0.4 cm per hour and base flow is $15 \mathrm{~m}^{3} / \mathrm{sec}$. If there is rainfall of 5.4 cm in 1 hour, the ordinate of the flood hydrograph at $15^{\text {th }}$ hour is
(A) $225 \mathrm{~m}^{3} / \mathrm{sec}$
(B) $240 \mathrm{~m}^{3} / \mathrm{sec}$
(C) $249 \mathrm{~m}^{3} / \mathrm{sec}$
(D) $258 \mathrm{~m}^{3} / \mathrm{sec}$

Ans :

$$
\begin{aligned}
& =(5.4-0.4) \times 60 \times \frac{15}{20}+15 \\
& =5 \times 60 \times \frac{15}{20}+15 \\
& =225+15 \\
& =240 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

13. A watershed got transformed from rural to urban over a period of time. The effect of urbanization on storm runoff hydrograph from the watershed is to
(A) Decrease the volume of runoff
(B) Increase the time to peak discharge
(C) Decrease the time base
(D) Decrease the peak discharge

Ans: (C)
14. The drainage area of a watershed is $50 \mathrm{~km}^{2}$. The $\emptyset$ index is 0.5 $\mathrm{cm} /$ hour and the base flow at the outlet is $10 \mathrm{~m}^{3} / \mathrm{s}$. One hour unit hydrograph (unit depth $=1 \mathrm{~cm}$ ) of the watershed is triangular in shape with a time base of 15 hours. The peak ordinate occurs at 5 hours. The peak ordinate (in $\mathrm{m} 3 / \mathrm{s} / \mathrm{cm}$ ) of the unit hydrograph is
(A) 10.00 (B) 18.52 (C) 37.03 (D) 185.20

Ans:

$$
\begin{aligned}
50 & \times 10^{6} \times \frac{1}{100}=\frac{1}{2} \times 15 \times 3600 \times \text { peak } \\
\text { Peak } & =\frac{50 \times 10^{4} \times 2}{15 \times 3600} \\
& =18.52 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

15. The drainage area of a watershed is $50 \mathrm{~km}^{2}$. The $\emptyset$ index is 0.5 $\mathrm{cm} /$ hour and the base flow at the outlet is $10 \mathrm{~m}^{3} / \mathrm{s}$. One hour unit hydrograph (unit depth $=1 \mathrm{~cm}$ ) of the watershed is triangular in shape with a time base of 15 hours. The peak ordinate occurs at 5 hours. For a storm of depth of 5.5 cm and duration of 1 hour, the peak ordinate (in $\mathrm{m}^{3} / \mathrm{s}$ ) of the hydrograph is
(A) 55.00 (B) 82.60 (C) 92.60 (D) 102.60

Ans:

$$
(5.5-0.5) \times 18.52+10=102.6 \mathrm{~m}^{3} / \mathrm{s}
$$

16. A direct-runoff hydrograph due to a storm was found to be triangular in shape with a peak of $150 \mathrm{~m}^{3} / \mathrm{s}$, time from start of effective storm to peak of 24 h and a total time base of 72 h . the duration of the storm in this case was
a) $<24 \mathrm{~h}$
b) Between 24 to 72 h
c) 72 h
d) $>72 \mathrm{~h}$

Ans: (a)
17. A 3-hour storm over a watershed had an average depth of 27 mm . the resulting flood hydrograph was found to have a peak flow of $200 \mathrm{~m}^{3} / \mathrm{s}$ and a base flow of $20 \mathrm{~m}^{3} / \mathrm{s}$. if the loss rate could be estimated as 0.3 $\mathrm{cm} / \mathrm{h}$, a 3-h unit hydrograph for this watershed will have a peak of
a) $66.7 \mathrm{~m}^{3} / \mathrm{s}$
b) $100 \mathrm{~m}^{3} / \mathrm{s}$
c) $111.1 \mathrm{~m}^{3} / \mathrm{s}$
d) $33.3 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { Rainfall excess }=27 \mathrm{~mm}-3 \mathrm{~mm} \times 3=18 \mathrm{~mm} \\
& \text { Peak without both flow }=200-20=180 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { For } 1 \mathrm{~cm} \text { rain fall excess, peak }=100 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

18. A triangular DRH due to a storm has a time base of 80 hrs and a peak flow of $50 \mathrm{~m}^{3} / \mathrm{s}$ occurring at 20 hours from the start. If the catchment area is $144 \mathrm{~km}^{2}$, the rainfall excess in the storm was
a) 20 cm
b) 7.2 cm
c) 5 cm
d) None of these

Ans:

$$
\begin{aligned}
& 144 \times 10^{6} \times \frac{h}{100}=1 / 2 \times 80 \times 3600 \times 50 \\
& \therefore \mathrm{~h}=5 \mathrm{~cm}
\end{aligned}
$$

19. The 12-hr unit hydrograph of a catchment is triangular in shape with a base width of 144 hours and a peak discharge value of $23 \mathrm{~m}^{3} / \mathrm{s}$. this unit hydrograph refers to a catchment of area
a) $756 \mathrm{~km}^{2}$
b) $596 \mathrm{~km}^{2}$
c) $1000 \mathrm{~km}^{2}$
d) None of these

Ans: $\quad A \times 10^{6} \times \frac{1}{100}=\frac{1}{2} \times 144 \times 3600 \times 23$

$$
\therefore \mathrm{A}=596.16 \mathrm{~km}^{2}
$$

20. The 6 -h unit hydrograph of a catchment is triangular in shape with a base width of 64 h and peak ordinate of $20 \mathrm{~m}^{3} / \mathrm{s}$. If a 0.5 cm rainfall excess occurs in 6 h in that catchment, the resulting surface-runoff hydrograph will have
a) A base of 128 h
b) A base of 32 h
c) peak of $40 \mathrm{~m}^{3} / \mathrm{s}$
d) peak of $10 \mathrm{~m}^{3} / \mathrm{s}$

Ans: (d)
21. A $90 \mathrm{~km}^{2}$ catchment has the 4 -h unit hydrograph which can be approximated as a triangle. If the peak ordinate of this unit hydrograph is $10 \mathrm{~m}^{3} / \mathrm{s}$ the time base is
a) $120 \mathrm{~h} \mathrm{b)} 64 \mathrm{~h} \mathrm{c)} 50 \mathrm{~h} \mathrm{d)} \mathrm{none} \mathrm{of} \mathrm{these}$

Ans:

$$
\begin{aligned}
& 1 / 2 \times B \times 3600 \times 10=90 \times 10^{6} \times \frac{1}{100} \\
& B=50 \mathrm{~h}
\end{aligned}
$$

22. A triangular DRH due to 6-h storm in a catchment has a time base of 100 h and a peak flow of $40 \mathrm{~m}^{3} / \mathrm{s}$. The catchment area is $180 \mathrm{~km}^{2}$. The 6-h unit hydrograph of this catchment will have a peak flow in $\mathrm{m}^{3} / \mathrm{s}$ of
a) 10 b) 20
c) 30
d) none of these

Ans:

$$
\begin{aligned}
& \quad 1 / 2 \times 100 \times 3600 \times 40=180 \times 1000^{2} \times \frac{h}{100} \\
& \therefore \mathrm{~h}=4 \mathrm{~cm} \\
& \therefore \text { Peak of UH }=\frac{40}{4}=10 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

23. The 3-hour unit hydrograph $U_{1}$ of a catchment of area $250 \mathrm{~km}^{2}$ is in the form of a triangle with peak discharge of $40 \mathrm{~m}^{3} / \mathrm{s}$. another 3-hour unit hydrograph $U_{2}$ is also triangular in shape and has the same base width as $U_{1}$ but with a peak flow of $80 \mathrm{~m}^{3} / \mathrm{s}$. the catchment which $\mathrm{U}_{2}$ refers to has an area of
a) $125 \mathrm{~km}^{2}$
b) $250 \mathrm{~km}^{2}$
c) $1000 \mathrm{~km}^{2}$
d) $500 \mathrm{~km}^{2}$

Ans:
As peak is double height its area is double i.e. $250 \times 2=500$ $k m^{2}$
24. A basin with an area of $756 \mathrm{~km}^{2}$ has 6 -h unit hydrograph which could be approximated as a triangle with a base of 70 hours. The peak discharge of direct runoff hydrograph due to 5 cm of rainfall excess in 6 hours from that basin is
a) $535 \mathrm{~m}^{3} / \mathrm{s}$
b) $60 \mathrm{~m}^{3} / \mathrm{s}$
c) $756 \mathrm{~m}^{3} / \mathrm{s}$
d) $300 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& 756 \times 10^{6} \times \frac{1}{100}=\frac{1}{2} \times 70 \times 3600 \times \text { peak } \\
& \therefore \text { Peak }=60 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { DRH peak }=5 \times 60=300 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

25. The peak flow of a flood hydrograph caused by isolated storm was observed to be $120 \mathrm{~m}^{3} / \mathrm{s}$. The storm was of 6 hours duration and had a total rainfall of 7.5 cm . if the base flow and the $\varphi$-index are assumed to be $30 \mathrm{~m}^{3} / \mathrm{s}$ and $0.25 \mathrm{~cm} / \mathrm{h}$ respectively, the peak ordinate of the 6-h unit hydrograph of the catchment is
a) $12.0 \mathrm{~m}^{3} / \mathrm{s}$
b) $15.0 \mathrm{~m}^{3} / \mathrm{s}$
c) $16.0 \mathrm{~m}^{3} / \mathrm{s}$
d) $20.0 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \text { Effective rainfall }=7.5-6 \times 0.25=6 \mathrm{~cm} \\
& \text { Peak }- \text { base flow }=120-30=90 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { Peak of UH }=\frac{90}{6}=15 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

26. The peak ordinate of 4-h unit hydrograph a basin is $80 \mathrm{~m}^{3} / \mathrm{s}$. an isolated storm of 4- hours duration in the basin was recorded to have a total rainfall of 7.0 cm . if it is assumed that the base flow and the $\varphi$ - index are $20 \mathrm{~m}^{3} / \mathrm{s}$ and $0.25 \mathrm{~cm} / \mathrm{h}$ respectively, the peak of the flood discharge due to the storm could be estimated as
a) $580 \mathrm{~m}^{3} / \mathrm{s}$
b) $360 \mathrm{~m}^{3} / \mathrm{s}$
c) $480 \mathrm{~m}^{3} / \mathrm{s}$
d) $500 \mathrm{~m}^{3} / \mathrm{s}$

Ans:
Effective rain fall $=7-0.25 \times 4=6 \mathrm{~cm}$
Peak with base flow $=6 \times 80+20=500 \mathrm{~m}^{3} / \mathrm{s}$
27. The peak flow of flood hydrograph caused by isolated storm was observed was observed to be $100 \mathrm{~m}^{3} / \mathrm{s}$. the storm had a duration of 8.0 hours and the total depth of rainfall of 7.0 cm . the base flow and the $\varphi$ index were estimated as $20 \mathrm{~m}^{3} / \mathrm{s}$ and $0.25 \mathrm{~cm} / \mathrm{h}$ respectively. If in the above storm the total rainfall were 9.5 cm in the same duration of 8 hours, the flood peak would have been larger by
a) $35.7 \%$
b) $40 \%$
c) $50 \%$
d) $20 \%$

Ans:

$$
\begin{aligned}
& \text { Effective rain fall }=7-8 \times 0.25=5 \mathrm{~cm} \\
& \text { Peak }=100^{3} / \mathrm{s} \\
& \text { Peak flow }=20 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { Peak }- \text { base flow }=100-20=80 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { Peak of unit hydrograph }=80 / 5=16 \mathrm{~m}^{3} / \mathrm{s} \\
& 9.5-0.25 \times 8=7.5 \mathrm{~cm} \\
& \text { Peak }=7.5 \times 16+20=140 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

$$
\text { It is } 40 \% \text { more than earlier }
$$

28. For a catchment with an area of $360 \mathrm{~km}^{2}$ the equilibrium discharge of the s-curve obtained by summation of 4-h unit hydrograph is
a) $250 \mathrm{~m}^{3} / \mathrm{s}$
b) $90 \mathrm{~m}^{3} / \mathrm{s}$
c) $278 \mathrm{~m}^{3} / \mathrm{s}$
d) $360 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\frac{\frac{1}{100} \times 360 \times 10^{6}}{4 \times 3600}=250 \mathrm{~m}^{3} /_{S}
$$

29. Which one of the following constitutes the basic assumption of unit hydrograph theory?
a) Non-linear response and time invariance
b) Non-linear time variance and linear response
c) Linear response and linear time variance
d) Time in variance and linear response.

Ans: (d)
30. If the base period of a 6-hour hydrograph of a basin is 84 hours, then a 12 hours unit hydrograph derived from this 6 hour unit hydrograph will have a base period of
a) 72 hours
b) 78 hours
c) 84 hours
d) 90 hours

Ans:

$$
84+6=90 \text { hours }
$$

31. A catchment area of 90 hectares has a run- off coefficient of 0.4 . a storm of duration larger than the time of concentration of the catchment and of intensity $4.5 \mathrm{~cm} / \mathrm{hr}$ creates a peak discharge rate of
a) $11.3 \mathrm{~m}^{3} / \mathrm{s}$
b) $0.45 \mathrm{~m}^{3} / \mathrm{s}$
c) $450 \mathrm{~m}^{3} / \mathrm{s}$
d) $4.5 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
90 \times 10^{4} \times \frac{4.5}{100} \times 0.4 & =16200 \mathrm{~m}^{3} / \mathrm{h} \\
& =\frac{16200}{3600}=4.5 \mathrm{~m}^{3} / \mathrm{S}
\end{aligned}
$$

32. A DRH due to storm over a basin has a time base of 90 hours with straight line portions of the hydrograph with flow rates of $0,10,70,90$, 40 and $0 \mathrm{~m}^{3} / \mathrm{s}$ at elapsed durations of $0,10,20,30,50$ and 90 hours as indicated on the above diagram, respectively. The catchment area is 300 $\mathrm{km}^{2}$. What is the rainfall excess in the storm?
a) 0.248 cm
b) 3.46 cm
c) 3.87 cm
d) 4.02 cm

Ans:

$$
\begin{aligned}
& 300 \times 10^{6} \times \frac{h}{100}= \\
& {\left[\frac{0+10}{2} \times 10+\frac{10+70}{2} \times 10+\frac{70+90}{2} \times 10+\frac{90+40}{2} \times 20 \frac{40+0}{2} \times\right.} \\
& 10] \times 3600 \\
& \therefore \mathrm{~h}=0.248 \mathrm{~cm}
\end{aligned}
$$

33. The time of concentration at the outlet in an urban area catchment of 1.5 $\mathrm{km}^{2}$ areawith a run off coefficient of 0.42 is 28 minutes. The maximum depth of rainfall with a 50 year return period of this time of concentration is 48 mm . what is the peak flow rate at the outlet for this return period?
a) $12 \mathrm{~m}^{3} / \mathrm{s}$
b) $14 \mathrm{~m}^{3} / \mathrm{s}$
c) $16 \mathrm{~m}^{3} / \mathrm{s}$
d) $18 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& 1.5 \times 10^{6} \times \frac{48}{1000} \times 0.42=30240 \\
& \frac{30240}{28 \times 60}=18 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

34. A $252 \mathrm{~km}^{2}$ catchment area has a 6 hr UH which is a triangle with base of 35 hours. What is the peak discharge of the DRH due to 5 cm effective rainfall in 6 hr from that catchment?
a) 45 cumecs
b) 115 cumecs
c) 200 cumecs
d) 256 cumecs

Ans:

$$
\begin{aligned}
& 252 \times 10^{6} \times \frac{1}{100}=1 / 2 \times 35 \times 3600 \times \text { peak } \\
& \text { Peak }=40 \mathrm{~m}^{3} / \mathrm{s} \\
& \text { Peak due to } 5 \mathrm{~cm}=5 \times 40=200 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

35. A 4-hour unit hydrograph of a basin can be approximated as a triangle with a base period of 48 hours and peak ordinate of $300 \mathrm{~m}^{3} / \mathrm{s}$. what is the area of the catchment basin?
a) $7776 \mathrm{~km}^{2}$
b) $5184 \mathrm{~km}^{2}$
c) $2592 \mathrm{~km}^{2}$
d) $1294 \mathrm{~km}^{2}$

Ans:

$$
\begin{aligned}
& \mathrm{A} \times 10^{6} \times \frac{1}{100}=1 / 2 \times 48 \times 3600 \times 300 \\
& \mathrm{~A}=2592 \mathrm{~km}^{2}
\end{aligned}
$$

36. In constructing a 4 hour synthetic unit hydrograph for a basin, the lag time is estimated to be 40 hours. When will the peak discharge in the synthetic unit hydrograph occur from the start of the storm?
a) 36 hours
b) 40 hours
c) 42 hours
d) 44 hours

Ans:
Lag time is Centre of rainfall excess to peak of hydrograph.

$$
\therefore 40+2=42 \text { hours }
$$

37. A unit hydrograph for a watershed is triangular in shape with base period of 20 hours. The area of the watershed is 500 ha. What is the peak discharge in $\mathrm{m}^{3} /$ hour?
a) 7000
b) 6000
c) 5000
d) 4000

Ans:

$$
\begin{aligned}
& 500 \times 10^{4} \times \frac{1}{100}=\frac{1}{2} \times 20 \times \text { peak } \\
& \therefore \text { Peak }=5000 \mathrm{~m}^{3} / \mathrm{hr}
\end{aligned}
$$

38. A triangular direct runoff hydrograph due to a storm has a time base of 60 hr and a peak flow of $30 \mathrm{~m}^{3} / \mathrm{s}$ occurring at 20 hr from the start. If the catchment area is $300 \mathrm{~km}^{2}$, what is the rainfall excess in the storm?
a) 50 mm
b) 20 mm
c) 10.8 mm
d) 8.3 mm

Ans:

$$
\begin{aligned}
& 300 \times 10^{6} \times \frac{h}{1000}=1 / 2 \times 60 \times 3600 \times 30 \\
& \therefore \mathrm{~h}=10.8 \mathrm{~mm}
\end{aligned}
$$

39. A 3 hr unit hydrograph $U_{1}$ of a catchment of area $235 \mathrm{~km}^{2}$ is in the form of a triangle with peak discharge $30 \mathrm{~m}^{3} / \mathrm{s}$. another 3 hr unit hydrograph $U_{2}$ is also triangular in shape and has the same width as $U_{1}$, but has a peak flow of $90 \mathrm{~m}^{3} / \mathrm{s}$. what is the catchment area of $\mathrm{U}_{2}$ ?
a) $117.5 \mathrm{~km}^{2}$
b) $235 \mathrm{~km}^{2}$
c) $470 \mathrm{~km}^{2}$
d) $705 \mathrm{~km}^{2}$

Ans:

$$
\begin{aligned}
& 235 \times 10^{6} \times \frac{1}{100}=1 / 2 \times B \times 3600 \times 30 \\
& \therefore B=43.5185 \mathrm{hr} \\
& A \times 10^{6} \times \frac{1}{100}=1 / 2 \times 43.5185 \times 3600 \times 90 \\
& \therefore A=705 \mathrm{~km}^{2}
\end{aligned}
$$

40. A catchment area of 60 ha has a runoff coefficient of 0.40 . If a storm of intensity $3 \mathrm{~cm} / \mathrm{h}$ and duration longer than the time of concentration occurs in the catchment, then what is the peak discharge?
a) $2.0 \mathrm{~m}^{3} / \mathrm{s}$
b) $3.5 \mathrm{~m}^{3} / \mathrm{s}$
c) $4.5 \mathrm{~m}^{3} / \mathrm{s}$
d) $2.5 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
60 \times 10^{4} \times \frac{3}{100} \times 0.4 \times \frac{1}{3600}=2 \mathrm{~m}^{3} / \mathrm{s}
$$

41. A catchment of area 200 ha has a runoff coefficient 0.5 . a storm of duration larger than the time of concentration of the catchment and of intensity $3.6 \mathrm{~cm} / \mathrm{h}$ causes a peak discharge of
a) $5 \mathrm{~m}^{3} / \mathrm{s}$
b) $10 \mathrm{~m}^{3} / \mathrm{s}$
c) $100 \mathrm{~m}^{3} / \mathrm{s}$
d) $360 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
200 \times 10^{4} \times \frac{3.6}{100} \times 0.5 \times \frac{1}{3600}=10 \mathrm{~m}^{3} / \mathrm{s}
$$

42. A direct-runoff hydrograph due to isolated storm was triangular in shape with a base of 80 h and a peak of $200 \mathrm{~m}^{3} / \mathrm{s}$. If the catchment area is $1440 \mathrm{~km}^{2}$ the effective rainfall of the storm is
a) 20 cm
b) 10 cm
c) 5 cm
d) 2 cm

Ans:

$$
\begin{aligned}
& 1440 \times 10^{6} \times \frac{h}{100}=\frac{1}{2} \times 80 \times 3600 \times 200 \\
& \therefore \mathrm{~h}=2 \mathrm{~cm} .
\end{aligned}
$$

43. An S-curve hydrograph has been obtained for catchments of $270 \mathrm{~km}^{2}$ from a 3 hour unit hydrograph. The equilibrium discharge for the scurve is
a) $750 \mathrm{~m}^{3} / \mathrm{s}$
b) $277.8 \mathrm{~m}^{3} / \mathrm{s}$
c) $250 \mathrm{~m}^{3} / \mathrm{s}$
d) $187 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\frac{1}{3} \times \frac{1}{100} \times 270 \times 10^{6} \times \frac{1}{3600}=250 \mathrm{~m}^{3} / \mathrm{hr}
$$

44. The excess runoff hydrograph from a catchment area $10 \mathrm{~km}^{2}$ due to a storm of 6 hrs duration has been observed to be triangular in shape. The peak flow is observed to be $10 \mathrm{~m}^{3} / \mathrm{s}$ and the base length is 20 hrs . the rainfall excess in the catchment is
a) 5.1 cm
b) 3.6 cm
c) 4.5 cm
d) 2.5 cm

Ans:

$$
\begin{aligned}
& 10 \times 10^{6} \times \frac{h}{100}=\frac{1}{2} \times 20 \times 3600 \times 10 \\
& \mathrm{~h}=3.6 \mathrm{~cm}
\end{aligned}
$$

45. The rainfall hyetograph shows the variation of which one of the following?
a) Cumulative depth of rainfall with time
b) Rainfall depth with area
c) Rainfall intensity with time
d) Rainfall intensity with cumulative depth of rainfall

Ans:(c)

## Flood estimation, reservoir capacity, reservoir and channel routing.

1. While applying the Rational formula for computing the design discharge, the rainfall duration is stipulated as the time of concentration because
a) this leads to the largest possible rainfall intensity
(b) this leads to the smallest possible rainfall intensity
(c) the time of concentration is the smallest rainfall duration for which the Rational formula is applicable
(d) the time of concentration is the largest rainfall duration for which the Rational formula is applicable
Ans: (d)
2. A flood wave with a known inflow hydrograph is routed through a large reservoir. The outflow hydrograph will have
(A) attenuated peak with reduced time-base
(B) attenuated peak with increased time-base
(C) increased peak with increased time-base
(D) increased peak with reduced time-base

Ans: (B)
3. The correct match of Group-I with Group-II is

Group-I
P. Evapotranspiration
Q. Infiltration

Group-II
R. Synthetic unit hydrograph
3. Muskingum method
S. Channel Routing 4. Horton's method
(A) P-1, Q-3, R-4, S-2
(B) P-1, Q-4, R-2, $S-3$
(C) P-3, Q-4, R-1, $S-2$
(D) P-4, Q-2, R-1, S-3

Ans: (B)
4. The hydrologic flood routing methods use
a) Equation of continuity only
b) Both momentum and continuity equations
c) Energy equation only
d) Equation of motion only

Ans: (a)
5. The hydraulic methods of flood routing use
a) Equation of continuity only
b) Both momentum and continuity equations
c) Energy equation only
d) Equation of motion only

Ans: (b)
6. The prism storage in a river reach during the passage of a flood wave is
a) a constant
b) a function of inflow and outflow
c) function of inflow only
d) function of outflow only

Ans: (a)
7. The wedge storage in a river reach during the passage of a flood wave is
a) a constant
b) negative during rising phase
c) positive during rising phase
d) positive during falling phase

Ans: (c)
8. In routing a flood through a reach the point of intersection of inflow and outflow hydrographs coincides with the peak of outflow hydrograph
a) In all cases of flood routing
b) When the inflow is into a reservoir with an uncontrolled outlet
c) In channel routing only
d) In all cases of reservoir routing

Ans: (b)
9. Which of the following is a proper reservoir routing equation
a) $\frac{1}{2}\left(I_{1}-I_{2}\right) \Delta t+\left(S_{1}+\frac{\mathrm{Q}_{1} \Delta t}{2}\right)=\left(S_{2}-\frac{\mathrm{Q} 2 \Delta t}{2}\right)$
b) $\left(I_{1}+I_{2}\right) \Delta t+\left(\frac{2 S 1}{\Delta t}-Q_{1}\right)=\left(\frac{2 S 2}{\Delta t}+Q_{2}\right)$
c) $\frac{1}{2}\left(I_{1}+I_{2}\right) \Delta t+\left(S_{2}-\frac{\mathrm{Q} 2^{2} t}{2}\right)=\left(S_{1}+\frac{\mathrm{Q} 1 \Delta t}{2}\right)$
d) $\left(I_{1}+I_{2}\right)+\left(\frac{2 S 1}{\Delta t}-Q_{1}\right)=\left(\frac{2 S 2}{\Delta t}+Q_{2}\right)$

Ans: (d)
10. The Muskingum method of flood routing is a
a) Form of reservoir routing method
b) Hydraulic routing method
c) Complete numerical solution of St Venant equations
d) Hydrologic channel routing method

Ans: (d)
11. The Muskingum method of flood routing assumes the storage S is related to inflow rate I and outflow rate Q of a reach as $\mathrm{S}=$
a) $K[x I-(1-x) Q]$
b) $K[x Q+(1-x) I]$
c) $K[x I+(1-x) Q]$
d) $K x[I-(1-x) Q]$

Ans: (c)
12. The Muskingum method of flood routing gives $Q_{2}=C_{0} I_{2}+C_{1} I_{1}+$ $C_{2} Q_{1}$. The coefficients in this equation will have values such that
a) $C_{0}+C_{1}=C_{2}$
b) $C_{0}-C_{1}-C_{2}=1$
c) $C_{0}+C_{1}+C_{2}=0$
d) $C_{0}+C_{1}+C_{2}=1$

Ans: (d)
13. The Muskingum channel routing equation is written for the outflow from the reach Q in terms of the inflow I and coefficients $C_{0}, C_{1}$ and $C_{2}$ as
a) $\quad Q_{2}=C_{0} I_{0}+C_{1} Q_{1}+C_{2} I_{2}$
b) $\quad Q_{2}=C_{0} I_{2}+C_{1} I_{1}+C_{2} Q_{1}$
c) $Q_{2}=C_{0} I_{0}+C_{1} I_{1}+C_{2} I_{2}$
d) $Q_{2}=C_{0} Q_{0}+C_{1} Q_{1}+C_{2} I_{2}$

Ans: (b)
14. In the Muskingum method of channel routing the routing equation is written as $Q_{2}=C_{0} I_{2}+C_{1} I_{1}+C_{2} Q_{1}$, if the coefficients $K=12 \mathrm{~h}$ and $\mathrm{x}=0.15$ and the time step for routing $\Delta t=4 \mathrm{~h}$, the coefficient $C_{0}$ is
a) 0.016
b) 0.048
c) 0.328
d) 0.656

Ans: (a)
15. In the Muskingum method of channel routing the weighing factor x can have a value
a) Between -0.5 to 0.5
b) Between 0.0 to 0.5
c) Between 0.0 to 1.0
d) Between -1.0 to 1.0

Ans: (b)
16. In the Muskingum method of channel routing if $x=0.5$, it represents an outflow hydrograph
a) That has reduced peak
b) With an amplified peak
c) That is exactly the same as the inflow hydrograph
d) With a peak which is exactly half of the inflow peak

Ans: (c)
17. If the storage S , inflow rate I and outflow rate Q for a river reach is written as

$$
S=K\left[x I^{n}+(1-x) Q^{n}\right]
$$

a) $\mathrm{n}=0$ represents storage routing through reservoir
b) $\mathrm{n}=1$ represents the Muskingum method
c) $\mathrm{n}=0$ represents the Muskingum method
d) $\mathrm{n}=0$ represents a linear channel

Ans: (b)
18. A linear reservoir is one in which the
a) Volume varies linearly with elevation
b) Storage varies linearly with the outflow rate
c) Storage varies linearly with time
d) Storage varies linearly with the inflow rate

Ans: (b)
19. An isochrone is a line on the basin map
a) Joining rainguage stations with equal rainfall duration
b) Joining points having equal standard time
c) Connecting points having equal time of travel of the surface runoff to the catchment outlet
d) That connects points of equal rainfall depth in a given time interval Ans: (c)
20. Probability of a 10 year flood to occur at least once in the next 4 years is
a) 2

Ans:

$$
1-\left(\frac{9}{10}\right)^{4}=0.343=35 \%
$$

21. A bridge has an expected life of 50 years and is designed for a flood magnitude of return period 100 years. What is the risk associated with this hydrologic design
a) $1-0.9950$
b) $0.5^{50}$
c) 0.9950
d) 0.99100

Ans:
$1-0.9950$
22. A culvert is designed for a flood magnitude of return period 100 years and has expected life of 20 years. The risk in this hydrologic design is
a) $1-0.99^{20}$
b) $1-0.01^{20}$
c) $1-0.09^{20}$
d) $1-0.10^{20}$

Ans:
$1-0.99^{20}$
23. The hydrologic risk of a 100 year flood occurring during the 2 year service life of a project is
a) $9.8 \%$
b) $9.9 \%$
c) $19.9 \%$
d) $1.99 \%$

Ans:

$$
1-0.99^{2}=0.019=1.99 \%
$$

24. The probability that a 100 year flood is equaled or exceeded, at least once in 100 years is
a) $99 \%$
b) $64 \%$
c) $36 \%$
d) $1 \%$

Ans:

$$
1-0.99100=0.63=64 \%
$$

25. 

In Muskingum method of flood routing if $C_{0}=0.3$ and $C_{1}=0.35$ then what is the value of $C_{2}$
a) 0.35
b) 0.3
c) 0.45
d) 0.5
Ans:
$C_{2}=1-0.3-0.35=0.35$

## Well hydraulics.

1. In an area of 200 hectare, water table drops by 4 m . If the porosity is 0.35 and the specific retention is 0.15 , change in volume of storage in the aquifer is
(A) $160 \mathrm{~m}^{3}$
(B) $1.6 \times 10^{6} \mathrm{~m}$
(C) $8 \times 10^{6} \mathrm{~m}$
(D) $1.6 \times 10^{3} \mathrm{~m}$

Ans:

$$
\text { Specific yield } \begin{aligned}
\left(S_{y}\right) & =5-S_{r} \\
& =0.35-0.15=0.2
\end{aligned}
$$

Change in volume of storage in aquifer $=0.2 \times$ $200 \times 10^{4} \times 4=1.6 \times 10^{6} \mathrm{~m}^{3}$
2. When there is an increase in the atmospheric pressure, the water level in a well penetrating in a confined aquifer
(A) Increases
(B) Decreases
(C) May increase or decrease depending on the nature of the aquifer
(D) Does not undergo any change

Ans: (D)
3. Water is pumped from a well tapping an unconfined aquifer at a certain discharge rate and the steady state drawdown (X) in an observation well is monitored. Subsequently, the pumping discharge is doubled and the steady state drawdown in the same observation well is found to be more than double (i.e., more than 2 X ). This disproportionate drawdown is caused by
(a) well losses
(b) decrease in the saturated thickness of the aquifer
(c) nonlinear flow
(d) delayed gravity yield

Ans: (c)
4. Two observation wells penetrated into a confined aquifer and located 1.5 km apart in the direction of flow, indicate head of 45 m and 20 m . If the coefficient of permeability of the aquifer is $30 \mathrm{~m} /$ day and porosity is 0.25 , the time of travel of an inert tracer from one well to another is
(a) 16.7 days
(b) 500 days
(c) 750 days
(d) 3000 days

Ans:

$$
\begin{aligned}
& \mathrm{i}=\frac{45-20}{1500}=0.0167 \\
& K=30 \mathrm{~m} / \text { day } \\
& \mathrm{P}=K \mathrm{i}=30 \times 0.0167=0.5 \mathrm{~m} / \text { day } \\
& \text { Seepage velocity } \mathrm{P}_{s}=\frac{\mathrm{P}}{y}=\frac{0.5}{0.25}=2 \mathrm{~m} / \text { day } \\
& \text { Velocity }=\frac{\text { distance }}{\text { time }} \\
& \text { Time }=\frac{1500}{2}=750 \text { days }
\end{aligned}
$$

5. For steady flow to a fully penetrating well in a confined acquifer, the drawdowns at radial distances of $r_{1}$ and $r_{2}$ from the well have been measured as $s_{1}$ and $s_{2}$ respectively, for a pumping rate of $Q$. The transmissivity of the aquifer is equal to
(a) $\frac{Q}{2 \pi} \frac{\ln \left(r_{2} / r_{1}\right)}{s_{1}-s_{2}}$
(b) $\frac{Q}{2 \pi} \frac{\ln \left(r_{2}-r_{1}\right)}{s_{1}-s_{2}}$
(c) $\frac{\mathrm{Q}}{2 \pi} \ln \left(\frac{\left(r_{2} / r_{1}\right)}{s_{1} / s_{2}}\right)$
(d) $2 \pi Q \frac{\left(r_{2}-r_{1}\right)}{\ln \left(\frac{s_{2}}{S_{1}}\right)}$

Ans: (a)
6. A volume of $3.0 \times 10^{6} \mathrm{~m}^{3}$ of groundwater was pumped out from an unconfined aquifer, uniformly from an area of $5 \mathrm{~km}^{2}$. The pumping lowered the water table from initial level of 102 m to 99 m . The specific yield of the aquifer is
(A) 0.20
(B) 0.30
(C) 0.40
(D) 0.50

Ans:

$$
=\frac{3 \times 10^{6}}{5 \times 10^{6} \times 3}=0.2
$$

7. The relationship among specific yield $\left(S_{y}\right)$, specific retention $\left(S_{r}\right)$ and porosity (5) of an aquifer is
(A) $S_{y}=S_{r}+5$
(B) $S_{y}=S_{r}-5$
(C) $S_{y}=5-S_{r}$
(D) $S_{y}=S_{r}+25$

Ans: (C)
8. A well of diameter 20 cm fully penetrates a confined aquifer. After a long period of pumping at a rate of 2720 liters per minute, the observations, of drawdown taken at 10 m and 100 m distances from the center of the well are found to be 3 m and 0.5 m respectively. The transmissivity of the aquifer is
(A) $676 \mathrm{~m}^{2} / \mathrm{day}$
(B) $576 \mathrm{~m}^{2} / \mathrm{day}$
(C) $526 \mathrm{~m}^{2} /$ day
(D) $249 \mathrm{~m}^{2} /$ day

Ans:

$$
\begin{aligned}
Q=2720 \frac{\text { lit }}{\min n} & =2720 \times 10^{-3} \times 60 \times 24 \\
& =3916.8 \mathrm{~m}^{3} / \mathrm{s} \\
T=\frac{\mathrm{Q}}{2 \pi} \frac{\text { loe }_{e}{ }^{r_{2}} / r_{1}}{\mathrm{Z}_{2}-\mathrm{Z}_{1}} & =\frac{3916.8}{2 \pi} \times \frac{\log _{e}{ }^{100} / 10}{2^{3-0.5}} \\
& =574.15 \frac{\mathrm{~m}^{2}}{d a y} \approx 576 \mathrm{~m}^{2} / \text { day }
\end{aligned}
$$

9. In an aquifer extending over 150 hectare, the water table was 20 m below ground level. Over a period of time the water table dropped to 23 m below the ground level. If the porosity of aquifer is 0.40 and the specific retention is 0.15 , what is the change in ground water storage of the aquifer?
(A) $67.5 \mathrm{ha}-\mathrm{m}$
(B) $112.5 \mathrm{ha}-\mathrm{m}$
(C) $180.0 \mathrm{ha}-\mathrm{m}$
(D) 450.0 ha-m

Ans:

$$
0.25 \times 150 \times 10^{4} \times 3=112.5 h a-m
$$

10. An aquifer confined at top and bottom by impervious layers is stratified into three layers as follows
Layer Thickness (m) Permeability (m/day)
$\begin{array}{lll}\text { Top } & 3.0 & 30\end{array}$
Middle $2.0 \quad 10$
Bottom 5.020
The transmissibility of the Aquifer in $m^{2} /$ day
a) 6000
b) 18.2
c) 20
d) 210

Ans:

$$
=3 \times 30+2 \times 10+5 \times 20=210 \mathrm{~m}^{2} / d a y
$$

11. A stratified unconfined Aquifer has three horizontal layers as below.
Layer coefficient of depth (m) Permeability ( $\mathrm{m} /$ day)

| 6 | 2.0 |
| :--- | :--- |
| 16 | 4.0 |
| 24 | 3.0 |

The effective coefficient of permeability of this Aquifer in $\mathrm{m} /$ day
a) 13
b) 15
c) 24
d) 16

Ans:

$$
=\frac{6 \times 2+16 \times 4+24 \times 3}{2+4+3}=16.44 \mathrm{~m} / \mathrm{day}
$$

12. The unit of Intrinsic permeability is
a) $\mathrm{Cm} /$ day
b) $m /$ day
c) day/day
d) $\mathrm{cm}^{2}$

Ans: (d)
13. The dimensions of coefficient of transmissibility T are
a) $L^{2} / T$
b) $\quad L^{2} / T^{2}$
c) $\mathrm{L} / \mathrm{T}^{2}$
d) Dimensionless

Ans: (a)
14. An unconfined aquifer of porosity $35 \%$ permeability $35 \mathrm{~m} /$ day and specific yield of 0.15 has an area of $100 \mathrm{~km}^{2}$. The water table falls by 0.2 m during a draught. The volume of water lost from storage in $\mathrm{Mm}^{3}$ is
a) 7.0
b) 3.0
c) 4.0
d) 18.0

Ans:

$$
=0.15 \times 100 \times 10^{6} \times 0.2=3 \mathrm{Mm}^{3}
$$

15. Two observation wells penetrating into a confined Aquifer are located 1.5 KM apart in the direction of flow. Heads of 45 m and 20 m are indicated at the Aquifer is $30 \mathrm{~m} /$ day and porosity is 0.25 , the time of travel of an inert tracer from one well to another is about
a) 417days
b) 500days
c) 750days
d) 3000days

Ans:

$$
\begin{aligned}
& \mathrm{i}=\frac{45-20}{1500}=0.0167 \\
& K=30 \mathrm{~m} / \text { day } \\
& \mathrm{P}=K \mathrm{i}=30 \times 0.0167=0.5 \mathrm{~m} / \text { day } \\
& \text { Seepage velocity } \mathrm{P}_{s}=\frac{\mathrm{P}}{y}=\frac{0.5}{0.25}=2 \mathrm{~m} / \text { day } \\
& \text { Velocity }=\frac{\text { distance }}{\text { time }} \\
& \text { Time }=\frac{1500}{2}=750 \text { days }
\end{aligned}
$$

16. Soil has a coefficient of permeability of $0.51 \mathrm{~cm} / \mathrm{s}$. If the kinematic viscosity of water is $0.009 \mathrm{~cm}^{2} / \mathrm{s}$, the intrinsic permeability in Darcy is about
a) $5.3 \times 10^{4}$
b) 474
c) $4.7 \times 10^{7}$
d) 4000

Ans:

$$
\begin{aligned}
& K=k \frac{\mu}{\gamma_{\mathrm{w}}}=k \frac{\mathrm{p}}{\mathrm{~g}} \\
& \quad=\frac{0.51 \times 0.009}{981}=4.67 \times 10^{-6} \\
& 1 \text { Darcy }=9.86 \times 10^{-9} \mathrm{~cm}^{2} \\
& K=\frac{4.67 \times 10^{-6}}{9.86 \times 10^{-9}}=474.53 \mathrm{~cm}^{2}
\end{aligned}
$$

## Duty, delta, estimation of evapo-transpiration.Crop water requirements.

1. A tube well having a capacity of $4 m^{3} /$ hour operates for 20 hours each day during the irrigation season. How much area can be commanded if the irrigation interval is 20 days and depth of irrigation is 7 cm ?
(A) $1.71 \times 10^{4} \mathrm{~m}^{2}$ (B) $1.14 \times 10^{4} \mathrm{~m}^{2}$
(C) $22.9 \times 10^{4} \mathrm{~m}^{2}$ (D) $2.29 \times 10^{4} \mathrm{~m}^{2}$

Ans:
Volume of water in 20 days $=4 \times 20 \times 20=$
$1600 \mathrm{~m}^{3}$

$$
\begin{aligned}
& 1600=\mathrm{A} \times \frac{7}{100} \\
& \therefore A=2.29 \times 10^{4} \mathrm{~m}^{2}
\end{aligned}
$$

2. A field was supplied water from an irrigation tank at a rate of 120 lit/sec to irrigate an area of 2.5 hectares. The duration of irrigation is 8 hours. It was found that the actual delivery at the field, which is about 4 km from the tank, was $100 \mathrm{lit} / \mathrm{sec}$. The runoff loss in the field was estimated as $800 \mathrm{~m}^{3}$. The application efficiency in this situation is
(A) $62 \%$
(B) $72 \%$
(C) $76 \%$
(D) $80 \%$

Ans:

$$
\begin{aligned}
\text { Water delivered to the field } & =\frac{100}{1000} \times 3600 \times 8 \\
& =2880 \mathrm{~m}^{3}
\end{aligned}
$$

The water lost as runoff $=800 \mathrm{~m}^{3}$
Water stored $=2880-800=2080 \mathrm{~m}^{3}$
Application efficiency $=\frac{2080}{2880} \times 100=72 \%$
3. A canal was designed to supply the irrigation needs of 1200 hectares to land growing rice of 140 days base period having a Delta of 134 cms . If this canal water is used to irriagate wheat of base period 120 days having a Delta of 52 cm , the area (in Hectares) that can be irrigated is
(A) 2650
(B) 3608
(C) 543
(D) None of the above

Ans:

$$
\begin{aligned}
& D_{\text {rice }}=8.64 .{ }_{\Delta}^{B}=8.64 \times \frac{140}{1.34}=902.69 \mathrm{ha} / \mathrm{cumec} \\
& \text { Discharge } \mathrm{Q}=\frac{A}{D}=\frac{1200}{902.69}=1.3294 \mathrm{~m}^{3} / \mathrm{s} \\
& D_{\text {wheat }}=8.64 \times \frac{120}{0.52} \\
& \quad=1993.85 \mathrm{ha} / \mathrm{cumec} \\
& A=D . Q=1993.85 \times 1.3294=2650 \mathrm{ha} .
\end{aligned}
$$

4. The total irrigation depth of water, required by a certain crop in its entire growing period ( 150 days), is 25.92 cm . The culturable command area for a distributary channel is 100,000 hectares. The distributary channel shall be designed for a discharge.
(a) Less than 2 cumecs
(b) 2 cumecs
(c) 20 cumecs
(d) More than 20 cumecs

Ans:

$$
\frac{100,000, \times 10^{4} \times \frac{25.92}{100}}{150 \times 86400}=20 \text { cumecs }
$$

5. The moisture content of soil in the root zone of an agricultural crop at certain stage is found to be 0.05 . The field capacity of the soil is 0.15 . The root zone depth is 1.1 m . The consumptive use of crop at this stage is $2.5 \mathrm{~mm} /$ day and there is no precipitation during this period. Irrigation efficiency is $65 \%$. It is intended to raise the moisture content to the field capacity in 8 days through irrigation. The necessary depth of irrigation is
(a) 115 mm
(b) 169 mm
(c) 200 mm
(d) 285 mm

Ans:

$$
\begin{aligned}
\frac{\gamma_{d}}{\gamma_{\mathrm{w}}} \cdot d \cdot[F \cdot C-M \cdot C] & =\frac{15}{10} \times 1100 \times[0.15-0.10] \\
& =165 \mathrm{~mm}
\end{aligned}
$$

Consumptive use in 8 days $=8 \times 2.5=20 \mathrm{~mm}$
Total $=165+20=185 \mathrm{~mm}$
Applying application efficiency $=\frac{185}{0.65}=285 \mathrm{~mm}$
6. A canal irrigates a portion of a culturable command area to grow sugarcane and wheat. The average discharges required to grow sugarcane and wheat area, respectively, 0.36 and 0.27 cumecs. The time factor is 0.9 . The required design capacity of the canal is
(a) 0.36 cumecs
(b) 0.40 cumecs
(c) 0.63 cumecs
(d) 0.70 cumecs

Ans:
$0.36+0.27=0.63$ cumec
Design capacity $=\frac{0.63}{0.9}=0.7$ cumecs
7. The culturable commanded area for a distributary is $2 \times 10^{8} \mathrm{~m}^{2}$. The intensity of irrigation for a crop is $40 \%$. If kor water depth and kor period for the crop are 14 cm and 4 weeks, respectively, the peak demand discharge is
(a) $2.63 \mathrm{~m}^{3} / \mathrm{s}$
(b) $4.63 \mathrm{~m}^{3} / \mathrm{s}$
(c) $8.58 \mathrm{~m}^{3} / \mathrm{s}$
(d) $11.58 \mathrm{~m}^{3} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \mathrm{A}=2 \times 10^{8} \times 0.4=80 \times 10^{6} \mathrm{~m}^{2} \\
&=8000 \mathrm{ha} \\
& \mathrm{D}=8.64 \times \frac{28}{0.14}= 1728 \mathrm{ha} / \mathrm{cumecc} \\
& \mathrm{Q}=\frac{A}{D}=\frac{8000}{1728}=4.63 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

8. In a cultivated area, the soil has porosity of $45 \%$ and field capacity of $38 \%$. For a particular crop, the root zone depth is 1.0 m , the permanent wilting point is $10 \%$ and the consumptive use is 15 $\mathrm{mm} / \mathrm{d}$. If the irrigation efficiency is $60 \%$, what should be the frequency of irrigation such that the moisture content does not fall below $50 \%$ of the maximum available moisture?
(a) 5 d
(b) 6 d
(c) 9 d
(d) 15 d

Ans:

$$
\begin{aligned}
& \mathrm{F}=\frac{\gamma \mathrm{w}}{\gamma_{d}} \times \text { Porosity } \\
& 0.38=\frac{9.81}{\gamma_{d}} \times 0.45 \\
& \therefore \gamma_{d}=11.6171 \mathrm{KN} / \mathrm{m}^{3} \\
& \text { Water required }=\frac{11.6171}{9.81} \times 1000 \times\left[\frac{0.38-0.1}{2}\right]=165.79 \mathrm{~mm} \\
& \text { Frequency }=\frac{165.79}{15}=11 \text { days. } \\
& \text { So Ans is } 9 \text { days. }
\end{aligned}
$$

9. The consumptive use of water for a crop during a particular stage of growth is $2.0 \mathrm{~mm} /$ day. The maximum depth of available water in the root zone is 60 mm . Irrigation is required when the amountof available water is $50 \%$ of the maximum available water in the root zone. Frequency of irrigation should be
(a) 10 days
(b) 15 days
(c) 20 days
(d) 25 days

Ans:

$$
\frac{60 \times 0.5}{2}=15 \text { days }
$$

10. The culturable command area for a distributary channel is 20,000 hectares. Wheat is grown in the entire area and the intensity of irrigation is $50 \%$. The kor period for wheat is 30 days and the kor water depth is 120 mm . The outlet discharge for the distributary should be
(a) $2.85 \mathrm{~m} 3 / \mathrm{s}$
(b) $3.21 \mathrm{~m} 3 / \mathrm{s}$
(c) $4.63 \mathrm{~m} 3 / \mathrm{s}$
(d) $5.23 \mathrm{~m} 3 / \mathrm{s}$

Ans:

$$
\begin{aligned}
& \mathrm{A}=20,000 \times 0.5=10,000 \mathrm{ha} \\
& \mathrm{D}=8.64 \times \frac{30}{0.12}=2160 \mathrm{ha} / \mathrm{cumec} \\
& \mathrm{Q}=\frac{A}{D}=\frac{10000}{2160}=4.63 \mathrm{~m}^{3} / \mathrm{s}
\end{aligned}
$$

11. An outlet irrigates an area of 20ha. The discharge ( $1 / \mathrm{s}$ ) required at this outlet to meet the evapotranspiration requirement of 20 mm occurring uniformly in 20 days neglecting other field losses is

$$
\text { (A) } 2.52 \text { (B) } 2.31 \text { (C) } 2.01 \text { (D) } 1.52
$$

Ans:

$$
\begin{aligned}
& 20 \times 10^{4} \times \frac{20}{1000}=\frac{\mathrm{Q}}{1000} \times 86400 \times 20 \\
& \mathrm{Q}=2.31 \mathrm{lit} / \mathrm{sec}
\end{aligned}
$$

12. An agricultural land of 437 ha is to be irrigated for a particular crop. The base period of the crop is 90 days and the total depth of water required by the crop is 105 cm . If a rainfall of 15 cm occurs during the base period, the duty of irrigation water is
(A) 437ha/cumec
(B) 486ha/cumec
(C) 741ha/cumec
(D) 864ha/cumec

Ans:

$$
\mathrm{D}=8.64 \times \frac{90}{\frac{(105-15)}{100}}=864 \mathrm{ha} / \mathrm{cumec}
$$

13. The moisture holding capacity of the soil in a 100 hectare farm is $18 \mathrm{~cm} / \mathrm{m}$. The field is to be irrigated when 50 percent of the available moisture in the root zone is depleted. The irrigation water is to be supplied by a pump working for 10 hours a day. and water application efficiency is 75 percent. Details of crops planned for cultivation are as follows
Crop X Y

Root zone depth (m) $\quad 1.0 \quad 0.8$
$\begin{array}{lll}\text { Peak rate of moisture } & 5.0 & 4.0\end{array}$
use mm /day
The capacity of irrigation system required to irrigate crop X in 36 hectares is
(A) 83 litres $/ \mathrm{sec}$
(B) 67 litres $/ \mathrm{sec}$
(C) 57 litres/sec
(D) 53 litres $/ \mathrm{sec}$

Ans:

> Root Zone depth $=1.0 \mathrm{~m}$
> Moisture use $=5 \mathrm{~mm} /$ day
> $\mathrm{A}=36$ ha
> Frequency $=\frac{18 \times 10 \times 0.5}{5}=18$ days

$$
\begin{aligned}
& \text { Quantity of water }=36 \times 10^{4} \times \frac{9}{100}=32400 \mathrm{~m}^{3} \\
& Q=\frac{32400 \times 1000}{0.75 \times 18 \times 3600 \times 10}=66.67 \approx 67 \mathrm{lit} / \mathrm{sec}
\end{aligned}
$$

14. The moisture holding capacity of the soil in a 100 hectare farm is $18 \mathrm{~cm} / \mathrm{m}$. The field is to be irrigated when 50 percent of the available moisture in the root zone is depleted. The irrigation water is to be supplied by a pump working for 10 hours a day. and water application efficiency is 75 percent. Details of crops planned for cultivation are as follows
Crop X Y
$\begin{array}{lll}\text { Root zone depth (m) } & 1.0 & 0.8\end{array}$
Peak rate of moisture $\quad 5.0 \quad 4.0$
use mm /day
The area of crop $Y$ that can be irrigated when the available capacity of irrigation system is 40 litres/sec is
(A) 40 hectares
(B) 36 hectares
(C) 30 hectares (D) 27 hectares

Ans:

$$
\begin{gathered}
\frac{40}{1000} \times 10 \times 3600=\frac{1440 m^{3}}{d a y} \\
\frac{4 m m}{1000} \times A \times 10^{4}=1440 \times 0.75 \\
\therefore A=27 \mathrm{ha}
\end{gathered}
$$

15. Wheat crop requires 55 cm of water during 120 days of base period. The total rainfall during this period is 100 mm . Assume the irrigation efficiency to be $60 \%$. The area (in ha) of the land which can be irrigated with a canal flow of $0.01 \mathrm{~m}^{3} / \mathrm{s}$ is
(A) 13.82 (B) 18.85 (C) 23.04 (D) 230.40

Ans:

$$
\begin{aligned}
& \mathrm{D}=8.64 \times \frac{120}{0.45}=2304 \text { ha/cumecs } \\
& \mathrm{A}=\mathrm{D} \times Q \\
& \mathrm{~A}=2304 \times 0.6 \times 0.01=13.824
\end{aligned}
$$

16. The transplantation of rice requires 10 days and total depth of water required during transplantation is 48 cm . During transplantation, there is an effective rainfall (useful for irrigation) of 8 cm . The duty of irrigation water (in hectares/cumec) is:
(A) 612 (B) 216 (C)300 (D) 108

Ans:

$$
\mathrm{D}=8.64 \times{ }_{0.4}^{10}=216 \mathrm{ha} / \text { cumecc }
$$

17. Delta ( $\Delta$ ) in cm, duty D in ha/cumecs and base period B in days are related of.
(a) $\Delta=864{ }^{\mathrm{B}}$
(c) $\mathrm{B}=864 \mathrm{D}$
(b) $\mathrm{B}=864 \stackrel{\Delta}{\mathrm{D}}$
(d) $\mathrm{D}=8.64{ }_{\Delta}^{\mathrm{B}}$.

Ans: (a)
18. Water table drops by 3 m in an irrigation land as 50 ha . If porosity and specific retention are 0.3 and 0.1 respectively. The change in storage in ha- $m$ is.
(a) 15 (b) 30 (c) 45
(d) 60

Ans:

$$
50 \times 3 \times 0.12=30 \text { ha. } \mathrm{m}
$$

19. If duty D is 1428 ha /cumec and base period B is 120 days for an irrigation crop, then delta $\Delta$ in $m$ is given by.
(a) 102.8 (b) 0.73 (c) 1.38 (d) 0.01 .

Ans:

$$
\begin{aligned}
\Delta & =8.64 \times \frac{B}{D} \\
& =8.64 \times \frac{120}{1428}=0.73 \mathrm{~m}
\end{aligned}
$$

20. A tube well having capacity of $4 \mathrm{~m}^{3} /$ hoperates for 20 hrs each day during the irrigation season. How much area can be commanded if the irrigation interval is 20 days and depth of irrigation is 7 cm ?
(a) $1.72 \times 10^{4} \mathrm{~m}^{2}$ (c) $22.9 \times 10^{4} \mathrm{~m}^{2}$
(b) $1.14 \times 10^{4} \mathrm{~m}^{2}$ (d) $2.29 \times 10^{4} \mathrm{~m}^{2}$.

Ans:

$$
\begin{aligned}
& 4 \times 20 \times 20=1600 \mathrm{~m}^{3} \\
& 1600=\frac{7}{100} \times A \\
& \therefore A=2.29 \times 10^{4} \mathrm{~m}^{2}
\end{aligned}
$$

21. In farmland irrigation by a system of pumps from wells, the area irrigation is 50 ha. Water pumped from wells is conveyed through a canal to the forms. Efficiency of conveyed is $85 \%$ and pumps work $12 \mathrm{hr} /$ day. Available moisture holding capacity of soil is $20 \mathrm{~cm} / \mathrm{m}$. and average root zone depth is 1 m . water application efficiency is $80 \%$. Irrigation is started when moisture extraction efficiency level of $50 \%$ of available moisture is reached. Peak rate of moisture use by plants is 5 mm . calculate the irrigation period in days and total pumping capacity required in lit/min.
a) 20,6125
b) 10,6000
c) 25,3000
d) 15,8125

Ans:
Root zone $=1 \mathrm{~m}$
Moisture holding capacity $=20 \mathrm{~cm} / \mathrm{m} \times 1 \mathrm{~m}=20 \mathrm{~cm}$
Irrigation is started when $50 \%$ means 10 cm depletion

```
Frequency \(=\frac{10 \times 10 \mathrm{~mm}}{5 \mathrm{~mm}}=20\) days
Per day water requirement \(=50 \times 10^{4} \times \frac{5}{1000}=2500 \mathrm{~m}^{3}\).
Application efficiency \(=80 \%\)
    \(\therefore \frac{2500}{0.8}=3125 \mathrm{~m}^{3}\)
Conveyance efficiency \(=85 \%\)
\(\therefore \frac{3125}{0.85}=3675 \mathrm{~m}^{3} / \mathrm{day}\)
\(\therefore \frac{3675 \times 1000}{10 \times 60}=6125 \mathrm{lit} / \mathrm{m}\)
```

22. Given that the base period is 100days and the duty of the canal is 1000 hectares per cumecs, the depth of water will be
a) 0.864 cm
b) 8.64 cm
c) 86.4 cm
d) 864 cm

Ans:

$$
\Delta=8.64 \times \frac{100}{1000}=86.4 \mathrm{~cm}
$$

23. The following data were recorded from an irrigated field :
24. Field capacity: $20 \%$
25. Permanent wilting point: $10 \%$
26. Permissible depletion of available soil moisture : $50 \%$
27. Dry unit weight of soil: $1500 \mathrm{~kg} / \mathrm{m}^{3}$
28. Effective rainfall: 25 mm

Based on these date, the net irrigation requirement per meter depth of soli will be
a) 75 mm
b) 125 mm
c) 50 mm
d) 25 m

Ans:

$$
\frac{1500}{1000} .1000 \times(0.2-0.1) \times 0.5-25=50 \mathrm{~mm}
$$

24. $10 \mathrm{~m}^{3} / \mathrm{s}$ of water is diverted to a 32 hectare field for 4 hours. Soil probing after irrigation showed that 0.3 m of water had been stored in the root zone. Water application efficiency in this case would be
a) $96 \%$
b) $66.60 \%$
c) $48 \%$
d) 245

Ans:

```
Water applied \(=\frac{10 \times 3600 \times 4}{32 \times 10^{4}}=0.45\)
Water stored \(=0.3\)
Application efficiency \(=\frac{0.3}{0.45} \times 100=66.6 \%\)
```

25. A canal was designed to supply the irrigation needs of 1000ha of land growing rice of 140 days base period and having a delta of 130 cm . if the canal water is used to irrigate wheat of base period 119 days and having a delta of 50 cm , the area that can be irrigated is
a) 452 ha
b) 904 ha
c) 1105 ha
d) 2210 ha

Ans:

$$
\begin{aligned}
& 1000 \times \frac{130}{140}=A \times \frac{50}{119} \\
& \therefore A=2210 \mathrm{ha}
\end{aligned}
$$

26. The delta for crop having base period 120 days is 70 cm . what is the duty?
a) 2480 hectare/cumec
b) 1481 hectare/cumec
c) 148 hectare/cumec
d) 1.481 hectare/cumec

Ans:

$$
\mathrm{D}=864 \times \frac{120}{70}=1481 \mathrm{ha} / \mathrm{cumec}
$$

27. For a culturable command area of 1000 hectare with intensity of irrigation of $50 \%$ the duty on filed for a certain crop is 2000 hectare/cumec. What is the discharge required at head of water course with $25 \%$ losses of water?
a) $3 / 16$ cumec
b) $1 / 4$ cumec
c) $1 / 3$ cumec
d) $1 / 2$ cumec

Ans:

$$
\begin{aligned}
& \mathrm{A}=1000 \times 50 \%=500 \mathrm{ha} \\
& \mathrm{D}=2000 \mathrm{ha} / \mathrm{cumec} \\
& \mathrm{Q}=\frac{A}{D}=\frac{5000}{2000}=0.25 \mathrm{~m}^{3} / \mathrm{sec}=\frac{1}{4} \\
& \mathrm{Q} \text { at water course }=\frac{1}{0.75}=\frac{1}{3}=1 \mathrm{~m}^{3} / \mathrm{sec}
\end{aligned}
$$

28. What is the moisture depth available for evapo-transpiration in root zone of 1 m depth soil, if dry weight of soil is $1.5 \mathrm{gm} / \mathrm{cc}$, field capacity is $30 \%$ and permanent wilting point is $10 \%$ ?
a) 450 mm
b) 300 mm
c) 200 mm
d) 150 mm

Ans:

$$
\underset{1}{1.5} \times 1 \times(0.3-0.1)=0.3 \mathrm{~m}=300 \mathrm{~mm}
$$

29. If the discharger required for different crops is 0.4 cumecs in the field and the capacity factor and time factors are 0.8 and 0.5 respectively, then what is the design discharge of the distributary as its head?
a) 0.80 cumecs
b) 0.16 cumecs
c) 1.0 cumecs
d) 1.24 cumecs

Ans:

$$
\frac{0.4}{0.8 \times 0.5}=1 \text { cumec }
$$

30. During a particular stage of the growth of a crop, consumptive use of water is $2.8 \mathrm{~mm} /$ day. If the amount of water available in the soil is $25 \%$ of 80 mm depth of water, what is the frequency of irrigation?
a) 9days
b) 13days
c) 21days
d) 25 days

Ans:

$$
\frac{75 \% \text { of } 80 \mathrm{~mm}}{2.8}=\frac{60}{2.8}=21.42 \text { say } 21 \text { days }
$$

31. In a canal irrigation project, $76 \%$ of the culturable command area(CCA) remained without water during Kharif season; and 58\% of CCA remained without water during Rabi season in particular year. Rest of the areas got irrigated in each crop respectively. What is the intensity of irrigation for the project in the year?
a) $134 \%$
b) $76 \%$
c) $66 \%$
d) $58 \%$

Ans:

$$
(100-76)+(100-58)=24+42=66 \%
$$

32. The discharge required for Rabi and Kharif crops are $0.4 \mathrm{~m}^{3} / \mathrm{s}$ and $0.3 \mathrm{~m}^{3} / \mathrm{s}$ respectively. The capacity and time factors are 0.8 and 0.5 respectively at each season. The design discharge of the distributary at its head is
a) $0.8 \mathrm{~m}^{3} / \mathrm{S}$
b) $0.16 \mathrm{~m}^{3} / \mathrm{S}$
c) $1.0 \mathrm{~m}^{3} / \mathrm{S}$
d) $1.24 \mathrm{~m}^{3} / \mathrm{S}$

Ans:

$$
0.4 /(0.8 \times 0.5)=1 \mathrm{~m}^{3} / \mathrm{s}
$$

Design of: lined and unlined canals, waterways, head works, gravity dams and spillways.

1. On which of the canal systems, R.G. Kennedy, executive engineer in the Punjab Irrigation Department made his observations for proposing his theory on stable channels?
(a) Krishna Western Delta canals
(b) Lower Bari Doab canals
(c) Lower Chenab canals
(d) Upper Bari Doab canals

Ans: (d)
2. Which one of the following equations represents the downstream profile of Ogee spillway with vertical upstream face? $\{(\mathrm{x}, \mathrm{y})$ are the co-ordinates of the point on the downstream profile with origin at the crest of the spillway and $\mathrm{H}_{\mathrm{d}}$ is the design head \}
(a)

$$
\frac{y}{H_{d}}=-0.5\left(\frac{x}{H_{x}}\right)^{185}
$$

(b)

$$
\frac{y}{H_{d}}=-0.5\left(\frac{x}{H_{d}}\right)^{1 / 1.85}
$$

(c)

$$
\frac{y}{H_{d}}=-2.0\left(\frac{\mathrm{x}}{\mathrm{H}_{\mathrm{d}}}\right)^{1.85}
$$

(d)

$$
\frac{y}{H_{d}}=-2.0\left(\frac{x}{H_{d}}\right)^{1 / 1.85}
$$

Ans:

$$
\begin{aligned}
x^{1.85} & =2 . H_{d}{ }_{d}^{0.85} . \mathrm{y} \\
\frac{y}{H_{d}} & =x^{1.85} \times \frac{1}{2} \times H_{d}^{-1.85} \\
& =-0.5 \times\left(\frac{x}{H_{d}}\right)^{1.85}
\end{aligned}
$$

3. A triangular irrigation lined canal carries a discharge of $25 \mathrm{~m}^{3} / \mathrm{s}$ at bed slope $=1 / 6000$. If the side slopes of the canal are $1: 1$ and Manning's coefficient is 0.018 , the central depth of flow is equal to
(a) 1.98 m
(b) $\quad 2.98 \mathrm{~m}$
(c) $\quad 3.62 \mathrm{~m}$
(d) 5.62 m

Ans:

$$
\begin{aligned}
& \mathrm{Q}=25 \mathrm{~m}^{3} / \mathrm{S} \\
& =1 / 6000 \mathrm{n} \\
& =0.018 \\
& \mathrm{~A}=y^{2}(\theta+\cot \theta)=y^{2} \times\left(\frac{\pi}{4}+1\right) \\
& =1.7854 y^{2} \\
& \mathrm{R}=\mathrm{y} / 2 \\
& \mathrm{Q}=\mathrm{AV} \\
& =\mathrm{A} \times \frac{1}{n} \times R^{2 / 3} S^{\frac{1}{2}} \\
& 25=1.7854 y^{2} \times \frac{1}{0.018} \times\left(\frac{y^{2 / 3}}{2}\right)^{1 /\left(\frac{1}{6000}\right)}{ }^{1 / 2} \\
& 25=y^{8 / 3} \times 0.8067 \\
& \mathrm{y}=3.62 \mathrm{~m}
\end{aligned}
$$

4. A launching apron is to be designed at downstream of a weir for discharge intensity of $6.5 \mathrm{~m}^{3} / \mathrm{s} / \mathrm{m}$. For the design of launching aprons the scour depth is taken two times of Lacey scour depth. The silt factor of the bed material is unity. If the tailwater depth is 4.4 m , the length of launching apron in the launched position is
(a) $\sqrt{5} m$
(b) 4.7 m
(c) 5 m
(d) $5 \sqrt{5 m}$

Ans:

$$
\begin{aligned}
& \mathrm{Q}=6.5 \mathrm{~m}^{3} / \mathrm{s} / \mathrm{m} \\
& \mathrm{f}=1 \\
& \text { Tail water depth }=4.4 \mathrm{~m} \\
& \text { Lacey's scour depth }=1.35 \cdot\left(\frac{q^{2}}{\mathrm{f}}\right)^{1 / 3} \\
& \qquad=1.35 \cdot\left(\frac{6.5^{2}}{1}\right)^{1 / 3}=4.7 \mathrm{~m}
\end{aligned}
$$

$$
\mathrm{D}=2 \times 4.7-4.4=5 \mathrm{~m}
$$

$$
\text { The length of launching apron }=\sqrt{5} \mathrm{D}
$$

$$
\begin{aligned}
& =\sqrt{5} \times 5 \\
& =5 \sqrt{5} \mathrm{~m}
\end{aligned}
$$

5. A very wide rectangular channel is designed to carry a discharge of $5 \mathrm{~m}^{3} / \mathrm{s}$ per meter width. The design is based on the Manning's equation with the roughness coefficient obtained from the grain size using Strickler's equation and results in a normal depth of 1.0 m . By mistake, however the engineer used the grain diameter in mm in the Stickler's equation instead of in meter. What should be the correct normal depth?
(a) $\quad 0.32 \mathrm{~m}$ (b) $\quad 0.50 \mathrm{~m}$
(c) $\quad 2.00 \mathrm{~m}$ (d) $\quad 3.20 \mathrm{~m}$

Ans:

$$
\begin{aligned}
\mathrm{Q} & =\mathrm{A} \cdot \mathrm{~V} \\
5 & =\mathrm{y} \times{ }_{n}^{1} \cdot y^{2 / 3} \cdot S^{1 / 2}
\end{aligned}
$$

According to sticklers formula
$\mathrm{n}={ }_{24}^{1} d^{1 / 6}$
n a $y^{5 / 3}$

$$
\begin{aligned}
& \text { or } \mathrm{y} \mathrm{a} d^{\frac{1}{6} \times \frac{3}{5}} \\
& \therefore \text { i.e. } \mathrm{y} \text { a } d^{1 / 10} \\
& \frac{y_{1}}{y_{2}}=\frac{d_{1}^{1 / 10}}{d_{2}^{1 / 10}} \\
& \therefore y_{2}=\frac{y_{1} d_{2}^{1 / 10}}{d_{1}^{1 / 10}}=1 \times\left(\frac{d_{2}}{d_{1}}\right)^{\frac{1}{10}} \\
& =1 \times(0.001)^{1 / 10}=0.5 \mathrm{~m}
\end{aligned}
$$

6. As per the Lacey's method for design of a alluvial channels, identify the true statement from the following
(a) Wetted perimeter increases with an increase in design discharge
(b) Hydraulic radius increases with an increase in silt factor.
(c) Wetted perimeter decreases with an increase in design discharge.
(d) Wetted perimeter increases with an increase in silt factor

Ans:

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

Hence Wetted perimeter increases with an increase in design discharge
7. A stable channel is to be designed for a discharge of $\mathrm{Q} \mathrm{m}^{3} / \mathrm{s}$ with silt factor f as per Lacey's method. The mean flow velocity ( $\mathrm{m} / \mathrm{s}$ ) in the channel is obtained by
(A) $\left(\mathrm{Qf}^{2} / 140\right)^{1 / 6}$
(B) $(\mathrm{Qf} / 140)^{1 / 3}$
(C) $\left(\mathrm{Q}^{2} \mathrm{f}^{2} / 140\right)^{1 / 6}$
(D) $0.48(\mathrm{Q} / \mathrm{f})^{1 / 3}$

Ans:

$$
\mathrm{V}=\left(\frac{\mathrm{Qf}^{2}}{140}\right)^{1 / 6} \mathrm{~m} / \mathrm{s}
$$

8. The base width of an elementary profile of gravity dam of height $\mathbf{H}$ is $b$. The specific gravity of the material of the dam is $G$ and uplift pressure coefficient is K. the correct relationship for no tension at the heel is given by
(A) $\frac{b}{H}=\frac{1}{\sqrt{G-K}}$
(B) ${ }_{H}^{b}=\sqrt{G}-K$
(C) $\frac{b}{H}=\frac{1}{G-K}$
(D) $\frac{b}{H}=\frac{1}{K \sqrt{G-K}}$

Ans:

$$
\begin{aligned}
& \mathrm{B}=\frac{H}{\sqrt{G-K}} \\
& \therefore \frac{B}{H}=\frac{1}{\sqrt{G-K}}
\end{aligned}
$$

9. The depth of flow in an alluvial channel is 1.5 m . If critical velocity ratio is 1.1 and Manning's $n$ is 0.018 , the critical velocity of the channel as per Kennedy's method is
(A) $0.713 \mathrm{~m} / \mathrm{s}$
(B) $0.784 \mathrm{~m} / \mathrm{s}$
(C) $0.879 \mathrm{~m} / \mathrm{s}$
(D) $1.108 \mathrm{~m} / \mathrm{s}$

Ans:

$$
\begin{aligned}
& V_{0}=0.55 \mathrm{~m} y^{0.64} \\
& =0.55 \times 1.1 \times 1.5^{0.64}=0.784 \mathrm{~m} / \mathrm{s} .
\end{aligned}
$$

10. A trapezoidal channel is 10.0 m wide at the base and has a side slope of 4 horizontal to 3 vertical. The bed slope is 0.002 . The channel is lined with smooth concrete (Manning's $n=0.012$ ). The hydraulic radius (in m ) for a depth of flow of 3.0 m is
(A) 20.0
(B) 3.5
(C) 3.0
(D) 2.19

Ans:

$$
\begin{aligned}
& \mathrm{A}=\mathrm{y}(\mathrm{~B}+\mathrm{y} \theta+\mathrm{y} \cot \theta) \\
& \theta
\end{aligned}=\tan ^{-1} \frac{3}{4}=36.87^{0}=0.643 \mathrm{rad}, ~ \begin{aligned}
& \mathrm{y}=3 \mathrm{~m} \\
& \begin{aligned}
\therefore \mathrm{A} & =3\left(10+3 \times 0.643+3 \times \cot 36^{\prime} .877^{\circ}\right) \\
& =47.786 \mathrm{~m}^{2} \\
\mathrm{P} & =\mathrm{B}+2 \mathrm{y} \theta+2 \mathrm{ycot} \theta \\
& =10+2 \times 3 \times 0.643+2+3 \times \cot 36^{\prime} .870 \\
& =21.86 \mathrm{~m} \\
\mathrm{R} & =\frac{A}{P}=\frac{47.786}{21.86}=2.186 \mathrm{~m}
\end{aligned}
\end{aligned}
$$

11. The maximum height of a low gravity dam of elementary profile made of concrete of relative density 2.5 and safe allowable stress of foundation material 3.87 MPa without considering uplift force is about
a) 113 m
b) 217 m
c) 279 m
d) 325 m

Ans:

$$
\mathrm{H}=\frac{\mathrm{f}}{r_{\mathrm{w}}\left[S_{c}-C+1\right]}=\frac{3.87 \times 10^{6}}{9810[2.5+1]}=113 \mathrm{~m} .
$$

12. In order to ensure that no scouring takes place in the bed of a channel of bed slope ' $S$ ' constructed on alluvial soil of particle size ' d ' cm , the flow velocity should be restricted to
a) $4.85 \mathrm{~d}^{1 / 2} \mathrm{~S}^{1 / 6}$
b) $4.85 \mathrm{~d}^{-1 / 2} \mathrm{~S}^{1 / 6}$
c) $0.48 \mathrm{~d}^{1 / 2} \mathrm{~S}^{-1 / 6}$
d) $0.048 \mathrm{~d}^{-1 / 2} \mathrm{~S}^{1 / 6}$

Ans:

$$
\begin{aligned}
\mathrm{d} & \geq 11 \mathrm{RS} \\
\mathrm{R} & =\frac{d}{11 \times S} \\
\mathrm{n} & =\frac{d^{1 / 6}}{24} \\
\mathrm{~V} & =\frac{1}{n} \times R^{2 / 3} S^{1 / 2} \\
& =\frac{24}{d^{1 / 6}} \times\left(\frac{d}{11 s}\right)^{2 / 3} \times S^{2} \\
& =\frac{24}{11^{2} / 3} d^{2} \times \frac{1}{5} \times S_{z^{-}}^{\frac{1}{3}} \\
& =4.85 \times d^{\frac{1}{2}} S^{-\frac{1}{6}}
\end{aligned}
$$

13. The Lacey's silt factor for a particular alluvium is 2.0 .this alluvium would comprise
a) Medium sand of size 0.5 mm
b) Coarse sand of size 0.75 mm
c) Medium bajri of size 1.3 mm
d) Coarse bajri of size 2.4 mm

Ans:

$$
\begin{aligned}
& \mathrm{f}=2 \\
& \mathrm{f}=1.76 \sqrt{d_{m m}} \\
& 2=1.76 \sqrt{d_{m m}} \\
& d_{m m}=1.3 \mathrm{~mm}
\end{aligned}
$$

14. Consider the following statements :

Garret's diagram for the design of irrigation channel is based on:

1. Kennedy's theory
2. Lacey's theory
3. Kutter's formula
4. Manning's formula

Which of these statements are correct?
a) 1 and 3
b) 1 and 4
c) 2 and 3
d) 2 and 4

Ans: (a)
15. The total number of independent equations that form the Lacey's regime theory is
a) 2
b) 3
c) 4
d) 6

Ans: (b)
16. What is the regime scour depth for a channel in soil with silt factor of unity and carrying $8 \mathrm{~m}^{2} / \mathrm{S}$ of discharge intensity in accordance with Lacey's regime theory?
a) 3.6 m
b) 4 m
c) 5.4 m
d) 25.6 m

Ans:

$$
\mathrm{R}=1.35\left(\frac{q^{2}}{\mathrm{f}}\right)^{1 / 3}=1.35 \times\left(\frac{8^{2}}{1}\right)^{1 / 3}=5.4 \mathrm{~m}
$$

17. Which one of the following equations represents the downstream curve of the "Ogee' spillway (where $x$ and $y$ are the coordinates of the crest profile measured from the apex of the crest, and $H$ is the design head)?
a) $\mathrm{x}^{1.85}=2 \mathrm{H}^{0.85} \mathrm{y}$
b) $\mathrm{x}^{0.85}=2 \mathrm{H}^{1.85} \mathrm{y}$
c) $x=2 H^{1.85} y \cdot 0.85$
d) $x=2 H^{0.85} y \cdot 1.85$

Ans: (a)
18. The base width of solid gravity dam is 25 m . the material of the dam has a specific gravity of 2.56 and the dam is designed as an elementary profile ignoring uplift. What is the approximate allowed height of the dam?
a) 64 m
b) 40 m
c) 164 m
d) 80 m

Ans:

$$
\begin{aligned}
& \mathrm{B}=\frac{H}{\sqrt{S_{C}}} \\
& 25=\frac{H}{\sqrt{2.56}} \\
& \therefore \mathrm{H}=40 \mathrm{~m}
\end{aligned}
$$

19. The channel section can be designed on the basis of Lacey's theory. The steps are mentioned bellow:
20. Finding out the perimeter
21. Finding out the velocity
22. Calculation of the site factor
23. Finding out the area What is the correct sequence of the steps?
a) 4-2-3-1
b) 3-1-4-2
c) 4-1-3-2
d) 3-2-4-1

Ans: (d)
20. In Lacey's regime theory, the velocity of flow is proportional to
a) $\mathrm{Qf}^{2}$
b) $Q / f^{2}$
c) $\left(\mathrm{Qf}^{2}\right)^{1 / 6}$
d) $\left(\mathrm{Q} / \mathrm{f}^{2}\right)^{1 / 6}$

Ans: (c)
21. For medium silt whose average grain size is 0.16 mm . Lacey's silt factor is likely to be
a) 0.3
b) 0.45
c) 0.7
d) 1.32

Ans:

$$
\mathrm{f}=1.76 \sqrt{d_{m m}}=1.76 \sqrt{0.16}=0.704
$$

## Design of weirs on permeable foundation.

1. A masonry dam is founded on previous sand having porosity equal to $45 \%$ and specific gravity of sand particles is 2.65 . For a desired factor of safety of 3 against sand boiling, the maximum permissible upward gradient will be
(a) 0.225
(b) 0.302
(c) 1.0
(d) None of these

Ans:

$$
\begin{aligned}
& \text { Upward force }=r_{w} \text {.h } \\
& \text { Downward force }=r^{\prime} \times L \\
& \text { F. } S=\frac{\text { downward }}{\text { upward }} \\
& 3=\frac{r_{s a t} \cdot L}{r_{w, h}} \\
& \therefore \frac{h}{L}=\frac{r^{F}}{3 r_{\mathrm{w}}} \\
& =\frac{1}{3} \times \frac{G r_{\mathrm{w}}+r_{\mathrm{w}} \cdot e}{(1+e) r_{\mathrm{w}}}-\gamma_{\mathrm{w}} \\
& =\frac{1}{3} \times\left(\frac{G+e}{1+e}-1\right) \\
& =\frac{1}{3} \times \frac{G-1}{1+e} \quad e=\frac{y}{1-y}=\frac{0.45}{1-0.45}=0.818 \\
& =\frac{1}{3} \times \frac{2.65-1}{1+0.818}=0.302
\end{aligned}
$$

2. While designing a hydraulic structure, the piezometric head at bottom of the floor is computed as 10 m . The datum is 3 m below floor bottom. The assured standing water depth above the floor is 2 m . The specific gravity of the floor material is 2.5 . The floor thickness should be
(a) 2.00 m
(b) 3.33 m
(c) 4.40 m
(d) $\quad 6.00 \mathrm{~m}$

Ans:

$$
\begin{aligned}
& \text { Upward force }=r_{\mathrm{w}} \times 7 \\
& \text { Downward force }=2.5 r_{\mathrm{w}} \times t+r_{\mathrm{w}} \times 2 \\
& r_{\mathrm{w}} \times 7=2.5 r_{\mathrm{w}} \mathrm{t}+r_{\mathrm{w}} \times 2 \\
& r_{\mathrm{w}} \times \mathrm{S}=2.5 r_{\mathrm{w}} \\
& \mathrm{t}=\frac{5}{2.5}=2 \mathrm{~m}
\end{aligned}
$$

3. Uplift pressures at points E and D (Figure A) of a straight horizontal floor of negligible thickness with a sheet pile at downstream end are $28 \%$ and $20 \%$, respectively. If the sheet pile is at upstream end of the floor (Figure B), the uplift pressures at points $D_{1}$ and $C_{1}$ are

(a) $68 \%$ and $60 \%$ respectively
(b) $80 \%$ and $72 \%$ respectively
(c) $88 \%$ and $70 \%$ respectively
(d) $100 \%$ and zero respectively

Ans:
Loss in between E to $\mathrm{D}=8 \%$
Loss in between $D$ to $C=20 \%$
Loss in between $E_{1}$ to $D_{1} \quad \therefore$ At $D_{1}=80 \%$
Loss in between $D_{1}$ to $C_{1}=8 \%$ At $C_{1}=72 \%$
(b)
4. To provide safety against piping failure, with a factor of safety of 5, what should be the maximum permissible exit gradient for soil with specific gravity of 2.5 and porosity of 0.35 ?
(a) 0.155
(b) 0.176
(c) 0.195
(d) 0.213

Ans:

$$
\begin{aligned}
\mathrm{e}=\frac{n}{1-n}= & \frac{0.35}{0.65}=0.5385 \\
\mathrm{i} & =\frac{1}{5} * \frac{G-1}{1+e} \dagger \\
& =\frac{1}{5} * \frac{G-1}{1+e} \dagger \\
& =\frac{1}{5} * \frac{2.5-1}{1+0.5385}+ \\
& =0.195
\end{aligned}
$$

5. A weir on a permeable foundation with down-stream sheet pile is shown in the figure below. The exit gradient as per Khosla's method is

(A) 1 in 6.0
(B)
(C)
1 in 3.4
(D) $\quad 1$ in 2.5

Ans:

$$
\begin{aligned}
& G_{E}=\frac{H}{d} \cdot \frac{1}{\pi \sqrt{ }} \\
& \lambda=\frac{1+\sqrt{1+\alpha^{2}}}{2} \\
& \quad \therefore \alpha=\frac{10}{4}=2.5 \\
& \mathrm{a}=\frac{b}{d} \\
& \lambda=\frac{1+\sqrt{1+2.5^{2}}}{2}=1.846 \\
& G_{E}=\frac{5}{4} \cdot \frac{1}{\pi \sqrt{1.846}}=0.293 \text { i.e. } 1 \text { in } 3.4
\end{aligned}
$$

6. At a certain point in the floor of weir, the uplift pressure head due to seepage is 4.5 m . if the relative density of concrete is 2.5 , the minimum thickness of floor required at this point to counteract the uplift pressure is
a) 1 m
b) 2 m
c) 3 m
d) 4 m

Ans:

$$
\begin{aligned}
& r_{\mathrm{w}} \times 4.5+r_{\mathrm{w}} \times \mathrm{t}=2.5 r_{\mathrm{w}} \mathrm{t} \\
& \therefore 4.5+\mathrm{t}=2.5 \mathrm{t} \\
& \mathrm{t}=3 \mathrm{~m}
\end{aligned}
$$

7. Bligh's creep theory assumes that
a) The percolation water creep is along the contact of the base profile of the apron with the subsoil
b) The percolation water creep is straight path under the floor
c) The percolation water creep is straight path under the foundation
d) None of the above

Ans: (a)
8. Find the hydraulic gradient and uplift pressure at a point 15 m from the upstream end of the floor in the figure below as per Bligh's theory.

a) $0.093,2.91$
b) $0.136,3.11$
c) $0.032,6.00$
d) $0.320,3.00$

Ans:

$$
\begin{aligned}
& L=6+6+10+3+3+20+8+8=64 m \\
& \mathrm{i}={ }_{h}={ }_{6}=0.093 \\
& \begin{aligned}
\text { At C, loss } & =\mathrm{i} \times 33=0.093 \times 33=3.069 \\
& =6-3.069=2.931 \approx 2.91
\end{aligned}
\end{aligned}
$$

9. Find the hydraulic gradient and uplift pressure at a point 15 m from the upstream end of the floor in the figure below as per Lane's theory.

a) $0.093,2.90$
b) $0.136,2.86$
c) $0.032,6.00$
d) $0.320,3.00$

Ans:

$$
\text { Lane'stheory }=6+6+\frac{10}{3}+3+3+\frac{20}{3}+8+8=44
$$

$$
\mathrm{i}=\frac{6}{44}=0.136
$$

$$
=6+6+\frac{15}{3}+3+3=23
$$

$$
\begin{aligned}
& 44 \rightarrow 6 m \\
& 23 \rightarrow ?=3.14 \\
& \\
& 6-3.14=2.86
\end{aligned}
$$

10. Find the pressure at points D and E for the structure below

a) $1.325,1.94$
b) $1.94,1.325$
c) $3.675,3.06$
d) $3.06,3.675$

Ans:
$\alpha=\frac{b}{\bar{d}}=\frac{50}{\overline{10}}=5$
$\lambda=\frac{1+\sqrt{1+\alpha^{2}}}{2}=3.05$
$\emptyset_{E}=\frac{1}{\pi} \cos ^{-1} \underline{-2}=0.388$
$\emptyset_{D}={ }_{\pi}^{1} \cos ^{-1} \underline{-1}=0.265$
Pressure at $\mathrm{D}=0.265 * 5=1.325$
Pressure at $\mathrm{E}=0.388 * 5=1.94$
11. Find the pressure at points $D_{1}$ and $C_{1}$ for the structure below

a) $1.325,1.94$
b) $1.94,1.325$
c) $3.675,3.06$
d) $3.06,3.675$

Ans:

$$
\begin{aligned}
& \alpha=\frac{b}{d}=\frac{50}{10}=5 \\
& \lambda=\frac{1+\sqrt{1+\alpha^{2}}}{2}=3.05 \\
& \emptyset_{C}=\frac{1}{\pi} \cos ^{-1} \underline{-2}=0.388 \\
& \emptyset_{D}=\frac{1}{\pi} \cos ^{-1}-1=0.265
\end{aligned}
$$

Pressure at $D_{1}=(1-0.265) * 5=3.675$
Pressure at $C_{1}=(1-0.388) * 5=3.06$
12. Find the pressure at points $D_{1}{ }^{\prime}$ and $D^{\prime}$ for the structure below

a) $0.815,0.185$
b) $0.185,0.815$
c) $0.615,0.385$
d) $0.515,0.485$

Ans:

$$
\begin{aligned}
& \alpha=\frac{20}{\mathrm{~d}}=4 \\
& \lambda=\frac{1+\frac{\sqrt{1+a^{2}}}{2}=2.56}{2} \\
& \emptyset_{\mathrm{E}}=1 \cos ^{-1}(\underline{-2})=0.43 \\
& \emptyset_{\mathrm{D}}=1 \cos ^{-1}\left(-\frac{-1}{}\right)=0.29 \\
& \emptyset_{D^{F}}=\emptyset_{\mathrm{D}}-{ }_{3}^{2}\left(\emptyset_{\mathrm{E}}-\emptyset_{\mathrm{D}}\right)+\frac{0.03}{\mathrm{a}^{2}}=0.185 \\
& \emptyset_{\mathrm{D}_{1}{ }^{F}}=1-\emptyset_{D^{F}=}=0.815
\end{aligned}
$$

13. Find the pressure percentage for the intermediate pile shown in the figure below:

a) $2.05,2.75,3.55$
b) $2.75,3.55,2.05$
c) $2.05,3.55,2.75$
d) $3.55,2.75,2.05$

Ans:

$$
\begin{aligned}
& a_{1}=\frac{\mathrm{b} 1}{\mathrm{~d}}=1.6, \mathrm{a}_{2}=\frac{\mathrm{b} 2}{\mathrm{~d}}=2.4 \\
& \lambda_{1}=\frac{\sqrt{1+\mathrm{a} 1^{2}+\sqrt{1+\mathrm{a}^{2}}} \frac{2}{2}=2.24}{} \\
& \lambda_{2}=\frac{\sqrt{1+\mathrm{a}^{2}}-\sqrt{1+\mathrm{a} 2^{2}}}{2}=-0.357 \\
& \emptyset_{\mathrm{E}}=1 \cos ^{-1}\left(\frac{2-1}{1}\right)=0.71 \\
& \emptyset_{\mathrm{D}}=1 \cos ^{-1}\left(\frac{2}{1}\right)=0.55 \\
& \emptyset_{\mathrm{C}}=1 \cos ^{-1}\left(\frac{2+1}{1}\right)=0.41 \\
& \emptyset_{E}=0.71 \times 5=3.55 \\
& \emptyset_{D}=0.55 \times 5=2.75 \\
& \emptyset_{C}=0.41 \times 5=2.05
\end{aligned}
$$

14. Determine the interference correction percentage pressure at the upstream pile at C

a) 1.35
b) -1.35
c) 1.5
d) -1.5

Ans:

Interference Correction at $\left.\mathrm{C}=19 \frac{(d+D)}{b}\right) \sqrt{\frac{D}{b^{F}}}$

$$
\begin{aligned}
& =19\left(\frac{4+4}{57}\right) \sqrt{\frac{4}{15.5}} \\
& =1.35 \%
\end{aligned}
$$

15. If $\emptyset_{D}=82 \%$ and $\emptyset_{C}=73 \%$ for the upstream pile as shown in figure, what is the correction at C due to floor thickness.

a) 1.8
b) 1.5
c) 2.5
d) 3.0

Ans:

$$
\text { Correction due to floor thickness } \frac{150-149}{150-145} *(82-73)=1.8 \%
$$

16. Determine the interference correction percentage pressure at the intermediate pile at $E_{1}$

a) 1.35
b) -1.35
c) 1.5
d) -1.5

$$
\begin{aligned}
& =-19\left(\frac{4+4}{57}\right) \sqrt{\frac{4}{15.5}} \\
= & -1.35 \%
\end{aligned}
$$

17. Determine the interference correction percentage pressure at the intermediate pile at $C_{1}$

a) 1.35
b) -1.35
c) 1.79
d) -1.79

Ans:

$$
\begin{aligned}
\text { Interference Correction at } C_{1} & \left.=19 \frac{(d+D}{b}\right) \frac{\sqrt{D}}{b^{F}} \\
& =19\left(\frac{4+8}{57}\right) \sqrt{\frac{8}{40}} \\
& =1.79 \%
\end{aligned}
$$

18. If $\emptyset_{\mathrm{D} 1}=64 \%$ and $\emptyset_{\mathrm{E} 1}=70 \%$ for the upstream pile as shown in figure, what is the correction at $E_{1}$ due to floor thickness.

a) 1.8
b) 1.5
c) 1.2
d) -1.2

$$
\begin{aligned}
& \overline{150-145} \\
= & -1.2 \%
\end{aligned}
$$

19. If $\emptyset_{D 1}=64 \%$ and $\emptyset_{C 1}=58 \%$ for the upstream pile as shown in figure, what is the correction at $C_{1}$ due to floor thickness.

a) 1.8
b) 1.5
c) 1.2
d) -1.2

Ans:
Correction due to floor thickness $\frac{150-149}{150-145} *(64-58)=1.2 \%$
20. Determine the interference correction percentage pressure at the

downstream pile at $E_{2}$
a) 0.186
b) -0.186
c) 1.79
d) -1.79

Ans:

$$
\begin{aligned}
\text { Interference Correction at } C_{1}=19 & \left.\frac{(d+D}{b}\right) \sqrt{\frac{D}{b^{F}}} \\
& =-19\left(\frac{4.5+0.5}{57}\right) \sqrt{\frac{0.5}{40}} \\
& =-0.186 \%
\end{aligned}
$$

Types of irrigation system, irrigation methods. Water logging and drainage, sodic soils.

1. A sprinkler irrigation system is suitable when
(a) The land gradient is steep and the soil is easily erodible.
(b) The soil is having low permeability
(c) The water table is low
(d) The crops to be grown have deep roots

Ans: (a)
2. Alkali soils are reclaimed by
a) Leaching only
b) Addition of gypsum and leaching
c) Addition of gypsum only
d) Provision of drainage

Ans: (b)
3. Leaching is a process
a) By which alkali salts present in the soil are dissolved and drained away
b) By which alkali salts in soil comes up with water
c) Of draining excess water of irrigation
d) Which controls water logging

Ans: (a)
4. Lift irrigation is flow
a) By gravity
b) From lower level to higher level
c) By percolation
d) Through sprinkler heads

Ans: (b)
5. Water logging is eliminated by
a) Deep ploughing
b) Shallow ploughing
c) Irrigation
d) Providing tile drains

Ans: (d)
6. The land is said to be waterlogged, if the soil pores within
a) A depth of 40 cm is saturated
b) A depth of 60 cm is saturated
c) Root zone of crops is saturated
d) Soil upto ground water table is saturated

Ans: (c)
7. A land is known as waterlogged
a) When the permanent wilting point is reached
b) When gravity drainage has ceased
c) Capillary fringe reaches the root zone of plants
d) None of the above

## Ans: (c)

8. Select the incorrect statement
a) Intensive irrigation should be avoided in areas susceptible to water logging.
b) Extensive irrigation should be adopted in areas susceptible to water logging
c) Lift irrigation increases water logging.
d) all of the above

Ans: (c)
9. Which of the following soil pH levels indicates an alkaline soil?
a) $\mathrm{PH}=5.5$
b) $\mathrm{PH}=6.5$
c) $\mathrm{PH}=7.5$
d) Additional information needed

Ans: (c)
10. Which one of the following methods of applying water may be used on rolling land
a) Border flooding
b) Check flooding
c) Furrow flooding
d) Free flooding

Ans: (a)
11. The measure to remove water logging of land, is
a) To reduce percolation from canals and water courses
b) To increase outflow from the ground water reservoir
c) Both (a) and (b)
d) Neither (a) nor (b)

Ans: (c)
12. For cereal crops the most commonly adopted method of irrigation, is
a) Free flowing method
b) Check method
c) Furrow method
d) Sprinkling method

Ans: (b)

