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UPPSC AE 2019
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 3

Part Syllabus Test

Hydrology & Water Resource Engineering

ANSWER KEY

1.	(d)	11.	(b)	21.	(d)	31.	(c)	41.	(c)
2.	(c)	12.	(a)	22.	(b)	32.	(b)	42.	(d)
3.	(a)	13.	(b)	23.	(d)	33.	(b)	43.	(a)
4.	(c)	14.	(b)	24.	(c)	34.	(d)	44.	(b)
5.	(b)	15.	(a)	25.	(b)	35.	(a)	45.	(b)
6.	(a)	16.	(a)	26.	(a)	36.	(a)	46.	(a)
7.	(a)	17.	(c)	27.	(a)	37.	(a)	47.	(b)
8.	(a)	18.	(c)	28.	(d)	38.	(d)	48.	(d)
9.	(a)	19.	(c)	29.	(a)	39.	(c)	49.	(c)
10.	(a)	20.	(b)	30.	(c)	40.	(b)	50.	(b)

EXPLANATIONS

1. (d)

The discharge (Q) in canal remains same.

Duty for rice, $D_1 = \frac{1000}{Q}$ ha/cumec

Duty for wheat, $D_2 = \frac{A_2}{Q}$ ha/cumec

Now $\frac{D_1\Delta_1}{B_1} = \frac{D_2\Delta_2}{B_2}$

or $\frac{A_1\Delta_1}{B_1} = \frac{A_2\Delta_2}{B_2}$

$$\therefore \quad A_2 = \frac{119}{140} \times \frac{130}{50} \times 1000$$

$= 2210$ ha

2. (c)

$$\text{Risk, } \bar{R} = 1 - \left(1 - \frac{1}{T}\right)^n$$

Here, $n = 25$ years, and $T = 100$ years

$$\therefore \quad \bar{R} = 1 - \left(1 - \frac{1}{100}\right)^{25}$$

3. (a)

The conditions favouring the use of **sprinkler irrigation method** are:

(i) When the land topography is irregular.
(ii) When the land gradient is steeper and soil is easily erodible.
(iii) When the land soil is excessively permeable.
(iv) When the water table is high.
(v) When the seasonal water requirement is low.
(vi) When the water availability is difficult and scarce.

4. (c)

$$\phi\text{-index} = \frac{\text{Total rainfall – Runoff depth}}{\text{Rainfall duration}}$$

$$\Rightarrow \quad 0.125 = \frac{(6.75 - 5.75)\text{ cm}}{t}$$

$$\Rightarrow \quad t = \frac{1}{0.125} = 8 \text{ hr}$$

5. (b)

Δ = Total water depth required – Effective rainfall
= 48 – 8 = 40 cm

$$\text{Duty (D)} = \frac{864B}{\Delta(\text{cm})} = \frac{864 \times 10}{40} = 216 \text{ ha/cumec}$$

6. (a)

$$\tau_0 = \gamma_w RS$$
$$= 1000 \times 2.5 \times \frac{1}{10000}$$
[$\because$ For wide rectangular channel, $R \simeq y$]
$$= 0.25 \text{ kg/m}^2$$

Now, on side slopes, shear stress $= 0.75\, \gamma_w RS$
$= 0.75 \times 0.25$
$= 0.1875 \text{ kg/m}^2 \simeq 0.19 \text{ kg/m}^2$

7. (a)

1. Wetted perimeter,

$$P = 4.75\sqrt{Q}$$
$$\Rightarrow \quad P \propto \sqrt{Q}$$

Hence, P increase with increase in design discharge.

2. Hydraulic radius, $R = \frac{5}{2}\frac{V^2}{f}$

$$R \propto \frac{1}{f}$$

Hence, R decreases with increase in silt factor.

Also consider,

$$v = \left(\frac{Qf^2}{140}\right)^{1/6}$$

or $$v^6 = \frac{Qf^2}{140}$$

or $$Q \propto \frac{1}{f^2}$$

8. (a)

Sequent peak algorithm is used for analysis for reservoir capacity demand problems.

9. (a)

$$\because \quad V = Q.t = A.d$$

$$\Rightarrow \quad \frac{1}{2} \times 30 \times 18 \times 3600 \times 10^{-6} = A \times 10^{-2}$$

$$\Rightarrow \quad A = 97.2 \text{ km}^2$$

10. (a)

A flow duration curve of a stream is a plot of dischage against percentage of time, flow is equalled or exceeded. This wave is also called as discharge frequency curve.

Hence option (a) is correct.

11. (b)

Irrigation efficiencies:

(i) Water conveyance efficiency, (η_c)

$$\eta_c = \frac{W_f}{W_r} \times 100$$

where, W_f = Water delivered to the field

W_r = Water delivered from the reservoir.

i.e., it includes losses which occur in conveyance from paint of diversion into canal system to the field.

(ii) Water application efficiency (η_a)

$$\eta_a = \frac{W_s}{W_f} \times 100$$

where, W_s = Water stored in root zone

W_f = Water delivered to the field

i.e., it included the losses such as runoff from the field and deep percolations.

(iii) Water use efficiency (η_u)

$$\eta_a = \frac{W_u}{W_f} \times 100$$

where, W_u = Water use consumptively

W_f = Water delivered to the field

i.e., it includes water required for leaching.

(iv) Water storage efficiency (η_s)

$$\eta_s = \frac{W_s'}{W_n} \times 100$$

where, W_s = Actual water stored in the root zone

W_n = Water needed to store to bring the water content upto field capacity

W_n = FC–Avauilable moisture

(v) Water distribution efficiency (η_d)

$$\eta_d - \left(1 - \frac{y}{d}\right) \times 100$$

where, y = Average numerical deviation in the depth of water stored from the average depth of irrigation stored

d = Average depth during irrigation

η_d evaluates the degree to which water is uniformly distributed throughout the root zone during irrigation. Hence it is called uniformity coefficient. Higher the value of η_d better is the crop response.

12. (a)

Duration of rainfall excess = 3h

Infiltration loss @ 0.3 cm/h for 3h = 0.9 cm

Total depth of rainfall = 5.9 cm

Rainfall excess = 5.9 – 0.9 = 5.0 cm

Peak flow:

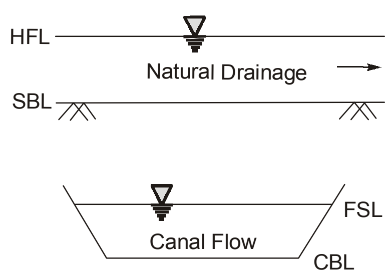
Peak of flood hydrograph = 270 m^3/s

Base flow = 20 m^3/s

∴ Peak of DRH = 270 – 20 = 250 m^3/s

$$\therefore \quad \text{Peak of 3-h unit hydrograph} = \frac{\text{Peak of DRH}}{\text{Rainfall excess}} = \frac{250}{5.0} = 50\ m^3/s$$

13. (b)



where,

HFL: High Flood Level of Drain

SBL: Stream Bed Level

FSL: Full Supply Level of Canal

CBL: Canal Bed Level

Superpassage, as the given elevation condition suits CDW (as shown in diagram).

14. (b)

Given: d = 0.2 m, D = 1.6 m

$$\text{Water distribution efficiency} = \left(1 - \frac{d}{D}\right)$$

$$= \left(1 - \frac{0.2}{1.6}\right) = 0.875 \simeq 0.88$$

15. (a)

$$R = \frac{5}{2}\left(\frac{v^2}{f}\right) = \frac{5}{2}\left(\frac{1.28^2}{1}\right)$$

$$= 4.096 \simeq 4.1 \text{ m}$$

16. (a)

$$\text{Discharge, } Q = 0.02 \text{ cumecs} = 0.02 \times 60 \times 60 \text{ m}^3/\text{hr}$$
$$= 72 \text{ m}^3/\text{hr}$$
$$f = 7.2 \text{ cm/hr} = 0.072 \text{ m/hr}$$

∴ Maximum area that can be irrigated,

$$A_{max} = \frac{Q}{f} = \frac{72}{0.072} = 1000 \text{ m}^2 = 0.1 \text{ hectare}$$

17. (c)

If points on the area having equal time of travel are considered and located on a map of the catchment, a line joining them is called an **isochrone**.

18. (c)

The mean annual PET (in cm) over various parts of the country is shown on the map. Isopleths are the line on a map through places having equal depth of "evapotransipiration".

19. (c)

20. (b)

Muskingum Method: Hydrological channel routing

The equation of total storage

$$S = k[x.I^m + (1 - x)Q^m]$$

Taking m = 1 for natural channel

$$S = k[(x.I + (1 - x)Q]$$

Where, k is a coefficient parameter known as storage time constant, has a dimension of time.

x is a dimensionless weightage factor between inflow and outflow, its valve varies between 0 to 0.5.

When $x = 0.5$

$$S = k[0.5 \times I + 0.5 \times Q]$$

i.e., S is depend on both inflow & outflow.

Hence at $x = 0.5$ storage is function of both inflow & outflow.

When $x = 0$

$$S = k[0 + 1 \times Q]$$
$$S = k(Q)$$

i.e., the inflow will not cause any influence on storage and storage will become a function of outflow only and this is called linear reservoir or linear storage reservoir.

Hence option (b) is correct.

21. (d)

The mass curve of rainfall is a plot of the accumulated precipitation against time, plotted in chronological order.

Hence option (d) is correct.

22. **(b)**

Intermittent stream has flowing water periods during the wet season but are normally dry during hot summer months. They do not have continuous flow to water throughout the year and are not "relatively permanent waters".

"Intermittent" streams normally cease flowing for weeks or months each year, and "ephemeral" streams flow only for hours or days following rainfall.

23. **(d)**

The areas where irrigation is not assured, mixed cropping is adopted. Mixed cropping means sowing different crops together in the same field. Farmers are not benefitted. If irrigation water is assured, mixed cropping may be eliminated and single superior crop may be grown to get the maximum benefits.

24. **(c)**

$$\text{Total rainfall} = 7 + 18 + 25 + 17 + 11 + 3 = 81 \text{ mm}$$

$$\text{Runoff} = 39 \text{ mm}$$

$$\text{Assuming } t_e = 6 \text{ hours}$$

$$W\text{-index} = \frac{81 - 39}{6} = 7 \text{ mm/hr}$$

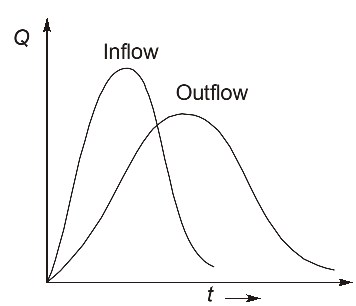
Thus intensity of 7 mm/hr and 3 mm/hr will not contribute to run off

$$\therefore \quad \text{Net infiltration for 4 hours} = 42 - 7 - 3 = 42 - 10 = 32 \text{ mm}$$

$$\phi = \frac{32}{4} = 8 \text{ mm/hr}$$

Check : Runoff = (18 – 8) + (25 – 8) + (17 – 8) + (11 – 8) = 39 mm which is same as given in questions.

25. **(b)**



The inflow hydrograph will have attenuated peak with increased time-base.

26. **(a)**

$$\text{SAR} = \frac{Na^{+}}{\sqrt{\dfrac{Ca^{++} + Mg^{++}}{2}}}$$

$$= \frac{24}{\sqrt{\dfrac{3.6 + 2}{2}}} = 14.34$$

27. (a)

It can be observed that

$$y_1 = 18 \text{ cm} = 0.18 \text{ m} = 0.2 \times 0.9 = 0.2y$$
$$y_2 = 72 \text{ cm} = 0.72 \text{ m} = 0.8 \times 0.9 = 0.8y$$

$$\therefore \quad V_{\text{mean}} = \frac{V_{0.2y} + V_{0.8y}}{2}$$
$$= \frac{0.6 + 0.4}{2} = 0.5 \text{ m/s}$$
$$\therefore \quad Q = AV$$
$$= \left[\frac{1}{2} \times 2 \times 0.9\right] \times 0.5 = 0.45 \text{ m}^3/\text{s}$$

28. (d)

Empirical IDP fomula by Sherman is given by:

$$i = \frac{a}{(t+b)^n}$$

Where, i = rainfall intensity (mm/hour)
t = duration in minutes
a, b & n are constants.

29. (a)

$$\text{Water depth required at canal} = \frac{\text{Water depth required in the field}}{\eta_a \cdot \eta_c}$$
$$= \frac{10}{0.8 \times 0.9} = 13.89 \text{ cm}$$

∴ Volume of water required for 10 ha field

$$= \left(\frac{13.89}{100} \text{m}\right) \times 10 \times 10^4 \text{ m}^2$$
$$= 13890 \text{ m}^3$$

30. (c)

Palmer index (PI), Aridity index (AI) and moisture availability index (MAI) are used for agricultural drought.

31. (c)

∵ Variation is more than ±10% i.e. $N_C = 150$ cm < 153 cm (0.9 N_A) and $N_B = 190$ cm > 187 cm (1.1 N_A)

$$P_A = \frac{N_A}{2}\left(\frac{P_B}{N_B} + \frac{P_C}{N_C}\right)$$
$$= \frac{170}{2}\left(\frac{160}{190} + \frac{140}{150}\right)$$
$$= 150.91 \simeq 151 \text{ cm}$$

32. (b)

$$Q = 2.78 \times \frac{A}{T} \text{ where A is in km}^2 \text{ and T is in hour}$$

$$= 2.78 \times \frac{480}{6} = 222.4 \text{ m}^3/\text{s}$$

Alternatively,

At equilibrium, all rainfall converts into runoff.

$\therefore$ $$Q = (\text{R.I.}) \times A$$

$$= \left(\frac{1}{6} \text{ cm/hr}\right) \times 480 \text{ km}^2$$

$$= \frac{1}{6} \times \frac{10^{-2}}{3600} \times 480 \times 10^6$$

$$\simeq 222.4 \text{ m}^3/\text{s}$$

33. (b)

Snyder was the one to develop a synthetic Unit Hydrograph based on a study of watersheds in the Appalachian Highlands. In basins ranging from 10 – 10,000 mi^2

Snyder relations are $t_p = C_t (L\ L_C)^{0.3}$

where t_p = basin lag (hr)

L = length of the main stream from the outlet to the divide (mi)

L_c = length along the main stream to a point nearest the watershed centroid (mi)

C_t = Coefficient usually ranging from 1.8 to 2.2

34. (d)

$$\text{Inflow (I)} = 5 \text{ ha-m}$$

$$\text{Evaporation loss (E)} = 100 \times \frac{11}{100} \times 0.7 = 7.7 \text{ ha-m}$$

$$\text{Rainfall (P)} = 100 \times \frac{5}{100} = 5 \text{ ha-m}$$

$$\text{Change in storage } (\Delta S) = 100 \times \frac{3}{100} = 3 \text{ ha-m} \quad \text{(Decrease in storage)}$$

Now, $(I + P) - (E + \text{Seepage loss}) = \Delta S$

$\Rightarrow$ $(5 + 5) - (7.7 + X) = -3$

$\Rightarrow$ $10 - 7.7 - X = -3$

$\Rightarrow$ $X = \text{Seepage loss} = 5.3 \text{ ha-m}$

35. (a)

The given peak can be arranged in decreasing order as:

Year	2002	2001	2003	2004	2005
Q_p (m^3/s)	450	430	320	310	290
Ranking	1	2	3	4	5

$$\therefore \quad P = \frac{m}{n+1} = \frac{3}{5+1}$$
$$= 0.5 \text{ or } 50\%$$

36. (a)

Using Stevenson's formula, since fetch (F) > 32 km, we have

$$\text{Height of the wave} = 0.032\sqrt{V.F}$$
$$= 0.032\sqrt{10 \times 40} = 0.64 \text{ m}$$

37. (a)

$$\gamma_d = \frac{\gamma}{1+w} = \frac{1.9}{(1+0.2)} = 1.58 \text{ g/cc}$$

$$\text{Maximum storage capacity of soil} = \frac{\gamma_d \cdot d}{\gamma_w}[F.C.] = \frac{1.58 \times 50 \times (0.3)}{1} = 0.237 \text{ m} = 23.7 \text{ cm}$$

38. (d)

The current meter is held at the requisite depth below the surface of the stream vertically by an observer who stands in the water. This technique is known as Wading and is used to determine the velocity of flow in shallow streams.

39. (c)

The number of optimum stations can be given as

$$N = \left(\frac{C_v}{\varepsilon}\right)^2 = \left(\frac{29.54}{10}\right)^2$$
$$= 8.72 \approx 9 \text{ stations}$$

40. (b)

Base flow: The delayed flow which enters the stream essentially as ground water flow called base flow.

Direct runoff = Total runoff – Base flow

Total runoff or storm or flood runoff= Direct runoff + Base flow

i.e., option (b) is correct.

41. (c)

Rouse equation is given as,

$$\frac{C}{C_a} = \left[\frac{a(D-y)}{y(D-a)}\right]^{W_0/KV^*}$$

where C is the sediment concentration at a distance y.

C_a is the sediment concentration at a distance a.

D = Total depth of water

42. (d)

The rain-gauge station should not be too close to the buildings or trees etc. The nearness of such objects affects entry rainfall in the funnel. Its distance from other objects should not be less than twice the height of the object above the rim of the gauge.

43. (a)

Orographic precipitation, also known as relief precipitation, is precipitation generated by a forced upward movement of air upon encountering a physiographic upland. This lifting can be caused by two mechanisms:

1. The upward deflection of large scale horizontal flow by the orography.
2. The upward vertical propagation of moist air up an orographic slope caused by daytime heating of the mountain barrier surface.

44. (b)

Conditions to be satisfied for Regime as per Lacey are:

(i) Channel should flow uniformly in "incoherent unlimited alluvium" of same character as that transported by the water;
(ii) Silt grade should be constant
(iii) Silt charge should be constant;
(iv) Discharge should be constant.
(v) Flow is uniform

45. (b)

Sensitivity, $$(s) = \frac{dq/q}{dy/y} = \frac{50}{70} = 0.714$$

46. (a)

- **Non-molecular outlet:** *Example:* Open sluice, drowned pie outlet, submerged pie outlet etc.
- **Semi-modular outlet:** *Example:* Venturiflume, open flume adjustable orifice semimodule etc.
- **Rigid module or modular outlet:** *Example:* Gibbs module, khanna rigid module, foot module etc.

47. (b)

$$\text{Water requirement of crop} = 70\% \text{ of } 70 \text{ m}$$
$$= \frac{70}{100} \times 70 \text{ mm} = 49 \text{ mm}$$
$$\therefore \quad \text{Frequency of irrigation} = \frac{49}{3} = 16.33 \text{ days} \simeq 16 \text{ days}$$

48. (d)

Using rational formula,

$$Q_p = kiA$$

where, i = intensity of rainfall

$$Q_p \propto i$$

$\therefore$ Q_p is independent of duration of storm

Thus, $\frac{Q_P}{Q'} = \frac{i}{2i}$

Where, Q' = Discharge corresponding to twice intensity that of design intensity

$\therefore$ $Q' = 2Q_P$

49. (c)

The climatic factors control the rising limb and the recession limb is independent of storm characteristics, being determined by catchment characteristics only.

50. (b)

According to Muskingham, method of routing,

$$C_0 + C_1 + C_2 = 1$$

$$\Rightarrow \quad -0.5 + 0.5 + C_2 = 1$$

$$\Rightarrow \quad C_2 = 1$$

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