3
CHAPTER

Abstraction from Precipitation

Q.1 If e_w and e_a are the saturated vapour pressures of the water surface and air respectively, the Dalton's law of evaporation E_L in unit time is given by E_L =
(a) $(e_w - e_a)$ (b) $K e_w e_a$
(c) $K(e_w - e_a)$ (d) $K(e_w + e_a)$

Q.2 The average pan coefficient for the standard US Weather Bureau class A pan is
(a) 0.85 (b) 0.70
(c) 0.90 (d) 0.20

Q.3 A canal is 80 km long and has an average surface width of 15 m. If the evaporation measured in a class *A* pan is 0.35 cm/day, the volume of water evaporated in a month of 30 days is (in m^3)
(a) 12600 (b) 18000
(c) 180000 (d) 126000

Q.4 If the wind velocity at a height of 2 m above ground is 5.0 kmph, its value at a height of 9 m above ground can be expected to be in km/h about
(a) 9.0 (b) 6.2
(c) 2.3 (d) 10.6

Q.5 Evapotranspiration is confined
(a) to daylight hours
(b) night-time only
(c) land surface only
(d) None of these

Q.6 The infiltration capacity of a soil was measured under fairly identical general conditions by a flooding type infiltrometer as f_i and by a rainfall simulator as f_r. One can expect
(a) $f_i = f_r$ (b) $f_i > f_r$
(c) $f_i < f_r$ (d) no fixed pattern

Q.7 In a small catchment the infiltration rate was observed to be 10 cm/h at the beginning of the rain and it decreased exponentially to an equilibrium value of 1.0 cm/h at the end of 9 hr of rain. If a total of 18 cm of water infiltered during 9 hr interval, the value of the decay constant K_h in Horton's infiltration equation in (h^{-1}) units is
(a) 0.1 (b) 0.5
(c) 1.0 (d) 2.0

Q.8 In Horton's infiltration equation fitted to data from a soil, the initial infiltration capacity is 10 mm/h, final infiltration capacity is 5 mm/h and the exponential decay constant is 0.5 h^{-1}. Assuming the infiltration takes place at capacity rates, the total infiltration depth for a uniform storm of duration 8 hours is
(a) 40 mm (b) 60 mm
(c) 80 mm (d) 50 mm

Q.9 The rainfall on five successive days on a catchment was 2, 6, 9, 5 and 3 cm. If the ϕ-index for the storm can be assumed to be 3 cm/day, the total direct runoff from the catchment is
(a) 20 cm (b) 11 cm
(c) 10 cm (d) 22 cm

Q.10 A 6-h storm had 6 cm of rainfall and the resulting runoff was 3.0 cm. If the ϕ-index remains at the same value the runoff due to 12 cm of rainfall in 9 h in the catchment is
(a) 9.0 cm (b) 4.5 cm
(c) 6.0 cm (d) 7.5 cm

Q.11 Match List-I with List-II and select the correct answer using the codes given below the lists:
List-I
A. Cetyl alcohol
B. Phytometer
C. Atmometer
D. Lysimeter
List-II
1. Transpiration suppressant
2. Evaporation inhibitor
3. Measurement of evapotranspiration
4. Measurement of transpiration
5. Measurement of evaporation
Codes:

	A	B	C	D
(a)	1	4	5	3
(b)	2	4	3	5
(c)	2	4	5	3
(d)	1	5	4	3

Q.12 The Indian Standard pan evaporimeter is
(a) is same as the US class *A* pan
(b) has an average pan coefficient value of 0.60
(c) has less evaporation than a US class A pan
(d) has more evaporation than a US class *A* pan

Q.13 The values of solar radiation reflection coefficient (albedo) for various surfaces are given in List-I (Surface) and List-II shows range of albedo values. Match List-I with List-II and select the correct answer using the codes given below the lists:
List-I
A. Close ground crops
B. Bare lands
C. Water surface
D. Snow
List-II
1. 0.45 - 0.95
2. 0.05
3. 0.05 - 0.45
4. 0.15 - 0.25
Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	2	1
(c)	4	3	1	2
(d)	4	2	3	1

Q.14 Match List-I with List-II and select the correct answer using the codes given below the lists:
List-I
A. Infiltration
B. Interflow
C. Evaporation
D. Evapotranspiration
List-II
1. Quick response flow
2. Annual runoff volume
3. Lysimeter
4. Dalton's law
5. Groundwater recharge
Codes:

	A	B	C	D
(a)	2	5	4	3
(b)	5	1	3	4
(c)	1	3	4	2
(d)	5	1	4	3

Q.15 Match List-I with List-II and select the correct answer using the codes given below the lists:
List-I
A. Hydraulic conductivity
B. Infiltration capacity
C. Transpiration
D. Relative humidity
E. Evaporation
List-II
1. Psychometer
2. Phytometer
3. Atmometer
4. Permeameter
5. Rainfall simulator
Codes:

	A	B	C	D	E
(a)	5	4	2	1	3
(b)	4	5	1	2	3
(c)	4	5	2	1	3
(d)	4	5	1	3	2

Q.16 Assertion (A): Estimated free water evaporation may be assumed to indicate potential evapotranspiration from the vegetated soil surface.
Reason (R): Transpiration is essentially evaporation of water from the leaves of plants.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.17 Instruments used to measure the speed of wind are called
(a) current meters (b) anemometers
(c) weather cocks (d) velocity meters

Q.18 Potential evapotranspiration (PET) is
(a) the evapotranspiration when there is sufficient moisture available in a fully vegetated area
(b) the evapotranspiration of a forest area
(c) actual evapotranspiration of a crop before application of irrigation water
(d) amount of water needed to bring the moisture content of a soil to its field capacity

Q.19 The vertical hydraulic conductivity of the top soil at certain location is 0.2 cm/hr. A storm of intensity 0.5 cm/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 cm/hr
(b) 0.2 cm/hr
(c) between 0.2 and 0.5 cm/hr
(d) 0.5 cm/hr

Q.20 The plan area of a reservoir is 1 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-meter, and 20 hectare-meter are abstracted from the reservoir for irrigation and power. The pan evaporation and rainfall recorded during the same period at a near by meteorological station are 12 cm and 3 cm respectively. The calibrated pan factor is 0.7. The seepage loss from the reservoir during this period (in cm) is
(a) 0.0 (b) 1.0
(c) 2.4 (d) 4.6

Q.21 The rainfall during three successive 2 hour periods are 0.5, 2.8 and 1.6 cm. The surface runoff resulting from this storm is 3.2 cm. The ϕ-index value of this storm is
(a) 0.20 cm/hr (b) 0.28 cm/hr
(c) 0.30 cm/hr (d) 0.80 cm/hr

Q.22 A 6-hour rainstorm with hourly intensities of 7, 18, 25, 17, 11 and 3 mm/hour produced a runoff of 39 mm. Then, the ϕ-index is
(a) 3 mm/hour (b) 7 mm/hour
(c) 8 mm/hour (d) 10 mm/hour

Q.23 Which of the following are interception losses?
1. Stream flow
2. Evaporation
3. Transpiration
The correct answer is
(a) both 2 and 3 (b) only 2
(c) only 2 (d) both 1 and 3

Q.24 The rainfall on three successive 6-h periods are 1.3, 4.6 and 3.1 cm. If the initial loss is 0.7 cm and the surface runoff resulting from this storm is 3 cm, the ϕ-index for the storm is
(a) 0.450 cm/h (b) 0.333 cm/h
(c) 0.392 cm/h (b) 0.167 cm/h

Q.25 The annual potential evapotranspiration for a major part of our country lies in the range of
(a) 140-180 cm (b) 200-250 cm
(c) 100-140 cm (d) 250-300 cm

Q.26 In estimating the maximum floods for design purposes, in the absence of any other data, the ϕ-index is usually assumed as
(a) 2.0 cm/h (b) 1.0 cm/h
(c) 0.5 cm/h (d) 0.1 cm/h

Q.27 Penmann's equation is based on
(a) energy budgeting only
(b) Energy budgeting and water budgeting
(c) Energy budgeting and mass transfer
(d) Water budgeting and mass transfer

Q.28 The value of W index as compared to ϕ-index is
(a) less or equal (b) more
(c) equal (d) None of these

Q.29 Consider the following chemical emulsions:
1. Methyl alcohol
2. Cetyl alcohol
3. Stearyl alcohol
4. Kerosene
Which of the above chemical emulsions is/are used to minimize the loss of water through the process of evaporation?
(a) 1 only (b) 1 and 4
(c) 2 and 4 (d) 2 and 3

Q.30 Lysimeter is used to measure
(a) Infiltration
(b) Evaporation
(c) Evapotranspiration
(d) Vapour Pressure

Q.31 The highest value of annual evapotranspiration in India is at Rajkot, Gujarat. Here the annual PET is about
(a) 150 cm (b) 150 mm
(c) 210 cm (d) 310 cm

Q.32 A 6-hour storm with hourly intensities of 7, 18, 25, 12, 10 and 3 mm per hour produced a run-off of 33 mm. Then the ϕ-index is
(a) 7 mm/h (b) 3 mm/h
(c) 10 mm/h (d) 8 mm/h

Q.33 During a 6-hour storm, the rainfall intensity was 0.8 cm/hour on a catchment of area 8.6 km^2. The measured runoff volume during this period was 2,56,000 m^3. The total rainfall was lost due to infiltration, evaporation, and transpiration (in cm/hour) is
(a) 0.80
(b) 0.304
(c) 0.496
(d) sufficient information not available

Q.34 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 cm/hr creates a peak discharge rate of
(a) 11.3 m^3/s (b) 0.45 m^3/s
(c) 450 m^3/s (d) 4.5 m^3/s

Q.35 Under the same conditions, which of the following shapes of water surface will give the highest rate of evaporation?
(a) Flat water surface
(b) Convex water surface
(c) Concave water surface
(d) Independent of shape of water surface

Q.36 The total rainfall observed in a 24-hr storm over a catchment of 1.8 km^2 area was 10 cm. An infiltration capacity curve prepared had initial infiltration capacity of 1 cm/hr and attained constant value of 0.3 cm/hr after 15 hours of rainfall with a Horton's constant $k = 5\ hr^{-1}$. An IMD pan installed in the catchment indicated a decrease of 0.6 cm in water level during 24 hours of its operation. Assuming pan coefficient of 0.70, the runoff form catchment is:
(a) 1.12 cm (b) 1.84 cm
(c) 2.24 cm (d) 2.54 cm

Q.37 The rates of rainfall for successive 30 minutes period of a 3-hour storm are : 1.6, 3.6, 5.0, 2.8, 2.2 and 1 cm/hr. The corresponding surface runoff is estimated to be 3.6 cm. The ϕ-index and w-index are respectively.
(a) 1.5 cm/hr, 1.6 cm/hr
(b) 1.2 cm/hr, 1.3 cm/hr
(c) 1.2 cm/hr, 1.6 cm/hr
(d) 1.5 cm/hr, 1.3 cm/hr

Q.38 If the water application efficiency is 65% and consumptive use coefficient for the growing season is 0.8. Assuming effective rainfall of 10.9 cm and monthly consumptive use 43.54 cm, the field irrigation requirement is
(a) 63.8 cm (b) 83.6 cm
(c) 36.9 cm (d) 28.4 cm

Q.39 In a 6 hr. duration storm of uniform intensity of 15 mm/hr, the total observed runoff volume is 21.6 × 10^6 m^3. The area of the basin is 300 km^2. The average infiltration rate and runoff coefficient for the basin respectively are:
(a) 2 mm/hr, 0.6 (b) 3 mm/hr, 0.6
(c) 2 mm/hr, 0.8 (d) 3 mm/hr, 0.8

Q.40 The equation for infiltration capacity curve for the basin is $f = 1.2 + \frac{3.3}{e^{t/2}}$ where f is in cm/hr and t in hr. The average infiltration loss assuming total rainfall of 2.29 cm in 30 minutes is:
(a) 1.16 cm/hr (b) 2.16 cm/hr
(c) 1.76 cm/hr (d) 2.76 cm/hr

Q.41 The infiltration rate at the beginning of the rain was observed to be 90 mm/hr and decreased exponentially to constant rate of 8 mm/hr after 2.5 hr. The total infiltration during 2.5 hr was 50 mm. The horton's equation for infiltration rate is:
(a) $4 + 42e^{-2.73t}$ (b) $8 + 82e^{-2.73t}$
(c) $8 + 42e^{-2.73t}$ (d) $4 + 82e^{2.73t}$

Q.42 For wheat assuming a growing season of 4 months December–March, the daily consumptive use of what in the month of January if pan evaporation for the month is 9.5 cm is given as:
(Take consumptive use coefficient 40%, stage growth of crop as 0.52).
(a) 2.1 mm/day (b) 1.6 mm/day
(c) 1.9 mm/day (d) 2.3 mm/day

Q.43 The peak discharge corresponding to storm of 5 cm in 1 hr is given as:
(Assuming data about a catchment of area 1000 km^2)

Time (hr)	0	1	2	3	4	5
Rainfall (cm)	0	2.5	0	0	0	0
Runoff (m^3/s)	300	300	1200	450	300	300

(a) 1176 m^3/sec (b) 1267 m^3/sec
(c) 1376 m^3/sec (d) 1622 m^3/sec

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Answers Abstraction from Precipitation

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

Explanations Abstraction from Precipitation

3. (d)

$$E = \frac{0.35}{100} \times 80 \times 1000 \times 15 \times 30$$
$$= 126000$$

4. (b)

$$5 = C(2)^{1/7}$$
$$C = 4.5286$$
$$u = 4.5286\,(9)^{1/7}$$
$$= 6.198 \text{ kmph}$$
$$\simeq 6.2 \text{ kmph}$$

7. (c)

$$18 = 9 + \frac{9}{K_h}; \qquad K_h = 1\ \text{hr}^{-1}$$

9. (b)

Runoff = (6 − 3) + (9 − 3) + (5 − 3) = 11 cm

10. (d)

$$\phi = \frac{6-3}{6} = 0.5 \text{ cm/h}$$
$$0.5 = \frac{12-R}{9}$$
$$R = 7.5 \text{ cm}$$

18. (a)

For a given set of atmospheric condition, evapotranspiration depends on the availability of water. If sufficient moisture is available to completely meet the needs of vegetation fully covering the area, the resulting evapo-transpiration is called potential evapo-transpiration (PET).

19. (b)

If the storm has lasted for a very long time, then infiltration rate will be the vertical hydraulic conductivity i.e., 0.2 cm/hr.

20. (d)

Evaporation loss from reservoir
$= 0.7 \times 12 = 8.4$ cm
Decline in water level in reservoir = 20 cm
Surface inflow = 10 cm
Abstraction = 20 cm
Rain fall = 3 cm
Inflow − Outflow = ΔStroage
$\Rightarrow$ $(10 + 3) - (20 + 8 + 4 + x) = -20$
$\Rightarrow$ $x = 4.6$ cm
$\therefore$ Seepage loss = 4.6 cm

21. (c)

Total rainfall = 0.5 + 2.8 + 1.6
= 4.9 cm
Surface run-off = 3.2 cm
$\therefore$ Infiltration = 4.9 − 3.2
= 1.7 cm

$\therefore$ ϕ-index $= \frac{1.7}{6} = 0.283$ cm/hr

But this makes the rainfall intensity of 1st 2 hour ineffective as this value $\frac{0.5}{2} = 0.25$ cm/hr is less than ϕ

$\therefore$ ϕ-index $= \frac{4.9 - 3.2 - 0.5}{4}$
= 0.3 cm/hr

23. (c)

The total interception on any drainage basin for a given condition of vegetation may be represented by the equation.

$x = a + bt$
a = Interception storage capacity
b = Evaporation rate from intercepting surfaces
t = Duration of shower.

29. (d)

Certain chemicals such as cetyl alcohol (hexadecanol) and stearyl alcohol (octadecanol) form monomolecular layers on a water surface. These layers act as evaporation inhibitors by preventing the water molecules to escape past them.

32. (d)

Total rainfall = 7 + 18 + 25 + 12 + 10 + 3
= 75 mm
Effective rainfall = 33 mm
Infiltration = 75 − 33 = 42 mm
Assuming t_o = 6 hrs

$$\phi = \frac{42}{6} = 7 \text{ mm/hr}$$

It is greater than 3 mm/hr and 7 mm/hr
So for 4 hours the infiltration would be
42 − 10 = 32 mm

$\therefore$ ϕ-index $= \frac{32}{4} = 8$ mm/hr

33. (b)

Rainfall lost = Rainfall − Runoff

$$= 0.8 \times 6 - \frac{256000}{8.6 \times 10^5} \times 100$$
$$= 4.8 - 2.977 = 1.823 \text{ cm}$$

Total rainfall lost in 6 hours
= 1.823 cm
$\therefore$ Rainfall lost per hour

$$= \frac{1.823}{6} = 0.304 \text{ cm/hr}$$

34. (d)

$$Q_{peak} = Kp_cA$$
$$= 0.4 \times \frac{4.5 \times 10^{-2}}{60 \times 60} \times 90 \times 10^4$$
$$= 4.5 \text{ m}^3\text{/sec}$$

36. (c)

Using Horton's equation;

$$F_p = \int_0^{24} \left[f_c + (f_0 - f_c)e^{-kt}\right]dt$$

$$= \int_0^{24} \left[0.3 + (1 - 0.3)e^{-5t}\right]dt$$

$$= \left[0.3t + \frac{0.7}{-5e^{5t}}\right]_0^{24}$$

$$= \left[0.3 \times 24 - \frac{0.7}{5e^{5\times 24}}\right] - \left[0 - \frac{0.7}{5e^0}\right]$$

$$= 7.2 + \frac{0.7}{5}\left(1 + \frac{1}{e^{120}}\right) = 7.34 \text{ cm}$$

Runoff $= P - E_p - E = 10 - 7.34 - (0.60 \times 0.70)$

$= 2.24$ cm

37. (a)

$\Sigma(i - \phi)t = P_{net}$ and thus it follows;

$$[(3.6 - \phi) + (5.0 - \phi) + (2.8 - \phi) + (2.2 - \phi)] \times \frac{30}{60} = 3.6$$

$\therefore \quad \phi = 1.6$ cm/hr

$$P = (1.6 + 3.6 + 5.0 + 2.8 + 2.2 + 1.0) \times \frac{30}{60} = 8.1 \text{ cm}$$

$$W\text{-index} = \frac{P - Q}{t_R} = \frac{8.1 - 3.6}{3} \doteq 1.5 \text{ cm/hr}$$

38. (c)

Seasonal consumptive use,

$U = k\Sigma f = 0.8 \times 43.54 = 34.83$ cm

Field irrigation requirement,

$$\text{FIR} = \frac{U - \Sigma P_e}{\eta_i}$$

where η_i = water application efficiency

FIR = Field irrigation requirement

$$= \frac{34.83 - 10.90}{0.65} = 36.9 \text{ cm}$$

39. (d)

(i) Infiltration loss,

F_p = Rainfall (P) − Runoff (R)

$$= 15 \times 6 - \frac{21.6 \times 10^6 \text{m}^3}{300 \times 10^6 \text{m}^2} \times 1000$$

$= 90 - 72 = 18$ mm

$$f_{avg} = \frac{F_p}{t} = \frac{18 \text{ mm}}{6 \text{ hr}} = 3 \text{ mm/hr}$$

(ii) Yield = CAP

$$21.6 \times 10^6 \text{ m}^3 = C \times 300 \times 10^6 \text{m}^2 \times \frac{90}{1000}$$

$\therefore \Rightarrow \quad C = 0.8$

40. (c)

Total infiltration loss F_p is determined by integrating the equation for duration of storm.

$$F_p = \int_0^t f dt = \int_0^{30/60} \left(1.2 + \frac{3.3}{e^{12t}}\right)dt$$

$$= \left[1.2t - \frac{3.3}{12e^{12t}}\right]_0^{30/60}$$

$$= \left[1.2 \times \frac{30}{60} - \frac{3.3}{12e^{12\times 30/60}}\right] - \left[0 - \frac{3.3}{12e^0}\right]$$

$$= 0.6 + \frac{3.3}{12}\left(1 - \frac{1}{e^6}\right)$$

$$= 0.6 + \frac{3.3}{12}\left(1 - \frac{1}{408}\right) = 0.88 \text{ cm}$$

Avg. infiltration loss,

$$f_{avg} = \frac{F_P}{t} = \frac{0.88 \text{ cm}}{1/2 \text{ hr}} = 1.76 \text{ cm/hr}$$

41. (b)

$$k = \frac{f_0 - f_c}{F_c} = \frac{90 - 8}{50 - 8 \times 25}$$

$= 2.73$ hr^{-1}

Horton's equation;

$f = f_c + (f_0 - f_c)\, e^{-kt}$

$= 8 + (90 - 8)e^{-2.73t}$

$f = 8 + 82\, e^{-2.73t}$

f is in mm/hr, t in hr.

42. (b)

$$E_t = KT_p$$

The crop season is December to March i.e. 120 days. By middle of January the number of days of growth is 47 i.e. $\frac{47}{120} = 0.40$ or 40% stage growth of the crop has reached and k for this stage is 0.52 and E_p for the month of January is 9.5 cm.

$E_t = 0.52 \times 9.5 = 4.94$ cm

Daily consumptive use for month of January

$$= \frac{4.94 \times 10}{31} = 1.6 \text{ mm/day}$$

43. (c)

Time (h)	Total runoff (m^3/s)	Base flow (m^3/s)	Direct runoff (m^3/s)
0	300	300	0
1	300	300	0
2	1200	300	900
3	450	300	150
4	300	300	0
5	300	300	0
		Sum =	1050

Volume of direct runoff

$= 1050 \times 60 \times 60 = 3.78$ Mm^3

Depth of runoff $= 3.78/100 = 0.0378$ m

$= 3.78$ cm

ϕ-index $= 4 - 3.78 = 0.22$ cm/hr

For 6 cm rainfall in one hour, rainfall excess

$= 6 - 0.22 = 5.78$ cm

$\therefore$ Surface runoff:

$$\Rightarrow \frac{5.78 \times 900}{3.78} \Rightarrow 1376 \text{ m}^3/\text{sec}$$

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