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IRRIGATION ENGINEERING

CIVIL ENGINEERING

Date of Test : 05/09/2026

ANSWER KEY

1.	(b)	7.	(c)	13.	(c)	19.	(c)	25.	(c)
2.	(a)	8.	(c)	14.	(d)	20.	(a)	26.	(a)
3.	(d)	9.	(b)	15.	(b)	21.	(b)	27.	(a)
4.	(a)	10.	(b)	16.	(a)	22.	(c)	28.	(b)
5.	(d)	11.	(b)	17.	(a)	23.	(d)	29.	(b)
6.	(b)	12.	(c)	18.	(b)	24.	(a)	30.	(c)

1. (b)

According to Bligh's creep theory, the total creep length is given by

$$L = (2\times 5) + (2\times 3) + 25 + (2\times 10) = 61 \text{ m}$$

Length of creep upto point A

$$= (2\times 5) + (2\times 3) + 10 = 26 \text{ m}$$

$\therefore$ Residual seepage head at point A is

$$h_A = 5\left(1 - \frac{26}{61}\right) = 2.87 \text{ m}$$

$\therefore$ Required thickness of floor at point A

or $$t = \frac{4}{3}\frac{h_A}{(G-1)} = \frac{4}{3}\times\frac{2.87}{(2.5-1)}$$

$$= \frac{4}{3}\times\frac{2.87}{1.5} = 2.55 \text{ m}$$

2. (a)

PET critically depends upon the climatological factors rather than on the characteristics of plants and soils; the AET is largely affected by the characteristics of soil and vegetation.

If the water requirement of a particular crop at a particular location is more, then lesser number of hectares of land it will irrigate.

3. (d)

$$A = 0.04 \text{ hectares}$$

$$= 0.04\times 10^4 \text{ m}^2 = 400 \text{ m}^2$$

$$Q = 0.02 \text{ cumecs} = 0.02 \text{ m}^3/\text{sec}$$

$$= 0.02\times 60\times 60 \text{ m}^3/\text{hr}$$

$$= 72 \text{ m}^3/\text{hr}$$

$$f = 4 \text{ cm/hr}$$

$$= \frac{4}{100} \text{ m/hr} = 0.04 \text{ m/hr}$$

$$y = 10 \text{ cm} = 0.1 \text{ m.}$$

We have

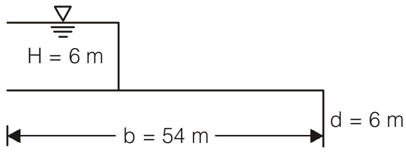
$$t = 2.3\frac{y}{f}\log_{10}\left(\frac{Q}{Q-fA}\right)$$

or $$t = 2.3\frac{0.10}{0.04}\log_{10}\left(\frac{72}{72-0.04\times 400}\right)\text{hr}$$

$$= 0.6276 \text{ hours}$$

$$= 37.66 \text{ minutes.}$$

4. (a)



Exit gradient, $G_E = \frac{H}{d} \times \frac{1}{\pi\sqrt{\lambda}}$

where $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$

and $\alpha = \frac{b}{d} = \frac{54}{6} = 9$

$\therefore$ $\lambda = \frac{1+\sqrt{1+81}}{2} = 5.028$

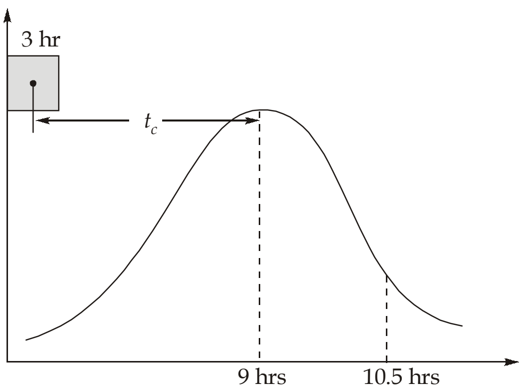
$G_E = \frac{6}{6} \times \frac{1}{\pi\sqrt{5.028}} = 0.142$

5. (d)

Evapotranspiration $\rightarrow$ Lysimeter

Capillary potential $\rightarrow$ Tensiometer

6. (b)



Time of concentration $= \left(9 - \frac{3}{2}\right)\text{hr} = 7.5\text{hr}$

7. (c)

Outlet index for orifice type outlet $= \frac{1}{2}$

Channel index $= \frac{5}{3}$

Setting $= \frac{\text{Outlet index}}{\text{Channel index}} = \frac{1/2}{5/3} = 0.3$

8. (c)

9. (b)

Due to urbanization, infiltration and storage capacity of soil reduces which leads to the following:

1. increase in peak discharge
2. decrease in time base and time of concentration
3. increase in the volume of runoff

10. (b)

$$\Delta = \frac{15}{100} = \frac{8.64 \times 25}{D}$$

$$\Rightarrow \quad D = \frac{8.64 \times 25 \times 100}{15} = 1440 \text{ ha/ cumec}$$

$$\therefore \quad \text{Discharge} = \frac{2880}{1440} = 2\text{m}^3$$

11. (b)

Available moisture = Field capacity – Permanent wilting point = 22 – 12 = 10%

Readily available moisture is 50% depletion of available moisture

$$= 10 \times \frac{50}{100} = 5\%$$

Optimum moisture = Field capacity – Readily available moisture = 22 – 5 = 17%

Depth of water stored in root zone

$$= \frac{\gamma}{\gamma_w} \times d \times (F - M_0)$$

$$= \frac{1.5}{1.0} \times 100(0.22 - 0.17) = 7.5 \text{ cm}$$

$$\text{Field irrigation required at 75\% efficiency} = \frac{7.5}{0.75} = 10 \text{ cm}$$

$$\text{Water application frequency} = \frac{D}{C_u} = \frac{10}{2.5} = 4 \text{ days}$$

12. (c)

Time duration (hr)	Rainfall (cm)	Rainfall intensity (cm/hr)	Runoff (cm)
$0 - 0.5$	2	$\frac{2}{0.5} = 4\,\text{cm/hr}$	$(4-4) \times \frac{1}{2} = 0\,\text{cm}$
$0.5 - 1$	4	$\frac{4}{0.5} = 8\,\text{cm/hr}$	$(8-4) \times \frac{1}{2} = 2\,\text{cm}$
$1 - 1.5$	3	$\frac{3}{0.5} = 6\,\text{cm/hr}$	$(6-4) \times \frac{1}{2} = 1\,\text{cm}$

Total runoff = (2 + 1) cm = 3 cm

13. (c)

$$\text{Sodium adsorption ratio (SAR)} = \frac{[Na^+]}{\sqrt{\dfrac{[Ca^{2+}]+[Mg^{2+}]}{2}}} = \frac{20}{\sqrt{\dfrac{10+5}{2}}}$$

$$= 7.30$$

14. (d)

Let $\bar{x}$ be the distance of the point of intersection of the resultant with the base of the dam from the toe. Then

$$\bar{x} = \frac{\Sigma M}{\Sigma V} = \frac{(2\times10^5)-(1\times10^5)}{5000} = 20\text{ m}$$

$$\text{Eccentricity} \quad e = \frac{b}{2} - \bar{x} = \left(\frac{50}{2} - 20\right) = 5\text{ m}$$

The maximum vertical stress is at the toe of the dam.

$$\sigma_{max} = \frac{\Sigma M}{b}\left(1+\frac{6e}{b}\right) = \frac{5000}{50}\left(1+\frac{6\times5}{50}\right)$$

$$= 160\text{ t/m}^2\text{ (compressive)}$$

Similarly the minimum vertical stress is at the heel of the dam.

$$\sigma_{min} = \frac{\Sigma V}{b}\left(1-\frac{6e}{b}\right) = \frac{5000}{50}\left(1-\frac{6\times5}{50}\right)$$

$$= 40\text{ t/m}^2\text{ (compressive)}$$

$$\text{Ratio of maximum to minimum vertical stress} = \frac{160}{40} = 4$$

15. (b)

$$\text{Inflow} - \text{Outflow} = \text{Change in storage}$$

$$(I + R) - (O + S + E) = \Delta S$$

$$\left(\frac{15\times30\times24\times3600}{30\times10^6}+\frac{15}{100}\right)-\left(\frac{20\times30\times24\times3600}{30\times10^6}+\frac{2}{100}+E\right) = -\frac{20\times10^6}{30\times10^6}$$

$$1.296 + 0.15 - 1.728 - 0.02 - E = -0.667$$

$$E = 0.365\text{ m} = 36.5\text{ cm}$$

16. (a)

Given,

ϕ-index = 1 cm/hr

Base flow = 10 m^3/s

Excess rainfall in first 2 hours = 2 cm − $\phi \times \Delta t$
= 2 cm − 1 cm/hr × 2
= 0 cm

Excess rainfall in second 2 hours = 6 cm − $\phi \times \Delta t$
= 6 cm − 1 cm/hr × 2
= 4 cm

Excess rainfall in third 2 hours = 4 cm − $\phi \times \Delta t$
= 4 cm − 1 cm/hr × 2
= 2 cm

The calculation are tabulated below:

Time (hr)	Ordinate of 2-h UH (m^3/s)	Ordinate of 0 cm DRH Col. 2 × 0	Ordinate of 4 cm DRH (Col. 2 lagged by 2h) × 4	Ordinate of 2 cm DRH (Col. 2 lagged by 4h) × 2	Ordinate of 6 cm DRH (Col. 3 + Col. 4 + Col. 5)
1	2	3	4	5	6
0	0	0	–	–	0
2	4	0	0	–	0
4	8	0	16	0	16
6	16	0	32	8	40
8	10	0	64	16	80
10	8	0	40	32	72
12	6	0	32	20	52
14	0	0	24	16	40
			0	12	12
				0	0

Hence, peak flow of 6 cm DRH = 80 m^3/s

So, peak flow of flood hydrograph = 80 + 10 = 90 m^3/s

17. (a)

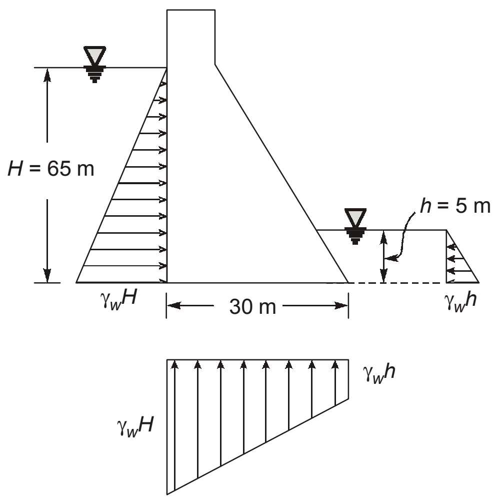
$$\text{Minimum size of sediment} = 11\,RS$$

$$= 11 \times 1.1 \times \frac{1}{2500}$$

$$= 4.84 \times 10^{-3} \text{ m}$$

$$= 4.84 \text{ mm}$$

18. (b)



$$\text{Uplift force} = 30 \times \left[\frac{\gamma_w H + \gamma_w h}{2}\right]$$

$$= 30 \times \left[\frac{9.81 \times 65 + 9.81 \times 5}{2}\right] = 10300.5 \text{ kN}$$

19. (c)

$$\Sigma H = 40.8 \text{ kN}$$
$$\Sigma V = 36.5 \text{ kN}$$
$$\text{FOS} = \frac{\mu \Sigma V + A \times q}{\Sigma H} \qquad \mu = \tan\phi = \tan 25° = 0.47$$
$$= \frac{0.47 \times 36.5 + 10 \times 4.9}{40.8} = 1.62$$

20. (a)

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}, \qquad A = \frac{\pi}{8} D^2, \qquad P = \frac{\pi D}{2}, \qquad R = \frac{A}{P}$$
$$\Rightarrow \quad 3 \times 10^{-3} = \frac{1}{0.011} \times \frac{\pi}{8} D^2 \times \left(\frac{D}{4}\right)^{2/3} \times \left(\frac{0.28}{100}\right)^{1/2}$$
$$D^{2.67} = 4 \times 10^{-3}$$
$$\Rightarrow \quad D = 126.46 \text{ mm}$$
$$\therefore \quad R = \frac{D}{4} = 31.6 \text{ mm}$$

21. (b)

$$d_w = \frac{\gamma_d}{\gamma_w} d(F_c - M_0)$$
$$= 1.6 \times 1.3 \times (0.16 - 0.12) = 0.0832 \text{ m}$$
$$\text{NIR} = 83.2 \text{ mm}$$
$$\text{Volume of irrigation water} = 0.0832 \times 13 \times 12 = 12.979 \text{ m}^3$$
$$\therefore \quad \text{Duration of irrigation} = \frac{12.979 \times 10^3 \, l}{26 \, l/\text{s}} = 499.2 \text{ sec.} = 8.32 \text{ min}$$

22. (c)

Detph of water required = 60 cm

Effective rainfall = 15 cm

Depth of irrigating water = 60 – 15 = 45 cm

$\Rightarrow$ Delta = 45 cm = 0.45 m

B = 15 days

$$\text{From relation, } \Delta = \frac{8.64 \times B}{D}$$
$$\Rightarrow \quad \text{Duty (D)} = \frac{8.64 \times 15}{0.45} = 288 \text{ ha/cumec}$$

Due to loss of water, duty at head of channel is reduced

Here losses are 15%

$$\text{So, duty at head of channel} = 288 \times \frac{85}{100}$$
$$= 244.80 \text{ ha/cumecs}$$

22. (d)

$$\text{Field capacity, F} = \frac{\text{weight of water retained in certain volume of soil}}{\text{weight of dry soil retaining that water}}$$

If saturated soil has volume = V

Let volume of it's voids to be V_V

So, weight of water contained in this soil = $\gamma_w \cdot V_V$

So, $$F = \frac{\gamma_w \cdot V_V}{\gamma_d \cdot V}$$

$$\Rightarrow \quad F = \frac{\gamma_w}{\gamma_d} n$$

$$\Rightarrow \quad \frac{\gamma_d}{\gamma_w} = \frac{n}{F} = \frac{0.4}{0.36} = 1.11$$

Depth of water stored in root zone, $$D = \left(\frac{\gamma_d}{\gamma_w}\right) \times d \times 0.6 [FC - PWP]$$

$$\Rightarrow \quad D = 1.11 \times 0.6 \times 0.6\,[0.36 - 0.15]$$

$$\Rightarrow \quad D = 0.084 \text{ m}$$

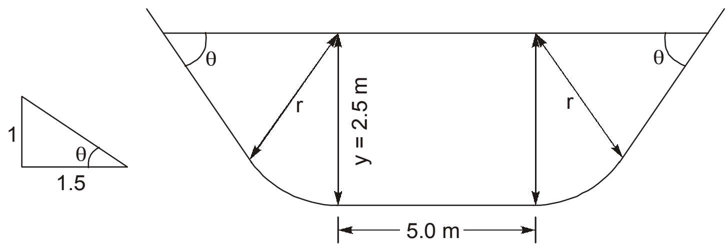
$$\Rightarrow \quad \text{Volume of water stored} = 0.084 \times 0.6 \times 10^4 \text{ m}^3$$

$$= 504 \text{ m}^3$$

$$\text{Actual irrigation water supplied} = 800 \text{ m}^3$$

$$\Rightarrow \quad \text{Efficiency of field application} = \frac{504}{800} \times 100 = 63\%$$

24. (a)



For a trapezoidal channel, corners are rounded

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

$$P = B + 2y(\theta + \cot\theta)$$

here, $\cot\theta = 1.5$, $\theta = 0.588$ radians

$$\Rightarrow \quad A = 2.5 \times 5 + 2.5^2(0.588 + 1.5) = 25.55 \text{ m}^2$$

$$\Rightarrow \quad P = 5 + 2 \times 2.5(0.588 + 1.5) = 15.44 \text{ m}$$

We know, $$R = \frac{A}{P} = \frac{25.55}{15.44} = 1.655 \text{ m}$$

Also, $$Q = \frac{1}{n} A.R^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$\Rightarrow \quad Q = \frac{1}{0.016} \times 25.55 \times (1.655)^{\frac{2}{3}} \times \frac{1}{\sqrt{1000}} = 70.65 \text{ m}^3/\text{s}$$

During KOR period of 10 days volume of water supplied by channel

$$= 70.65 \times 10 \times 24 \times 60 \times 60$$

$$= 61.042 \times 10^6 \text{ m}^3$$

Area which can be irrigated (A) × depth of water required

$$= \text{Volume of water available}$$

$$A \times 0.15 = 61.042 \times 10^6$$

$$A = 406.94 \text{ km}^2$$

25. (c)

$$p = \frac{1}{25} = 0.04 \,,\; q = 1 - 0.04 = 0.96$$

$$P_{(1,10)} = 10C_1\, p^1.\, q^9 = \frac{10!}{9!1!}(0.04)(0.96)^9 = 0.277$$

$$P_{(2,10)} = 10C_2\, p^2.\, q^8 = \frac{10!}{8!2!}(0.04)^2(0.96)^8 = 0.05194 \simeq 0.052$$

$$\text{Risk} = 1 - q^n = 1 - (0.96)^{10} = 0.3352$$

$$\text{Assurance} = q^n = (0.96)^{10} = 0.665 = 66.5\%$$

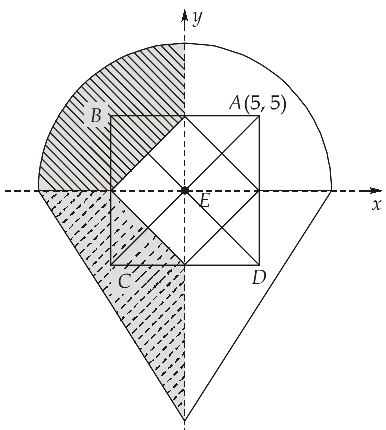
26. (a)

$$\tau_0 = \gamma_w RS = 1000 \times 2.5 \times \frac{1}{10000} = 0.25 \text{ kg/m}^2$$

Now, on side slopes, shear stress $= 0.75\, \gamma_w RS = 0.75 \times 0.25$

$$= 0.1875 \text{ kg/m}^2 \simeq 0.19 \text{ kg/m}^2$$

27. (a)



$$A_B = A_A = \left[\left(\frac{\pi 20^2}{4}\right) \times \frac{1}{4}\right] - \frac{1}{2} \times 5 \times 5 = 66.0398 \text{ km}^2 \simeq 66.04 \text{ km}^2$$

$$A_C = A_D = \frac{1}{2} \times 10 \times \left(\sqrt{20^2 - 10^2}\right) - \frac{1}{2} \times 5 \times 5$$

$$= 74.1025 \text{ km}^2 \simeq 74.1 \text{ km}^2$$

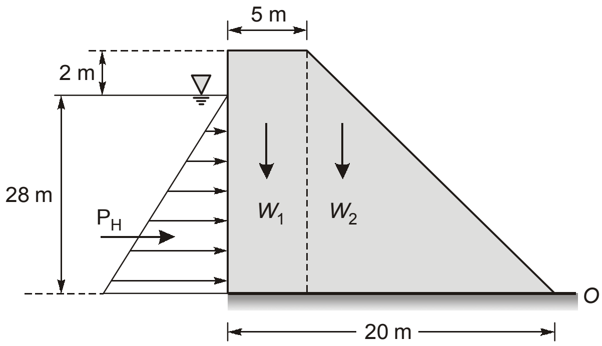
$$A_E = \left(\sqrt{50}\right)^2 = 50 \text{ km}^2$$

$$\therefore \quad \bar{P} = \frac{P_A A_A + P_B A_B + P_C A_C + P_D A_D + P_E A_E}{A_A + A_B + A_C + A_D + A_E}$$

$$\Rightarrow \quad \bar{P} = 85 \times 66.04 + \frac{90 \times 66.04 + 77 \times 74.1 + 80 \times 74.1 + 105 \times 50}{66.04 + 66.04 + 74.1 + 74.1 + 50} \text{mm}$$

$$\bar{P} = \frac{28440.7}{330.28} = 86.11 \text{ mm} \simeq 86.1 \text{ mm}$$

28. (b)



γ_c = 24 kN/m^3 (Considering inside length of dam as unity)

Force	Calculation	Magnitude (kN/m)	Lever arm (in m) (about 0)	Moment in (kN-m/m) (about 0)
W_1	$24 \times 30 \times 5$	3600	17.5	63000
W_2	$1/2 \times 24 \times 30 \times 15$	5400	10	54000
P_H	$1/2 \times 9.81 \times (28)^2$	3845.52	9.33	35878.7

∴ Resisting moment, M_R = 63000 + 54000 = 117000 kN-m/m

Overtuning moment, M_O = 35878.7 kN-m/m = 3.26

∴ FOS against overtuning $= \dfrac{M_R}{R_O} = \dfrac{117000}{35878.7} = 3.26$

(FOR) against sliding $= \dfrac{\mu \Sigma V}{\Sigma H} = \dfrac{0.5 \times (3600 + 5400)}{3845.52} = 1.17$

29. (b)

30. (c)

Mean depth, $D = \dfrac{2 + 1.9 + 1.8 + 1.6 + 1.5}{5} = 1.76$ m

∴ Value of deviation from mean are (2 – 1.76), (1.9 – 1.76), (1.8 – 1.76), (1.6 – 1.76), (1.5 – 1.76)

= 0.24, 0.14, 0.04, –0.16, –0.26

Average of absolute deviations

$$d = \frac{0.24 + 0.14 + 0.04 + 0.16 + 0.26}{5} = 0.168 \text{ m}$$

Water distribution efficiency, $\eta_d = \left(1 - \dfrac{d}{D}\right) \times 100 = \left(1 - \dfrac{0.168}{1.76}\right) \times 100 = 90.45\%$

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