Problem 1 (Pg. 17)

$$\text{Duty} = \frac{\text{Area (in hectares) to be irrigated}}{\text{Discharge in the field (cumec)}}$$

$$= \frac{40{,}000 \text{ hectares}}{\frac{300{,}000{,}000\ m^3}{\frac{365}{2} \times 86400 \text{ sec}}}$$

$$= 2102.4 \text{ hectares/cumec}$$

Problem 2 (Pg. 17)

$$\Delta = \frac{8.64\,B}{D} \Rightarrow D = \frac{8.64\,B}{\Delta}$$

$$\Rightarrow \text{Duty (kharif)} = \frac{8.64 \times (3 \times 7)}{0.60} = 302.4 \text{ hectares/cumec}$$

Area = 5000 hectares

$$Q_{\text{required}} \text{ (for kharif)} = \frac{5000 \text{ hectares}}{3024 \text{ hectares/cumec}}$$

$$= 16.54 \text{ m}^3/\text{s}$$

$$\text{Again Duty (Rabi)} = \frac{8.64 \times (4 \times 7)}{0.20} = 1209.6 \text{ hectares/cumec}$$

Area = 4000 hectares

$$Q_{\text{required}} \text{ (for Rabi)} = \frac{4000 \text{ hectares}}{1209.6 \text{ hectares/cumec}}$$

$$= 3.31 \text{ m}^3/\text{s}$$

Here $Q_{max} = 16.54 \text{ m}^3/\text{s}$.

So, channel shall be designed for a discharge of 16.54 m^3/s, so that discharge capacity can accomodate the supply for both seasons.

Problem 3 (Pg. 17)

For left canal,

Area under Rabi crop = $20000 \times 80\% = 16000$ hectares

Discharge = 20 cumecs

$$\text{Duty} = \frac{\text{Area}}{\text{Discharge}} = \frac{16000}{20} = 800 \text{ hectares/cumec}$$

For right canal,

Area under Rabi crop = $12000 \times 50\% = 6000$ hectares

Discharge = 8 cumec

$$\text{Duty} = \frac{\text{Area}}{\text{Discharge}} = \frac{6000}{8} = 750 \text{ hectares/cumec}$$

Problem 4 (Pg. 17)

Depth of water stored in root zone between FC & PWP $= \frac{\gamma_d \cdot d}{\gamma_w} (FC - PWP)$

$= 1.5 \times 0.70 (0.22 - 0.10)$

$= 0.126\ m$

$= 12.6\ cm$

$\frac{\gamma_d}{\gamma_w} = \frac{\rho_d \times g}{\rho_w \times g} = \frac{1.5}{1}$

Since, moisture varies between 22% & 14%, the deficiency created in this fall

$= 1.5 \times 0.70 (0.22 - 0.14)$

$= 0.084\ m$

$= 8.4\ cm$, Hence, 8.4 cm depth of water is the net irrigation requirement.

$$F.I.R = \frac{NIR}{\eta_a} = \frac{8.4\ cm}{0.75} = 11.20\ cm$$

Problem 5 (Pg. 17)

Available soil moisture = (22 - 12)% = 10%

Readily available moisture at 5% depletion of available soil moisture = (10 × 5%)%

= 0.50%

Optimum moisture = FC - Readily Available Moisture

= (22 - 0.50)%

= 21.50%

Hence, depth of water = $\frac{\gamma_d}{\gamma_w} \times d \times (FC - OMC)$

$= \frac{\rho_d \times g}{\rho_w \times g} \times d \times (FC - OMC)$

$= \frac{\rho_d}{\rho_w} \times d \times (FC - OMC)$

$= 1.5 \times 1 \times (0.22 - 0.215)$

$= 0.0075 m$

$= 7.5 mm$

Field Irrigation required at 50% efficiency

$$= \frac{7.5\,mm}{0.50}$$

$$= 15\,mm$$

Water application frequency $= \frac{15\,mm}{2.5\,mm/day}$

$= 6$ days

Problem 6 (Pg. 17)

Weight of moist soil = (2.76 − 1.56) kg

= 1.20 kg

Weight of dry soil = (2.61 − 1.56) kg

= 1.05 kg

$$\text{Moisture Content} = \left(\frac{1.20 - 1.05}{1.05} \times 100\right)\%$$

= 14.29 %

$$\text{Volume of the core sampler} = \frac{\pi}{4} \times \left(\frac{7.5}{100}\right)^2 \times \frac{15}{100}$$

$$= 0.000663\ m^3$$

$$\text{Apparent specific gravity} = \frac{1.05\ kg}{0.000663\ m^3} \times \frac{1}{1000\ kg/m^3}$$

= 1.58

Available Moisture holding capacity of soil = (1.58 × 14.29) cm/m depth of soil

= 22.58 cm/m depth of soil

Problem 7 (Pg. 18)

(i) Moisture content at different depths of the root zone:

Depth of sampling (cm)	Moisture Content before Irrigation (%)	Depth of water required at root zone $\frac{SB}{SW} \times d \times DMC$ (cm)
0-25	$\frac{(134-126.82)}{126.82} \times 100 = 5.66$	$1.5 \times 0.25 \times 5.66 = 2.12$
25-50	$\frac{(136.28-127.95)}{127.95} \times 100 = 6.51$	$1.5 \times 0.25 \times 6.51 = 2.44$
50-75	$\frac{(122.95-115.32)}{115.32} \times 100 = 6.62$	$1.5 \times 0.25 \times 6.62 = 2.48$
75-100	$\frac{(110.92-102.64)}{102.64} \times 100 = 8.07$	$1.5 \times 0.25 \times 8.07 = 3.03$

(ii) Moisture content in the root zone at the time of irrigation

$= (2.12 + 2.44 + 2.48 + 3.03) = 10.07$ cm

(iii) NIR = 17.8 cm/m − 10.07 cm/m

= 7.73 cm/m depth of root zone

(iv) $GIR = \frac{7.73}{0.70}$ cm

$= 11.04$ cm

Problem 8 (Pg. 18)

Moisture holding capacity of root zone

$= 0.140 \frac{m}{m}$ depth of soil $\times$ 0.3 m deep root zone

$= 0.042 m$

$= 4.2 cm$

Allowable depletion = 35%

Allowable depletion between irrigations

$= 4.2 \times 0.35 = \underline{1.47 cm}$

Frequency of irrigation $= \frac{1.47 cm}{0.5 cm/day} = \underline{2.94 days}$

$FIR = \frac{NIR}{\eta a} = \frac{1.47}{0.40} = \underline{3.675 cm}$

∴ Volume of water required = 3.675 cm depth $\times$ 60 hectares area

$= \frac{3.675}{100} m \times 60 \times 10^4 m^2$

$= 22050 m^3$

Volume of water required for irrigating 1 hectares of land $= \frac{3.675}{100} m \times 4 \times 10^4 m^2$

$= 1470 m^3$

Time required to supply $1470\ m^3$ of water to the field $= \dfrac{1470\ m^3}{(28 \times \frac{1}{1000})\ m^3/s}$

$= 52500$ seconds

$= 14.58$ hours

Problem 9 (Pg. 18)

Mean Depth, $D = \frac{2.0+1.9+1.8+1.6+1.5}{5}$

$= 1.76 \text{ m}$

Average value of deviations from mean

$$d = \frac{|1.76-2| + |1.76-1.9| + |1.76-1.8| + |1.76-1.6| + |1.76-1.5|}{5}$$

$= 0.168 \text{ m}$

Water distribution efficiency, $\eta_d = (1 - d/D) \times 100\%$

$= (1 - \frac{0.168}{1.76}) \times 100\%$

$= 90.45\%$

Problem 10 (Pg. 18)

Conveyance efficiency $= \left(\frac{100}{130} \times 100\right)\% = 76.92\%$

Water supplied to the field = 100 litres/second for 8 hours

$= 0.100\ m^3/s \times 8\ hours$

$= 0.100\ m^3/s \times 8 \times 3600\ s$

$= 2880\ m^3$

application efficiency $= \left(\frac{2880 - 420}{2880}\right) \times 100\%$

$= 85.42\%$

Moisture holding capacity of soil = 20 cm/m length of soil x 1.7 m deep root zone

$= 34\ cm$

Moisture available at the start of irrigation

$= 34 \times 0.50 = 17\ cm$

Additional water required $= (34 - 17)\ cm$

$= 17\ cm$

Volume of water required = Depth x Area

$= \frac{17}{100}\ m \times 1.6 \times 10^4\ m^2$

$= 2720\ m^3$

Water stored in the root zone $= (2880 - 420)\,m^3$

$= 2460\,m^3$

storage efficiency $= \left(\frac{2460}{2720} \times 100\right)\%$

$= 90.44\%$

Mean depth of water in root zone

$= \frac{1.7 + 1.1}{2} = 1.4\,cm$

Average value of deviations from the mean

$= \frac{|1.4 - 1.7| + |1.4 - 1.1|}{2}$

$= 0.30\,m$

distribution efficiency $= \left(1 - \frac{0.30}{1.40}\right) \times 100\%$

$= 78.57\%$