

Water Resource Engineering (315314)

MSBTE K-Scheme · Model Question Paper — Set B · Model Answers

Q.1 Attempt any FIVE of the following:**10 M****a) Name any four types of irrigation projects classified according to purpose.**

2 M

Irrigation projects are classified on the basis of purpose as:

1. **Protective irrigation project** – provided to protect crops against failure of rainfall / famine in drought-prone areas; financial return is not the main aim.
2. **Productive irrigation project** – provided to increase production and give financial return (revenue) on the investment.
3. **Single-purpose project** – serves only one purpose, i.e. irrigation.
4. **Multipurpose project** – serves irrigation along with hydropower, water supply, flood control, navigation, fisheries, recreation etc.

Note: On the basis of culturable command area (CCA), projects are also classified as major (CCA > 10,000 ha), medium (2,000–10,000 ha) and minor (< 2,000 ha).

(Any four, ½ M each)

b) Define: i) Precipitation ii) Evaporation.

2 M

Precipitation: Precipitation is the fall of moisture from the atmosphere to the earth surface in any form, e.g. rain, snow, hail, sleet and drizzle.

Evaporation: Evaporation is the process by which water changes from the liquid state to the vapour state from free water surfaces (sea, lakes, reservoirs) and from moist soil, due to heat of the sun.

(Each definition 1 M)

c) Define: i) Crop period ii) Base period.

2 M

Base period (B): The period (in days) from the first watering of the land for sowing to the last watering before harvesting of a crop, i.e. the period during which irrigation water is supplied to the crop.

Crop period: The total time (in days) from the sowing of the crop to its harvesting. Crop period is slightly more than base period.

(Each definition 1 M)

d) Enlist the forces acting on a gravity dam.

2 M

Forces acting on a gravity dam:

1. Weight of dam (self-weight)
2. Water pressure (external)
3. Uplift pressure
4. Silt pressure

5. Wave pressure
6. Earthquake forces
7. Ice pressure

(Any four, ½ M each)

e) Define spillway. State any two advantages of providing a spillway.

2 M

Spillway: A spillway is a structure constructed at a dam site to pass the surplus flood water safely from the reservoir to the downstream river when the reservoir is full.

Advantages: (i) prevents overtopping and failure of the dam; (ii) keeps the reservoir water level within the H.F.L. and passes floods safely without damage to the dam and downstream.

(Definition 1 M, two advantages 1 M)

f) Define sprinkler irrigation.

2 M

Sprinkler irrigation: It is a method of irrigation in which water under pressure is carried through pipes and sprayed into the air through nozzles (sprinklers) so that it falls on the crop and soil uniformly like natural rainfall.

(Definition 2 M)

g) Define: i) Super passage ii) Canal siphon.

2 M

Super passage: A CD work in which the natural drain is carried over the canal in a trough, and the F.S.L. of the canal is below the bottom of the drain trough, so the canal water flows freely below under atmospheric pressure.

Canal siphon: A CD work in which the canal is carried below the drain, and the F.S.L. of the canal is above the bed of the drain, so the canal water flows under pressure through siphon barrels below the drain.

(Each definition 1 M)

Q.2 Attempt any THREE of the following:

12 M

a) Draw a neat sketch of Symon's rain gauge. Differentiate between non-recording and recording type rain gauges.

4 M

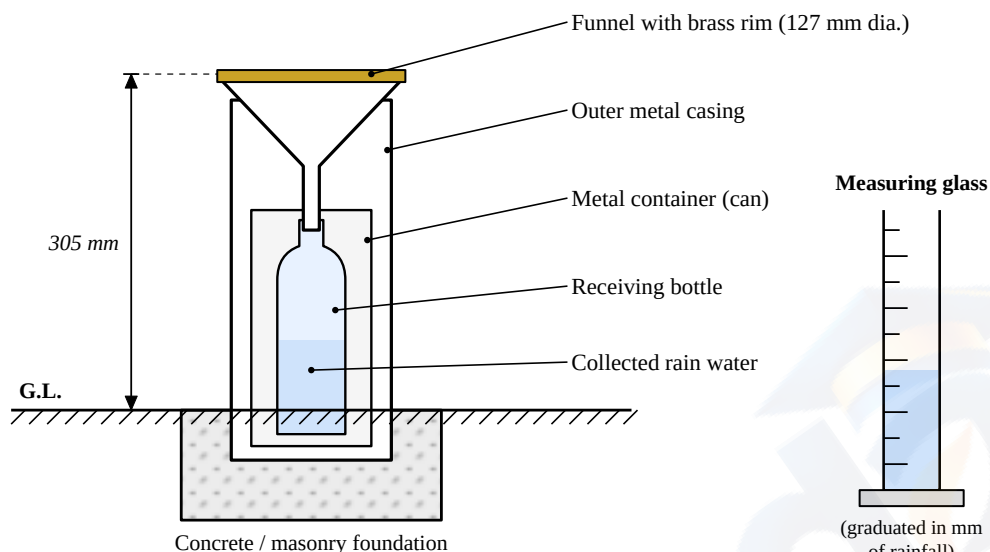


Fig.: Symon's (non-recording) rain gauge

Working: Rain falling on the 127 mm funnel is collected in the receiving bottle; once a day (8:30 a.m.) it is measured with the graduated measuring glass, which reads directly in mm of rain. The gauge rim is kept 305 mm above G.L. on a concrete block, on open level ground.

Non-recording vs recording (automatic) rain gauge:

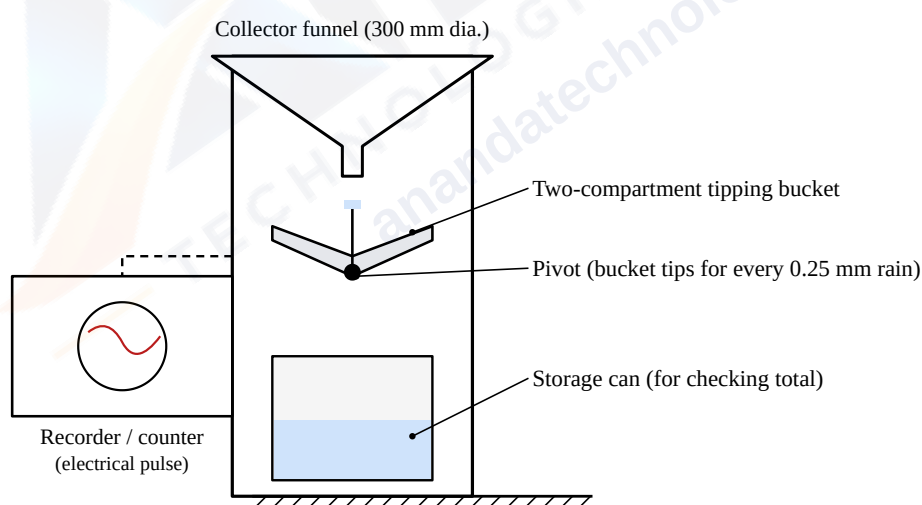


Fig.: Tipping bucket type automatic (recording) rain gauge

Non-recording gauge (e.g. Symon's)	Recording gauge (e.g. tipping bucket)
Gives only total rainfall in 24 h.	Gives a continuous record (mass curve) of rainfall with time.
Intensity and duration cannot be found.	Intensity and duration of rain can be found.

Needs an observer every day.	Works automatically; can be used in remote places.
Simple and cheap.	Costly; needs maintenance of mechanism.

(Sketch 2 M, differences 2 M)

b) The areas between successive isohyets of a storm over a catchment are given below. Find the average depth of rainfall over the catchment.

Isohyets (mm)	140–160	120–140	100–120	80–100	60–80
Area between isohyets (km ²)	45	120	210	260	150

4 M

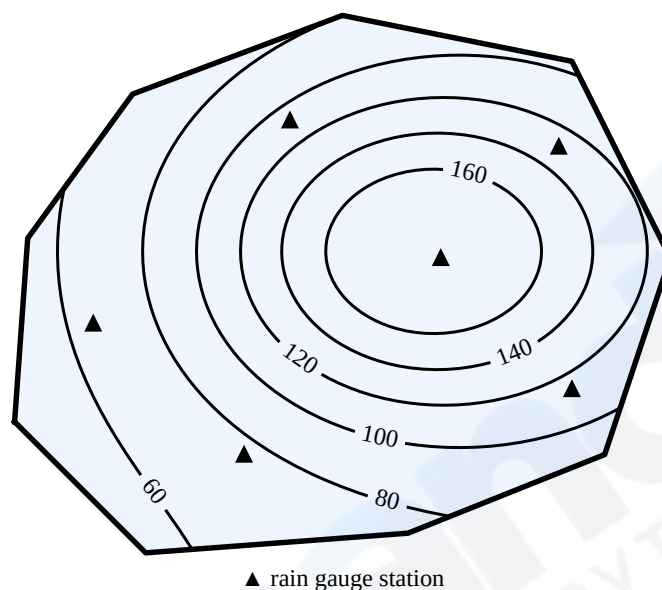


Fig.: Isohyetal map of the catchment (isohyets in mm)

Isohyetal method: $P_{av} = \Sigma[A \times (P_1 + P_2)/2] / \Sigma A$, where A = area between two successive isohyets of values P_1 and P_2 .

Isohyets (mm)	Area between (km ²)	Mean rainfall (mm)	A × P _{mean}
140–160	45	150	6,750
120–140	120	130	15,600
100–120	210	110	23,100
80–100	260	90	23,400
60–80	150	70	10,500
Total	785		79,350

$$P_{av} = 79,350 / 785 = 101.08 \text{ mm}$$

(Formula 1 M, table 2 M, answer 1 M)

c) Define runoff. State the factors affecting runoff.

4 M

Runoff: Runoff is the portion of precipitation which, after all losses (interception, evaporation, infiltration and depression storage) are satisfied, flows over the land surface and through the soil into streams and rivers.

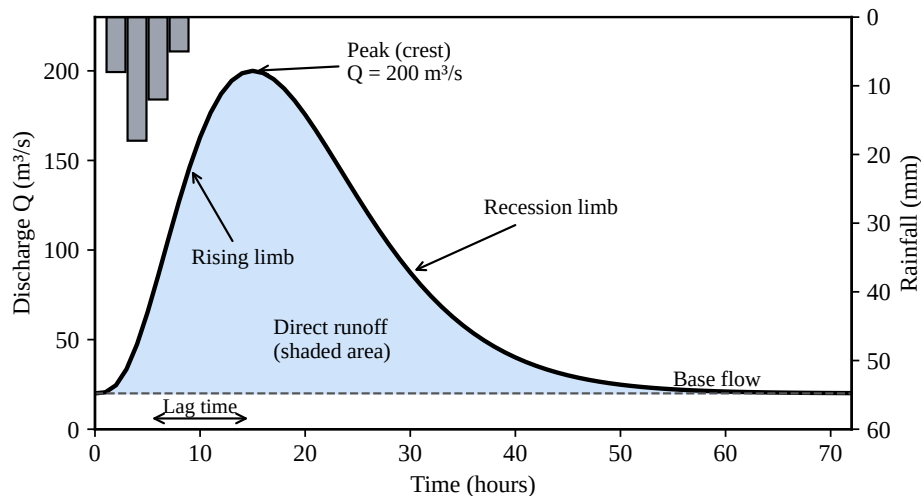


Fig.: Typical flood hydrograph (ordinates computed, base flow $20 \text{ m}^3/\text{s}$)

The graph of stream discharge against time (hydrograph) shows how runoff rises after a storm, reaches a peak and then recedes.

Factors affecting runoff:

1. Intensity, duration and areal distribution of rainfall.
2. Size, shape and slope of the catchment.
3. Soil type, permeability and initial moisture of the soil.
4. Vegetation cover and land use (forest, crops, urban area).
5. Climatic factors – temperature, wind, humidity (evaporation).
6. Storage in the catchment – tanks, lakes, depressions.

(Definition 1 M, factors 3 M)

d) Define silting of reservoir. State the factors affecting silting and any two control measures.

Silting of reservoir: When a river enters a reservoir its velocity reduces, so the sediment (silt, sand) carried by it settles in the reservoir. This deposition of sediment, which gradually reduces the storage capacity of the reservoir, is called silting of reservoir (reservoir sedimentation).

Factors affecting silting:

1. Amount of sediment load carried by the river (depends on soil erosion in the catchment).
2. Nature of catchment – soil type, slope, vegetation cover and land use.
3. Intensity of rainfall and flood frequency.
4. Size and shape of reservoir relative to inflow (capacity–inflow ratio, i.e. trap efficiency).
5. Method of operation of reservoir and position / use of sluices.

Control measures: afforestation and soil conservation in catchment (contour bunding, check dams); construction of silt-arresting check dams upstream; proper location and operation of scouring sluices to flush silt; providing extra dead storage; selecting site where sediment yield is low.

(Definition 1 M, factors 2 M, control 1 M)

Q.3 Attempt any THREE of the following:

12 M

a) A crop requires a total depth of water of 60 cm during its base period of 120 days. Find the duty of water. If the culturable command area is 5000 ha and the intensity of irrigation is 70 %, find the discharge required at the field. 4 M

Given: $\Delta = 60 \text{ cm} = 0.60 \text{ m}$, $B = 120 \text{ days}$, $CCA = 5000 \text{ ha}$, intensity of irrigation = 70 %.

Relation: $\Delta = 8.64 B / D \rightarrow D = 8.64 B / \Delta = 8.64 \times 120 / 0.6 = 1,728 \text{ ha/cumec}$

Area actually irrigated $A = CCA \times \text{intensity} = 5000 \times 0.70 = 3,500 \text{ ha}$

Discharge $Q = A / D = 3,500 / 1,728 = 2.025 \text{ m}^3/\text{s}$

(Duty 2 M, area 1 M, discharge 1 M)

b) Compare gravity dam and earthen dam with respect to: foundation, material, seepage, spillway. 4 M

Point	Gravity dam	Earthen dam
1. Foundation	Needs strong, sound rock foundation.	Can be built on weak, soil or pervious foundations.
2. Material	Concrete or masonry.	Earth (soil) — locally available, natural material.
3. Seepage	Seepage is very small.	Seepage through body is more; core, filter and drains are needed.
4. Spillway	Spillway can be provided on the dam body itself.	Spillway cannot be provided on the dam; separate spillway is needed.
5. Cost	Initial cost is high.	Initial cost is low.

(Four points asked, 1 M each)

c) Explain the types of earthen dams with neat sketches. 4 M

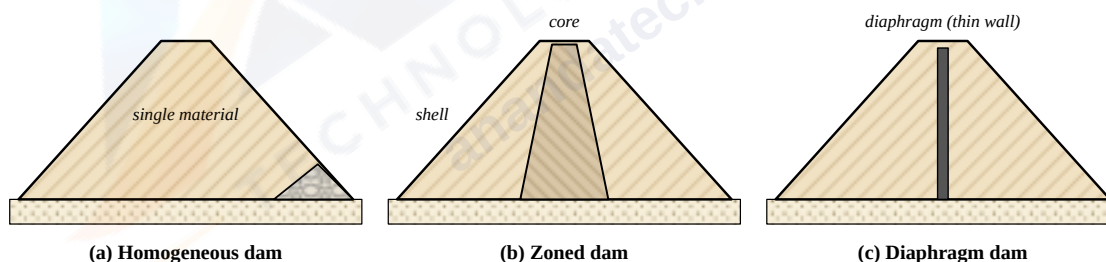


Fig.: Types of earthen dams

- Homogeneous earthen dam** – built of only one kind of soil (fairly impervious) throughout the section; a rock toe / filter drain is provided at the downstream toe to control seepage. Used for low dams.
- Zoned earthen dam** – has a central impervious **core** (clay) flanked by pervious **shells** (casing) of sand / gravel / soil; the core checks seepage and the shells give stability. Most common type.
- Diaphragm type earthen dam** – the body is of pervious material and a thin impervious wall (diaphragm) of concrete, masonry, steel or clay is provided at the centre (or upstream face) to check seepage.

(Each type with sketch 1½ M)

d) Explain the necessity of energy dissipation below a spillway. Describe any one energy dissipator with a sketch.

4 M

Energy dissipation: Water passing over a spillway falls from a great height and has very high velocity (kinetic energy) at the toe. If this water is released directly, it scours the river bed and may undermine the toe of the dam. Hence the excess energy must be destroyed (dissipated) before the water joins the river; the arrangements provided are called **energy dissipators**.

1. Hydraulic jump type stilling basin: The high-velocity (supercritical) flow at the toe is made to form a hydraulic jump on a concrete apron; turbulence in the jump (roller) dissipates energy. Chute blocks, baffle blocks and an end sill stabilise the jump. Used when tail water depth is suitable.

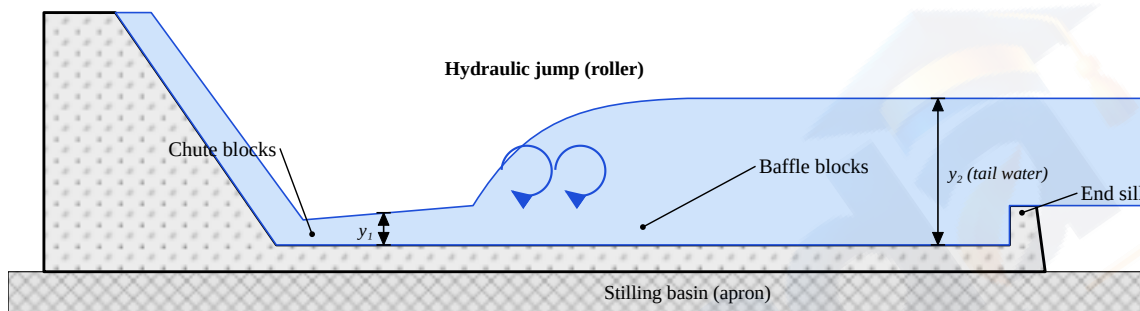


Fig.: Hydraulic jump type stilling basin (energy dissipator)

2. Bucket type (ski-jump / flip bucket): A curved bucket with a lip at the toe throws the jet up into the air; energy is lost in air friction and the jet strikes the river bed far away from the dam. Used when tail water depth is less and the river bed is of sound rock. (Roller bucket is used when tail water depth is large.)

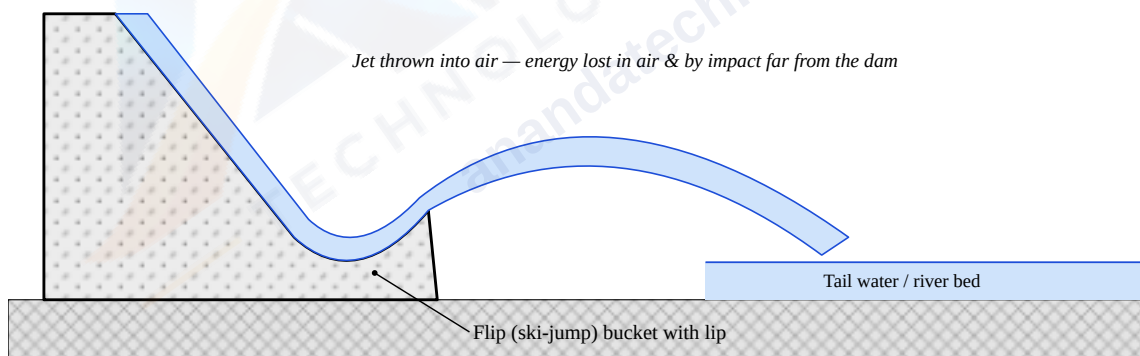


Fig.: Ski-jump (flip) bucket energy dissipator

(Explanation 2 M, any one dissipator with sketch 2 M)

Q.4 Attempt any THREE of the following:

12 M

a) State any four requirements of an ideal site for a bandhara.

4 M

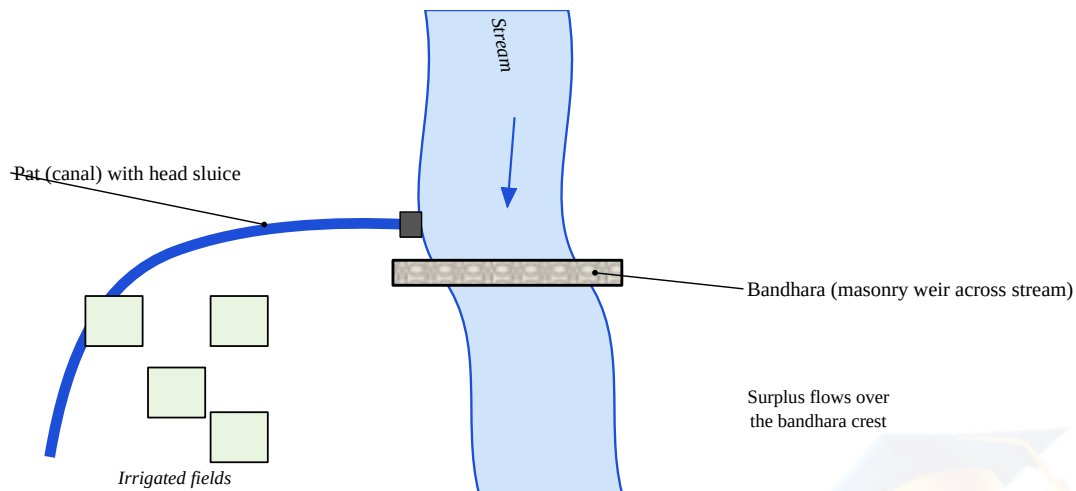


Fig.: Layout of bandhara irrigation (plan)

Requirements of an ideal site for bandhara:

1. The stream should be perennial or flow for most part of the year (sufficient post-monsoon flow).
2. The stream bed should have a hard, impervious rock foundation at shallow depth.
3. The section of the stream should be narrow with high, stable banks so that the length of bandhara is small.
4. The site should be at a higher level than the command area so that water can flow by gravity through the pat (canal).
5. Good fertile land should be available in the command near the site; material (stone, sand) should be available nearby.
6. There should be minimum submergence of land upstream.

(Any four, 1 M each)

b) Draw the layout of a drip irrigation system and state the functions of its components.

4 M

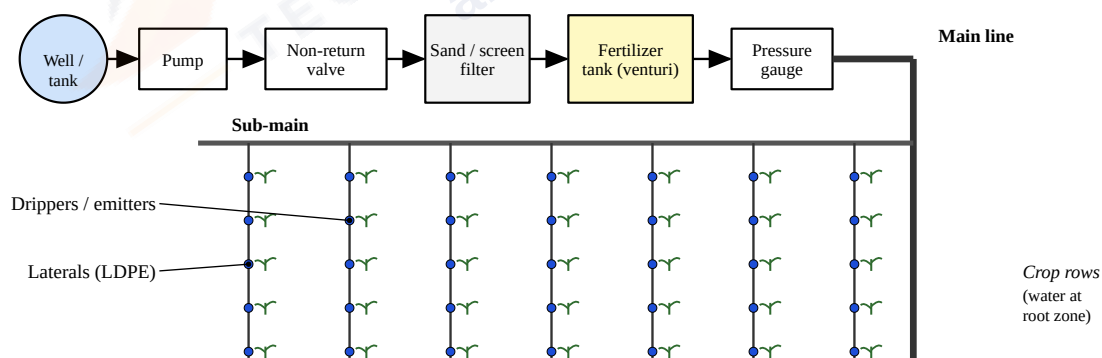


Fig.: Layout of drip irrigation system

Drip (trickle) irrigation: water is applied drop by drop at the root zone of each plant through a network of pipes and emitters.

1. **Pump / head unit** – lifts water from well / tank and gives the required pressure.
2. **Filters** (sand / screen) – remove suspended particles so that drippers do not get clogged.
3. **Fertilizer tank / venturi** – to add fertilizer with irrigation water (fertigation).
4. **Main and sub-main pipes** (PVC) – carry water to the field.
5. **Laterals** (LDPE pipes) – laid along crop rows.
6. **Drippers / emitters** – discharge water at 2–8 litres per hour near each plant.
7. Valves, pressure gauge and flush valves for control.

(Layout 2 M, components 2 M)

c) State the advantages and disadvantages of well irrigation.

4 M

Advantages of well irrigation:

1. Simple and cheap; can be constructed by the farmer himself.
2. Water is available whenever needed (control is with the farmer), so water is used economically.
3. No conveyance losses and no water logging / rise of water table.
4. Groundwater contains dissolved salts useful to crops and is free from weeds.

Disadvantages:

1. Limited area can be irrigated by one well.
2. Lifting water needs power (electricity / diesel), so running cost is high.
3. Wells may dry up in drought or when water table falls due to over-pumping.
4. Water may be saline in some areas; yield is uncertain.

(Two advantages 2 M, two disadvantages 2 M)

d) Compare weir and barrage with respect to: cost, afflux, silt control and maintenance.

4 M

Point	Weir	Barrage
1. Cost	Less costly.	More costly.
2. Afflux	Afflux (rise of water level u/s during floods) is high.	Afflux is low because gates are opened during floods.
3. Silt control	Silt deposits upstream; poor silt control.	Good control of silt by opening gates.
4. Maintenance	Less maintenance.	More maintenance (gates, hoists).

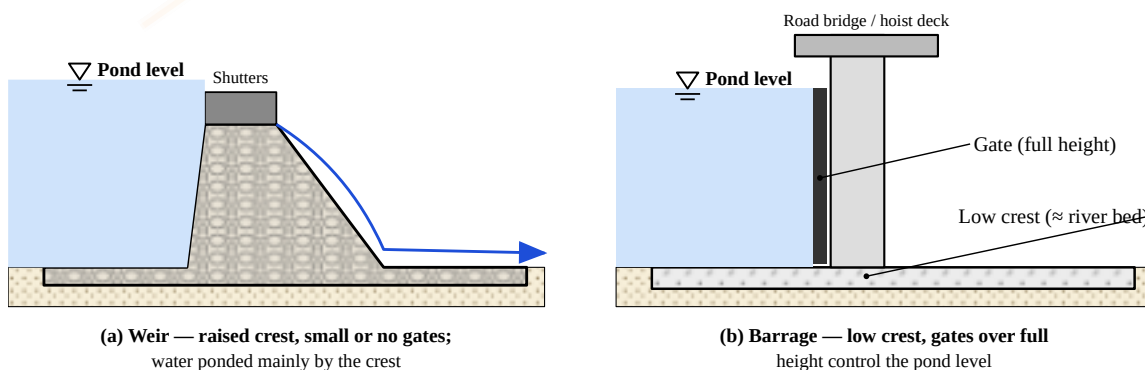


Fig.: Weir and barrage (sections)

(Each point 1 M (sketch for illustration))

e) Draw a neat layout of diversion headworks showing all component parts.

4 M

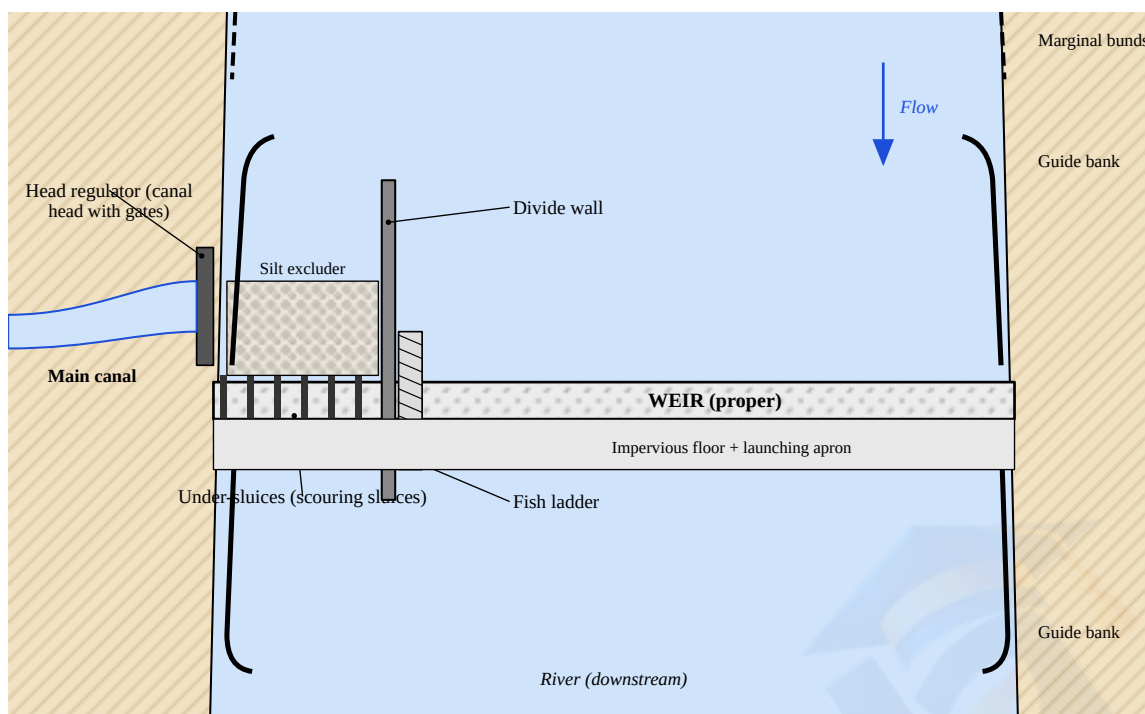


Fig.: Layout (plan) of diversion headworks

Components: weir, under-sluices, divide wall, fish ladder, silt excluder, canal head regulator, guide banks, marginal bunds, impervious floor and launching apron.

(Neat layout 3 M, labels 1 M)

Q.5 Attempt any TWO of the following:

12 M

a) Fix the control levels of a medium size reservoir from the following data: effective storage required for crops = 14.5 Mm³; tank losses = 20 % of effective storage; carry-over allowance = 10 % of effective storage; dead storage = 12 % of gross storage; flood lift = 2.5 m; free board = 2.5 m.

Contour R.L. (m)	450	453	456	459	462	465	468
Capacity (Mm ³)	0.6	1.9	4.1	7.3	11.6	17.2	24

1. **Live (useful) storage** = 14.50 (effective storage for crops) + 2.900 (tank losses 20 %) + 1.450 (carry-over 10 %) = **18.850 Mm³**

2. **Gross storage:** dead storage = 12 % of gross storage, so live storage = 0.88 × gross.
Gross storage = 18.850 / 0.88 = **21.420 Mm³**; Dead storage = 21.420 – 18.850 = **2.570 Mm³**

3. **D.S.L. (dead storage level / sill level)** – capacity 2.570 lies between 1.90 (R.L. 453.00) and 4.10 (R.L. 456.00). By linear interpolation:

D.S.L. = 453.00 + (3.00) × (2.570 – 1.90) / (4.10 – 1.90) = **453.91 m**

4. **F.R.L.** – gross storage 21.420 lies between 17.20 (R.L. 465.00) and 24.00 (R.L. 468.00):

F.R.L. = 465.00 + (3.00) × (21.420 – 17.20) / (24.00 – 17.20) = **466.86 m**

5. **Flood lift** (given) = 2.50 m

6. **H.F.L.** = F.R.L. + flood lift = 466.86 + 2.500 = **469.36 m**

6 M

7. T.B.L. (top of bund / dam level) = H.F.L. + free board = 469.36 + 2.50 = **471.86 m**

Control level	R.L. (m)
Dead storage level (D.S.L.)	453.91
Full reservoir level (F.R.L.)	466.86
High flood level (H.F.L.)	469.36
Top of bund level (T.B.L.)	471.86

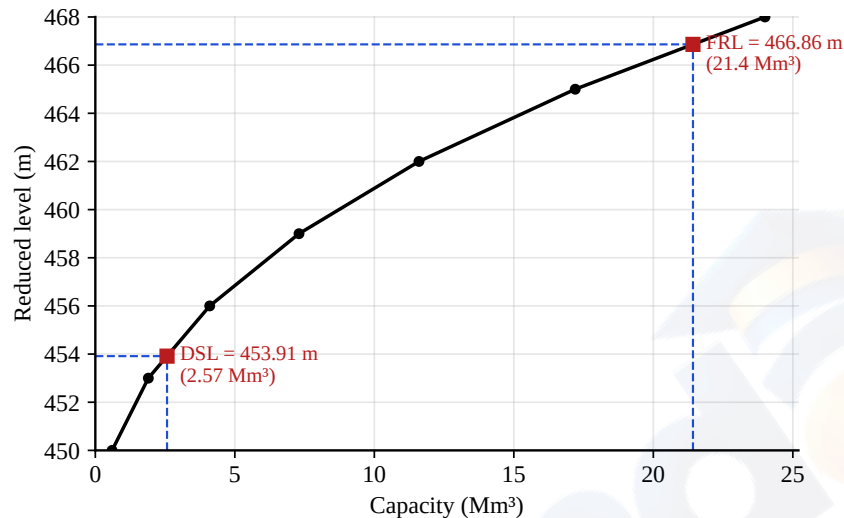


Fig.: Elevation–capacity curve (plotted from given data)

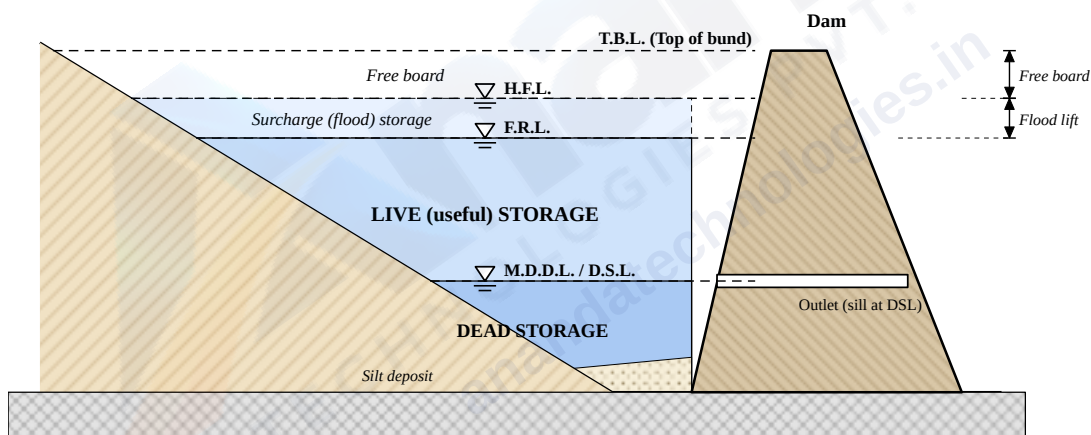


Fig.: Storage zones and control levels of a reservoir

(Live & gross storage 1 M, DSL 1 M, FRL 2 M, HFL & TBL 2 M)

b) Derive the relation between duty, delta and base period. Find the delta of a crop whose duty at the field is 1400 ha/cumec and base period is 110 days.

6 M

Let D = duty in hectare/cumec, B = base period in days, Δ = delta in metres.

Consider a field of area **D hectares** irrigated by **1 m³/s** of water flowing continuously for **B days**.

Total volume of water supplied = $1 \text{ m}^3/\text{s} \times (B \times 24 \times 60 \times 60) \text{ s} = \mathbf{86,400 B \text{ m}^3} \dots (i)$

The same water, spread over D hectares to a depth Δ : volume = area $\times$ depth = $(D \times 10^4 \text{ m}^2) \times \Delta = \mathbf{10^4 D \Delta \text{ m}^3} \dots (ii)$

Equating (i) and (ii): $10^4 D \Delta = 86,400 B$

$$\Delta = 8.64 B / D \quad (\Delta \text{ in m, } B \text{ in days, } D \text{ in ha/cumec})$$

i.e. delta is directly proportional to base period and inversely proportional to duty.

Numerical: $D = 1400 \text{ ha/cumec}$, $B = 110 \text{ days}$.

$$\Delta = 8.64 \times 110 / 1400 = 950.4 / 1400 = 0.679 \text{ m} \approx 67.9 \text{ cm}$$

(Derivation 4 M, numerical 2 M)

c) Suggest suitable routine maintenance measures for an earthen dam.

6 M

Routine maintenance measures for an earthen dam:

1. Regular inspection of crest, slopes and toe before and after monsoon; record seepage, settlement and cracks.
2. Cracks on crest or slopes are filled with clay / grouted immediately; rain cuts and gullies are refilled and compacted.
3. Upstream riprap (stone pitching) is repaired and displaced stones replaced; downstream slope turfing is maintained and grass watered / cut.
4. Trees, bushes and deep-rooted vegetation on the dam are removed; animal burrows (rats, crabs) are filled.
5. Toe drains, filters, rock toe and relief wells are cleaned so that seepage water flows freely; seepage quantity and colour (turbidity) are checked.
6. Spillway, gates and outlets are checked, greased and kept free of debris before monsoon so that flood can pass and over-topping is avoided.
7. Free board is maintained; crest road and parapet are repaired; surface drains on berms are cleaned.
8. Piezometer, settlement gauge and other instrument readings are taken and compared with design values.

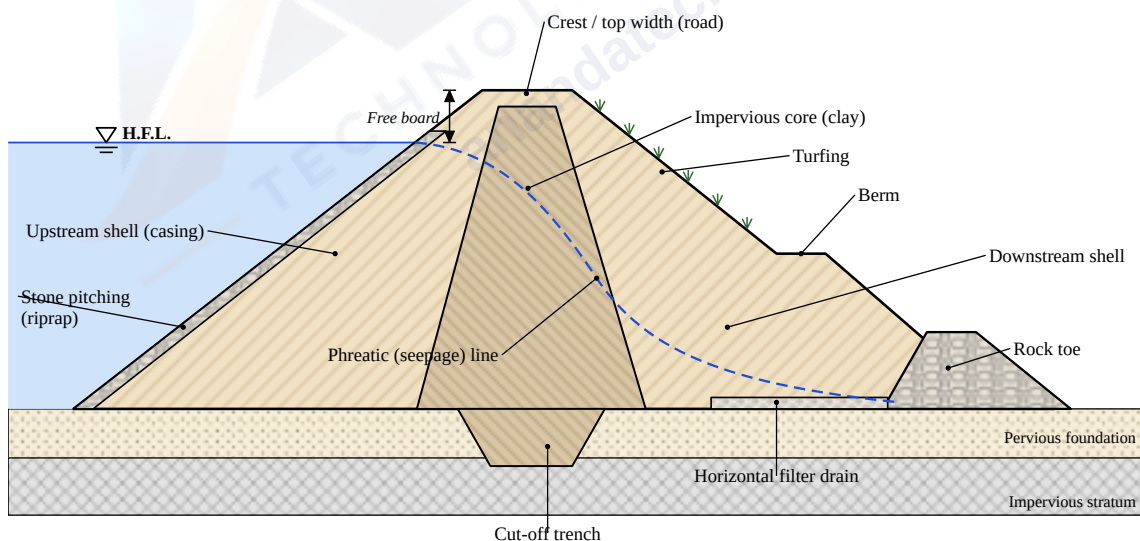


Fig.: Parts of an earthen dam to be inspected / maintained

(Any six measures, 1 M each)

Q.6 Attempt any TWO of the following:

12 M

a) Enlist the types of gates used on spillways. Explain radial gate and vertical lift gate with neat sketches.

6 M

Types of spillway / dam gates:

1. Vertical lift gates (plain sliding gates and fixed-wheel / roller gates)
2. Radial (Tainter) gates
3. Drum gates
4. Rolling (roller) gates
5. Flash boards and stop logs
6. Automatic gates (e.g. Vishweshwarayya automatic gates, first used at Lake Fife, Khadakwasla)

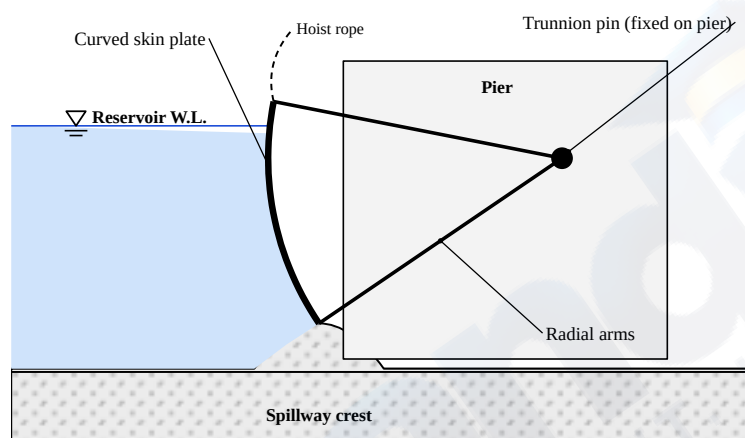


Fig.: Radial (Tainter) gate — side view

Radial (Tainter) gate: It consists of a curved skin plate (part of a cylinder) supported by radial arms which are hinged to a trunnion pin fixed on the piers. The water pressure on the curved face passes through the trunnion, so very little force is needed to lift the gate. It is raised by ropes / chains from a hoist on the bridge. It is light, economical and widely used for spillway crests and barrages.

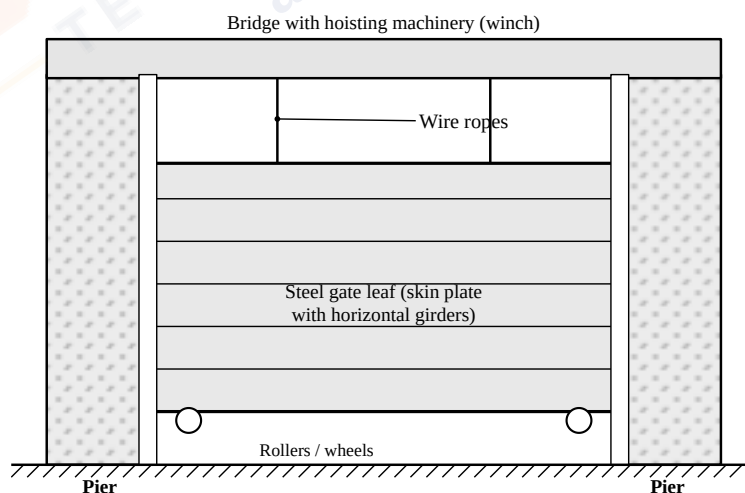


Fig.: Vertical lift gate between piers (front view; gate slides in pier grooves)

Vertical lift gate: A steel gate leaf (skin plate stiffened by horizontal girders) moves vertically in grooves provided in the piers. Wheels / rollers reduce friction. It is lifted by a winch or hoist from the bridge above. Simple in construction but needs high piers and larger lifting force.

(Types 2 M, any two gates with sketch 2 M each)

b) State any three advantages and three disadvantages of canal lining.

6 M

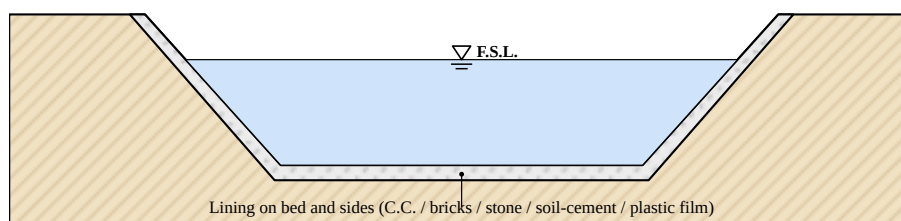


Fig.: Lined canal section

Canal lining is an impervious layer of concrete, bricks, stone, soil-cement, plastic film etc. provided on the bed and sides of a canal.

Advantages:

1. Seepage losses are reduced, so more water is available for irrigation.
2. Water logging and salinity of adjoining land are prevented.
3. Higher velocity can be allowed, so section is smaller and earthwork / land cost is less.
4. Weed growth is checked and maintenance cost (silt and weed clearance) is reduced.
5. Canal banks are protected against erosion and breaches.

Disadvantages:

1. High initial cost.
2. Lining gets damaged by uplift pressure / settlement of banks; repairs are difficult and costly.
3. Shifting of outlets or alteration of canal section is difficult.
4. Water cannot be easily stopped from the canal for repairs because the canal runs for long periods.

(Three advantages 3 M, three disadvantages 3 M)

c) Explain with neat sketches: i) Head regulator ii) Escape iii) Canal fall.

6 M

i) Head regulator: A gated regulator constructed at the head of a canal (or distributary) where it takes off from the river / parent canal. It regulates the supply entering the canal, controls entry of silt and shuts off the canal during floods or for repairs.

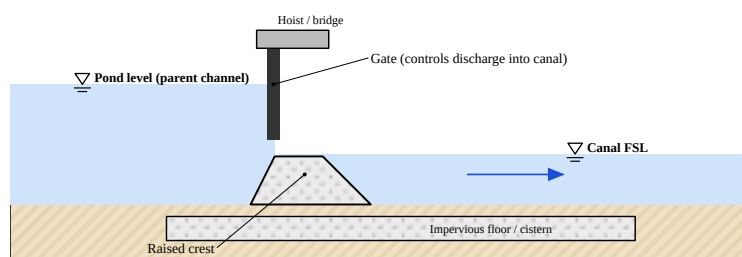


Fig.: Head regulator (section along canal)

ii) Escape: A side channel with a regulator / weir constructed on a canal to dispose of surplus water from the canal into a natural drain or river. It protects the canal banks from breaching when excess water enters due to sudden closure of outlets or rain, and is also used to empty the canal for repairs.

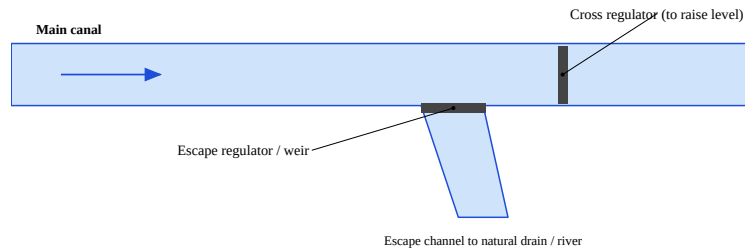


Fig.: Canal escape (plan)

iii) Fall: A masonry structure constructed in a canal where the natural ground slope is steeper than the designed bed slope of the canal. The bed is dropped suddenly at the fall and the energy of falling water is dissipated in a cistern (water cushion), so that excessive earthwork in filling is avoided.

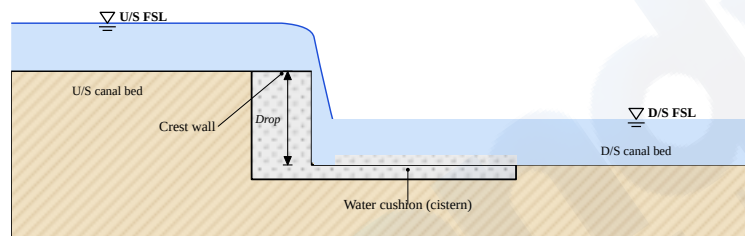


Fig.: Vertical drop canal fall (section)

(Each regulator with explanation 1 M and sketch 1 M)

Note: This is a **model question paper prepared by Ananda Technologies** only for practice and exam preparation, based on the pattern of previous MSBTE question papers and the K-scheme syllabus. It is **not an official MSBTE paper**, and it does **not** mean that these questions will come in the exam. Answers follow standard textbook points; marks shown are indicative. Free for students — anandatechnologies.in