- Introduction of lift irrigation systems
- & Design of lift irrigation systems

- Malik Aamir Manzoor

Irrigation Systems

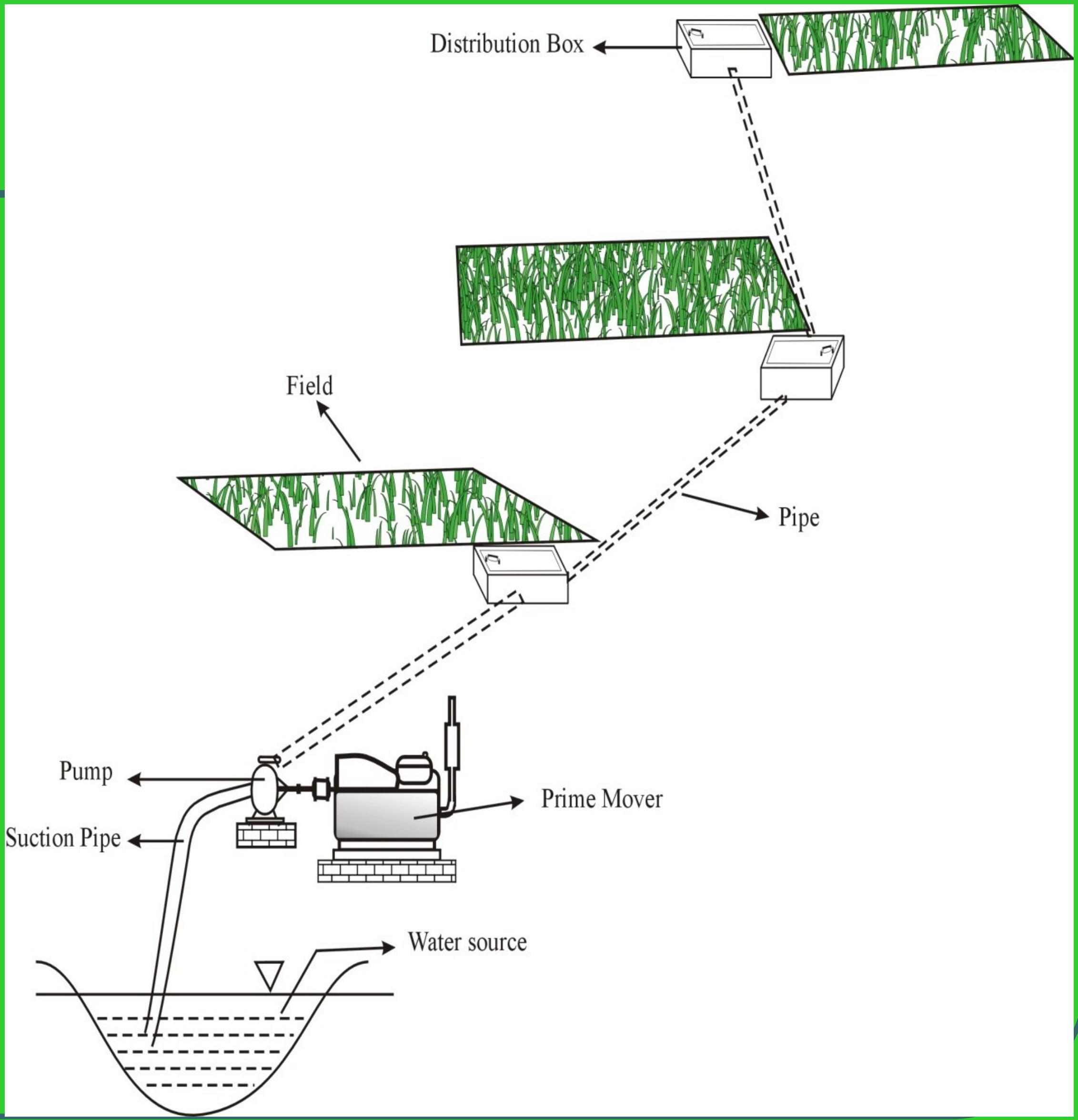
Gravity Flow Irrigation System	Pressurized Irrigation System
❑ Water flows under natural slopes	❑ Water flows under external pressures
❑ Consists of network of dams, head works, canals and watercourses	❑ Consists of pumping unit, pipes, accessories and distributions boxes
❑ Topographic conditions determine type of irrigation system	
❑ Plain terrains with positive gentle slopes provides feasibility for gravity flow irrigation systems	❑ Undulating terrains with negative slopes require lift irrigation systems for conveyance of water to the fields
❑ Large scale irrigation system	❑ Small scale irrigation system
❑ Initial cost very high	❑ Initial cost very low
❑ Operational cost very low	❑ Operational cost higher

Lift irrigation system

Definition

Parts

- ✓Prime Mover
- ✓Pumping unit
- ✓Pipes
- ✓Distribution box



FEASIBILITY OF LIFT IRRIGATION SYSTEMS

- **Technical feasibility**
  - Water source at lower elevations
  - Adjacent lands at higher elevations
- **Economic feasibility**
  - Converts already un irrigated lands to irrigated ones
  - Benefits generated are many fold
  - Detailed analysis should be carried out in case of long distant lift irrigation schemes

Requirements

- Purely technical job
- Requires basic knowledge
  - Soil water plant relationships
  - Crop water requirements
  - Pipe hydraulics
  - Operation and maintenance of irrigation equipments
  - Pipe installation

DESIGN OF LIFT IRRIGATION SYSTEM

- What is design
- Purpose of design
  - Purpose is to supply water to a farm to meet the peak crop water requirement with maximum efficiency and minimum cost
- Design of lift irrigation system
  - Involves making decisions about selection of certain parameters from the available farm resource data

- System capacity
- Irrigation depth
- Irrigation interval
- Daily operational hours of the pumping units
- Sizes of pumps and prime movers

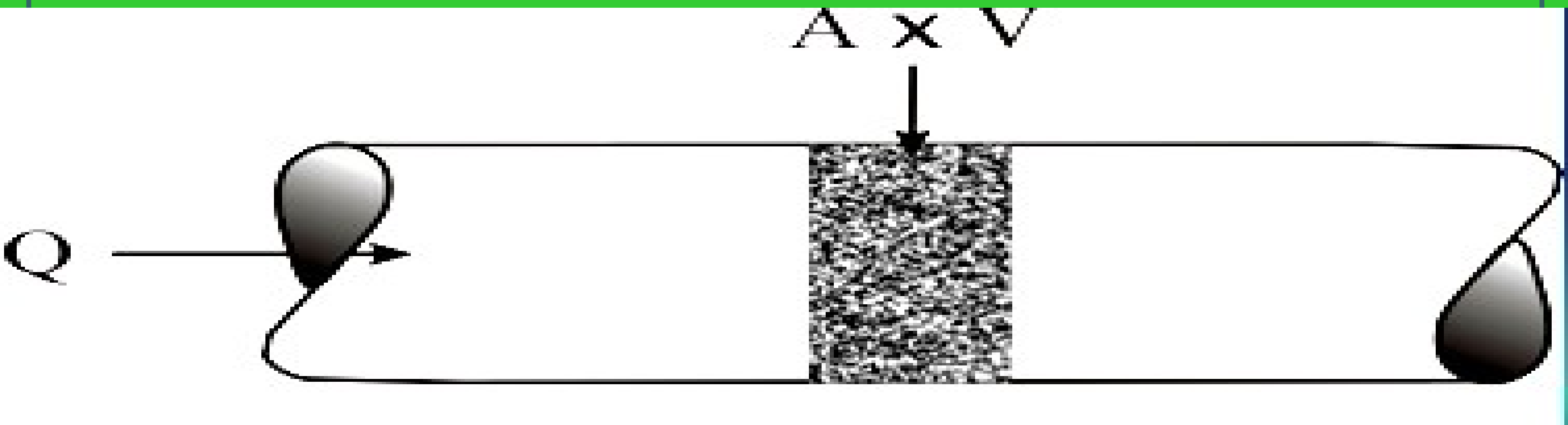
REVIEW OF TERMINOLOGY USED IN DESIGN PROCESS

Discharge

The quantity of water passing through the given section of pipe in unit time is called discharge and can be calculated by the following formula

$$Q = AV$$

Discharge = Cross sectional area of pipe x velocity of water



Discharge through Pipes

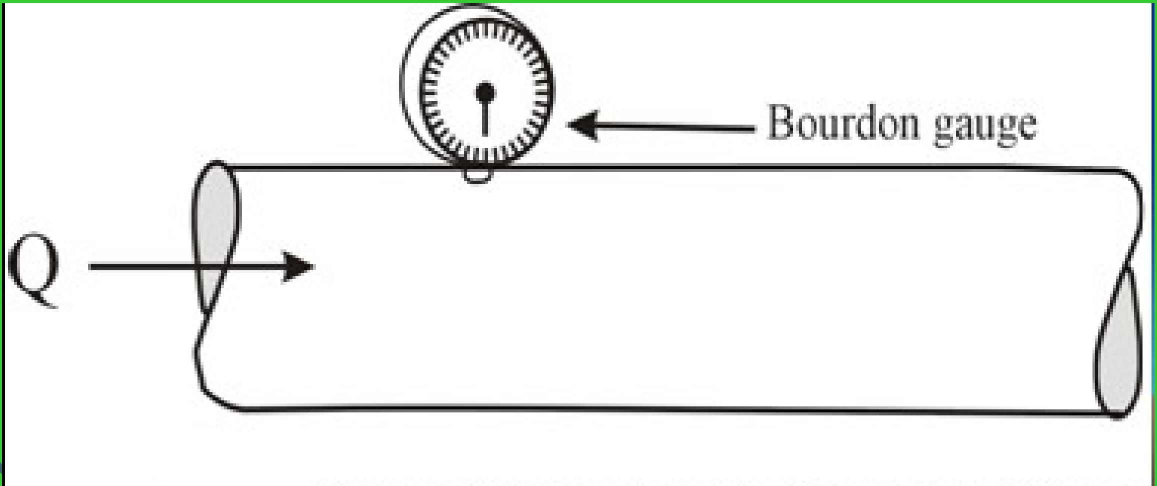
PRESSURE

$$P = \frac{\text{Force}}{\text{Area}} = \frac{F}{A}$$

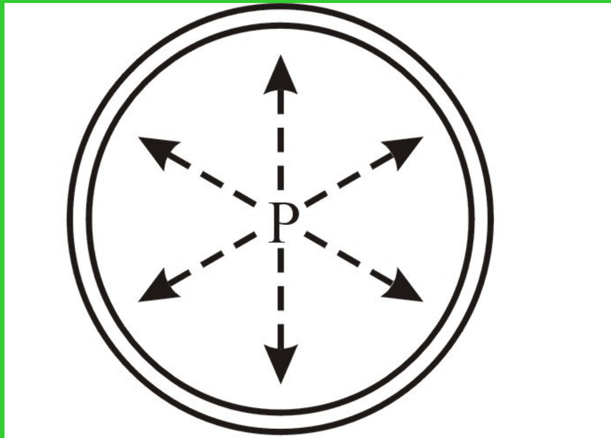
P = Pressure in ponds per square inch

F = Force in ponds

A = Area in square inches

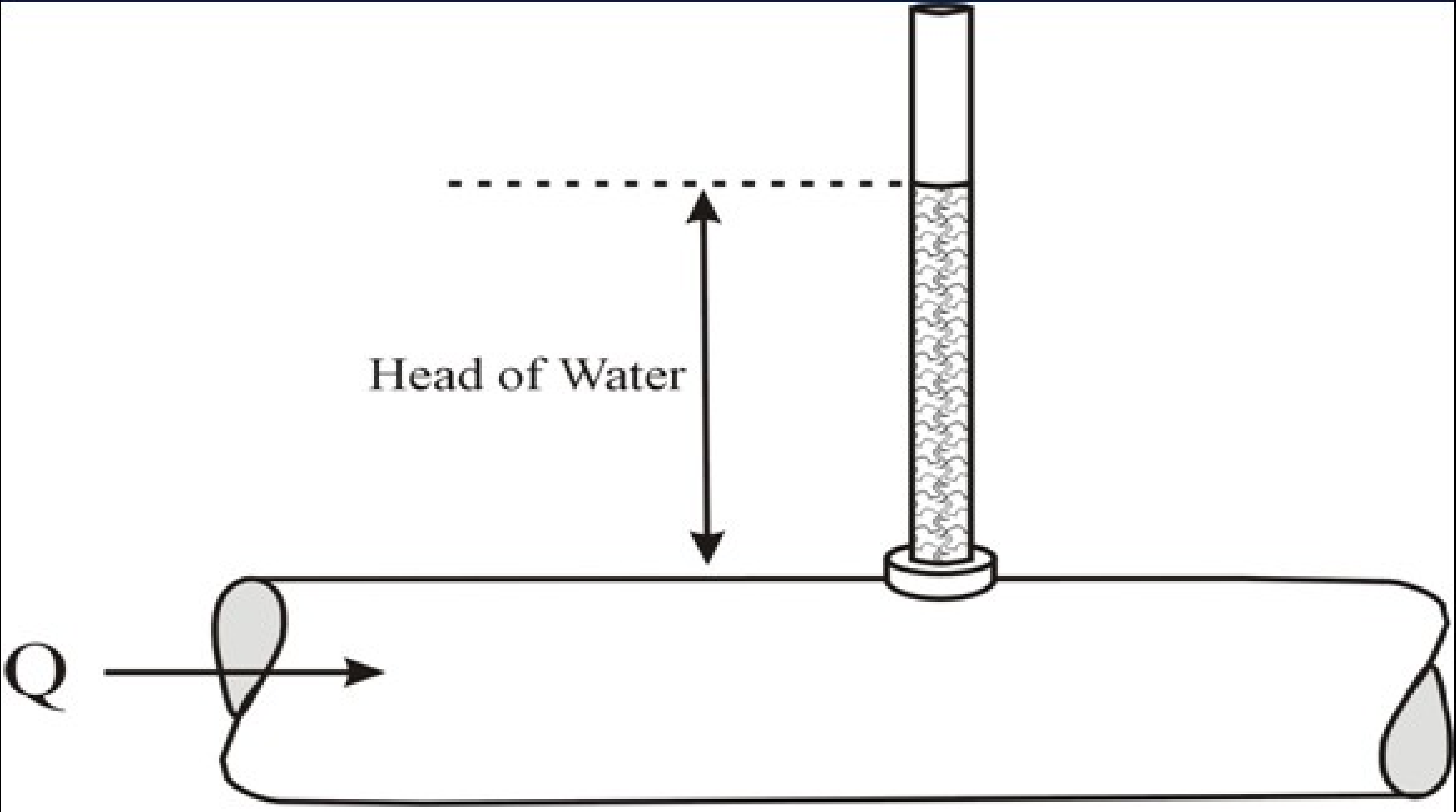


Pressure Measurement with Bourdon Gauge



Pressure on Pipe Walls

HEAD OF WATER



Measuring Head of Water

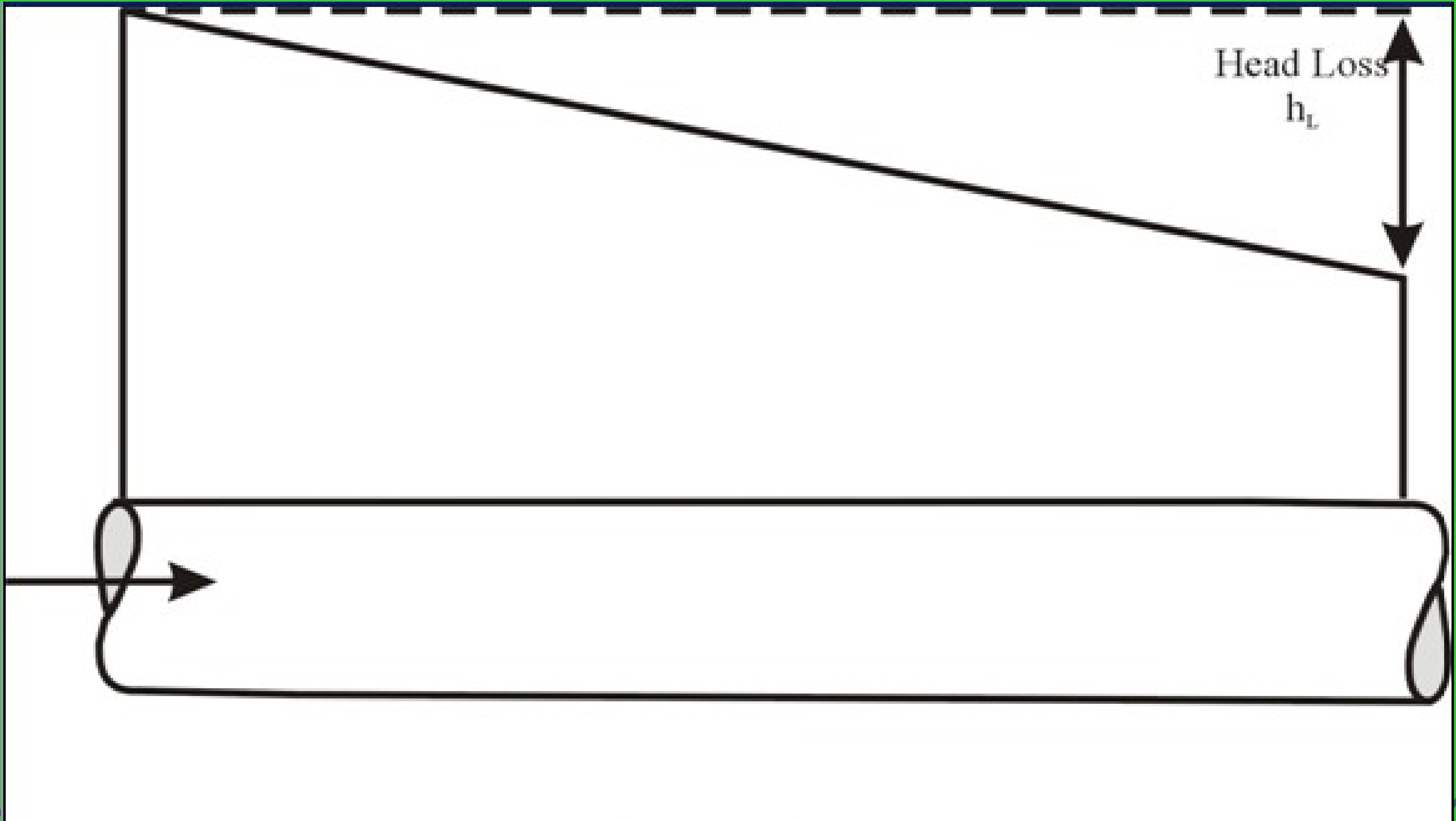
PRESSURE AND HEAD RELATIONSHIP

14.7 psi = 34 feet head of water

1 psi = 2.31 feet head of water

1 foot head of water = 0.433 psi

HEAD LOSS IN PIPES



Head Loss in Pipes

HEAD LOSS BY PIPE FRICTION

1) Hf = K (Q/C)1.852 LD-4.87

Where

K = 1.21 X 1010

Q = Pipe Line discharge, (lps)

C= Friction Coefficient which is a function of pipe material characteristics.

L = Length of pipe (m)

D = Inside diameter of pipe (mm)

hf = Frictional Head Loss, m

2) $Hf = f \frac{LV2}{2gD}$

f = Friction factor

D = Pipe diameter in m

L = Length of pipe in m

V = Velocity of flow in m/sec

g = acceleration due to gravity, 9.81 m/sec2

Design Procedure

- Step 1: **Collection of Basic Farm Resource Data**
  - Topo Graphic Map
  - Data on Climate, Source of Water, Power Source, Crops and Soils

- Step 2: **Irrigation Depth**

$$Id = \frac{TAW \times MAD}{100}$$

- Step 3: **Irrigation Interval**

$$Ii = \frac{Id}{\text{Peak } ETc}$$

Step 4: DESIGN SYSTEM CAPACITY

$$Q = \frac{2.78\ A \times Id}{Ii \times H \times E}$$

where

Q	=	Discharge, (lps)
A	=	Area, (Hectares)
Id	=	Depth of Irrigation (mm)
II	=	Irrigation Interval (Days)
H	=	Operation hours of pumping plant per day
E	=	Field application efficiency, (fraction)
2.78	=	Conversion Factor

Step 5: PIPE DIAMETER SELECTION

- **Maximum velocity approach**
- **Maximum head loss method**
- **Minimum cost approach**

RECOMMENDED TECHNIQUE

i) Compute the dia of pipe on the basis of maximum velocity approach using the formula given below.

$$D = 63.25 \sqrt{\frac{Q}{\pi V}}$$

where D = Pipe diameter in mm

Q = Discharge in lps

V = Velocity m/sec

63.25 = constant for conversion

The velocity range is 1-1.5 m/sec

The upper limit for the velocity may also be taken from manufacturer's recommendations.

ii) Revise the diameter as judgment indicates keeping in view, the availability of sizes in market, operational and initial costs.

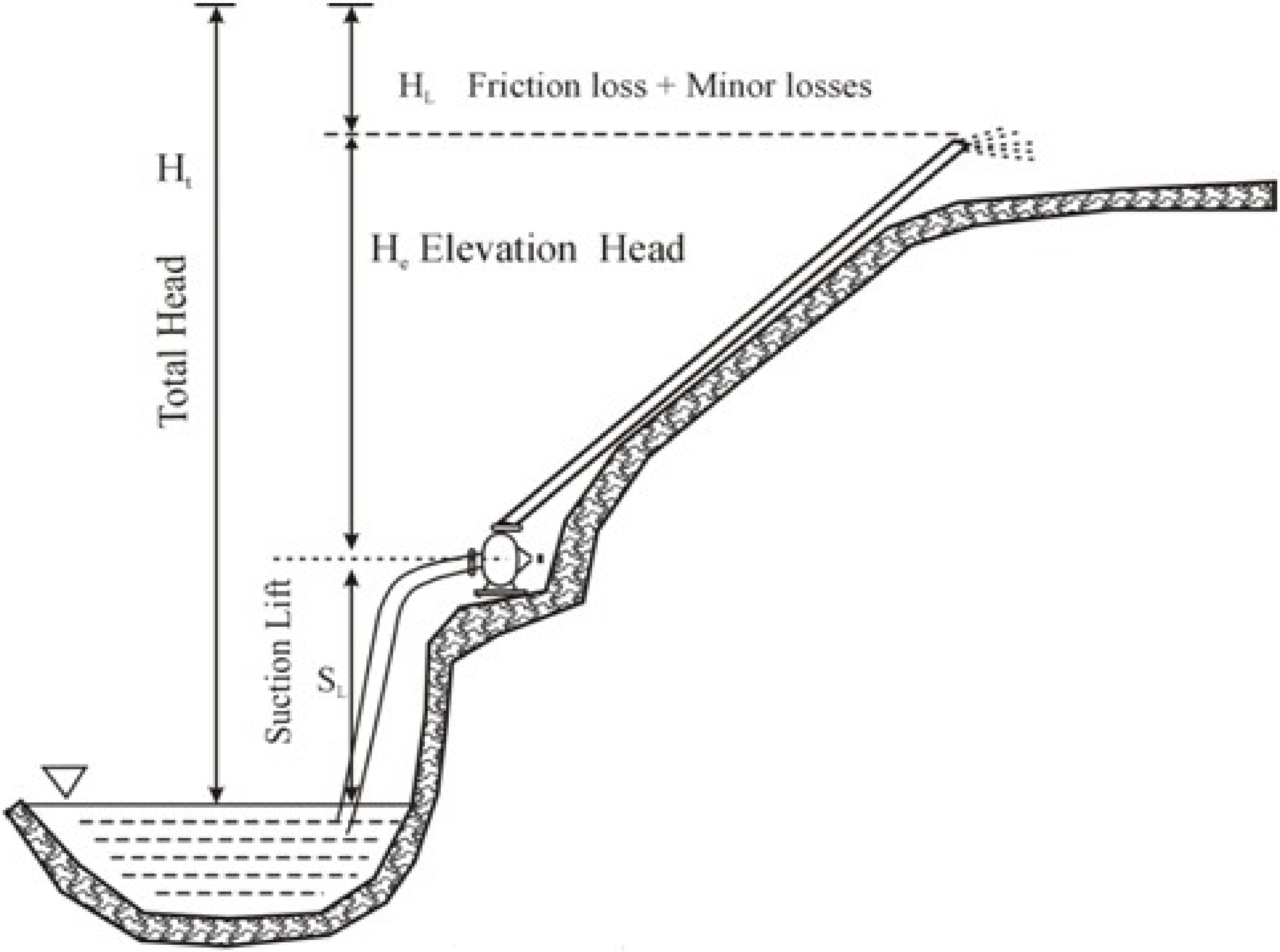
Step 6: SELECTION OF PUMP

Discharge and Head

Total Head

a. Elevation Head (Vertical distance from the center line of the pump to the highest field)
b. Friction losses
c. Pump suction lift
d. Minor losses (A figure of 10% to 15% of (b) above is normally used
e. Factor of safety

Ht = a + b + c + d + e



H_L Friction loss + Minor losses
H_t
Total Head
H_e Elevation Head
Suction Lift
S_L

Step 7: Calculation of Power

W.H.P = Q X Ht / 76

Q is in lps

Ht in meter

B.H.P = Q X Ht / 76 X Eff.

Where

W.H.P is water horsepower

B.H.P is the break horsepower

Eff. is the efficiency of the pumping system

WORKED EXAMPLE

Step-1 Collection of Basic Farm Resource Data

Location	Village Noorpur District Attock, Barani Lands
Soil type	Sandy loam
Cropping Pattern	Wheat, Maize, Potato
Water Source	Mini Dam
Power Source	Diesel Engine
Area of Farm	25 Acres
Topography	Undulating
Climate	Falls in Zone V, Barani Lands

WORKED EXAMPLE

Step-2 Irrigation Depth

AWHC of soil 125 mm/m

Rooting Depth 1.2 m

TAW 125X1.2 = 150 mm

MAD 50%

$$Id = \frac{TAW \times MAD}{100} = \frac{150 \times 50}{100} = 75 \text{ mm}$$

WORKED EXAMPLE

Step-3 Irrigation Interval

$$Ii = \frac{Id}{\text{Peak } ET_c}$$

Month	J	F	M	A	M	J	J	A	S	O	N	D
ETr mm/day	1.77	2.75	3.84	5.86	7.84	**8.5**	6.71	5.84	5.2	4.1	2.76	1.84
Kc	1.15	1.15	0.45	0.45	0.75	**1.15**	0.85	1.15	0.7	-	.35	0.75
Etc	2.03	3.16	1.73	2.64	5.88	**9.77**	5.7	6.72	3.84	-	0.97	1.38

$$Ii = \frac{75}{9.77} = 7.68$$

Say 8 days

WORKED EXAMPLE

Step-4 Design System Capacity

$$Q = \frac{2.78 \times A \times Id}{Ii \times H \times E}$$

$$= \frac{2.78X10X75}{8X20X0.70} = 18.6 \text{ lps}$$

Say = 18 lps

Qs = 18 lps

WORKED EXAMPLE

Step-5 Pipe diameter selection

$$D = 63.25 \sqrt{\frac{Q}{\pi V}}$$

$$D = 63.25 \sqrt{\frac{18}{3.14 X 1.55}} = 121.61mm = 4.78''$$

Say = 5”

Dia of Pipe = 5”

WORKED EXAMPLE

Step-6 Selection of pump

Total Head

a = Elevation Head = 8 m

b = Fiction Losses hf = $\frac{1.21 X 10^{10} (18/150)^{1.852} X 435}{(127)^{4.87}}$ = 5.89 m

c = Minor Losses = (10-15%) of b = 0.88 Say = 1 m

d = Factor of safety = say 1 m

Ht = 8 + 5.89 + 1 + 1 = 15.89 Say = 16 m

Pump will be selected on basis of Q = 18 lps and Ht = 16 m

WORKED EXAMPLE

Step-7 Calculation of power

$$W.H.P = \frac{QXHt}{76} = \frac{18X16}{76}$$

$$B.H.P = \frac{QXHt}{76XEff}$$

$$B.H.P = \frac{18X16}{76X0.4} \quad 9.47$$

$$Say = 12 \ H.P$$

CLASS EXERCISE

A farm has an area of 5 acres with sandy clay soils. Total length of main pipe is 300m and length of two branches is 67 & 67 m originating at end of main pipe. The total elevation difference from water level to highest field is 9m. The pump is to be placed at an elevation of 4m from water source. Design a lift irrigation system for the farm. Ask/assume any data if missing.

[waterholding capacity=183 mm/m, peak Etc=8.5 mm/day, rooting depth=1.3m, application efficiency=0.6, flow velocity=1.5 m/sec, MAD=50%, operating hours per day=3, available discharge from stream=28 lps]