Pharmaceutical Engineering

Unit - I

▲ Chapter - 1 :—

↳ Flow of fluids :—

- The substance having ability to flow.

- Solid → Movement without change in shape.
- Liquid → Movement with deformation in shape.

- Gas → Same as liquid.

∴ liquid & gas are fluids.

Fluid pressure :—

- The pressure applied by the fluid.
- Otherwise called Hydrostatic Pressure.

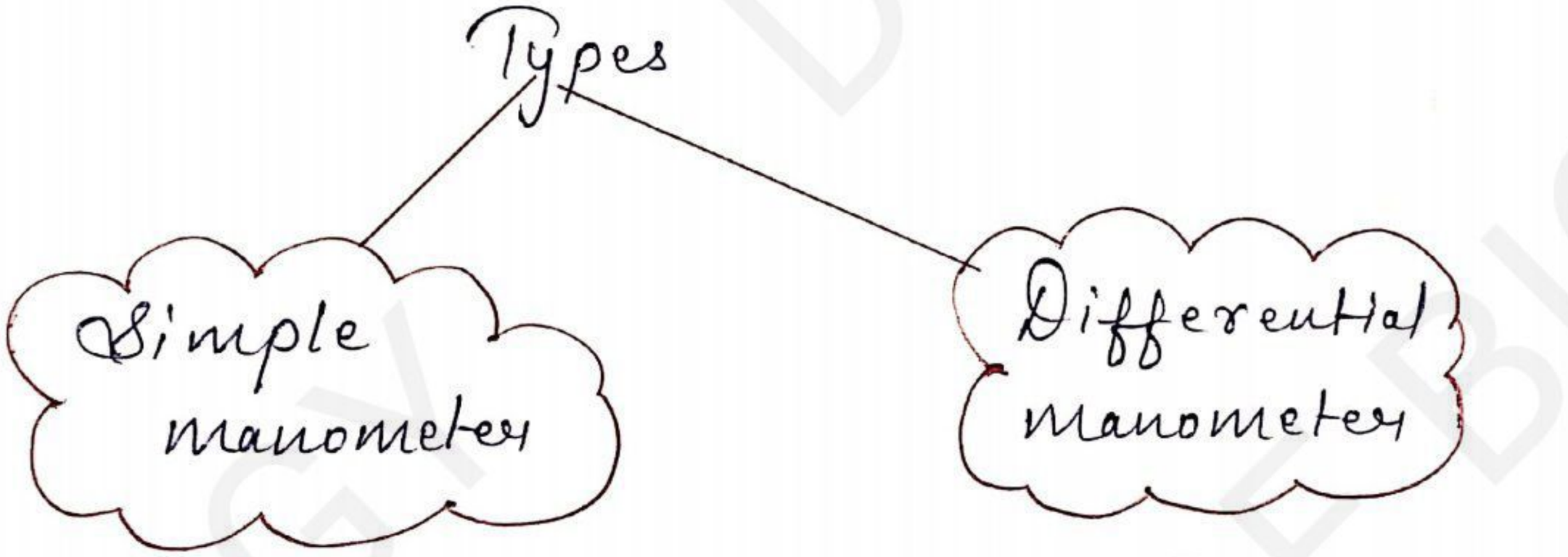
Pressure :- $\boxed{\frac{\text{Force}}{\text{Area}} = \frac{F}{A} = \frac{mg}{A}}$

$$P = \frac{f \times A \times h \times g}{A}$$

$$\boxed{P = f \times h \times g}$$

Manometer :-

- A device used to measure pressure difference.



① Simple manometer :-

- Manometer which measure the Pressure at any point in a tube..

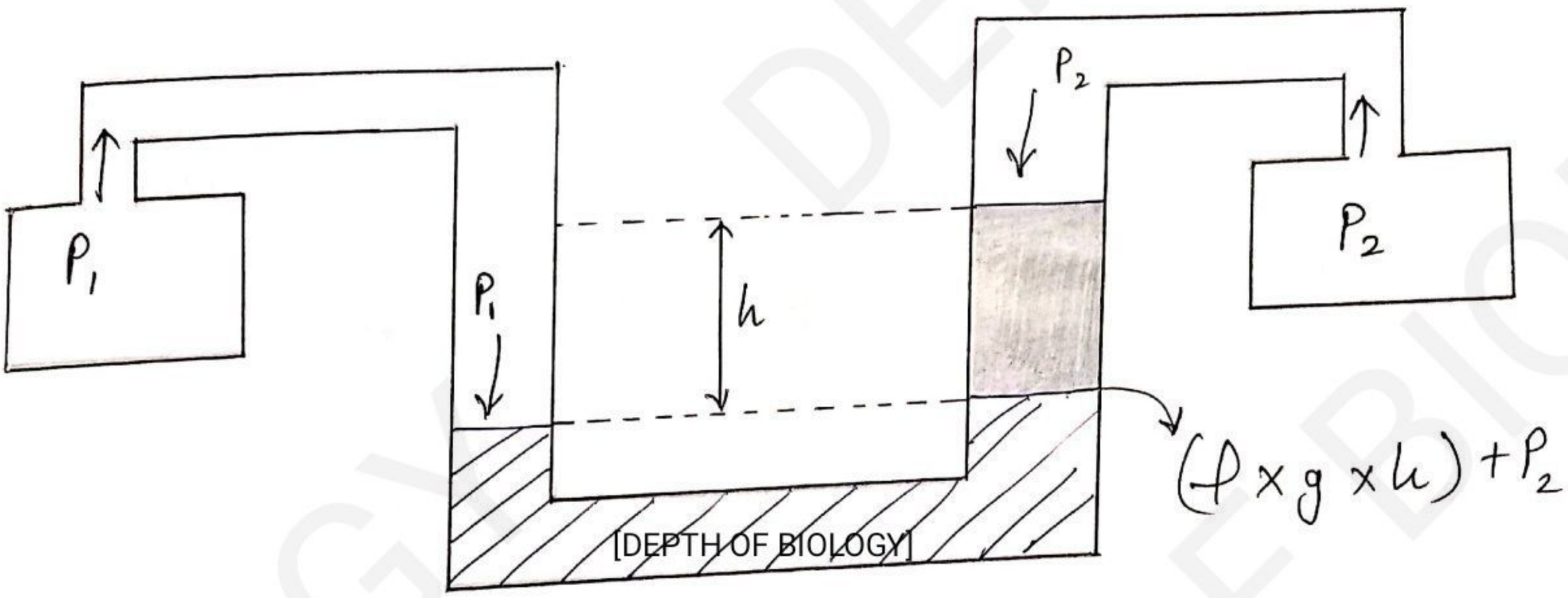
ex :- U-tube manometer.

② Differential manometer :-

- Manometers which used to measure the pressure difference bet^n any two fluids (gases & liquids).

ex :- U- tube differential manometer.

$$P = \rho hg$$



$P_1 > P_2$

$$P_1 = P_2 + \rho gh$$

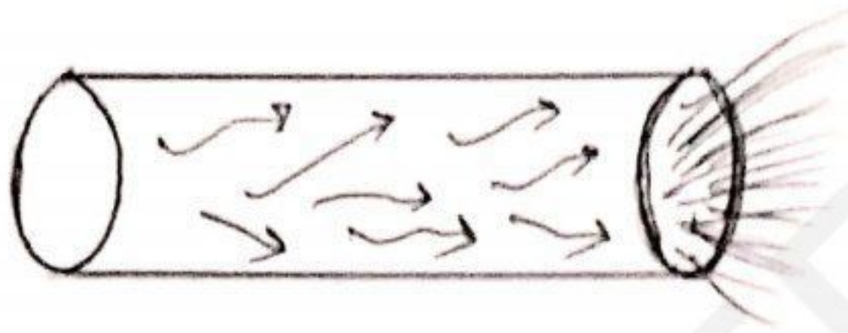
$$P_1 - P_2 = \rho gh$$

$$\boxed{\Delta P = \rho gh}$$

Flow :-

① Steady flow :- Constant flow ✓

② Turbulent flow :- Constant flow ✗



Reynolds number :-

- Ratio of inertial force & viscous force.

$$Re = \frac{\text{Inertial force}}{\text{viscous force}} \quad \begin{matrix}(\uparrow Re) \\ (Resists)\end{matrix}$$

$$\boxed{Re = \frac{\rho v d}{\eta}}$$

where, ρ = density of fluid

v = velocity

d = diameter of pipe

η = viscosity of fluid

- If Re < 1000, then flow is steady.
- If Re > 2000 approx, then it is turbulents.

↳ ∴ It is used to predict the nature of fluid.

↳ Also used to study the sedimentation rate.

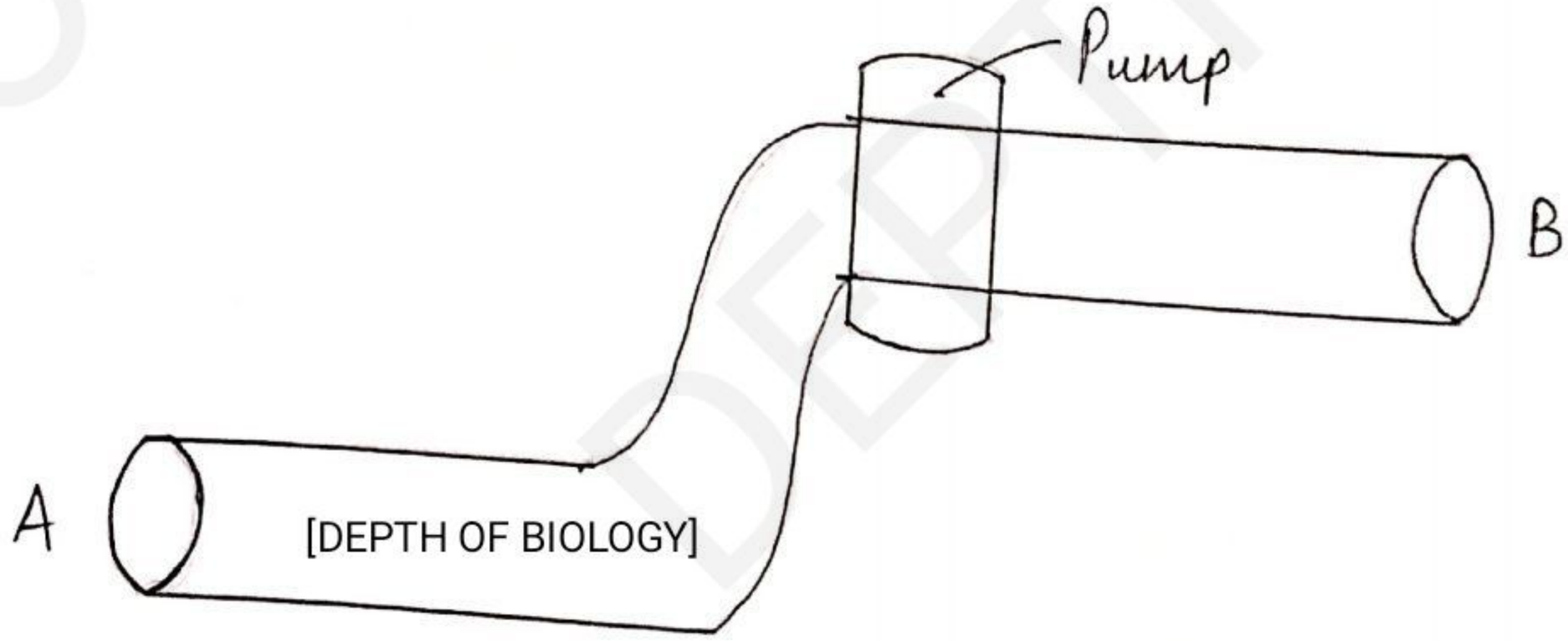
Bernaulè's Theorem :—

- The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and kinetic energy of the fluid motion remains constant.

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

where,

P = Pressure exerted by the fluids
v = velocity of the fluid
ρ = density of the fluid
h = height of the container



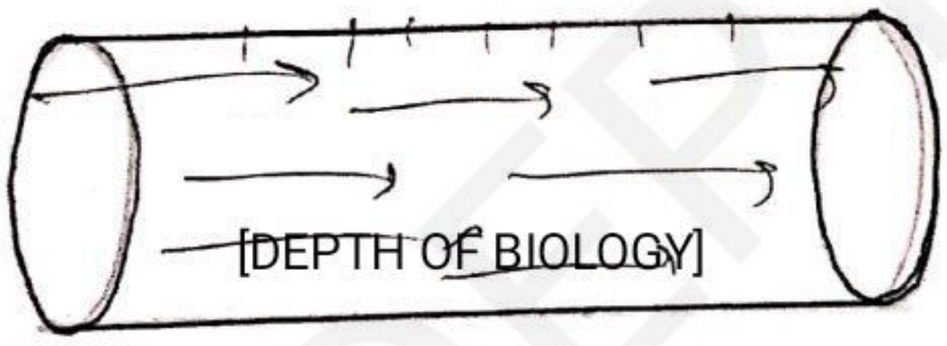
→ Flow

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h$$

Energy loses :—

- During flow some energy lose.

① **Frictional loss** :- During flow of fluids in pipe some friction apply on fluid by the walls of pipe and it oppose the flow & during this some energy loss.



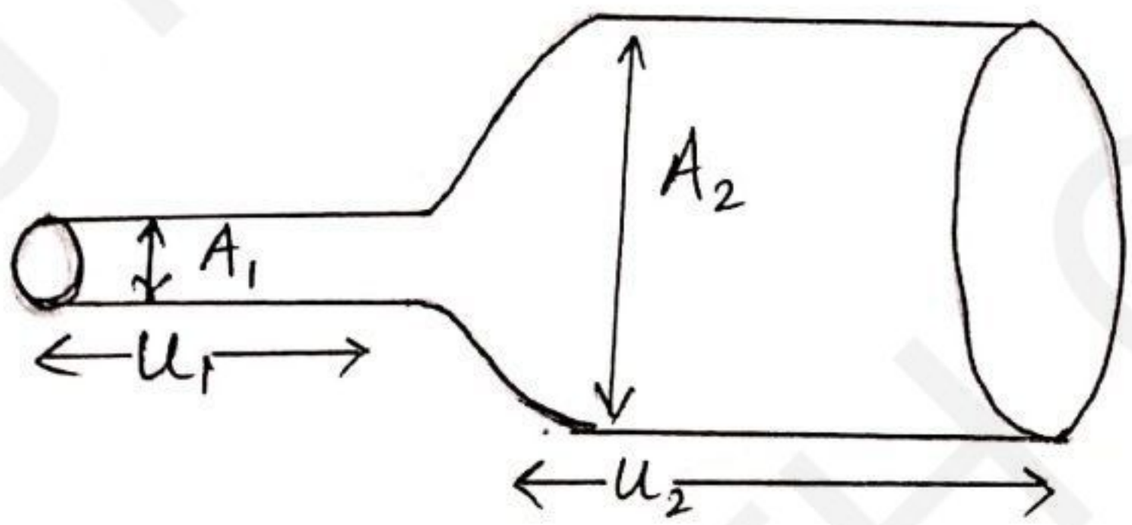
Hagen-Poiseuille eqn :—

$$\Delta P_f = \frac{32 L u u}{D^2}$$

where,

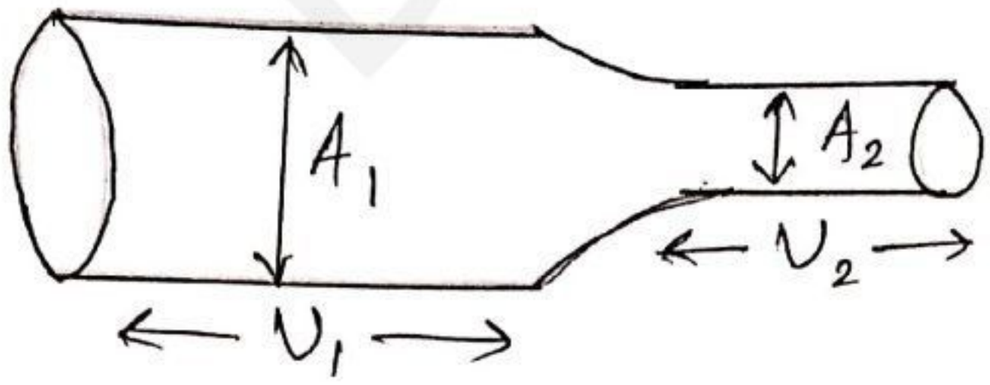
ΔP_f = friction loss
L = length of pipe
u = viscosity of fluid
u = velocity of fluid
D = diameter

② **Enlargement loss :—** On increasing the pipe size, some velocity changes, due to this energy loss occurs.



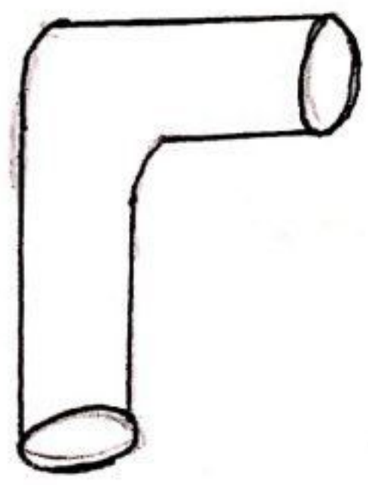
$$\Delta H_E = \frac{u_1^2 - u_2^2}{2g}$$

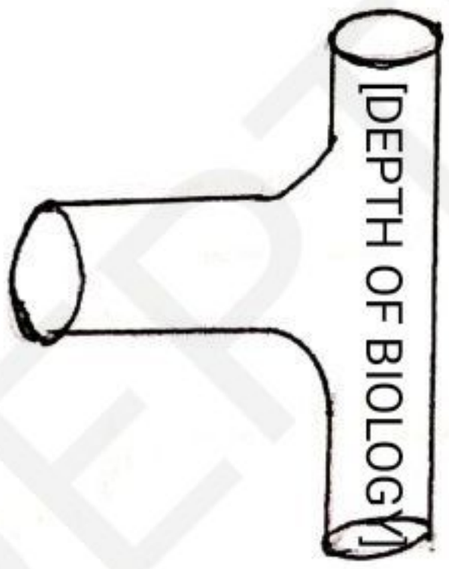
③ Constriction loss :- On decreasing the size of pipe, velocity increase, therefore, energy loss.

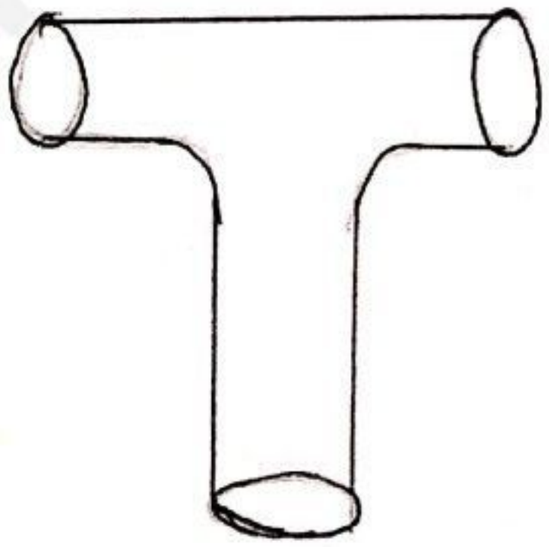


$$\Delta H = \frac{V_2^2 - V_1^2}{2g}$$

④ Fitting loss :- On bending the pipe flow of fluid's direction change and due to this change in direction there are some loss of energy.







▶ Rate of flow of fluids :—

- Direct method

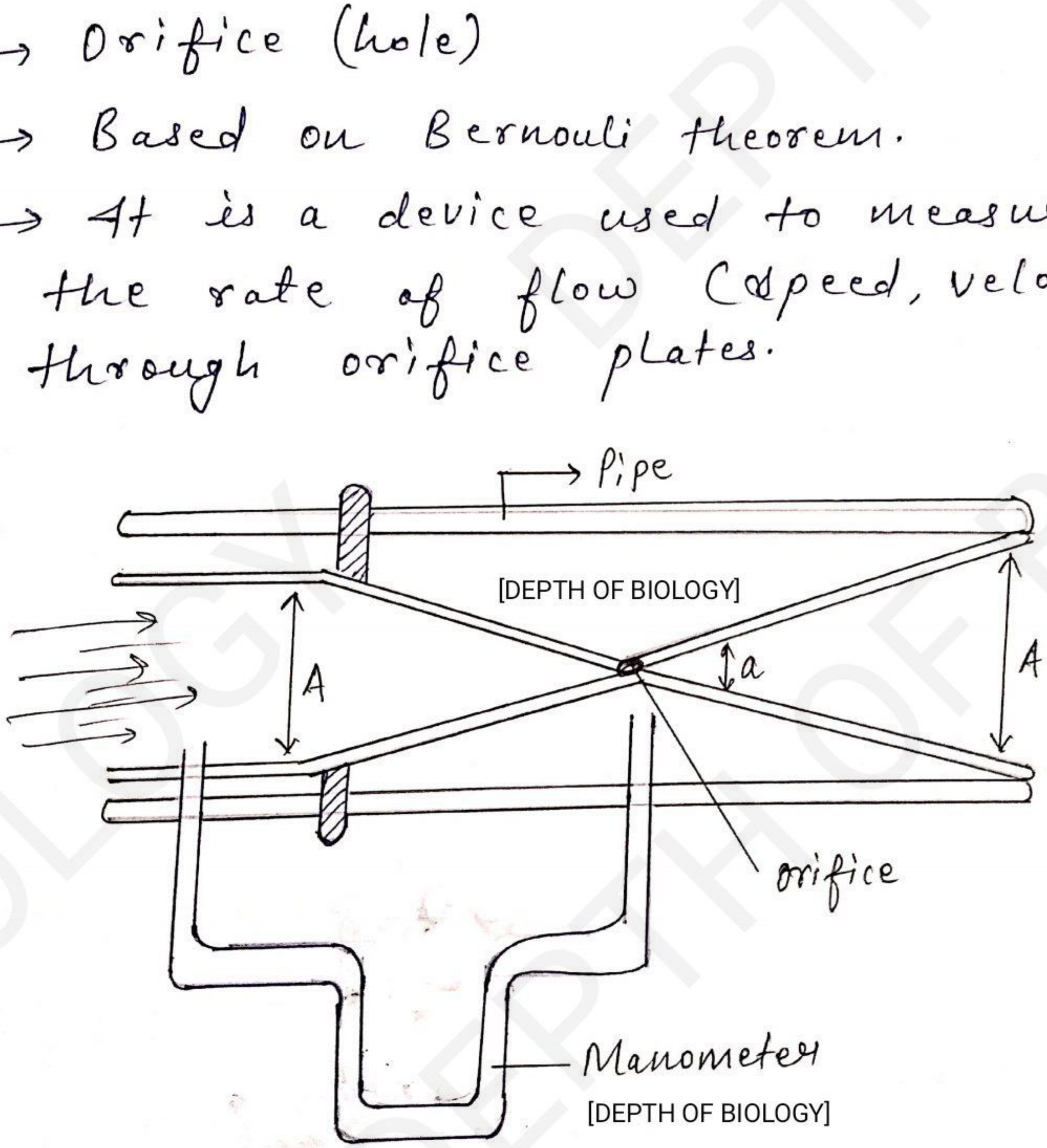
① orifice meter
② venturey meter
③ Pitot tube meter
④ Rotameter

① orifice meter :—

↳ Orifice (hole)

↳ Based on Bernouli theorem.

↳ It is a device used to measure the rate of flow (speed, velocity) through orifice plates.



$$v_0 = C_0 \sqrt{2g \cdot \Delta H}$$

where,

v_0 = Velocity of fluid

C_0 = Constant

$2g$ = gravitation force

ΔH = Pressure difference

↳ So, we can find ΔH through the manometer which we attached on pipe.

↳ On putting the value of pressure difference on orific meter formula, we find out the velocity of fluid easily.

▲ Uses :—

- Used to measure velocity of fluid.

▲ Advantages :—

① Simple to use.

② low cost, especially on large sizes.

③ No need to recalibration.

▶ Disadvantages :—

① Maintenance problem.

② Poor accuracy.

② Venturimeter :—

↳ Used to measure the rate of flow of liquid (speed, velocity) in a pipe.

Principle :—

- Based on the principle of Bernoulli's Theorem.

- Consists of two tappered section in the pipeline with a gradual constriction at its centre.

- On passing fluid through venturi-meter there are changes in pressure head (ΔH) and increase in velocity due to constriction of venturimeter.

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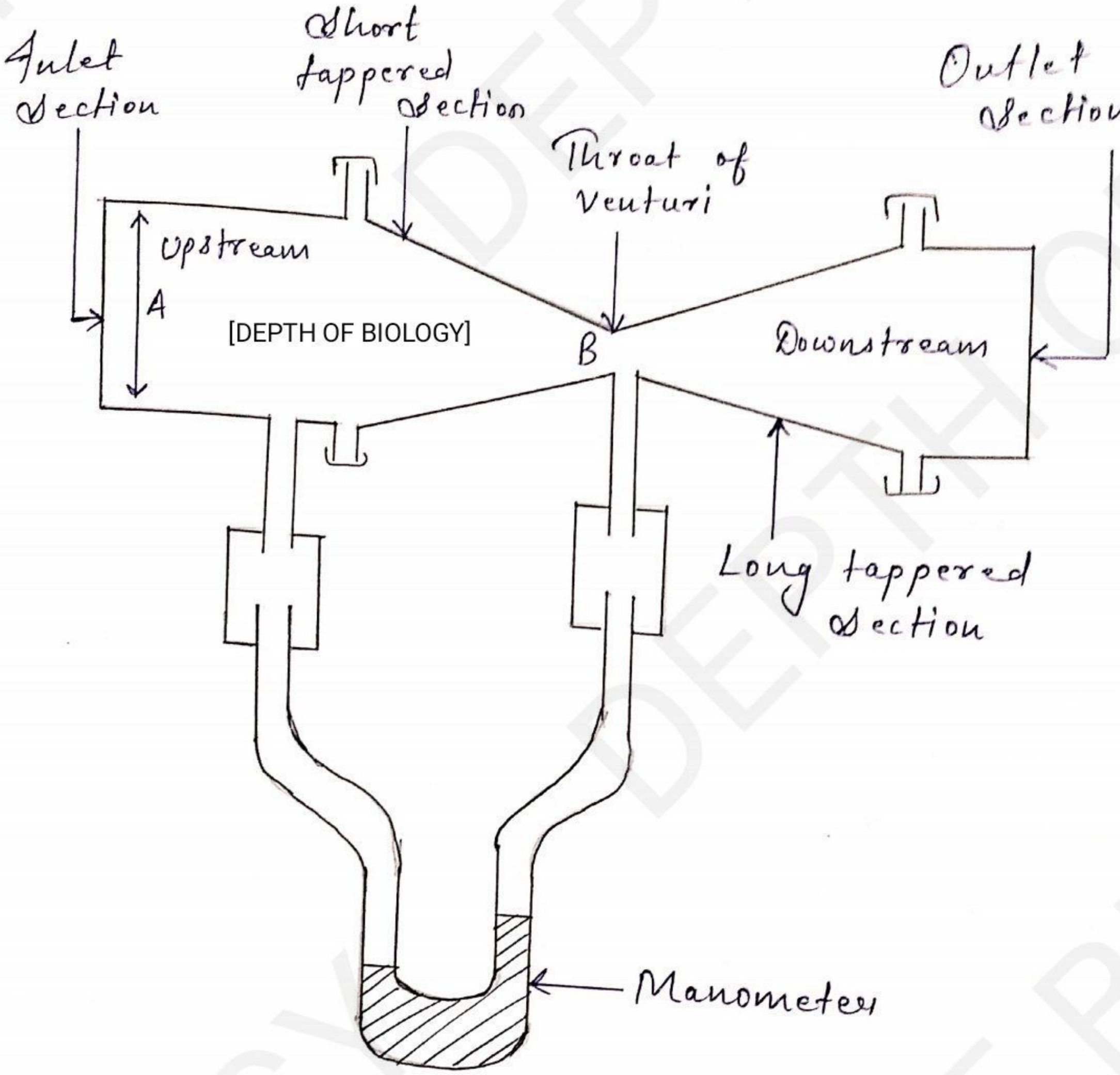
$$U_v = C_v \sqrt{2g \cdot \Delta H}$$



Venturimeter

- Consists of two tappered section inserted in a pipeline with constriction at meter's centre.

- Upstream cone is generally shorter than the downstream.

- Tapers are smooth and gradual.
- Manometer is connected at point A & B to measure the pressure difference.

▶ Working :—

↳ first of all venturimeter is inserted between pipeline.

↳ When fluid is passed through venturimeter, the velocity of the fluid is increased at the throat, due to the constriction.

↳ This result in decreased pressure in the upstream cone which further calculated through manometer.

↳ $$U_V = C_V \sqrt{2g.\Delta H}$$

where,

U_V = Velocity of fluid through venturimeter

C_V = Coefficient of the venturimeter

ΔH = Pressure head difference

Uses :- Commonly used for liquid and also for gases.

(3) Pitot Tube Meter :-

- Used to measure the rate of flow of liquid / velocity head.

Principle :-

↳ Measure the velocity at one point only. [DEPTH OF BIOLOGY]

↳ Based on the principle of Bernoulli's Theorem.

↳ On inserting it to the centre of pipe, the velocity of flow is increased at that point and change in pressure head, which further calculated through manometer.

↳ Put this value in eqn. and find out the value of velocity head.

$$V_{actual} = C_v \sqrt{2g \cdot \Delta H}$$

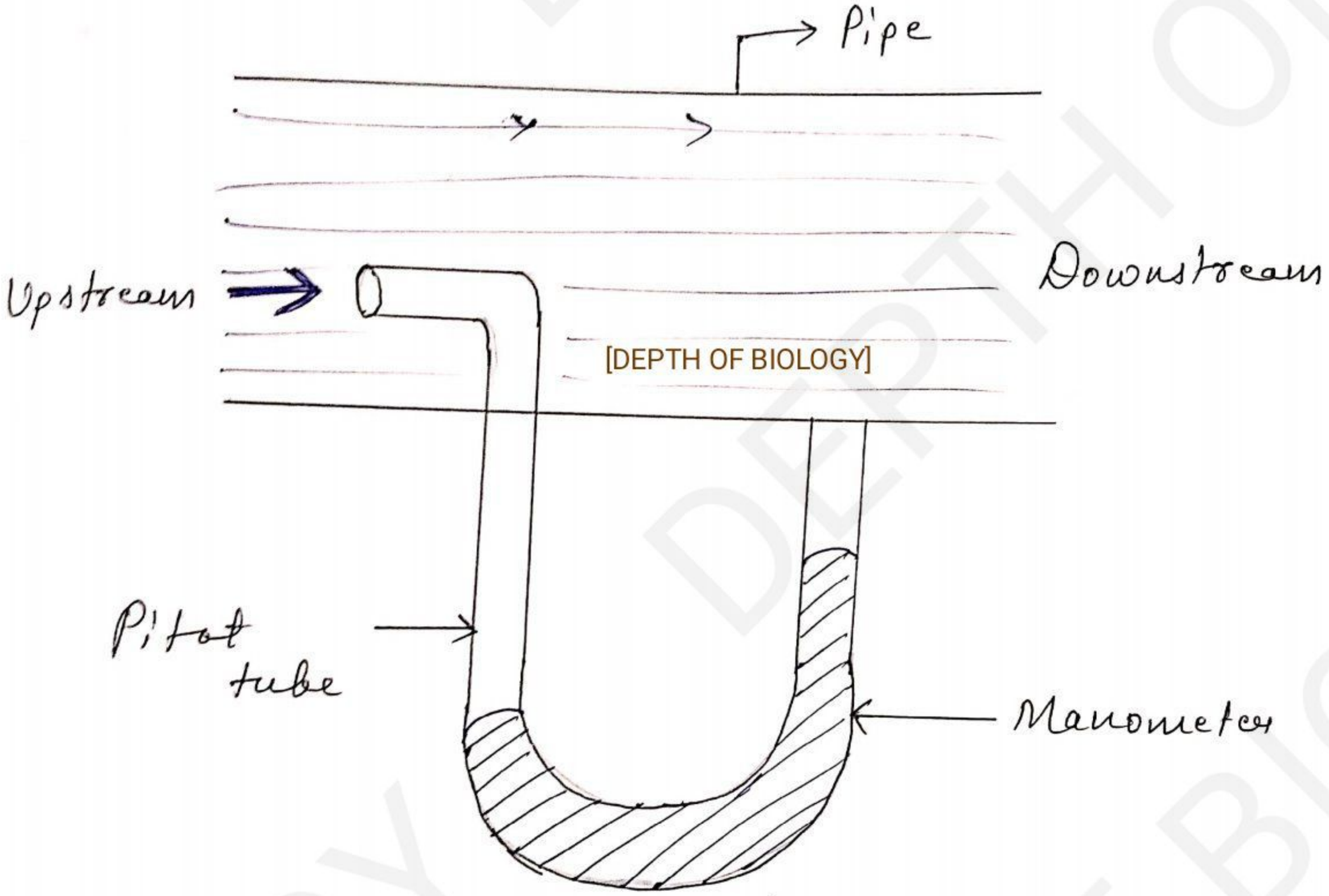
[DEPTH OF BIOLOGY]

where,

V_{actual} = Velocity of fluid / velocity head

C_v = Coefficient of pitot tube

ΔH = Pressure head difference



↳ Also called insertion meter.

↳ On comparison to pipe size is small.

↳ One tube is perpendicular to the flow of direction and other one is connected parallel to the direction of flow.

↳ Manometer is connected to measure the pressure head difference.

Working :— [DEPTH OF BIOLOGY]

- first of all insert the pitot tube in pipe.
- In tube velocity of fluid is increased due to constrict tube, results decrease in pressure head difference. [DEPTH OF BIOLOGY]
- ΔH measured in manometer and put this value in the formula and calculate the velocity head or rate of flow of liquid.

$$V_{act} = C_v \sqrt{2g \Delta H}$$

(4) Rota meter :— [DEPTH OF BIOLOGY]

↳ It is a variable area meter.

↳ i.e., it measures the area of flow, so as to produce a constant head differential.

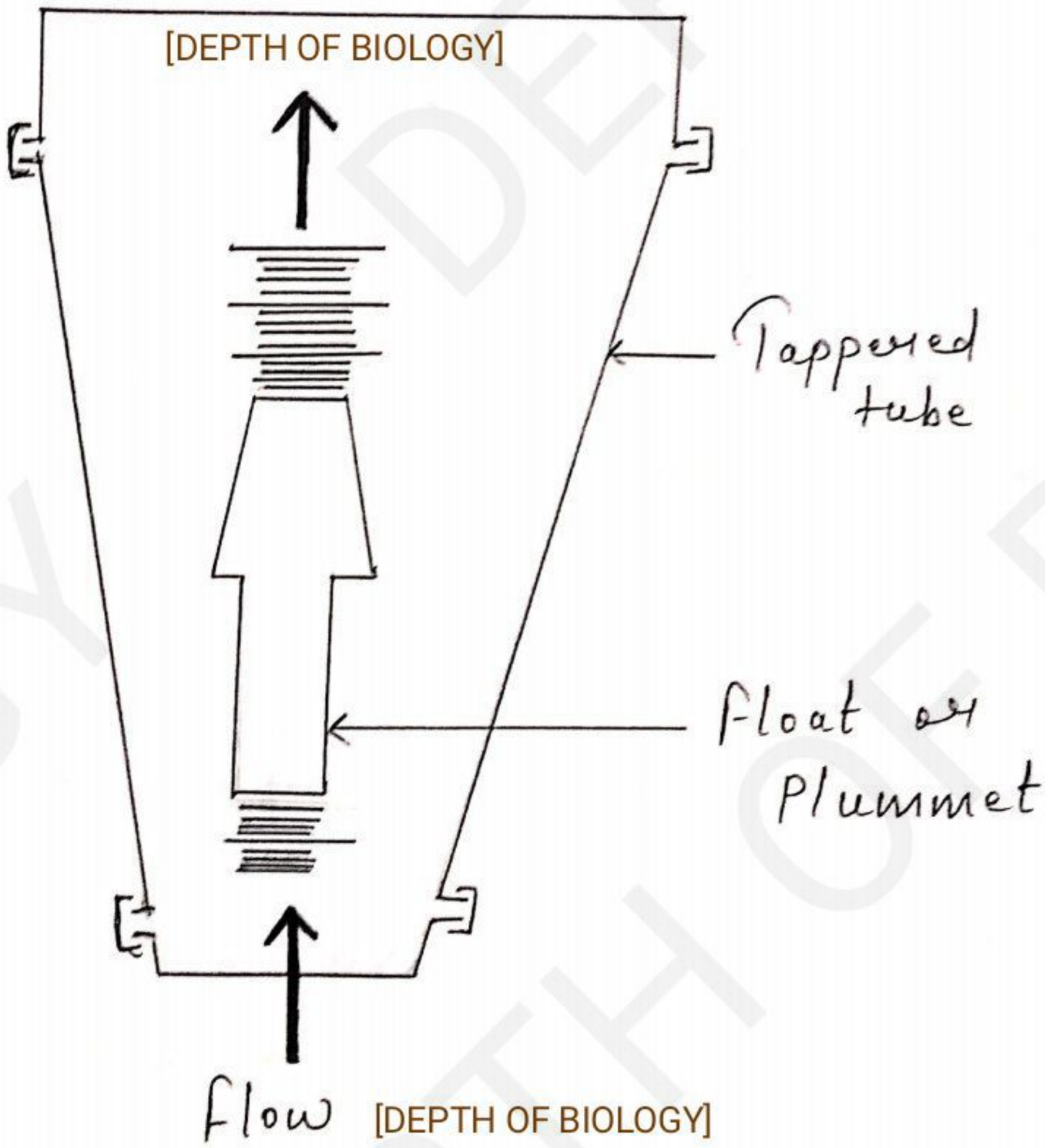
↳ ∴ rotameter is known as area meter.

Principle :—

↳ Consists of a vertical, tapered and transparent tube in which a plummet is placed.

↳ During the fluid flowing through the tube, the plummet rises and falls because of variation in flow.

Construction :—



↳ Consists of vertical tapered tube, which is mounted with a narrow end down.

↳ This tube is made of glass on which a linear scale is etched.

↳ A solid plummet is placed in the tube whose diameter is smaller than narrow end of tube.

↳ Plummet may be made of lead, aluminium, glass or plastic.

Working :—

↳ First of all rotameter is fitted on the pipe.

↳ Through a tapered tube the flow is upward, so the flow of fluid varies.

↳ The plummet surrounded by the fluid rises and falls depending on the rate of flow.

↳ Greater the flow rate, higher the plummet rise in the tube.

↳ In this, the pressure drop is constant or nearly constant.

↳ The flow can be read using the upper edge of the plummet as an index.

↳ The reading may be transmitted for recording, integrating and controlling.

Uses :-

↳ Used in chemical industries, such as bulk drugs.

↳ Through rotameter supply of air is Controlled.

↳ Suitable for both gases & liquids.