JECRC Foundation

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTER

Class – B.Tech Civil (III SEM)

Subject –Fluid Mechanics

Unit – 1

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VISION AND MISSION OF INSTITUTE

VISION OF INSTITUTE

To became a renowned centre of outcome based learning and work towards academic professional ,cultural and social enrichment of the lives of indivisuals and communities

MISSION OF INSTITUTE

Focus on evaluation of learining ,outcomes and motivate students to research apptitude by project based learning.

- Identify based on informed perception of indian ,regional and global needs ,the area of focus and provide plateform to gain knowledge and solutions.
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- Offer oppurtunites for interaction between academic and industry .
- Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders may emerge.

VISION AND MISSION OF DEPARTMENT

Vision

To become a role model in the field of Civil Engineering for the sustainable development of the society.

Mission

1)To provide outcome base education.

2)To create a learning environment conducive for achieving academic excellence.

3)To prepare civil engineers for the society with high ethical values.

Introduction, Objective and Outcome of Fluid Mechanics

Objective:

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The primary purpose of the study of Fluid mechanics is to develop the capacity to understand important basic terms used in fluid mechanics, understand hydrostatics and buoyancy with practice of solving problems. Student could be able to understand Kinematics of flow and fluid dynamics, Bernoulli's equation and laminar flow with practice of solving problems in practical life for the benefit of society and mankind.

Outcomes

- ➢ Student will be able to understand basics of fluid mechanics, types of fluids.
- ➢ Student will be able to understand fluid statics and buoyancy.
- ➢ Student will be to understand Kinematics of flow and fluid dynamics and solving relevant problems.
- ➢ Student will be to understand Bernoulli's equation and laminar flow with practice of solving problems.

CONTENTS

- Bernoulli's principle
- Venturimeter
- Applications

INTRODUCTION

- In fluid dynamics, Bernoulli's principle states that for an inviscid flow of a non-conducting fluid, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.The principle is named after Daniel Bernoulli who published it in his book Hydrodynamica in 1738.[3]

Bernoulli's principle

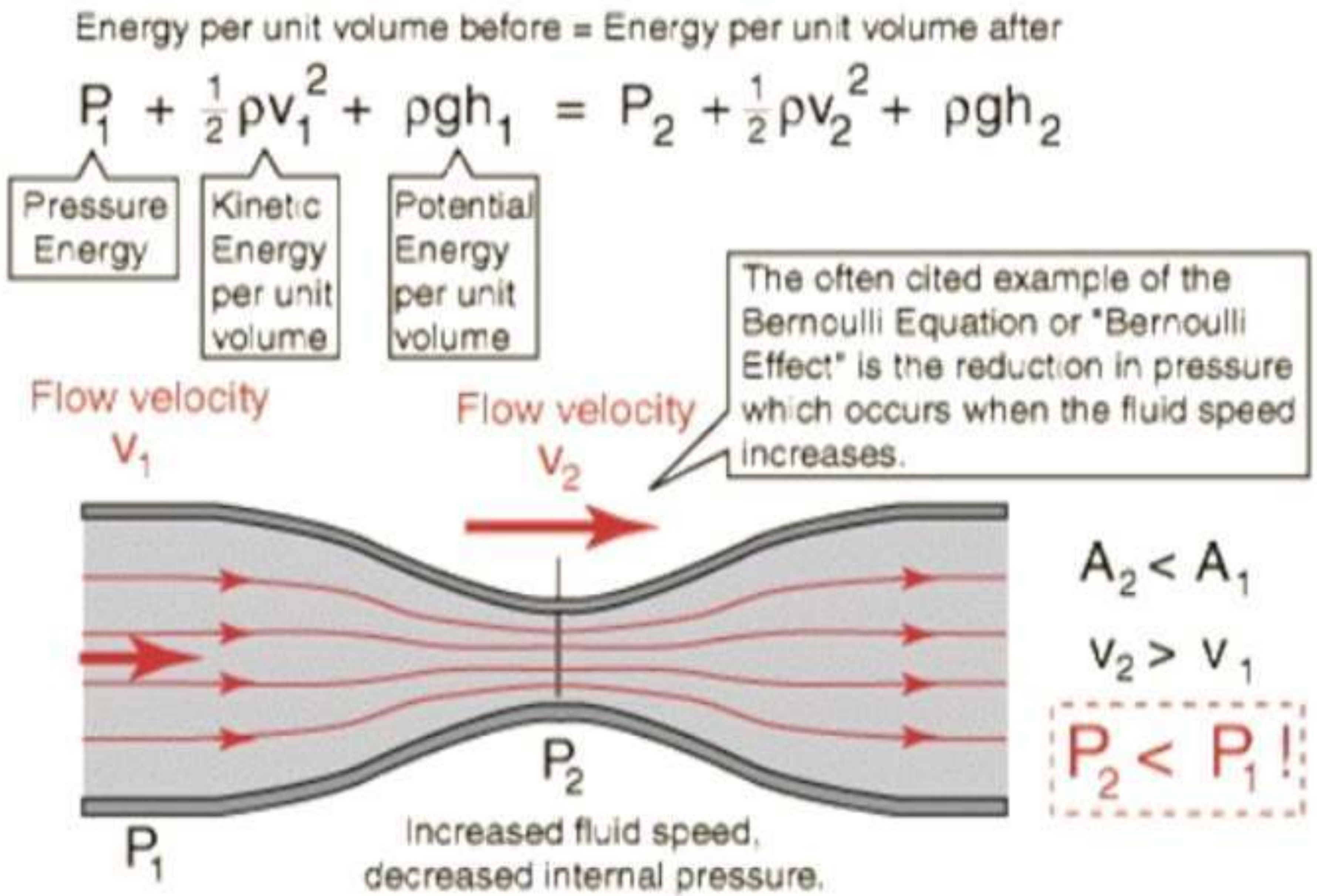
- Consider an element of fluid with uniform density. The change in energy of that

  the basis for Bern
- For any point along a flow tube or streamline

$$p + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$$

- Between any two points along a flow tube or streamline

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$


Energy per unit volume before = Energy per unit volume after
$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$
Pressure Energy
Kinetic Energy per unit volume
Potential Energy per unit volume
The often cited example of the Bernoulli Equation or "Bernoulli Effect" is the reduction in pressure which occurs when the fluid speed increases.
Flow velocity v_1
Flow velocity v_2
$A_2 < A_1$
$v_2 > v_1$
$P_2 < P_1$!
P_2
P_1
Increased fluid speed, decreased internal pressure.

DIMENSIONS

p [Pa] = [N.m^{-2}] = [N.m.m^{-3}] = [J.m^{-3}]

$\frac{1}{2}\rho v^2$ [kg.m^{-3}.m^2.s^{-2}] = [kg.m^{-1}.s^{-2}] = [N.m.m^{-3}] = [J.m^{-3}]

$\rho g h$ [kg.m^{-3} m.s^{-2}. m] = [kg.m.s^{-2}.m.m^{-3}] = [N.m.m^{-3}] = [J.m^{-3}]

Each term has the dimensions of energy / volume or energy density.

$\frac{1}{2}\rho v^2$ KE of bulk motion of fluid

$\rho g h$ GPE for location of fluid

p pressure energy density arising from internal forces within moving fluid (similar to energy stored in a spring)

DERIVATION

Derivation of Bernoulli's equation

Consider conservation of energy

Work done = kinetic energy + potential energy

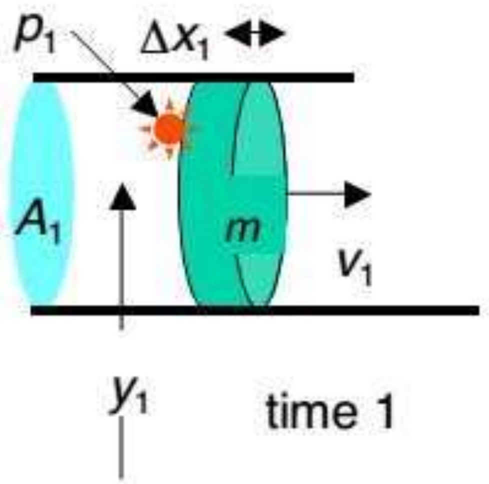
$$\Delta W = \Delta K + \Delta U$$

$$W = F_1 \Delta x_1 = p_1 A_1 \Delta x_1 = p_1 V$$

$$K = \frac{1}{2} m v_1^2 = \frac{1}{2} \rho V v_1^2$$

$$U = m g y_1 = \rho V g y_1$$

$$p_1 V = -\frac{1}{2} \rho V v_1^2 - \rho V g y_1$$



Rearranging

$$p_1 + \frac{1}{2} \rho v_1^2 + \rho g y_1 = constant$$

Applies only to an ideal fluid (zero viscosity)

Derivation of Bernoulli's equation

Mass element m moves from (1) to (2)

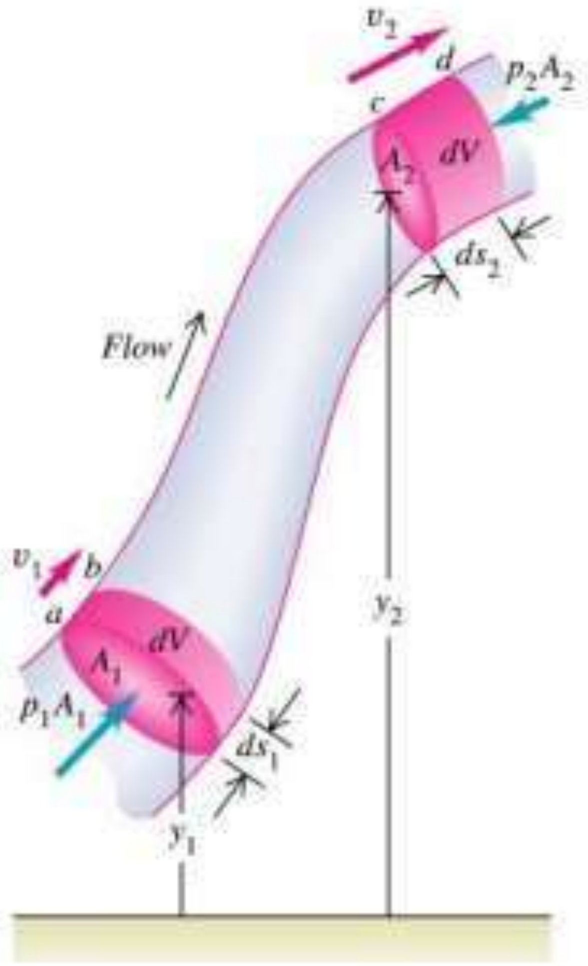
$m = \rho A_1 \Delta x_1 = \rho A_2 \Delta x_2 = \rho \Delta V$ where $\Delta V = A_1 \Delta x_1 - A_2 \Delta x_2$

Equation of continuity $A\,V$ = constant

$A_1 v_1 = A_2 v_2 \quad A_1 > A_2 \Rightarrow v_1 < v_2$

Since $v_1 < v_2$ the mass element has been accelerated by the net force

$F_1 - F_2 = p_1 A_1 - p_2 A_2$



Conservation of energy

A pressurized fluid must contain energy by the virtue that work must be done to establish the pressure.

A fluid that undergoes a pressure change undergoes an energy change.

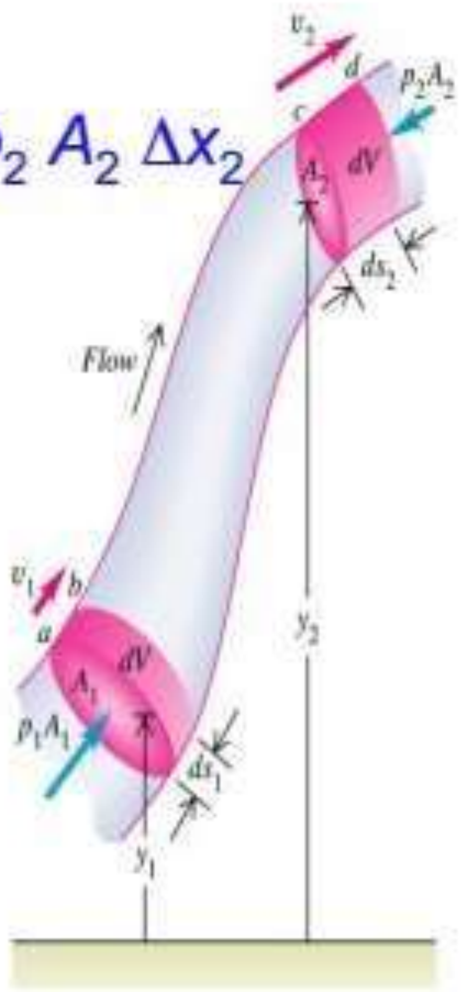
Change in kinetic energy

$$\Delta K = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 = \frac{1}{2} \rho \Delta V v_2^2 - \frac{1}{2} \rho \Delta V v_1^2$$

Change in potential energy

$$\Delta U = m g y_2 - m g y_1 = \rho \Delta V g y_2 - \rho \Delta V g y_1$$

$$\text{Work done } W_{net} = F_1 \Delta x_1 - F_2 \Delta x_2 = p_1 A_1 \Delta x_1 - p_2 A_2 \Delta x_2$$



Work done = change in kinetic + potential energy

$$W_{net} = p_1 \Delta V - p_2 \Delta V = \Delta K + \Delta U$$

$$p_1 \cancel{\Delta V} - p_2 \cancel{\Delta V} =$$
$$\frac{1}{2} \rho \cancel{\Delta V} v_2^2 - \frac{1}{2} \rho \cancel{\Delta V} v_1^2 + \rho \cancel{\Delta V} g y_2 - \rho \cancel{\Delta V} g y_1$$

Rearranging

$$p_1 + \frac{1}{2} \rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2} \rho v_2^2 + \rho g y_2$$

Applies only to an ideal fluid (zero viscosity)

ENERGY FORM:

$$\frac{P_2}{\rho} + \frac{V_2^2}{2} + gz_2 = \frac{P_1}{\rho} + \frac{V_1^2}{2} + gz_1$$

Pressure energy + Kinetic energy + potential energy = constant

HEAD FORM:

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1$$

Pressure head + kinetic head + potential head = constant

PRESSURE FORM:

$$P_2 + \rho\frac{V_2^2}{2} + \rho g z_2 = P_1 + \frac{\rho V_1^2}{2} + \rho g z_1$$

Static pressure + dynamic pressure + hydrostatic pressure = constant

APPLICATIONS

- In modern everyday life there are many observations that can be successfully explained by application of Bernoulli's principle, even though no real fluid is entirely inviscid[25] and a small viscosity often has a large effect on the flow.

- Bernoulli's principle can be used to calculate the lift force on an airfoil, if the behaviour of the fluid flow in the vicinity of the foil is known. For example, if the air flowing past the top surface of an aircraft wing is moving faster than the air flowing past the bottom surface, then Bernoulli's principle implies that the pressure on the surfaces of the wing will be lower above than below. This pressure difference results in an upwards lifting force.[26][27] Whenever the distribution of speed past the top and bottom surfaces of a wing is known, the lift forces can be calculated (to a good approximation) using Bernoulli's equations[28] – established by Bernoulli over a century before the first man-made wings were used for the purpose of flight. Bernoulli's principle does not explain why the air flows faster past the top of the wing and slower past the underside. See the article on aerodynamic lift for more info.

Flow measuring devices:

- The measurement of fluid flow is important in applications ranging from measurements of blood- flow rates in human artery to the measurement of liquid oxygen in a rocket.

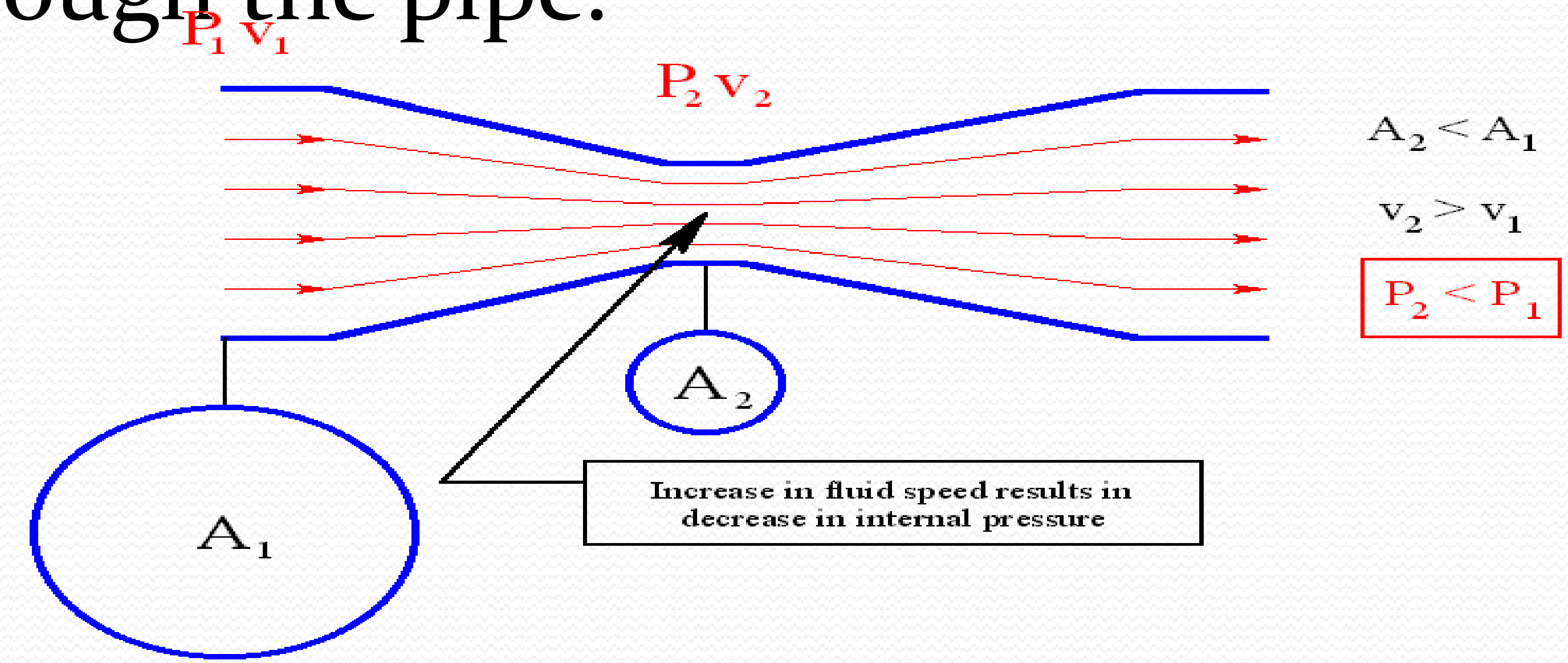
- Some sort of restriction is placed in the pipe or duct carrying the fluid. This flow restriction causes a pressure drop that varies with the flow rate.

Venturi Meter:

- A venturi meter is a variable head meter, which is used for measuring the flow rate of a fluid through a pipe.
- In this meter, the fluid is gradually accelerated to a throat and then gradually retarded in diverging section where the flow channel expands to the pipe size.
- Venturi meters have only a small head loss, no moving parts and do not clog easily.

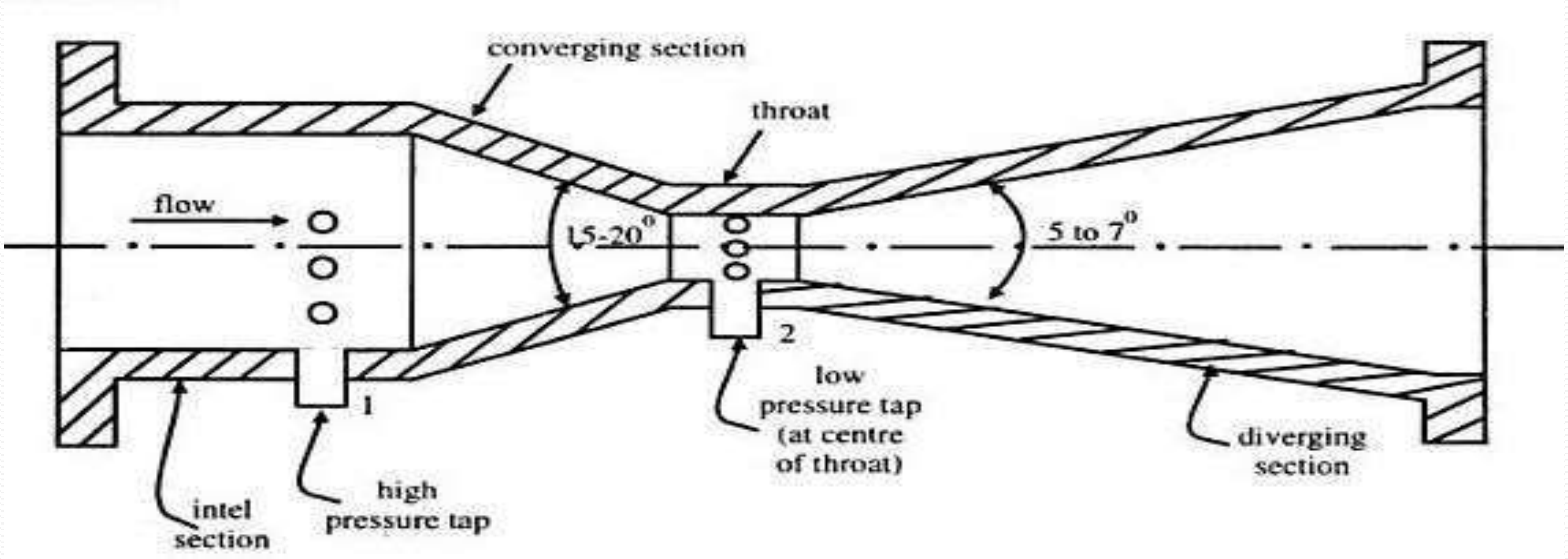
Working principle:

- By reducing the cross-sectional area of the flow passage, a pressure difference is created and the measurement of the pressure difference enables the estimation of the flow rate through the pipe.

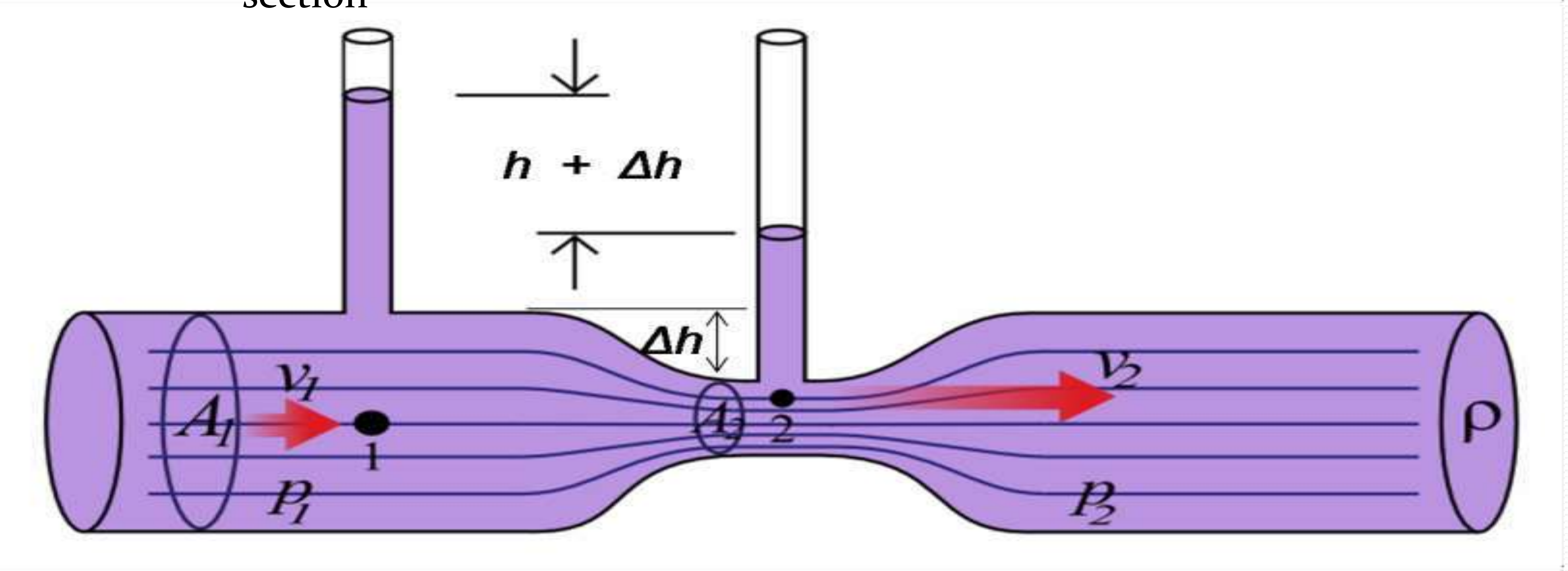


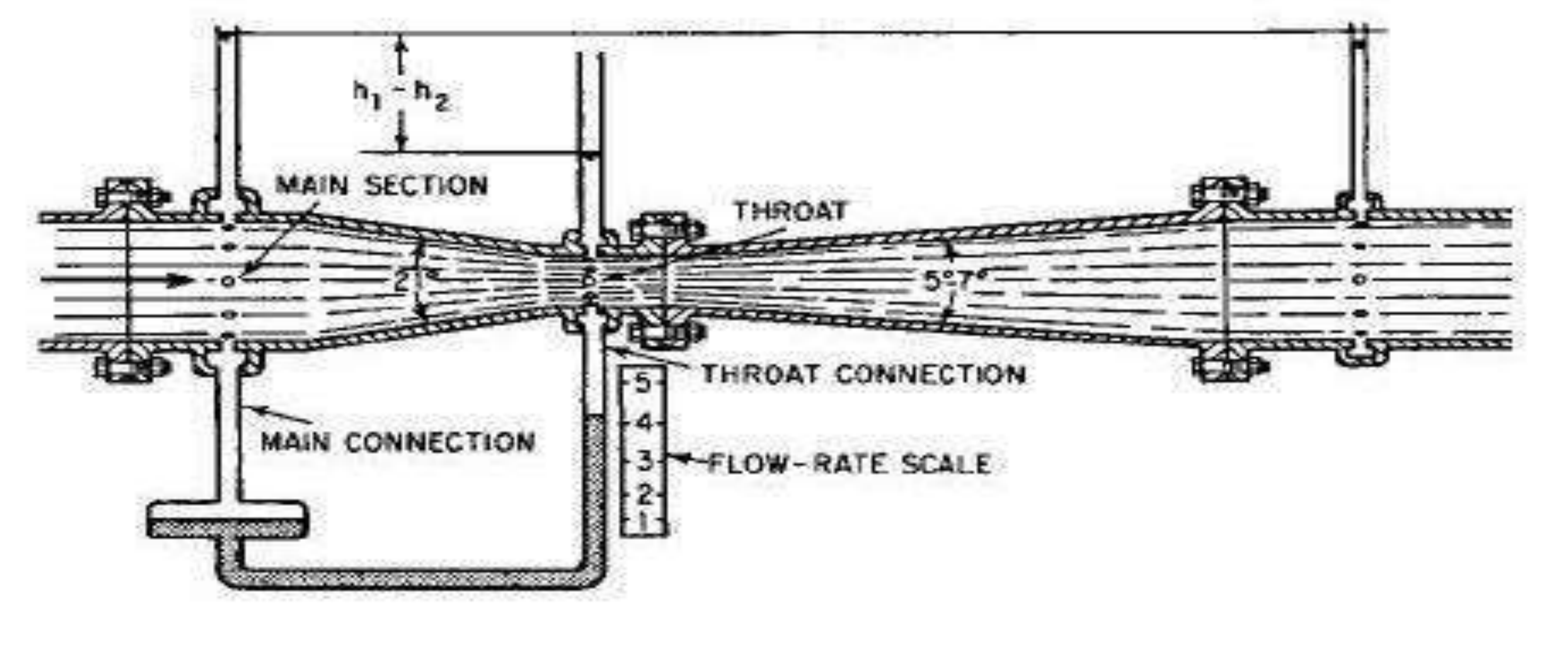
A venturi meter consists of following three parts:

1. A short converging conical part
2. Throat and
3. Diverging conical part


converging section
throat
flow
15-20°
5 to 7°
1
2
low
pressure tap
(at centre
of throat)
diverging
section
intel
section
high
pressure tap

ρ = density of fluid A_1 = area of inlet pipe
A_2=area of throat section




h1 - h2
MAIN SECTION
THROAT
21°
5°7°
THROAT CONNECTION
MAIN CONNECTION
FLOW-RATE SCALE
5
4
3
2
1

Coefficient of discharge:

- Ratio of Actual mass or volumetric flow rate to theoretical mass or volumetric rate .
- It encompasses all the energy losses taking place during flow through venturi meter.
- Its value depends upon the reynolds number and ranges from 0.95 to 0.98

Applications:

- It is used where we are working with small pressure head.
- Can be used for measuring flow rates of water, gases, suspended solids, slurries and dirty liquids.
- Can be used to measure high flow rates in pipes having diameters in a few meters.
- It doesn't clogs easily.

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Thank you!

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