॥ नमस्ते ॥

Venturi effect

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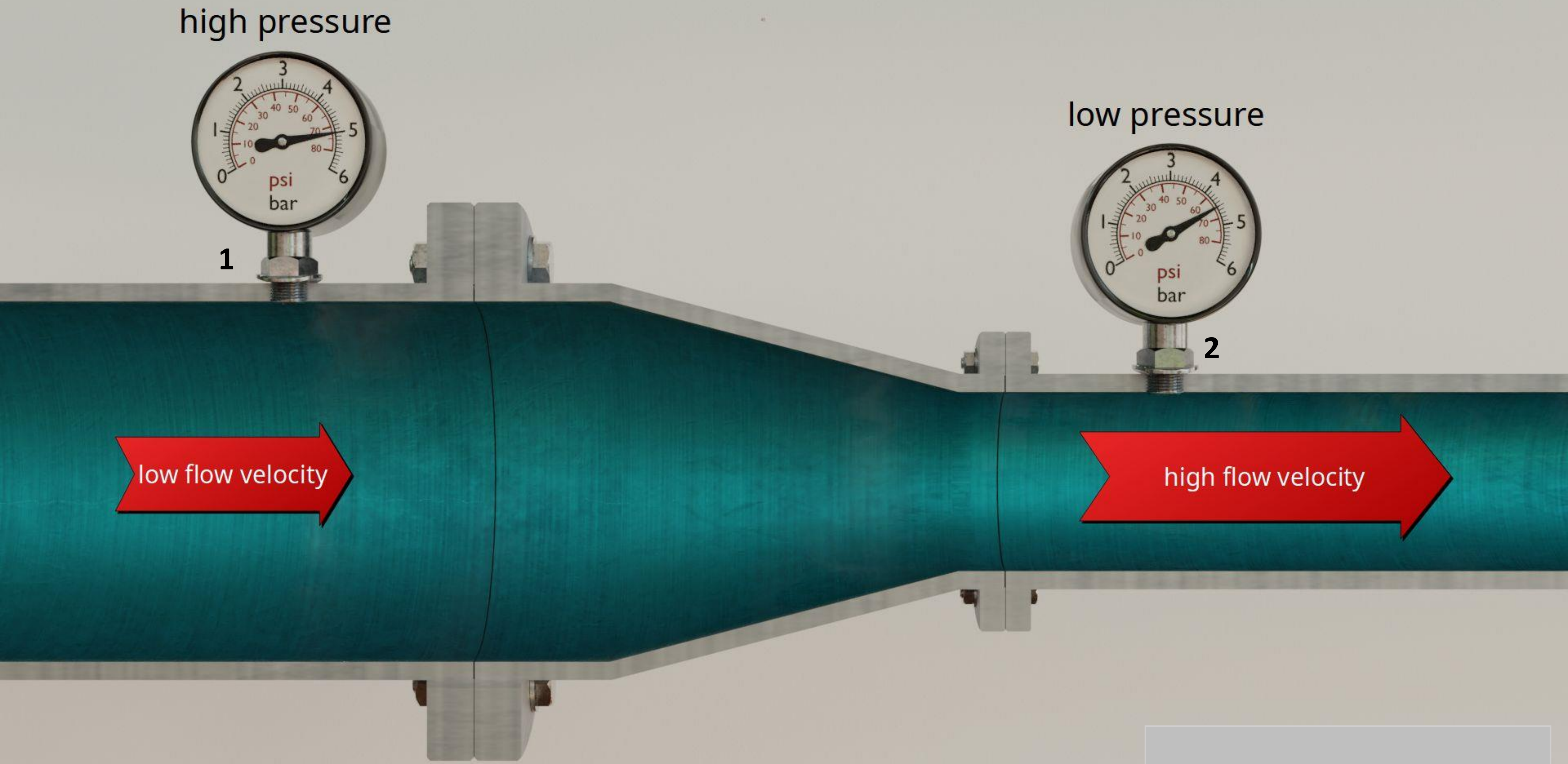
Venturi effect

- The Venturi effect states that in a situation with constant mechanical energy, the velocity of a fluid passing through a constricted /decreasing area will increase and its static pressure will decrease. & the velocity of a fluid passing through a expanding /Increasing area will decrease and its static pressure will increase.
- The effect utilizes both the principle of continuity as well as the principle of conservation of mechanical energy.



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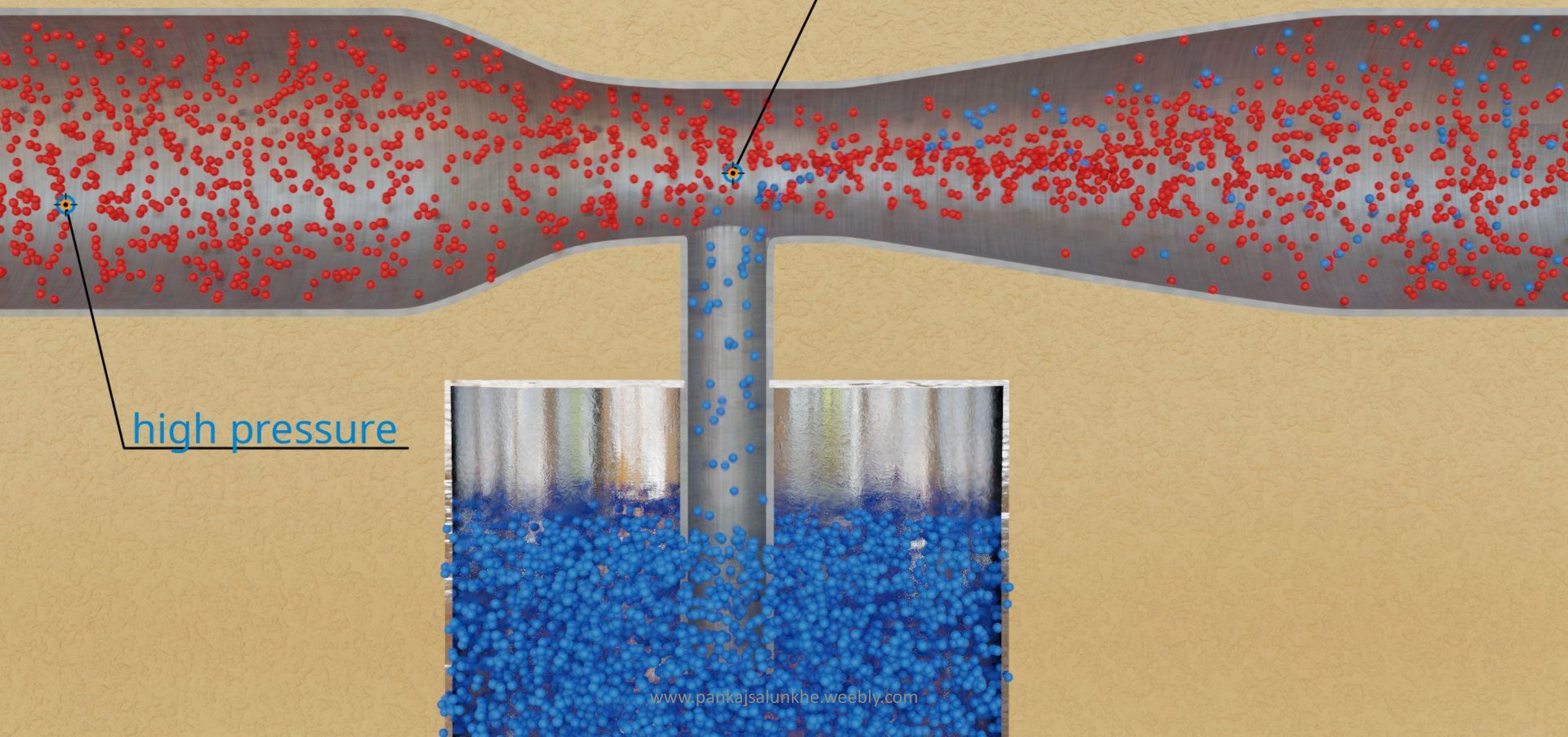

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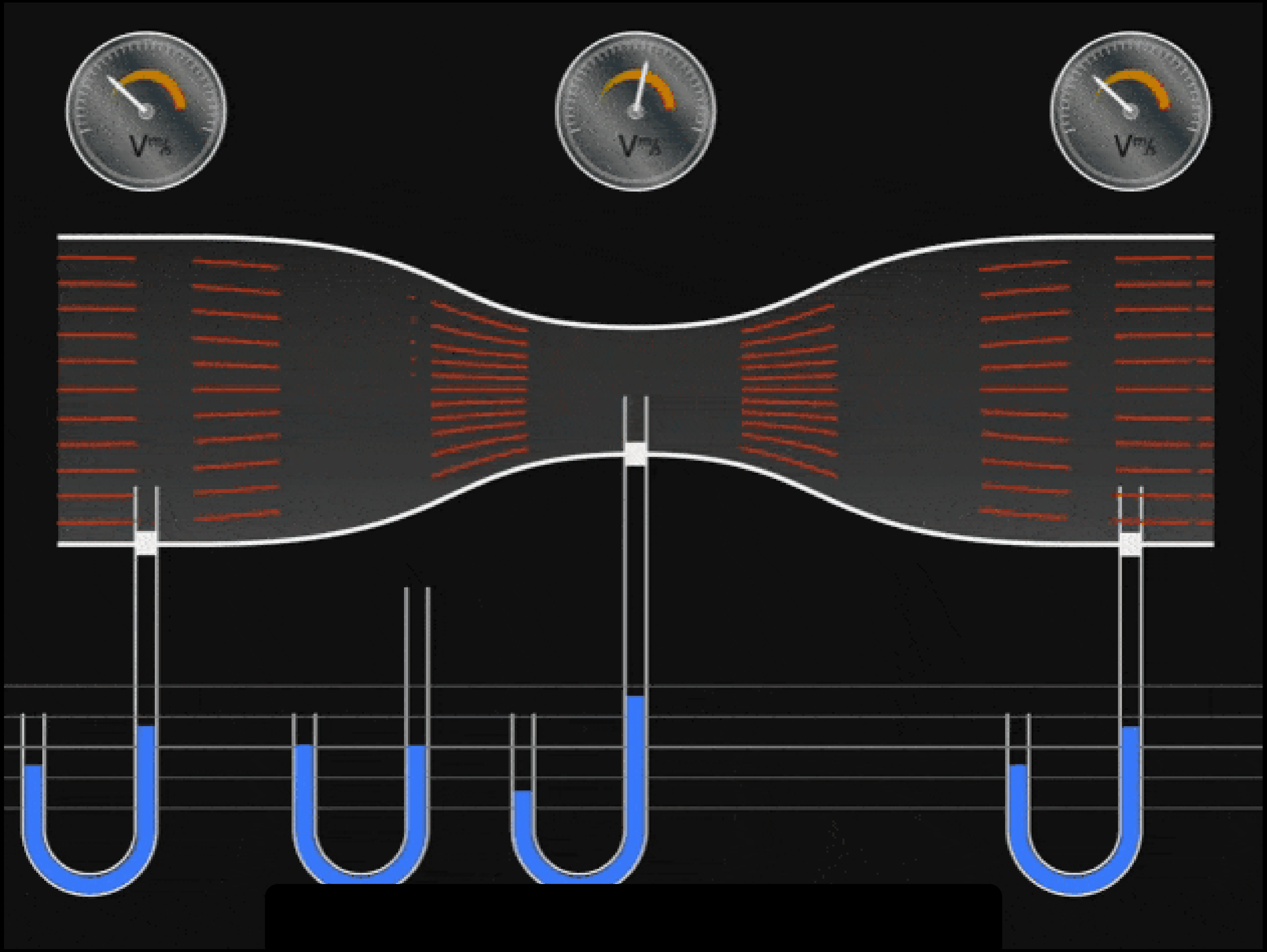

There are three fundamental equation in Aerodynamics.

1. Continuity Equation:-

   Mass flow rate is always constant thought out all path. That means Input is always equal to output.

2. Momentum Equation:-

   It states that the rate of change in linear momentum of a volume moving with a fluid is equal to the surface forces and the body forces acting on a fluid. Total Pressure in frictionless flow always constant. Bernoulli's theorem is kind of momentum equation.

3. Energy Equation:-

   Energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another. That mean total energy is always constant.

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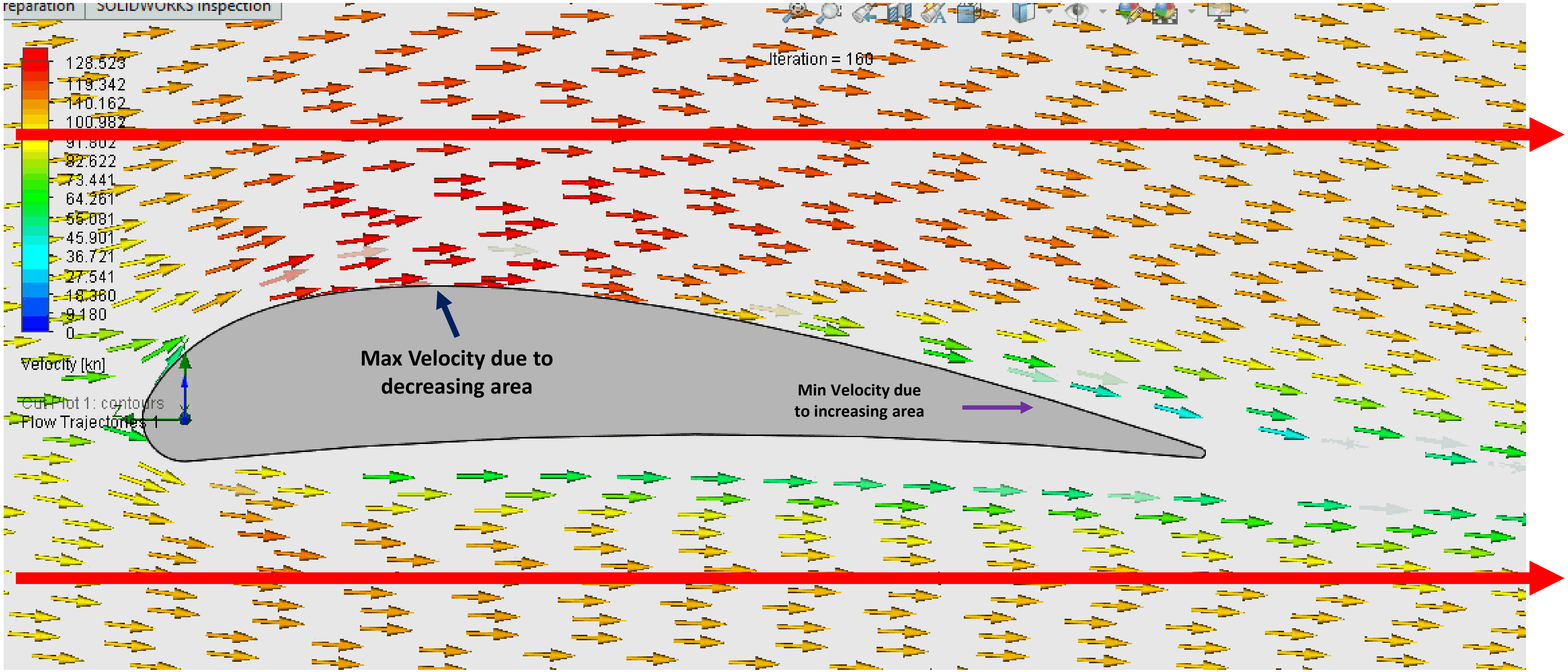
- Applying the continuity equation on venturi tube, We know that mass flow rate is always constant through flow.
- So, $Q_1 = Q_2$ ….(Q means quantity of fluid)
- $\boldsymbol{A_1 \times V_1 = A_2 \times V_2}$ **….(Quantity is product of area , velocity)**

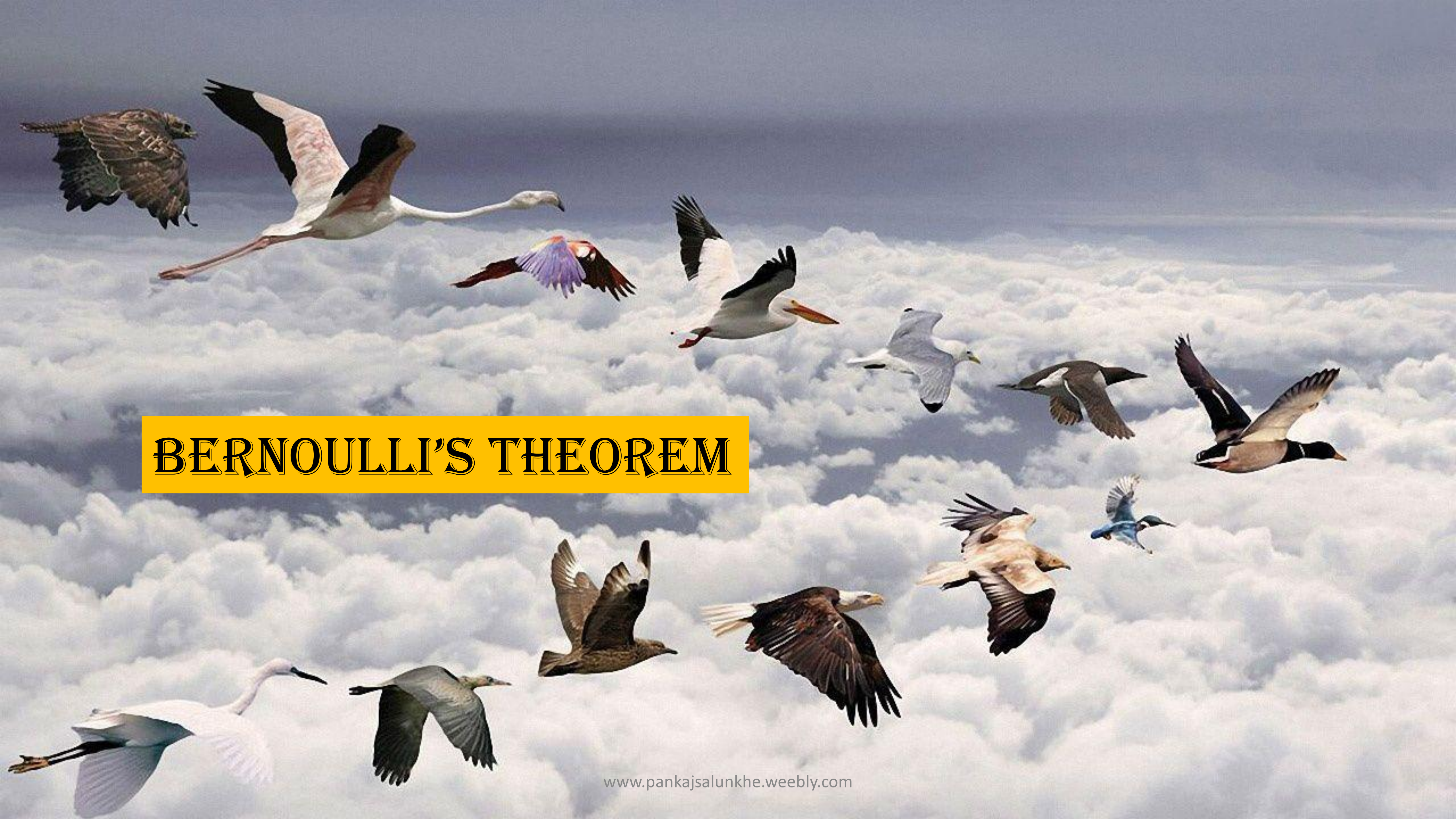
- Applying the momentum & Energy equation on venturi tube, Total energy and total pressure always constant in frictionless flow.
- So, $P_{t_1} = P_{t_2}$
- We know that,
- $\boldsymbol{P_1 + \frac{1}{2} \times \rho \times V_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \times \rho \times V_2^2 + \rho g h_2}$
- **Where, p is static pressure, ρ is air density, v is air velocity, h is height from datum line.**

- $h_1 = h_2$ due to same height from the datum / reference line.
- So we can neglect the $\rho g h$ term.
- So final Venturi Equation is,
- $P_1 + \frac{1}{2} \times \rho \times V_1^2 = P_2 + \frac{1}{2} \times \rho \times V_2^2$
- Where,
- P is static pressure,
- ρ is air density,
- v is air velocity,
- h is height from datum line.

[Click here to see Animation]

VENTURI FLOW OVER AEROFOIL

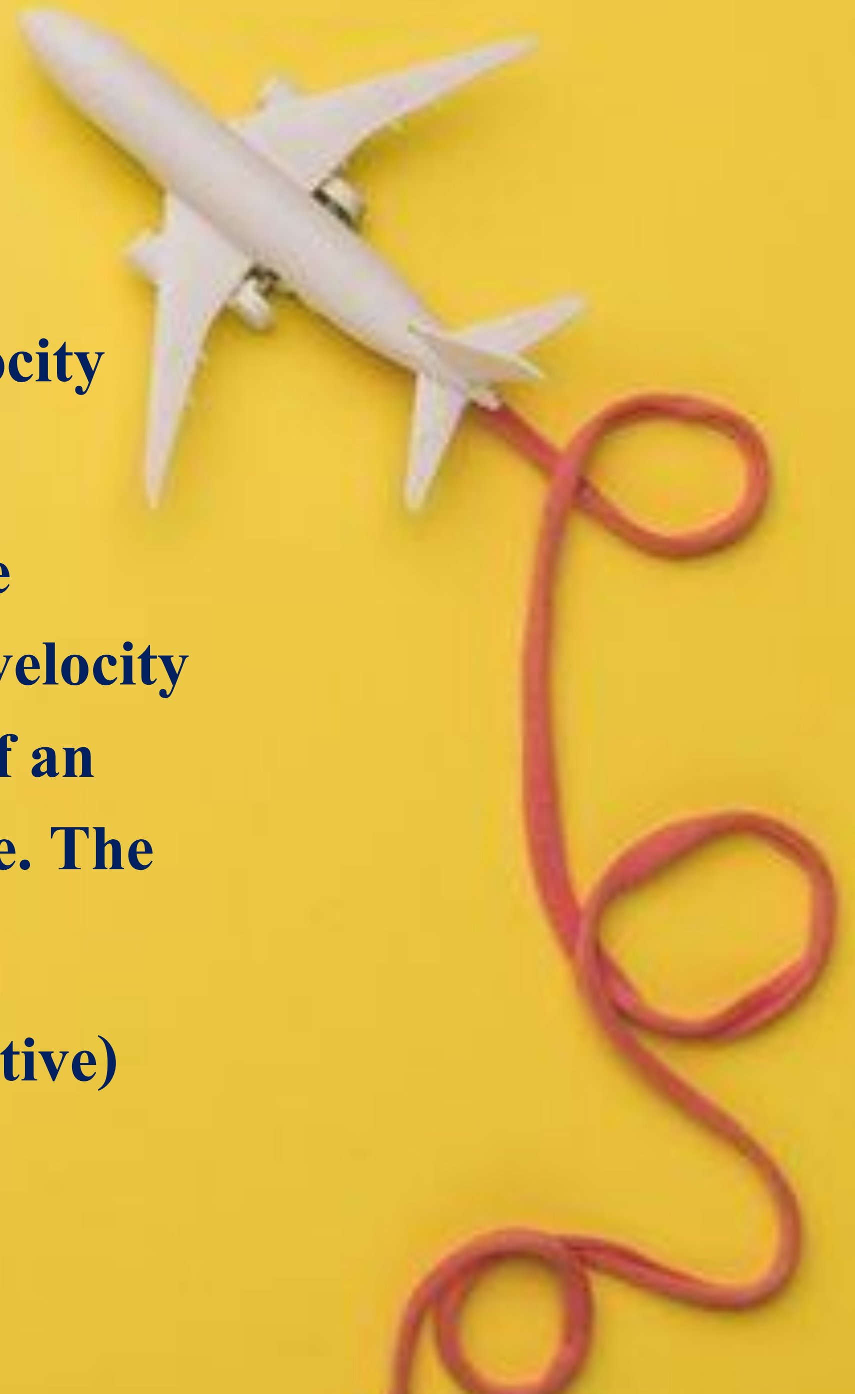




BERNOULLI'S THEOREM

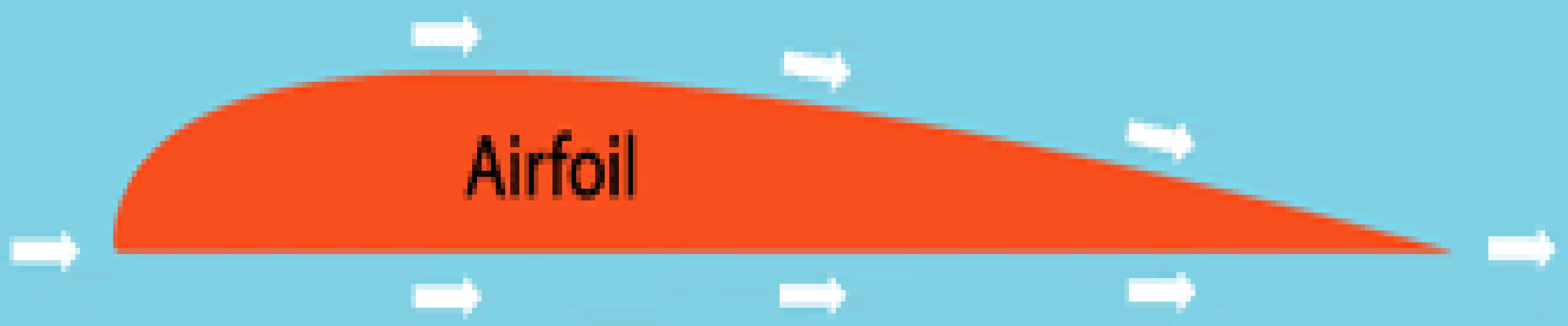
BERNOULLI'S THEOREM

- **The Bernoulli equation states that an increase in velocity leads to an decrease in pressure.**
- **Thus the higher the velocity of the flow, the lower the pressure. Air flowing over an airfoil will increase in velocity & decrease in pressure. Also Air flowing at bottom of an airfoil will decrease in velocity & increase in pressure. The pressure at bottom is greater than upper surface.**
- **The result is a net pressure force in the upward (positive) direction. This pressure force is lift.**



According law of Aerodynamics, **When two air molecules split at same time at leading edge then they will try to meet at trailing edge on same time same place.**
We know that aerofoil upper surface has more curvature than bottom surface. So that upper surface has molecule travel more distance than bottom surface but both need same time.
That is why upper surface air velocity is more and lower surface has lower air velocity. So pressure on top will be less than lower surface of aerofoil.
This pressure difference generate the lift force

[Click here For Animation]



- According to Bernoulli's theorem, Total Pressure is always constant.
- So, $P_t = constant$
- $p + \frac{1}{2} \times \rho \times v^2 + \rho g h = P_t = constant$
- We know that height (h) is same from the datum line so we can neglect $\rho g h$ term.
- $p + \frac{1}{2} \times \rho \times v^2 = P_t = constant$
- i.e. $p + q = P_t = constant$


Did You Know?
KNOW THE FACTS
An owl has three eyelids, One for blinking, One for sleeping, One for cleaning eye
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LIFT GENERATION

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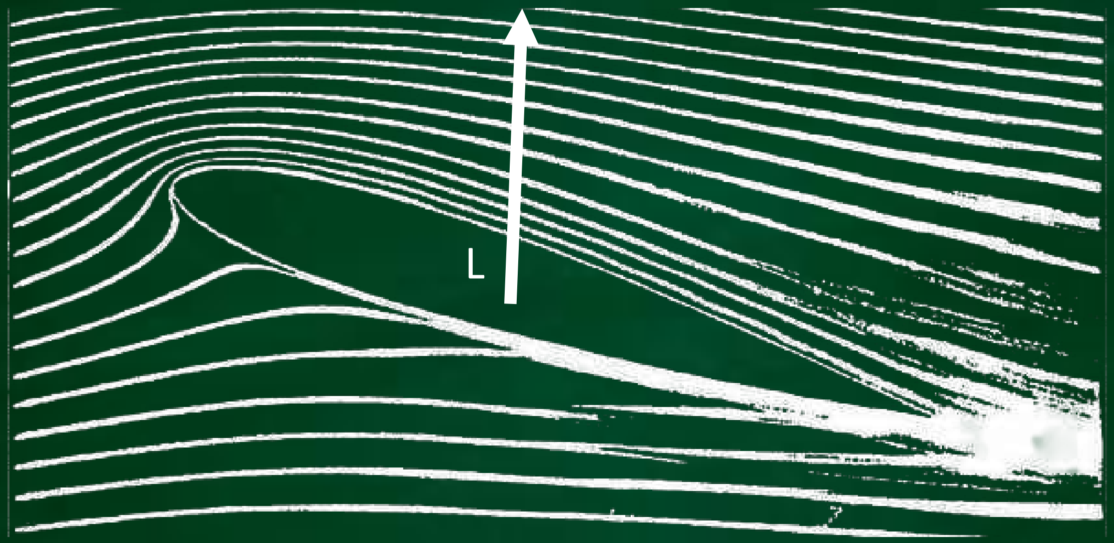
- The Bernoulli Theorem states that an increase in velocity leads to an decrease in pressure.
- Due to curvature on upper surface of aerofoil, velocity increase on upper surface & Reduce static pressure also velocity decrease on lower surface & increase static pressure.
- As per natural law high pressure always travels to lower pressure.
- So that lower surface high pressure air try to move upper surface where pressure low.
- This pressure difference generate the lift for aerofoil.

LIFT EQUATION



we need to derive equation for Force which is resultant of pressure difference.

$$F = P \times A$$

But due to air friction

$$F \propto P \times A$$

- But we take ‘ S ’ for aircraft wing area instead A.
- Also we are finding lift force so ‘ F ’ will be replaced by ‘ L ’.
- $L \propto \mathbf{P} \times S$
- Here P is pressure but on aerofoil static pressure is less but dynamic pressure contribution is most so we replace P by ‘ q ’.
- $L \propto \mathbf{q} \times S$
- As we know that dynamic pressure value. I.e $\mathbf{q} = \frac{1}{2} \times \rho \times \mathbf{v}^2$
- $L \propto \frac{1}{2} \times \rho \times \mathbf{v}^2 \times S$
- Equating the equation by taking Lift coefficient cl
- $L = \frac{1}{2} \times \rho \times \mathbf{v}^2 \times \mathbf{S} \times cl$

$$\boldsymbol{L = \frac{1}{2} \times \rho \times v^2 \times S \times cl}$$

- Where,
- L= Lift force generated by wings in Newton (N).
- ρ = Air density in ${}^{kg}/_{m^3}$
- V= Air velocity or aircraft velocity in ${}^{m}/_{s}$
- S= Wing area in m^2
- cl = coefficient of lift (no unit). It shows the efficiency of aerofoil

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धन्यवाद

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