

II. SUBSONIC AIRFLOW – BASIC AERODYNAMIC THEORY

1) Principles of Continuity

One of the fundamental laws of the universe is, ENERGY and MASS can neither be created nor destroyed, only change from one form to another.

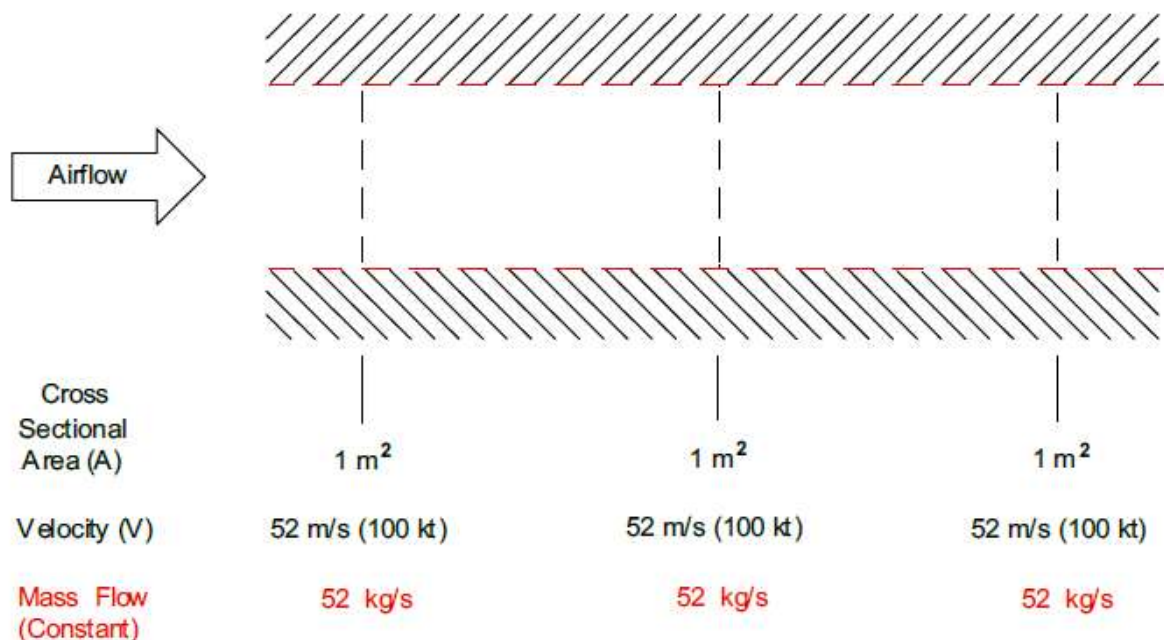
To demonstrate that, we must consider the Airmass Flow

Equation of Continuity:

$$\text{Mass Flow} = A \times V \times \rho$$

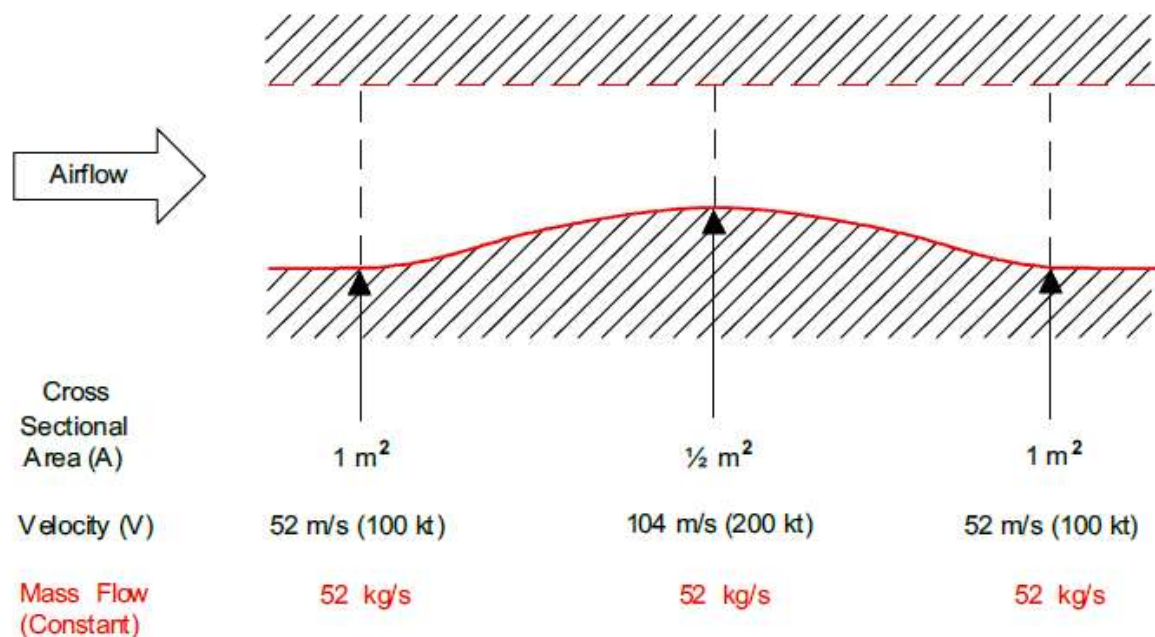
Air is a compressible fluid, any change of pressure will affect its density, however at low subsonic speed ($M < 0,4$), density change will be insignificant, the Equation of Continuity will be simplified:

$$\text{Mass Flow} = A \times V$$



The Principle of Continuity

Because the mass flow **must remain constant**, it can be seen from the equation of continuity that the reduction in the tube's cross-sectional area results in an increase in velocity and, vice versa.



The Principle of Continuity

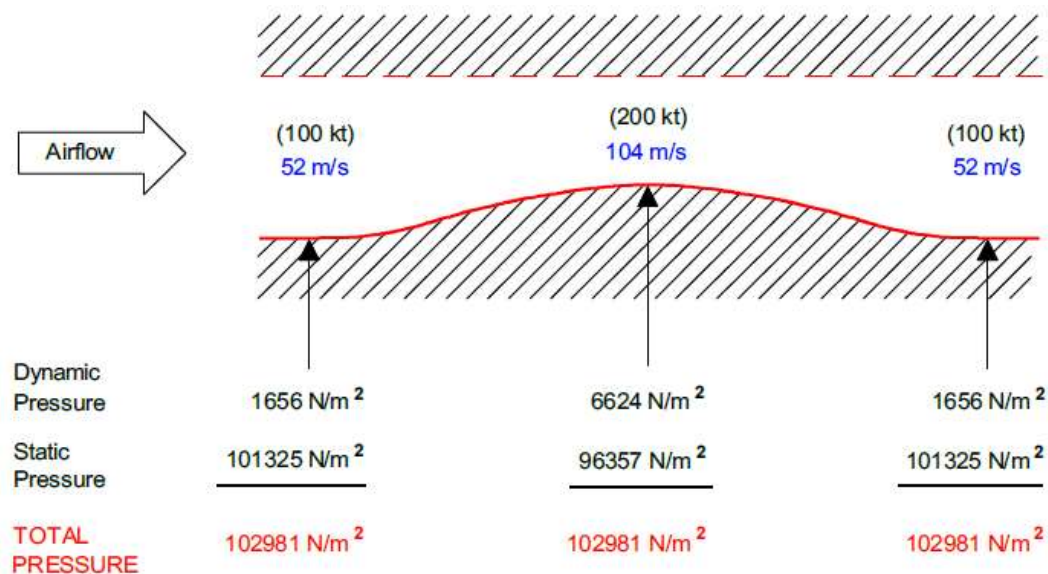
2) Bernoulli's Theorem

In a steady flow and ideal fluid, the sum of the kinetic energy and the pressure per unit volume remains constant.

Note: An ideal fluid is both incompressible and has no viscosity

$$P_{TOT} = Q + P_s$$

$$Q + P_s = K$$



Bernoulli's Theorem

SUMMARY

At flow speed of less than M0.4, pressure change will not affect the air density

Continuity:

- Air accelerates when the cross-sectional area of a streamline flow is reduced
- Air decelerates when the cross-sectional area increases again

Bernoulli

- If a streamline flow of air accelerates, its kinetic energy will increase and the static pressure will decrease.
- If air decelerates, the kinetic energy will decrease and the static pressure will increase again.

Now once all this is understood, the same phenomena will occur around the wings of the airplane.

If we look at an aerofoil (a section of the airplane's wings), the upper surface is cambered compared to the lower surface. The static pressure will be lower on the upper surface compared to the lower surface. The differential pressure will generate a Pressure Gradient Force (PGF) which will act through the aerofoil and LIFT the aerofoil upward. This force is called the LIFT and it's the main force that allows the airplane to fly against its weight.



Typical Aerofoil Section