MOTION IN A PLANE

RELATIVE VELOCITY IN TWO DIMENSIONS

Relative Velocity:

We encounter occasions where one or more objects move in a frame which is non-stationary with respect to another observer. For example, a boat crossing a river that is flowing at some rate or an aeroplane encountering wind during its motion. In all such instances, to describe the object's complete motion, we need to consider the effect that the medium is causing on the object. While doing so, we calculate the relative velocity of the object considering the velocity of the particle as well as the velocity of the medium. Here, we will learn how to calculate the relative velocity.

Relative Velocity

Let us consider two objects, A and B moving with velocities Va and Vb with respect to a common stationary frame of reference, say the ground, a bridge or a fixed platform.

- The velocity of the object A relative to the object B can be given as,

$$V_{ab} = V_a - V_b$$

- Similarly, the velocity of the object B relative to that of object a is given by,

$$V_{ba} = V_b - V_a$$

- From the above two expressions, we can see that

$$V_{ab} = -V_{ba}$$

- Although the magnitude of both the relative velocities is equal to each other. Mathematically,

$$|V_{ab}| = |V_{ba}|$$

Examples of Relative Velocity

We can understand the concept of relative velocity more clearly with the help of the following example.

Example: A plane is travelling at velocity 100 km/hr, in the southward direction. It encounters wind travelling in the west direction at a rate of 25 km/hr. Calculate the resultant velocity of the plane.

Given, the velocity of the wind $= V_w = 25$ km/hr

The velocity of the plane $= V_a = 100$ km/hr

The relative velocity of the plane with respect to the ground can be given as

The angle between the velocity of the wind and that of the plane is 90°. Using the Pythagorean theorem, the resultant velocity can be calculated as,

$R^2 = (100 \text{ Km/hr.}) + (25\text{Km/hr.})^2$

$R^2 = 10{,}000 \text{ Km}^2/\text{hr}^2 + 625 \text{ Km}^2/\text{hr}^2$

$R^2 = 10{,}625 \text{ Km}^2/\text{hr}^2$

Hence R=103.077 Km/hr.

Using trigonometry, the angle made by the resultant velocity with respect to the horizontal plane can be given as,

$$\tan\ \theta = \left(\frac{\text{wind velocity}}{\text{airplane velocity}}\right)$$

$$\tan\ \theta = \left(\frac{25}{100}\right)$$

$$\theta = \tan^{-1}\ \frac{1}{4}$$

$$\theta = 14.0^\circ$$