

Relative Motion

Velocity of A relative to B = \vec{v}_{AB}

Velocity of B relative to C = \vec{v}_{BC}

Velocity of A relative to C = \vec{v}_{AC}

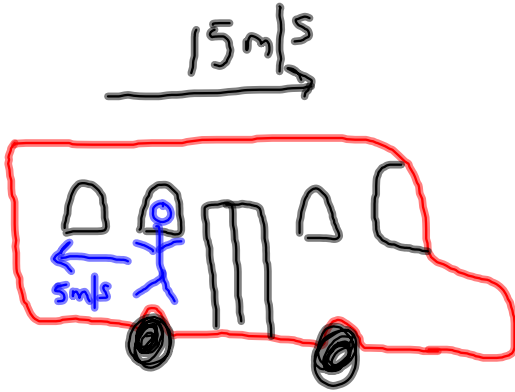
$$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$$

match in the middle

$$\vec{v}_{AB} = -\vec{v}_{BA}$$

Example 1:

A bus is traveling due east at 15 m/s relative to the ground. A passenger on the bus walks at 5 m/s due west. What is the velocity of the passenger relative to the ground?



$$\vec{v}_{BG} = \begin{pmatrix} x & y \\ 15 & 0 \end{pmatrix}$$

$$\vec{v}_{PB} = \begin{pmatrix} -5 & 0 \end{pmatrix}$$

$$\vec{v}_{PG} = ?$$

$$\vec{v}_{PG} = \vec{v}_{PB} + \vec{v}_{BG}$$

$$= \begin{pmatrix} -5 & 0 \end{pmatrix} + \begin{pmatrix} 15 & 0 \end{pmatrix}$$

$$\vec{v}_{PG} = \begin{pmatrix} 10 & 0 \end{pmatrix}$$

$$v_{PG} = \sqrt{10^2 + 0^2}$$

$$v_{PG} = 10 \text{ m/s due east}$$

Example 2:

A car is moving at 28 miles/hr due south. A motorcycle is moving at 35 miles/hr due north. Find the velocity of the car relative to the motorcycle.

$$\vec{v}_{CG} = (0, -28)$$

$$\vec{v}_{MG} = (0, 35)$$

$$\vec{v}_{CM} = \vec{v}_{CG} + \vec{v}_{GM}$$

$$\begin{aligned}\vec{v}_{CM} &= (0, -28) + (0, -35) \\ &= (0, -63)\end{aligned}$$

$$\vec{v}_{CM} = 63 \text{ mi/hr south}$$

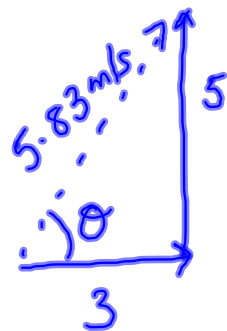
Example 3:

A river flows due east at 3 m/s. A boat that can move at 5 m/s relative to the river starts heading due north. Determine the velocity of the boat relative to the earth.

R = river B = boat E = earth

$$\vec{v}_{RE} = (3, 0)$$

$$\vec{v}_{BR} = (0, 5)$$



$$\begin{aligned} \vec{v}_{BE} &= ? \\ &= \vec{v}_{BR} + \vec{v}_{RE} \\ &= (0, 5) + (3, 0) \\ \vec{v}_{BE} &= (3, 5) \end{aligned}$$

$$v_{BE} = \sqrt{3^2 + 5^2}$$

$$\theta = \tan^{-1}\left(\frac{5}{3}\right) = 59^\circ \text{ NE @ } 5.83 \text{ m/s}$$