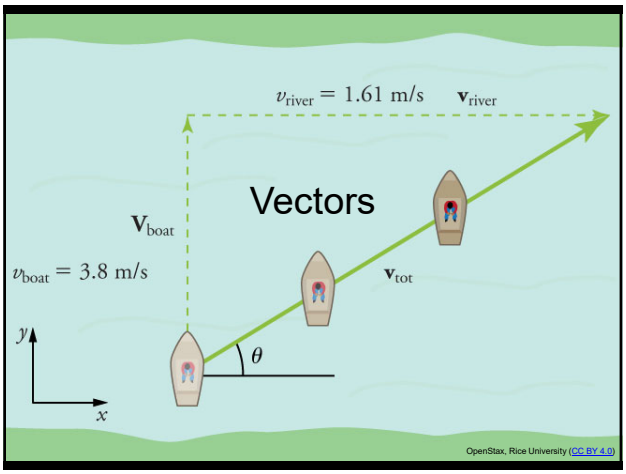
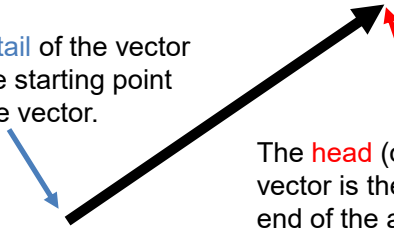


- Recall that a vector is a quantity that has magnitude and direction.
  - displacement, velocity, acceleration, and force
- In one-dimensional or straight-line motion, the direction of a vector can be given simply by a plus or minus sign.
- In two dimensions, a vector describes motion in two perpendicular directions, such as vertical and horizontal.
- For vertical and horizontal motion, each vector is made up of vertical and horizontal components.

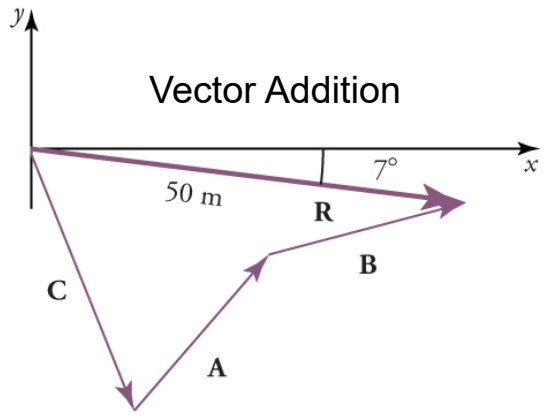
- Vectors are represented as an arrow.
- The length of the arrow represents the magnitude of the vector.
- The arrow points in the direction of the vector.

The tail of the vector is the starting point of the vector.



The head (or tip) of a vector is the pointed end of the arrow.

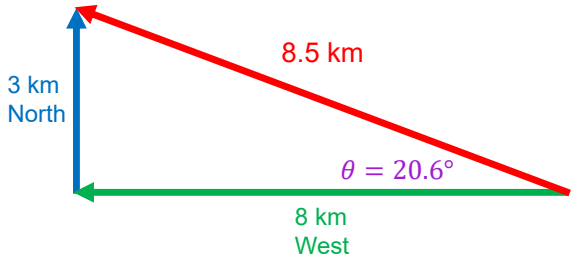
Vector Addition



- Vectors are added by drawing the vectors head to tail.
- The sum (resultant) is then found by joining the tail of the first vector to the tip of the last vector.

Example

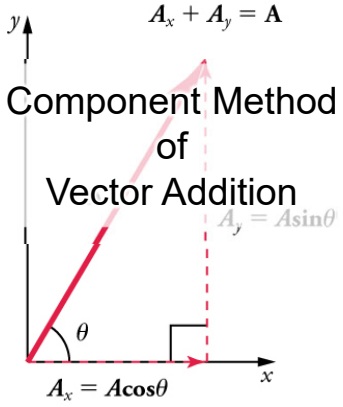
- A boy rides his bicycle 8 km West and then 3 km North. Calculate the displacement of the boy.



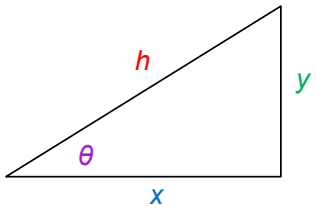
The displacement is 8.5 km 20.6° North of West.

$A_x + A_y = \mathbf{A}$

Component Method of Vector Addition



Trigonometric Ratios



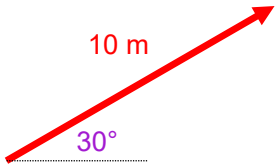
$$\sin\theta = \frac{y}{h}$$

$$\cos\theta = \frac{x}{h}$$

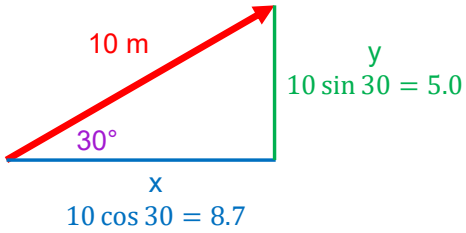
$$\tan\theta = \frac{y}{x}$$

Vector Components

- Consider a vector 10 m 30° north of east.



- The components are calculated using trigonometry.
  - x-component: $10 \cos 30 = 8.7$
  - y-component: $10 \sin 30 = 5.0$



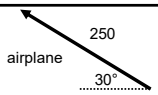
Steps

1. Calculate the components of each of the vectors.
2. Add all the x-components together.
3. Add all the y-components together.
4. Create a triangle using the sum of the x-components, the sum of the y-components, and a line joining them (the hypotenuse).

5. Calculate the hypotenuse using the Pythagorean theorem.
6. Calculate the angle between the x-component and the hypotenuse using trigonometry.

Example 1

- An airplane has a velocity of 250 m/s 30° north of west. The wind has a velocity of 12 m/s 25° north of east. Calculate the resulting speed of the airplane (known as ground speed).

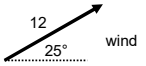


x

$-250 \cos 30 = -216.5$

y

$250 \sin 30 = 125$



x

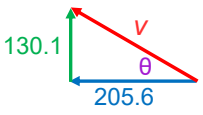
$12 \cos 25 = 10.9$

y

$12 \sin 25 = 5.1$

$x = -216.5 + 10.9 = -205.6$

$y = 125 + 5.1 = 130.1$



$v = \sqrt{(205.6)^2 + (130.1)^2} = 243.3$ m/s

$\theta = \tan^{-1}\left(\frac{130.1}{205.6}\right) = 32.3°$

The resultant velocity is 243.3 m/s 32.3° North of West.

Example 2

- A girl first walks 53.0 m in a direction 20.0° north of east then walks 34.0 m in a direction 63.0° north of east. Calculate the displacement.

81.2 m 36.6° north of east

53.0 m, 20°

x

$53 \cos 20 = 49.8$

y

$53 \sin 20 = 18.1$

34.0 m, 63°

x

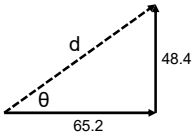
$34 \cos 63 = 15.4$

y

$34 \sin 63 = 30.3$

$x = 49.8 + 15.4 = 65.2$

$y = 18.1 + 30.3 = 48.4$



$d = \sqrt{(65.2)^2 + (48.4)^2} = 81.2$

$\theta = \tan^{-1}\left(\frac{48.4}{65.2}\right) = 36.6°$

The displacement is 81.2 m 36.6° North of East.