Velcome to the Vorld of Vectors

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Physics 201

Scalars & Vectors

- Scalar Quantity:
  - Has magnitude only, no direction
  - Can be expressed with a single number (and units)
- Vector Quantity:
  - Has magnitude and direction
  - Are expressed with numbers and arrows

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Scalars & Vectors

- Scalar Quantity:
  - Is usually written in *italics*
  - Speed can be represented as: *S*
- Vector Quantity:
  - Is usually written in **bold** or with an arrow above it
  - Velocity can be represented as: **V** or $\vec{V}$

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Scalar & Vectors

- Be careful with scalars that has + and – associated with them, for example temperature is a scalar.

- The fact that a quantity is positive or negative does not necessarily mean that the quantity is a vector.

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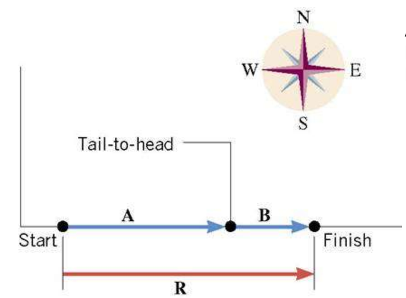
Vector Addition

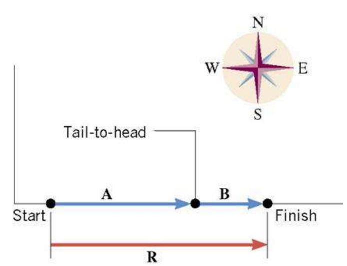
- When you add or subtract vectors, you have to take into account both the magnitude and the direction of the vector.
- The total vector is usually represented by **R**, which stands for the resultant vector.

Vector Addition



A = 275 m, east
B = 125 m, east
R = ?

Vector Addition

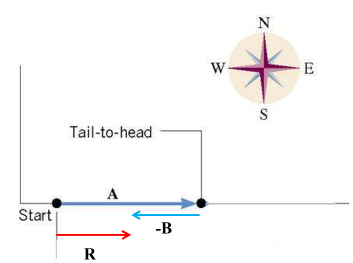


A = 275 m, east
B = 125 m, east
R = ?

R = **A** + **B** = 275m, east + 125 m, east = 400 m, east

Vector Addition

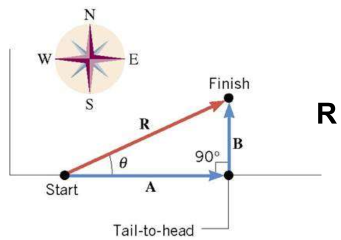
What if **B** = 125 m, west?



A = 275 m, east
B = 125 m, west
R = ?

R = **A** +(- **B**) = 275m, east + (-125 m, west) = 150 m, east

Vector Addition



A = 275 m, east
B = 125 m, north
R = ?

R = A + B is still true!!!!

$a^2 + b^2 = c^2$

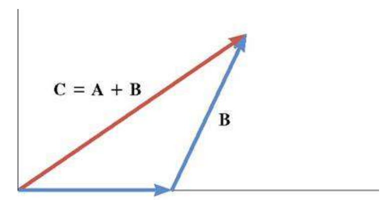
$R^2 = A^2 + B^2$

$R = \sqrt{(275 + 125)} = 302$ m

$\theta = \tan^{-1}(B/A) = 24.4^{\circ}$

R = 302 m, 24.4° north-east

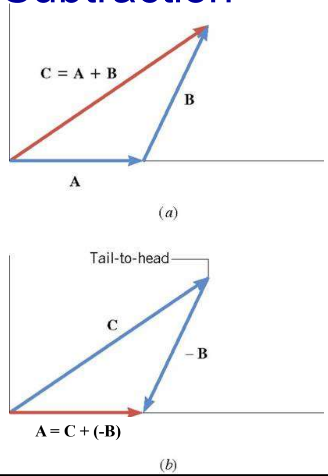
Vector Subtraction



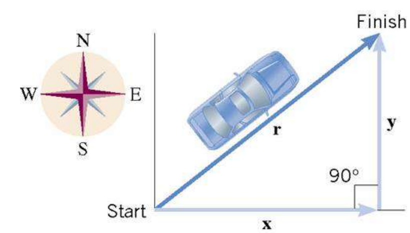
If **C = A + B** then **A = C – B** but what does that look like?

Vector Subtraction

- When a vector is multiplied by -1, the magnitude remains the same, but the direction is reversed.



Vector Components

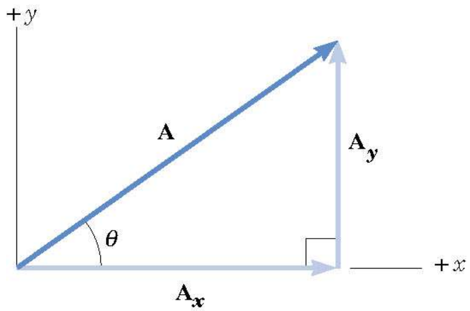


r = **x** + **y**, either notation represents how the finish point is displaced relative to the starting point

What if I went north first and then east, would I end up at the same point?

The components of any vector can be used in place of the vector itself in any calculation.

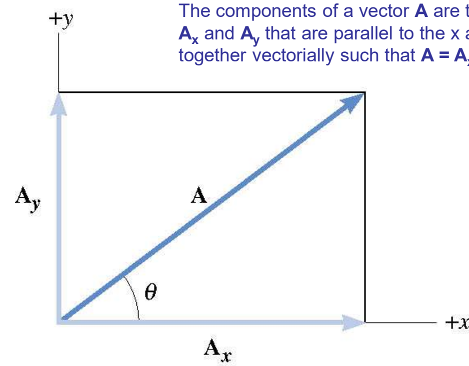
Vector Components



A = A_y + A_x

Vector Components

The components of a vector **A** are two perpendicular vectors: $\mathbf{A_x}$ and $\mathbf{A_y}$ that are parallel to the x and y axes and add together vectorially such that **A = A_x + A_y**.



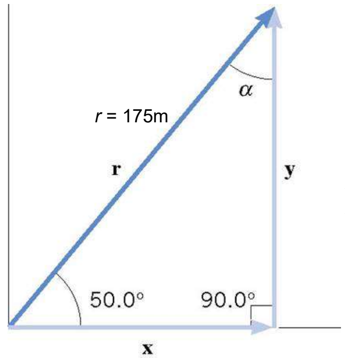
Scalar Components

- $\mathbf{A_x}$ and $\mathbf{A_y}$ can be broken into their scalar components.
- The component A_x has equal magnitude to $\mathbf{A_x}$ and has a:
  - + sign if $\mathbf{A_x}$ points along the +x axis
  - – sign if $\mathbf{A_x}$ points along the –x axis
- The component A_y has equal magnitude to $\mathbf{A_y}$ and has a:
  - + sign if $\mathbf{A_y}$ points along the +y axis
  - – sign if $\mathbf{A_y}$ points along the –y axis

Breaking a Vector into Components

A displacement vector **r** has a magnitude of r= 175m and points at an angle of 50.0^{O} relative to the x axis. Find the *x* and *y* components of its vector

Breaking a Vector into Components



$\sin 50^{O} = y/r$

$y = r \sin 50^{O}$

$y = (175\text{ m})(\sin 50^{O}) = 134\text{m}$

$\cos 50^{O} = x/r$

$x = r \cos 50^{O}$

$x = (175\text{ m})(\cos 50^{O}) = 112\text{m}$

Vector Addition & Components

Tail-to-head method drawn to scale gives you the actual resultant. But it's not always a practical method.

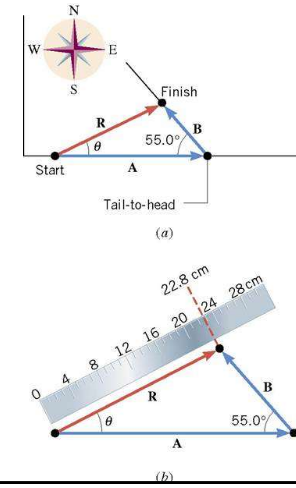
And since **A + B = R**, this means

$A_x + B_x = R_x$

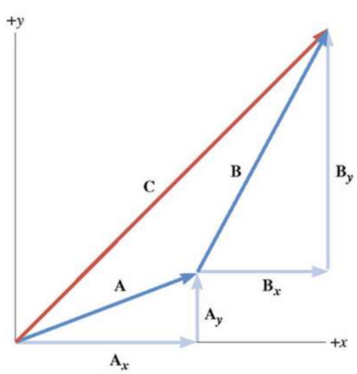
And

$A_y + B_y = R_y$

We can still solve problems like this using a little bit of trig and a little bit of algebra.



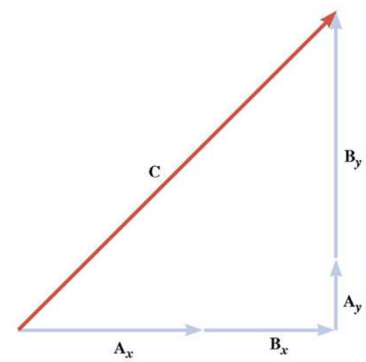
Adding Vector Components



C = A + B

Vector components allow us to use "regular" algebra to solve a problem.

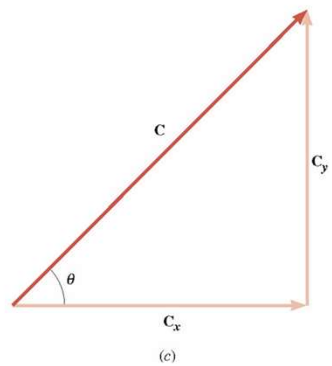
Adding Vector Components



$C_x = A_x + B_x$

$C_y = A_y + B_y$

Adding Vector Components



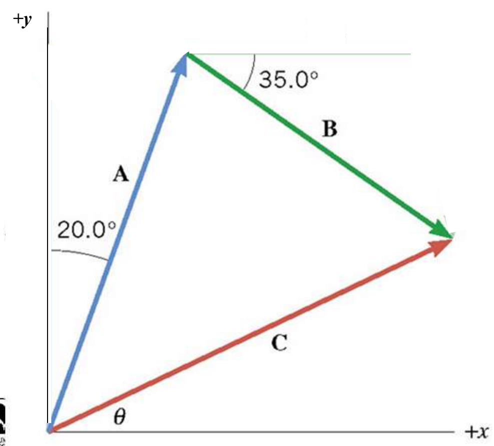
$C^2 = C_x^{\ 2} + C_y^{\ 2}$

$C = \sqrt{(C_x^{\ 2} + C_y^{\ 2})}$

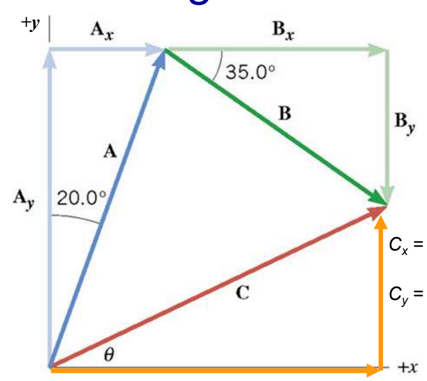
Adding Vector Components

A jogger runs 145m in a direction of 20^{O} east of north and then 105m in the direction of 35^{O} south of east. What is the resultant vector?

Adding Vector Components



Adding Vector Components



A_x = (145m) sin 20^{O} = 49.6 m

B_x = (105m) cos 35^{O} = 86.0 m

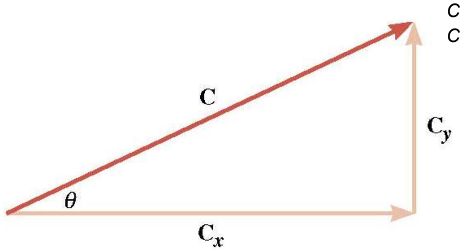
A_y = (145m) cos 20^{O} = 136 m

B_y = -(105m) sin 35^{O} = -60.2 m

$C_x = A_x + B_x$ = 49.6m + 86.0m = 135m

$C_y = A_y + B_y$ = 136m + (-60.2m) = 76m

Adding Vectors



C = ?

$C = \sqrt{(C_x^2 + C_y^2)}$

$C = \sqrt{((135m)^2 + (76m)^2)}$

C = 155m

θ = ?

$\theta = \tan^{-1}(C_y/C_x)$

$\theta = \tan^{-1}(76m/135m) = 29^O$

C = 155 m, 29^O

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Adding Vectors

1. Determine the x and y components, consider the direction of the x and y components.
2. Add the x components together and the y components together to find the resultant (*r*) x and y components.
3. Use the Pythagorean theorem to find the magnitude of the resultant vector (**r**).
4. Use one of the trigonometric functions to find the angle that specifies the direction of the resultant vector (**r**).

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