

Welcome to the World of Vectors



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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: \mathbf{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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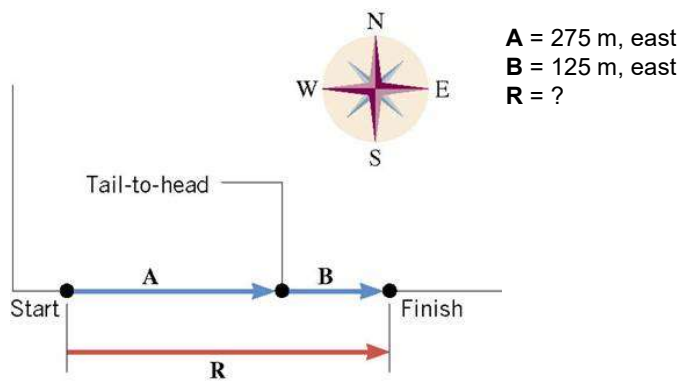
Vector Addition

- 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.



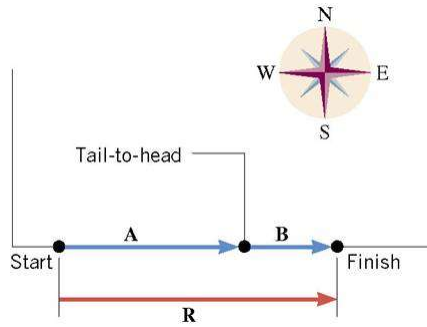
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Vector Addition



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Vector Addition



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

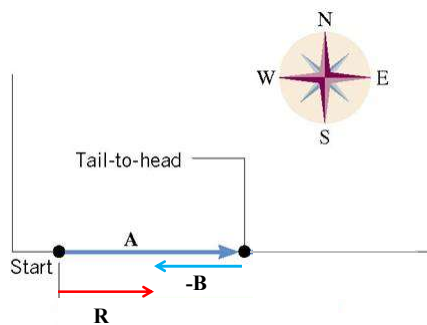
$$\mathbf{R} = \mathbf{A} + \mathbf{B} = 275\text{m, east} + 125\text{ m, east} = 400\text{ m, east}$$



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Vector Addition

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

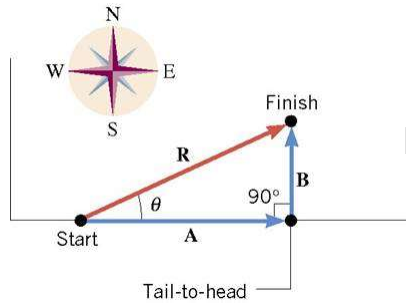


A = 275 m, east
B = 125 m, west
R = ?

$$\mathbf{R} = \mathbf{A} + (-\mathbf{B}) = 275\text{m, east} + (-125\text{ m, west}) = 150\text{ m, east}$$



Vector Addition



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

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

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

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

$$R = \sqrt{275^2 + 125^2} = 302 \text{ m}$$

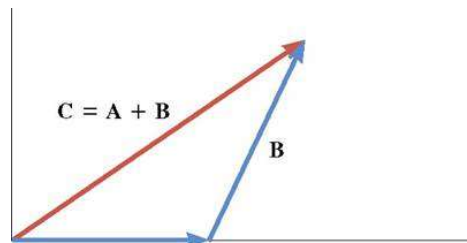
$$\theta = \tan^{-1}(B/A) = 24.4^\circ$$

$$R = 302 \text{ m}, 24.4^\circ \text{ north-east}$$



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Vector Subtraction



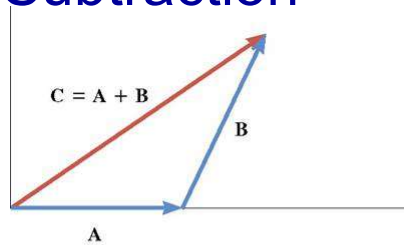
If $C = A + B$ then $A = C - B$ but what does that look like?



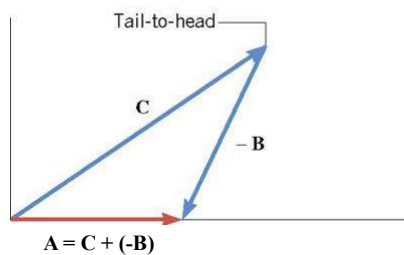
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Vector Subtraction

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



(a)

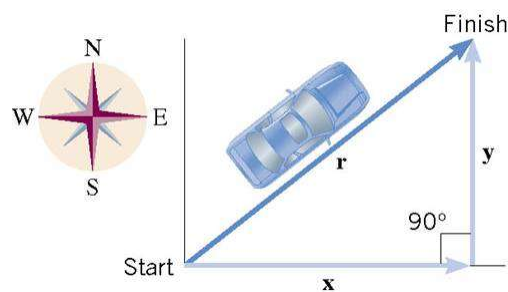


(b)



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Vector Components



$\mathbf{r} = \mathbf{x} + \mathbf{y}$, either notation represents how the finish point is displaced relative to the starting point

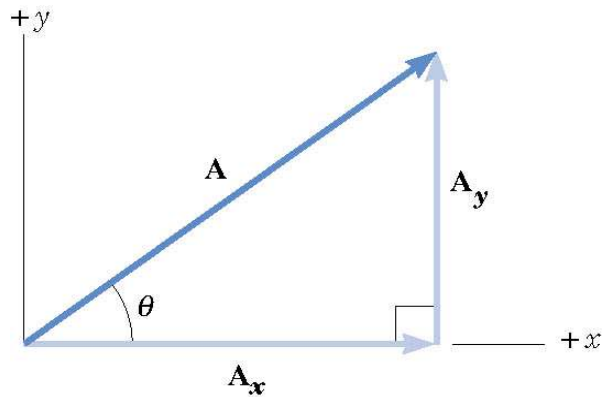
What if I went north first and then east, would I end up at the same point?

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



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Vector Components



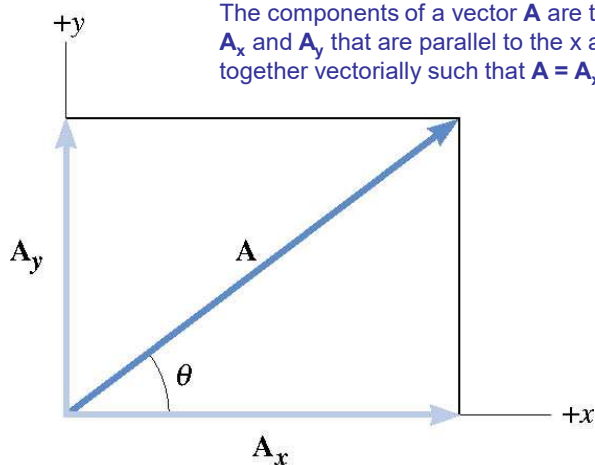
$$\mathbf{A} = \mathbf{A}_y + \mathbf{A}_x$$



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Vector Components

The components of a vector \mathbf{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 $\mathbf{A} = \mathbf{A}_x + \mathbf{A}_y$.



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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



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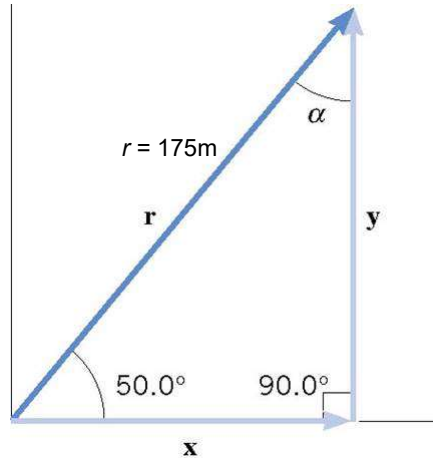
Breaking a Vector into Components

A displacement vector \mathbf{r} has a magnitude of $r = 175\text{m}$ and points at an angle of 50.0° relative to the x axis. Find the x and y components of its vector



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Breaking a Vector into Components



$$\sin 50^\circ = y/r$$

$$y = r \sin 50^\circ$$

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

$$\cos 50^\circ = x/r$$

$$x = r \cos 50^\circ$$

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



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Vector Addition & Components

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

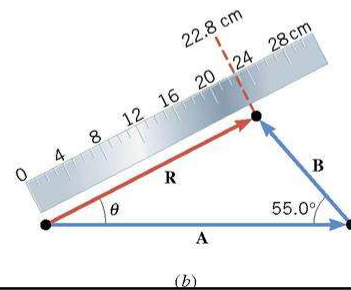
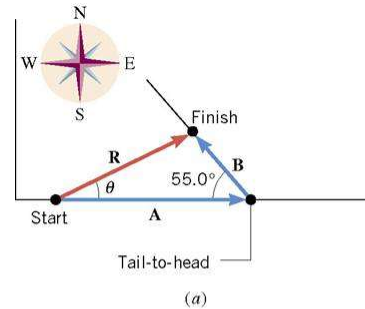
And since $\mathbf{A} + \mathbf{B} = \mathbf{R}$, this means

$$A_x + B_x = R_x$$

And

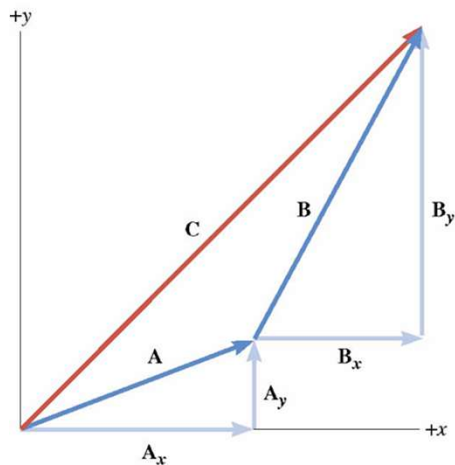
$$A_y + B_y = R_y$$

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



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Adding Vector Components



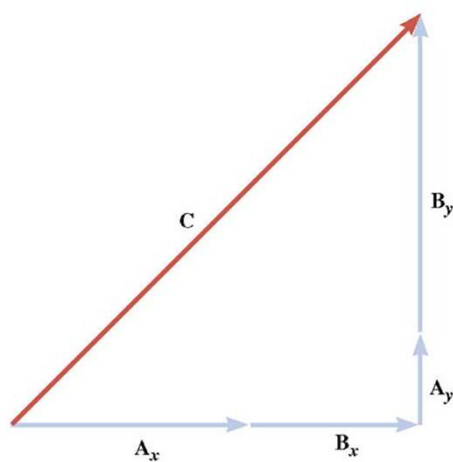
$$\mathbf{C} = \mathbf{A} + \mathbf{B}$$

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



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Adding Vector Components



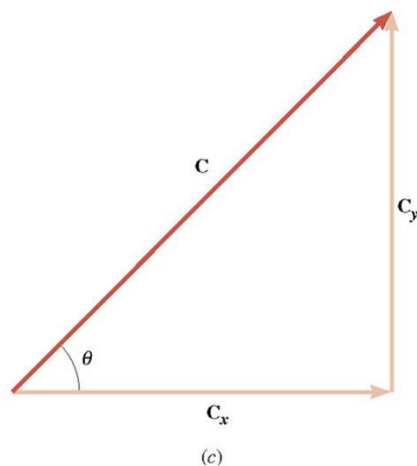
$$C_x = A_x + B_x$$

$$C_y = A_y + B_y$$



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Adding Vector Components



$$C^2 = C_x^2 + C_y^2$$

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



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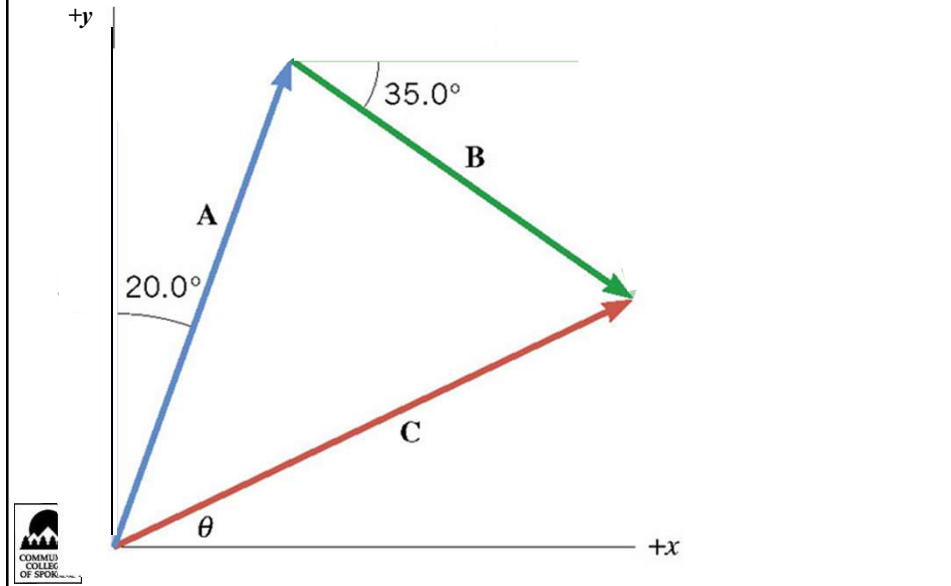
Adding Vector Components

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

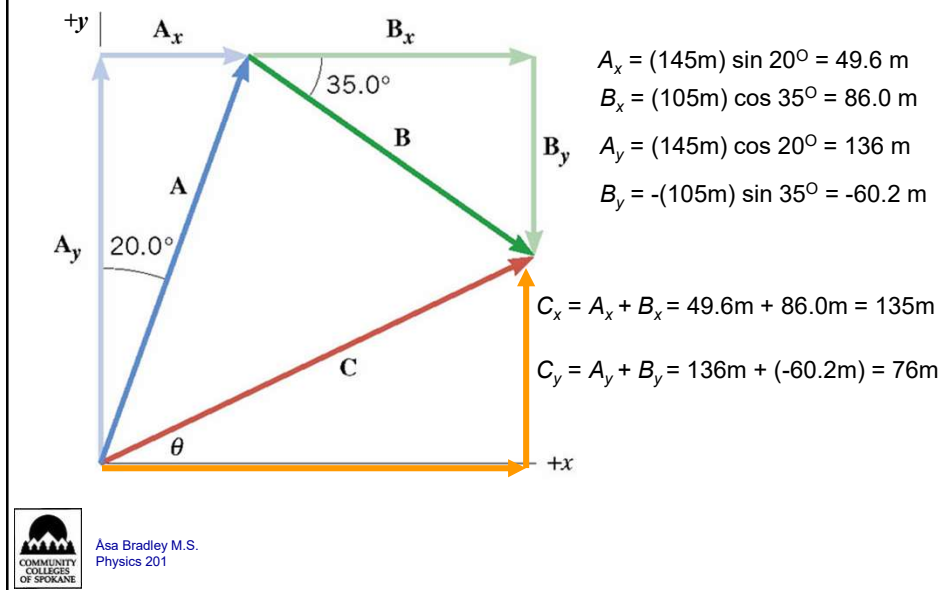


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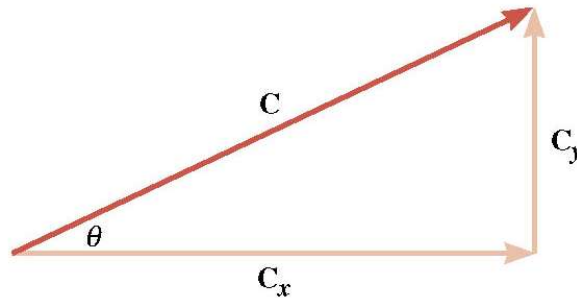
Adding Vector Components



Adding Vector Components



Adding Vectors



$$C = ?$$

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

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

$$C = 155\text{m}$$

$$\theta = ?$$

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

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

$$C = 155 \text{ m}, 29^\circ$$



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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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