Physics 1

Chapter 3 Vectors

1. Vectors & Scalars
2. Adding Vectors Geometrically
3. Components of Vectors
4. Unit Vectors
5. Adding Vectors by Components
6. Vectors & the Laws of Physics
7. Multiplying Vectors

Review & Summary

Questions

Exercises & Problems

Vectors & Scalars

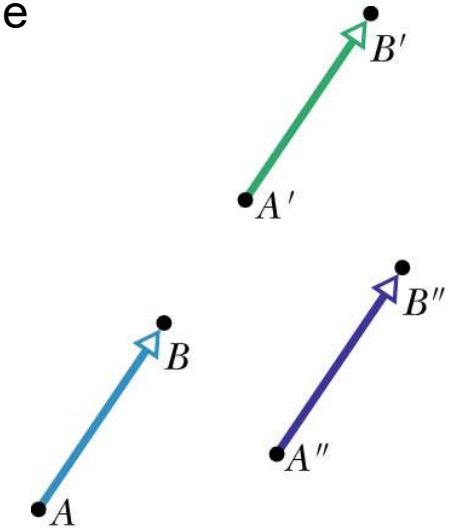
A **scalar quantity** only has a ***magnitude***.

e.g.: temperature, speed, mass, . . .

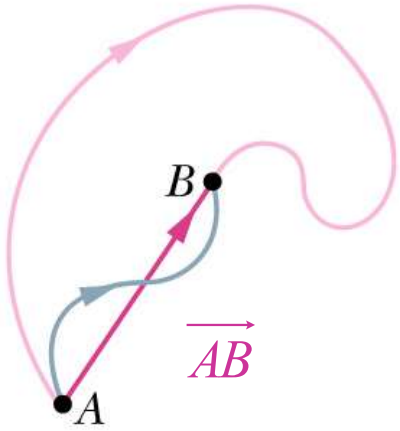
A **vector quantity** a ***magnitude*** and a ***direction***.

e.g.: displacement, velocity, acceleration, . . .

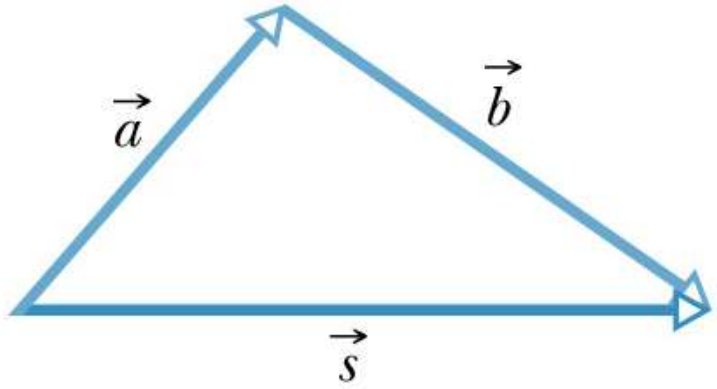
All 3 represent the same vector.



All 3 paths represent the same displacement vector.



Adding Vectors Geometrically

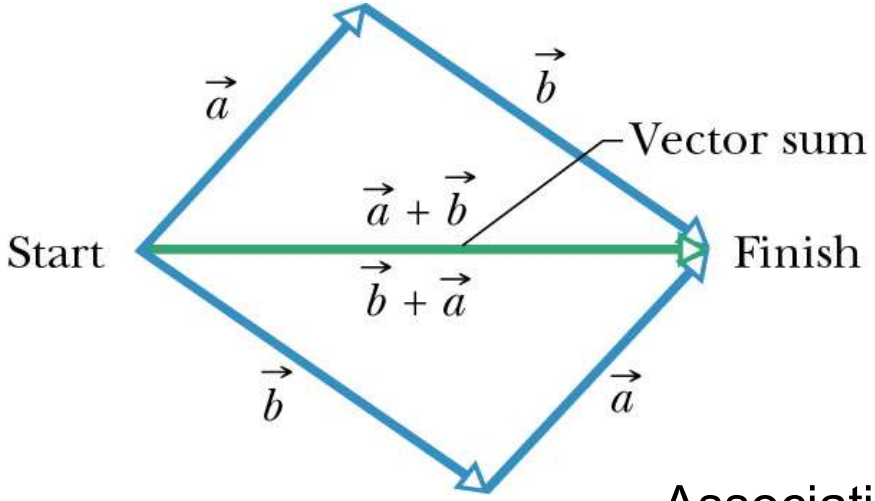


"head – to – tail"

$$\vec{s} = \vec{a} + \vec{b}$$

Adding Vectors Geometrically

Add vectors in *either* order:



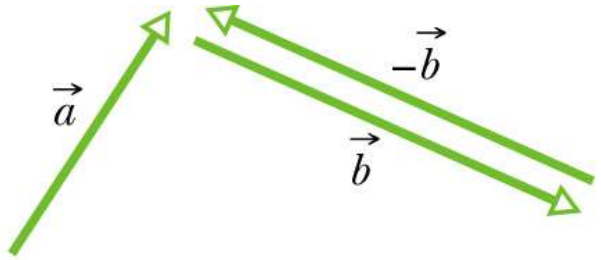
Commutative Law:

$$\vec{b} + \vec{a} = \vec{a} + \vec{b}$$

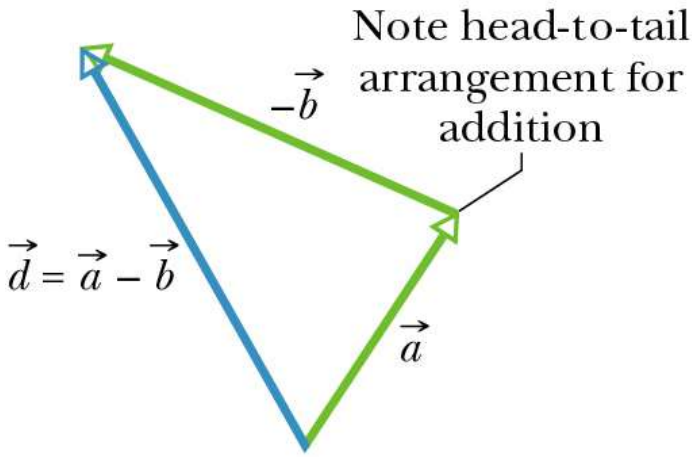
Associative Law:

$$\left(\vec{a} + \vec{b}\right) + \vec{c} = \vec{a} + \left(\vec{b} + \vec{c}\right)$$

Vector Subtraction

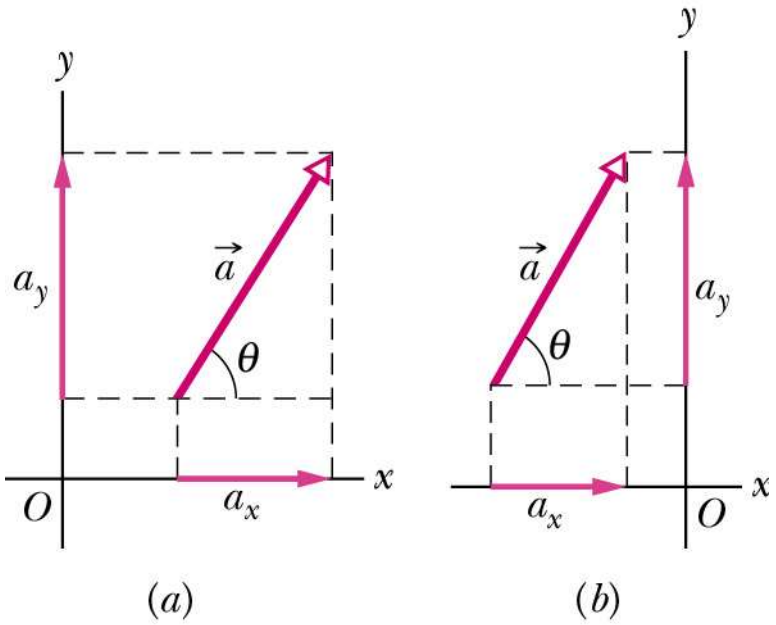


$-\vec{b}$ a vector with the *same magnitude* but the *opposite direction*.



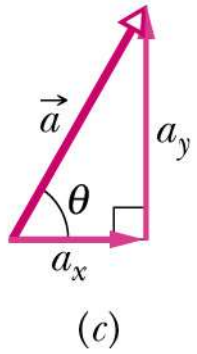
$$\vec{d} = \vec{a} + \left(-\vec{b}\right)$$

Components of Vectors



$$a_x = a\cos\theta$$

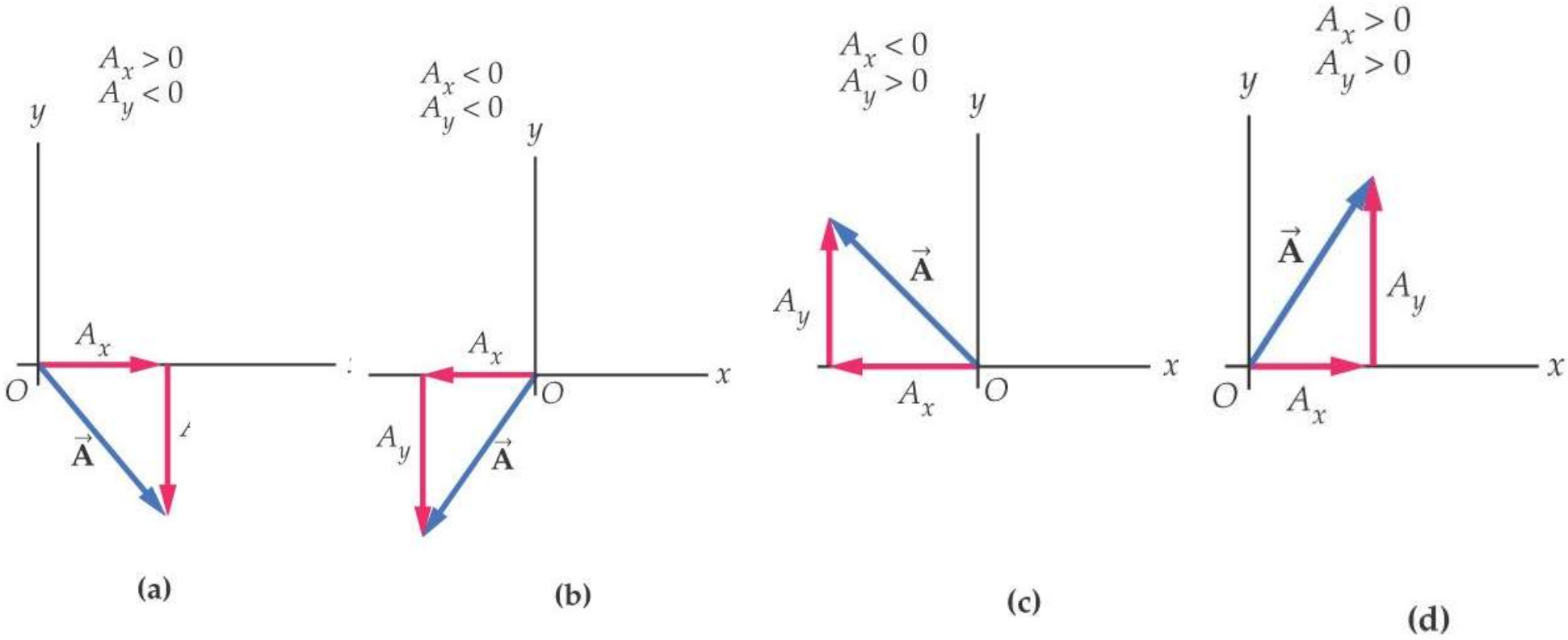
$$a_y = a\sin\theta$$



$$a = |\vec{a}| = \sqrt{a_x^2 + a_y^2}$$

$$\tan\theta = \frac{a_y}{a_x}$$

Vectors with Components of Different Signs



Unit Vectors $\vec{i}$ $\vec{j}$ $\vec{k}$

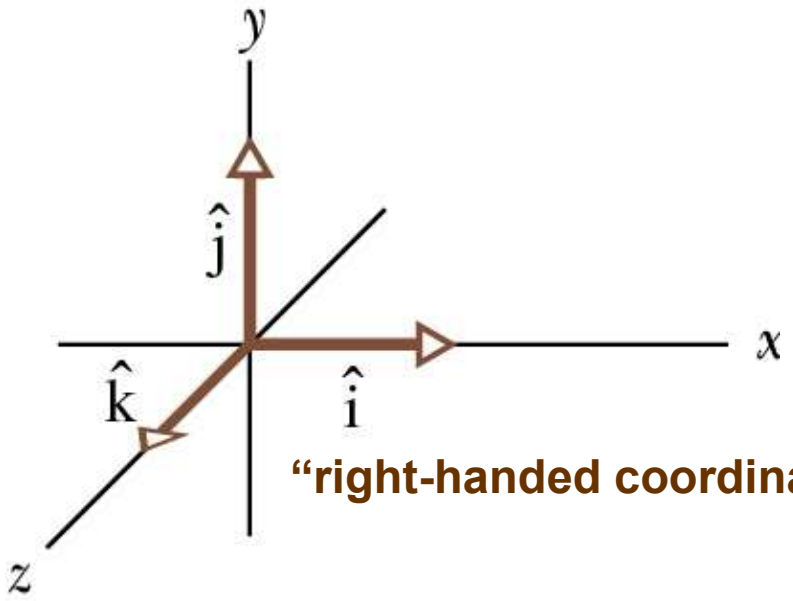
A **Unit Vector** only specifies a direction.

Unit vector magnitude = 1

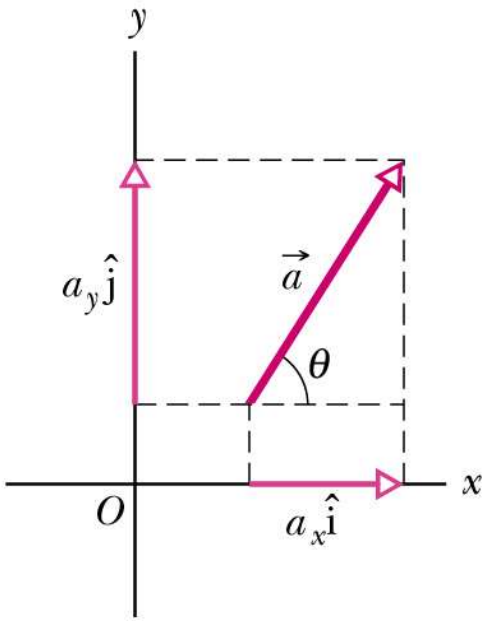
Unit vector has no units.

$$\vec{a} = a_x \vec{i} + a_y \vec{j}$$

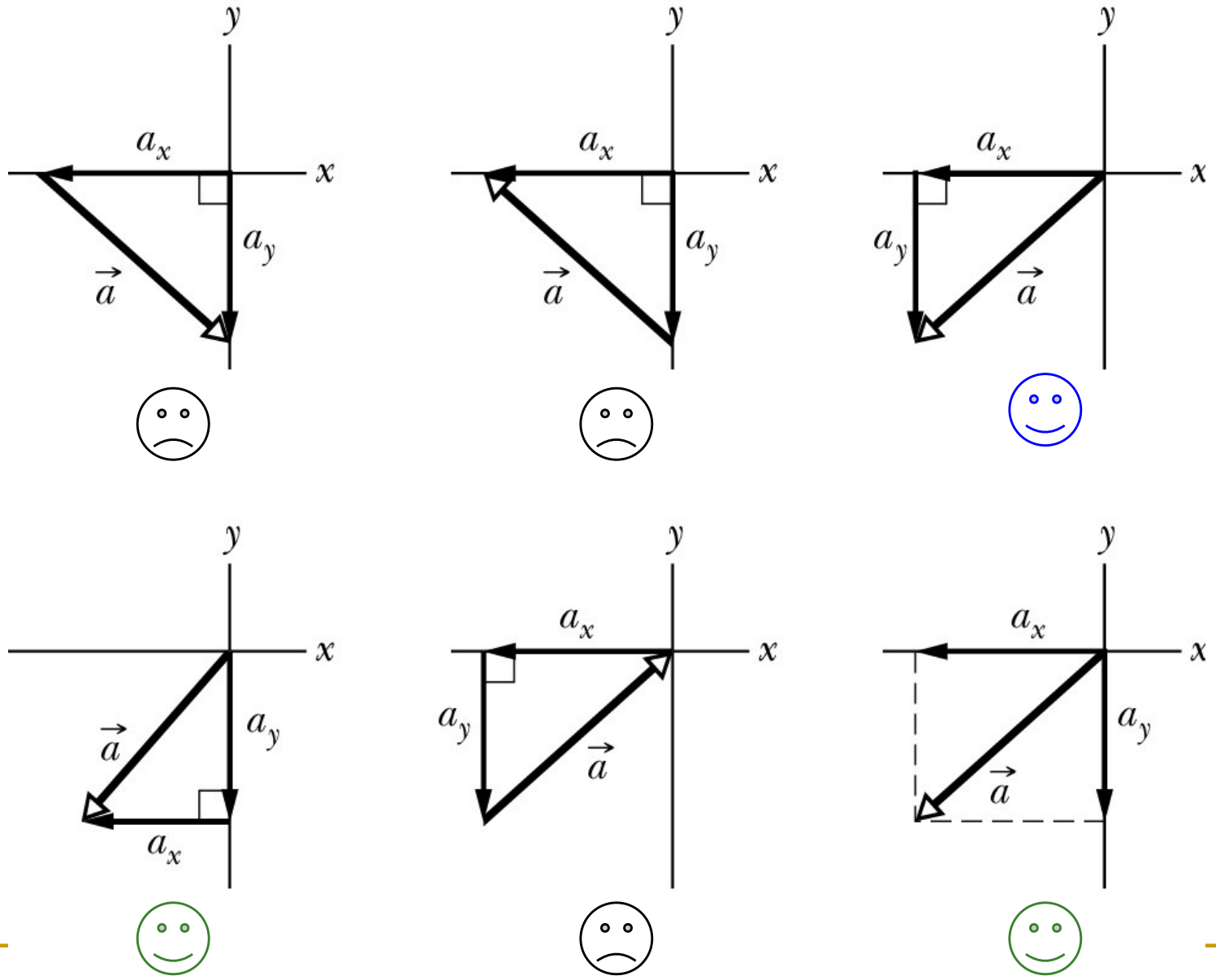
Unit Vectors in the positive directions of the x, y, z axes:



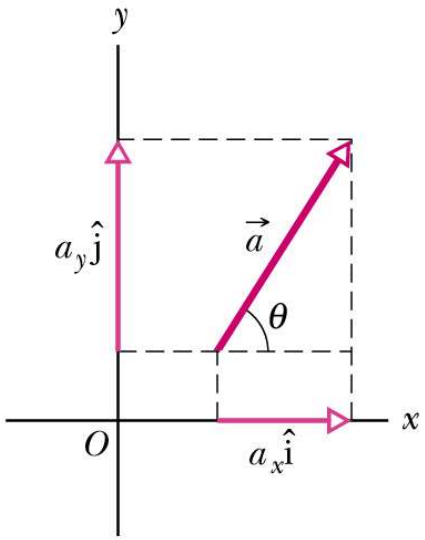
"right-handed coordinate system"



Proper combinations of a_x and a_y?



Adding Vectors by Components

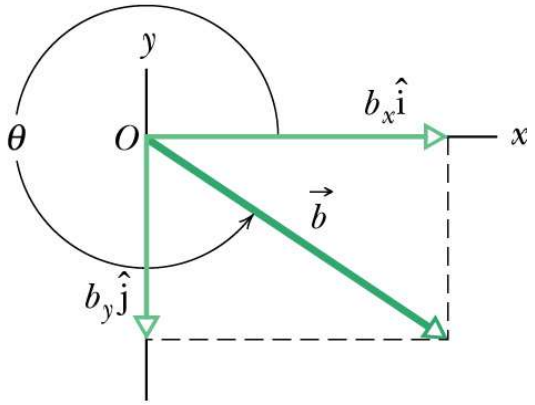


(a)

$$\vec{a} = a_x \vec{i} + a_y \vec{j}$$

$$\vec{r} = \vec{a} + \vec{b}$$

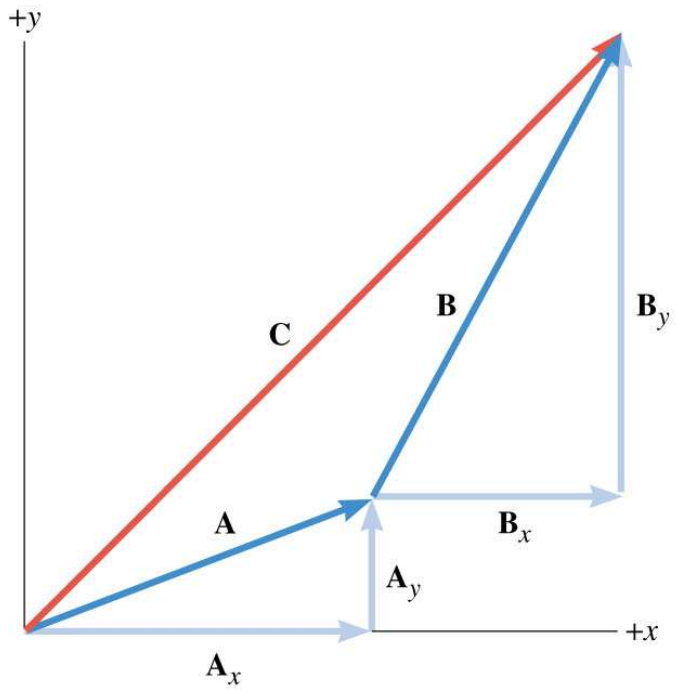
$$\vec{r} = (a_x + b_x)\vec{i} + (a_y + b_y)\vec{j}$$

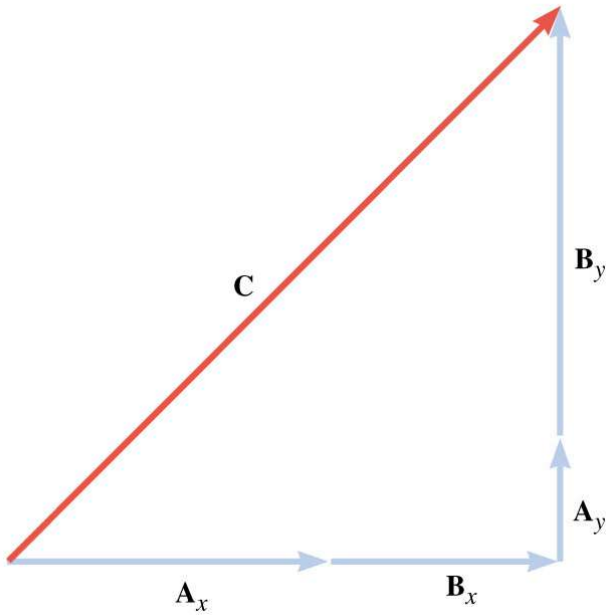


(b)

$$\vec{b} = b_x \vec{i} + b_y \vec{j}$$

Adding Vector Components



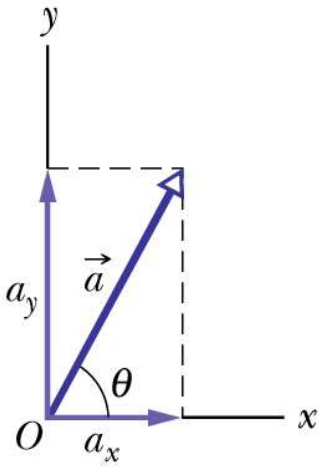


$$C_x = A_x + B_x$$

$$C_y = A_y + B_y$$

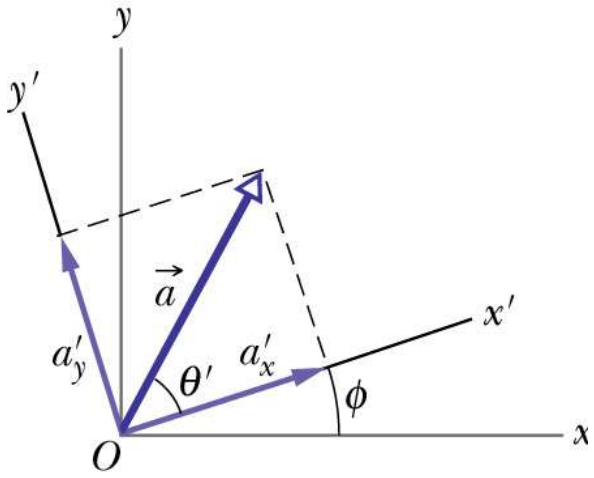
Vectors and the Laws of Physics

The properties of the vector do *not* depend on the choice of coordinate system.



$$\vec{a} = a_x \vec{i} + a_y \vec{j}$$

$$a_x = a\cos\theta$$



$$\vec{a} = a'_x \vec{i}' + a'_y \vec{j}'$$

$$a'_x = a\cos\theta'$$

$$\theta = \theta' + \phi$$

Multiplying Vectors

- Multiply a vector by a scalar:

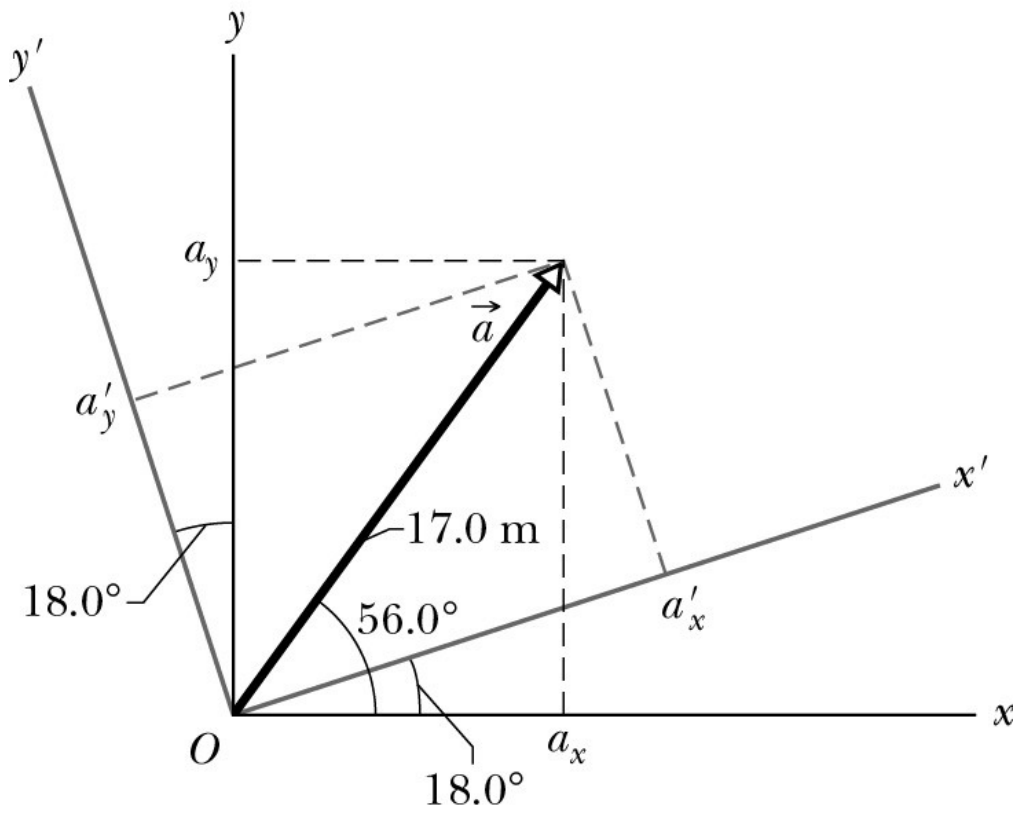
$$\vec{b} = s\,\vec{a} = (s\,a_x)\vec{i} + (s\,a_y)\vec{j}$$

- The Scalar Product
- The Vector Product

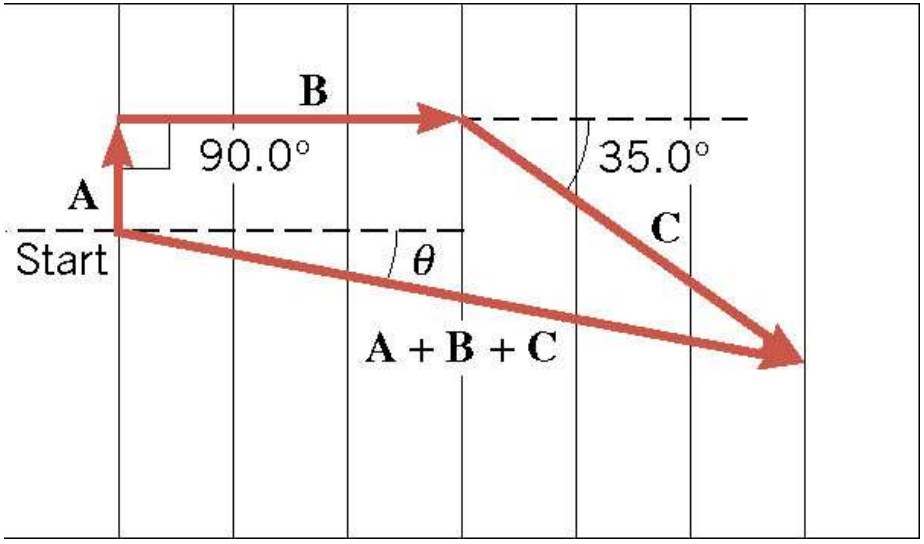
Example

Vector a with magnitude 17.0 m is directed $+56.0^0$ counterclockwise from the + x axis. What are the components a_x and a_y?.

A second coordinate system is inclined 18.0^0 with respect to the first. What are the components of a_x' and a_y'?



Example



A= 5.0 m

B=15.0m

C=18.0 m

R= ? (A + B + C), θ = ?