

# Physics 105 Class 3

## VECTORS AND 2-D MOTION

### Vector:

Has both magnitude and \_\_\_\_\_.

“Going 45 miles may or may not get you to Salt Lake”  
vector symbols:

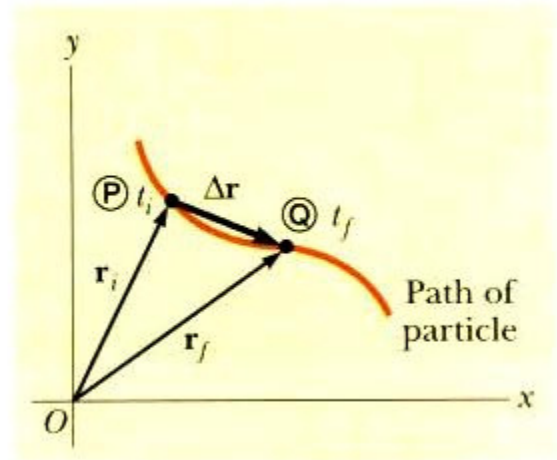
### Position:

Labeled by a **vector**  $\mathbf{r}$  from some origin ( $\mathbf{r}=\mathbf{0}$ ) to the position.

### Displacement:

Change in position:

$$\Delta \mathbf{r} =$$

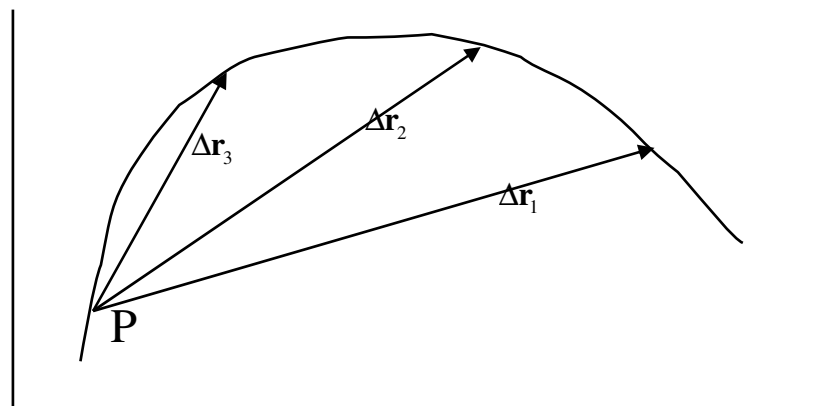


### Average velocity:

### Instantaneous velocity at point P, as a vector

$$\mathbf{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \mathbf{r}}{\Delta t}$$

Direction?



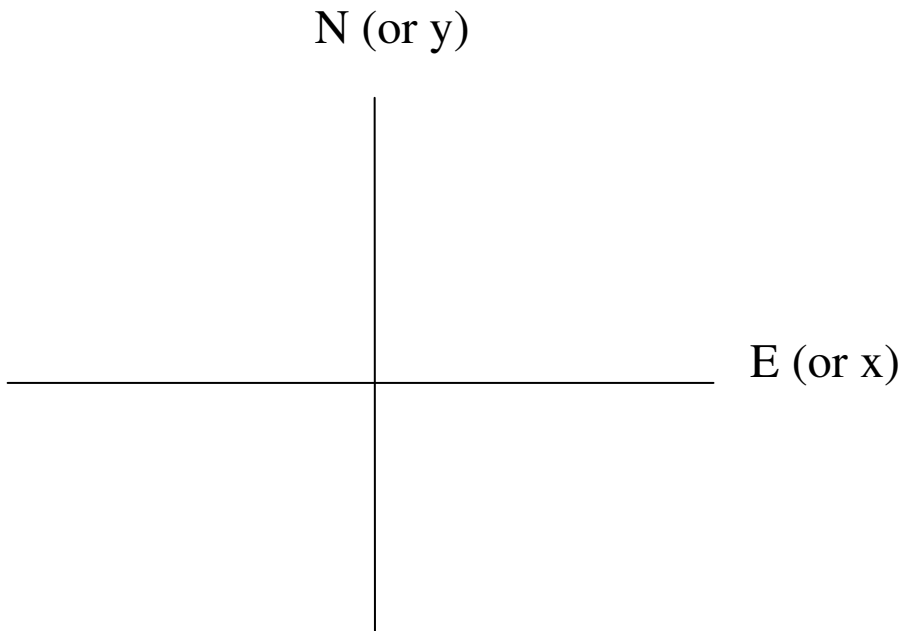
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A truck drives two legs of a journey.



**A:** 500 mi,  $40^\circ$  north of west **B:** 300 mi south.

**Draw** the two displacement vectors, from the origin:

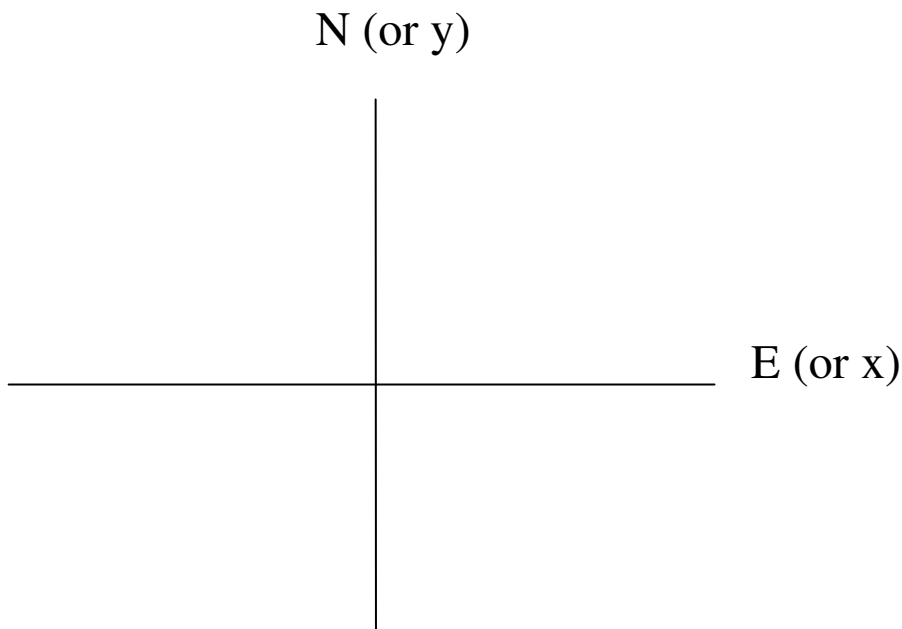


**Adding** vectors to find **total displacement vector**

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

**Method 1: Graphical addition**

Tail to head, or “triangle method”:

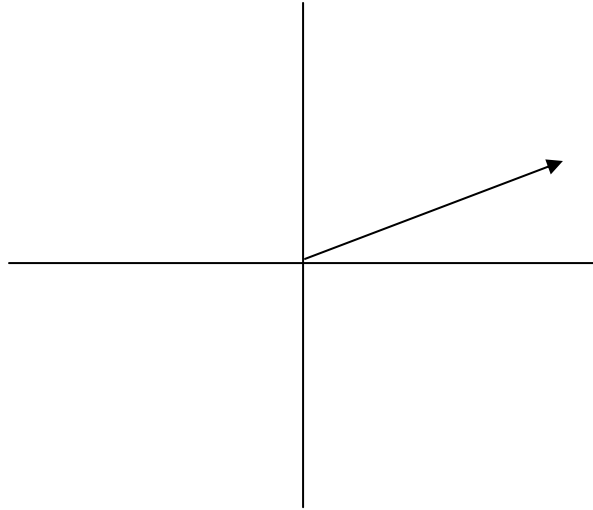


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### Method 2: Component addition

#### Components of a vector

Trigonometry



$$\frac{y}{r} =$$

$$\frac{x}{r} =$$

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

y, x are  $< r$ , so  $\cos(\theta)$  and  $\sin(\theta)$  \_\_\_\_\_

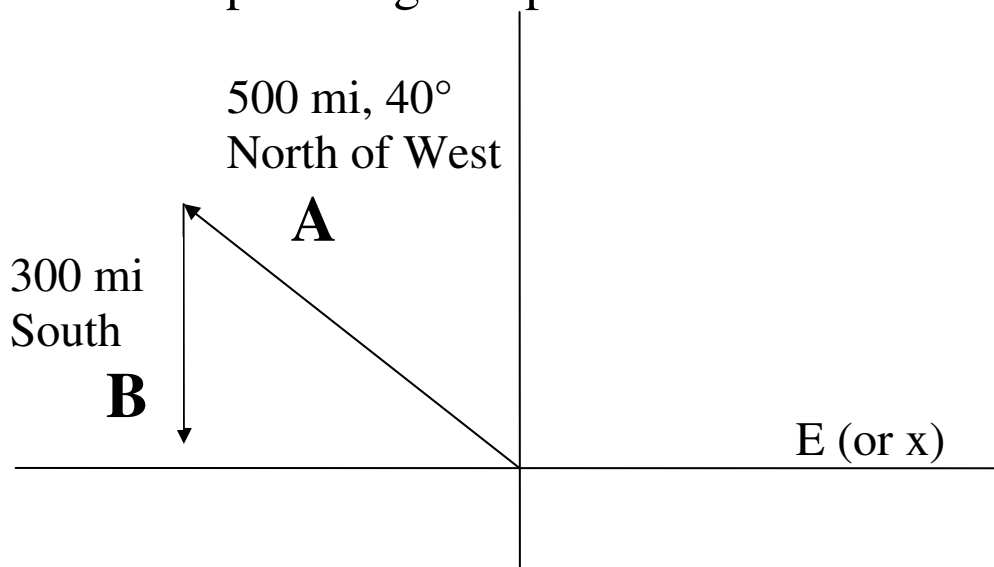
Magnitude  $r =$

Ways to write vector **A**:

- magnitude and direction
- components

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Our example using components:



What is the final *position*  $\vec{r}$  of the truck in x and y components?

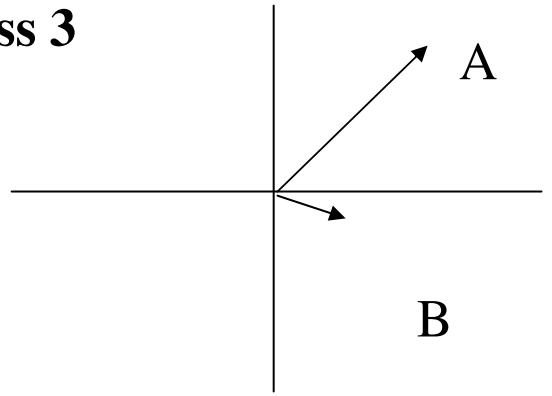
What is *angle* of the truck's position?

Relative to west?

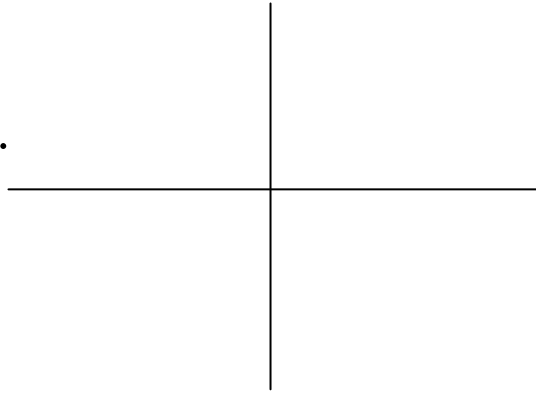
Relative to the x axis?

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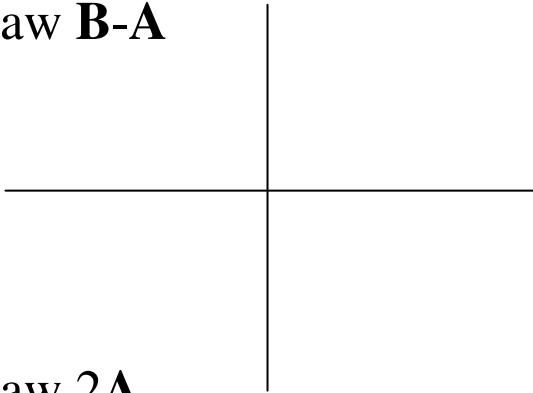
A few graphical exercises:



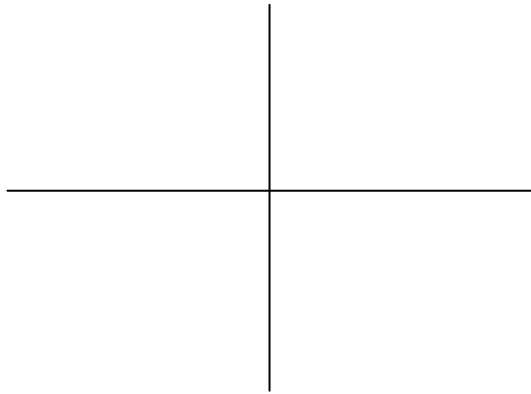
Draw **A-B**.



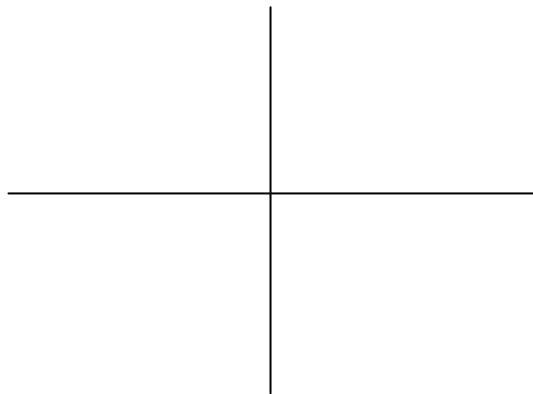
**P1.** Draw **B-A**



**P2.** Draw **2A**



**P3.** Draw **2A - 1/2 B**



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# Relative velocity

A car at 60 mph tries to overtake a truck going 40 mph, same direction. They are 5 mi apart. How long will it take them to meet?

This one is easy, but you need the *general* idea:

$$\begin{aligned} V_{\text{car rel to truck}} &= V_{\text{car rel to ground}} - V_{\text{truck rel to ground}} \\ &= V_{\text{car rel to ground}} + V_{\text{ground rel to truck}} \end{aligned}$$

### Vector equation:

Boat on moving water, plane on moving air

An observer floating on the water sees:  $\vec{v}_{\text{boat rel to water}}$

An observer standing on the shore sees:  $\vec{v}_{\text{boat rel to ground}}$

Connection:

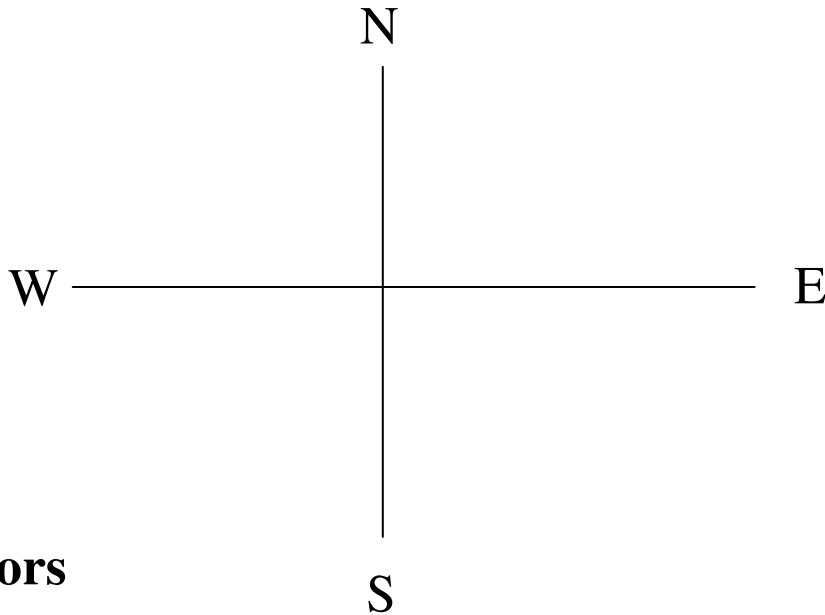
$$\vec{v}_{\text{boat rel to ground}} = \vec{v}_{\text{boat rel to water}} + \vec{v}_{\text{water rel to ground}}$$

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This is harder 😊

A jet pointed N at 100 mph airspeed flies in a 200 mph wind going NE.

What is the jet's *direction* relative to the ground?



**Vectors**

$$\mathbf{V}_{\text{plane rel to ground}} = \mathbf{V}_{\text{plane rel to air}} + \mathbf{V}_{\text{air rel to ground}}$$

$$\mathbf{V}_{\text{pg}} = \mathbf{V}_{\text{pa}} + \mathbf{V}_{\text{ag}}$$

**P4.** Find the components  $v_{\text{pa}} = (\underline{\hspace{2cm}}, \underline{\hspace{2cm}})$

**P5.** Find the components  $v_{\text{ag}} = (\underline{\hspace{2cm}}, \underline{\hspace{2cm}})$

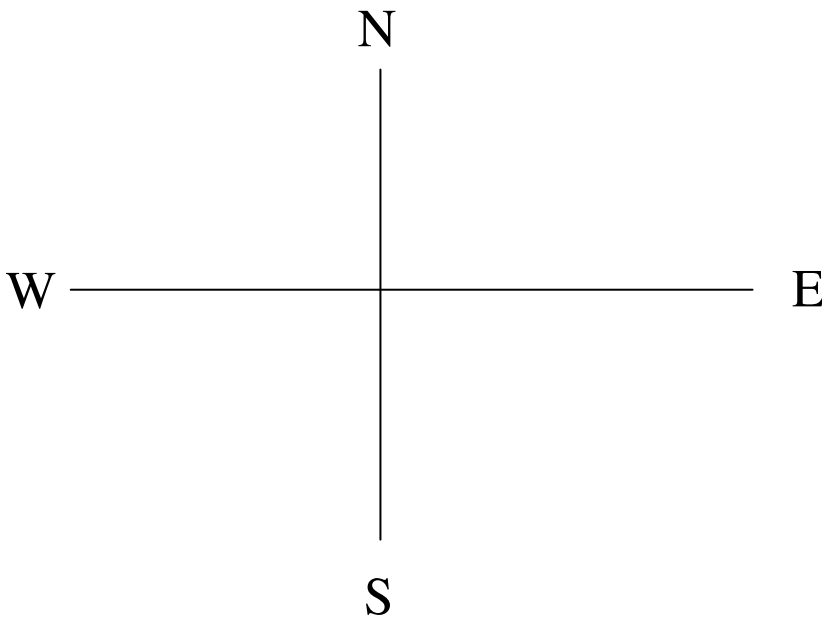
Angle:

**P6.** How *fast* is it flying relative to the ground (speed)?

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If a boat wishes to sail exactly **E** on a map, with a speed relative to the *earth* of 10 mph, what direction should the boat point (relative to the water), in a 10 mph current to the **N**?

**P7. Draw the vectors** correctly to make  $V_{be} = V_{bw} + V_{we}$



How fast will he have to go?

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### Thought Question

**P8.** You drop a ball from the top of a building, and measure the time to hit the ground. You go to a second building, and find that the ball takes *twice* as long to hit the ground.

The second building is

- a. less than twice as tall as the first
- b. twice as tall as the first
- c. more than twice as tall as the first

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### **HOMEWORK 3 NOTES:**