

September 29, 2010

Physics 121

Prof. E. F. Redish

## ■ Theme Music: Left Sock Theory

### *Do the Math*

## ■ Cartoon: Jef Mallett

### *Frazz*



9/29/10

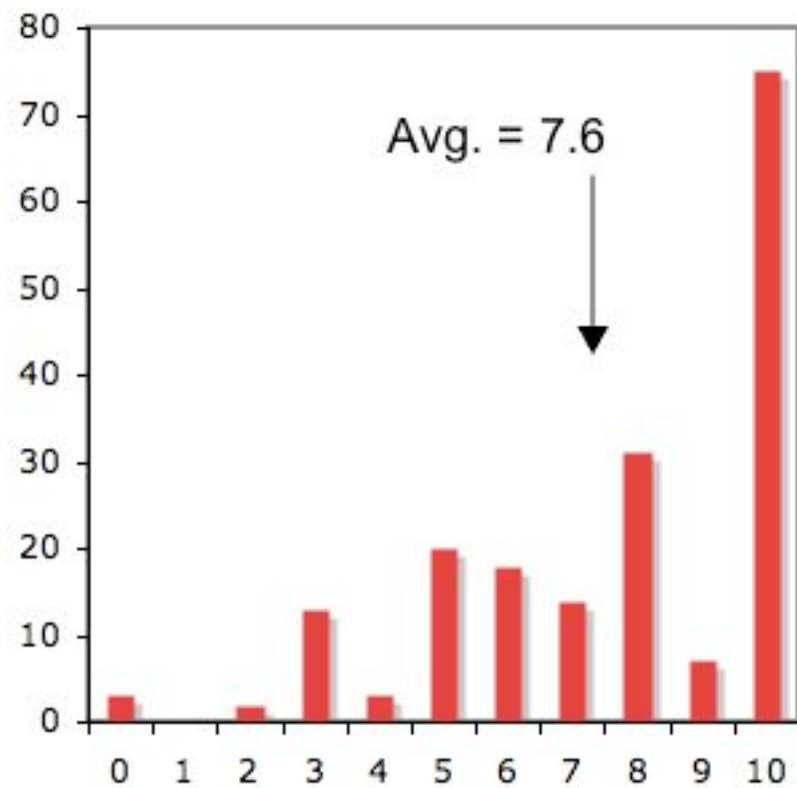
Physics 121

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# Quiz 3

Quiz 3

	3.1	3.2	3.3	3.4
a	2%	1%	1%	0%
b	4%	4%	93%	14%
c	17%	20%	3%	63%
d	2%	69%	3%	0%
e	68%	6%	1%	18%
ae	1%	0%	0%	0%
be	0%	0%	0%	4%
ce	7%	0%	0%	0%



# Newton 2 is a vector equation

- We have sort of been assuming that up and down forces were independent of sideways forces.
- This tests out true in detail. It means N2 is a vector equation:

$$\vec{a} = \vec{F}^{net} / m$$

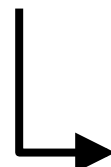
- A vector equation is a way of writing 2 equations at once:

$$a_x = F_x^{net} / m \quad a_y = F_y^{net} / m$$

# Our velocity and acceleration definitions generalize easily

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t} \quad \Delta \vec{r} = \vec{r}_f - \vec{r}_i$$

$$\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t} \quad \Delta \vec{v} = \vec{v}_f - \vec{v}_i$$


$$\begin{aligned} \langle v_x \rangle &= \frac{\Delta x}{\Delta t} & \langle v_y \rangle &= \frac{\Delta y}{\Delta t} \\ \langle a_x \rangle &= \frac{\Delta v_x}{\Delta t} & \langle a_y \rangle &= \frac{\Delta v_y}{\Delta t} \end{aligned}$$

If  $a$  is constant

$$\langle v \rangle = \frac{v_i + v_f}{2}$$

for either  $v_x$  or  $v_y$ .

# Recap: Coordinates and Vectors

- Set up a coordinate system
  - Pick an origin
  - Pick 3 perpendicular directions
  - Choose a measurement scale
- Each point in space is then specified by three numbers: the  $x$ ,  $y$ , and  $z$  coordinates.
- The position vector for a particular position is an arrow drawn from the origin to that position.

# Recap: Motion in a plane (2-dimensional coordinates)

- We now have 2 directions to specify. We must
  - Choose a reference point (origin)
  - Pick 2 perpendicular axes (x and y)
  - Choose a scale
- We specify our x and y directions by drawing little arrows of unit length in their positive direction.

$$\hat{i}, \hat{j}$$

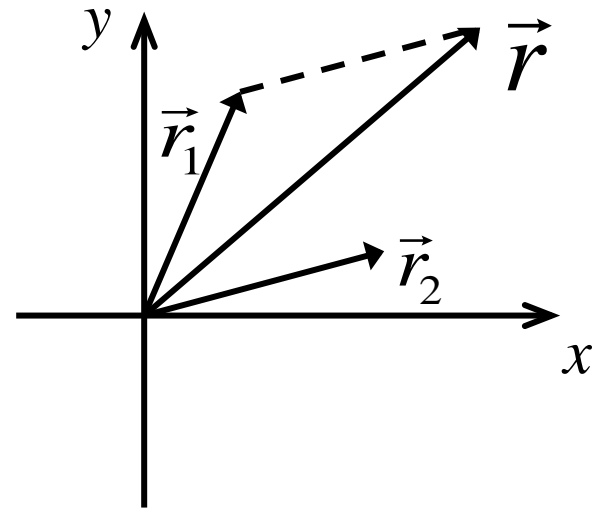
- A position specified by a point (x,y) is written

$$\vec{r} = x\hat{i} + y\hat{j}$$

# Adding Vectors: Meaning

- A position vector,  $\vec{r}$ , represents a displacement from the origin.
- We define the sum of two vectors as the results of their successive displacements.

$$\vec{r} = \vec{r}_1 + \vec{r}_2$$

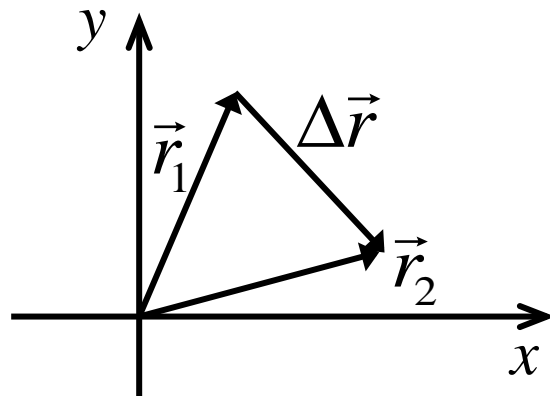
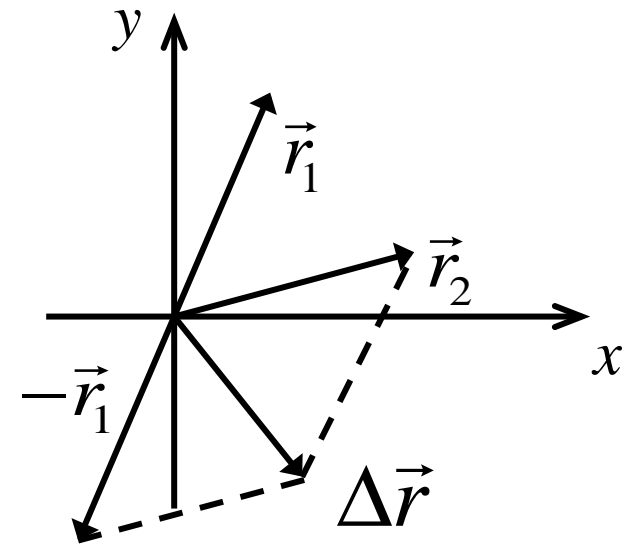


# Subtracting Vectors: Meaning

- We define the difference of two vectors from the definition of sum.

$$\Delta \vec{r} = \vec{r}_2 - \vec{r}_1 = \vec{r}_2 + (-\vec{r}_1)$$

- Or: The difference is what has to be added to the first to give the second.



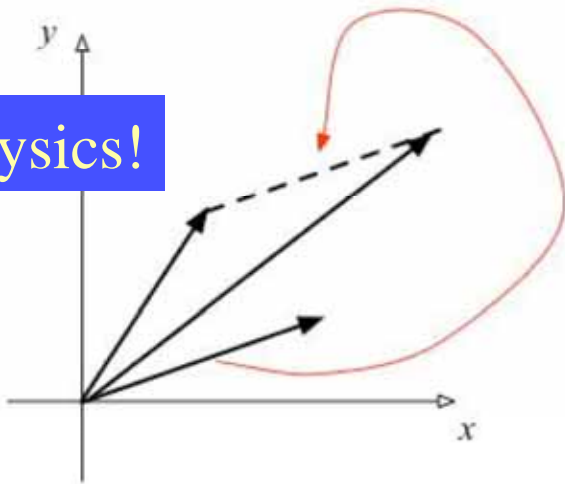
$$\Delta \vec{r} = \vec{r}_2 - \vec{r}_1$$
$$\vec{r}_2 = \vec{r}_1 + \Delta \vec{r}$$



# Adding Vectors: Methods

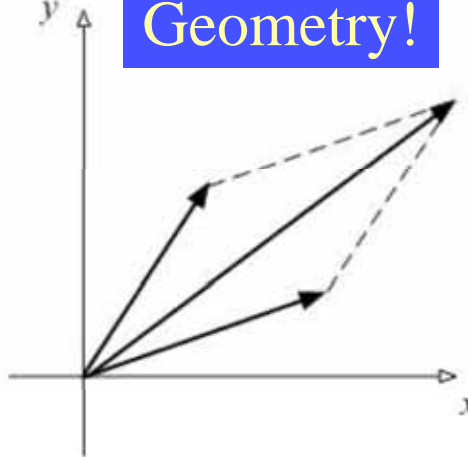
- There are 3 mathematical ways to add vectors

Physics!



head  
to tail

Geometry!



parallelogram  
rule

Algebra!

$$\vec{r}_1 = x_1\hat{i} + y_1\hat{j}$$

$$\vec{r}_2 = x_2\hat{i} + y_2\hat{j}$$

$$\begin{aligned}\vec{r}_1 + \vec{r}_2 &= x_1\hat{i} + y_1\hat{j} + x_2\hat{i} + y_2\hat{j} \\ &= x_1\hat{i} + x_2\hat{i} + y_1\hat{j} + y_2\hat{j} \\ &= (x_1 + x_2)\hat{i} + (y_1 + y_2)\hat{j}\end{aligned}$$

coordinates