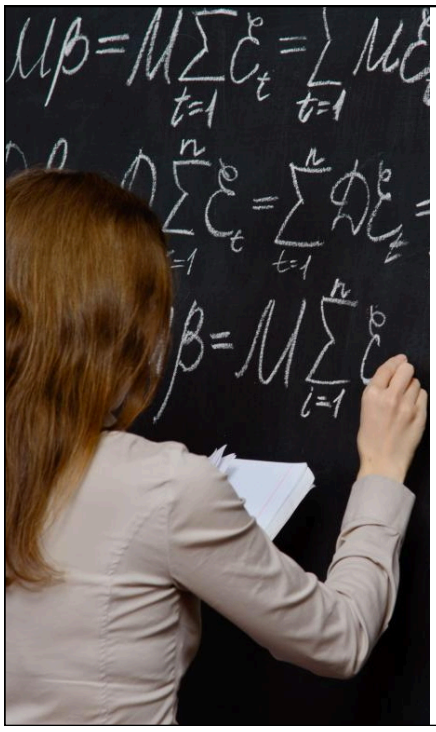
October 17, 2016 Physics 131 Prof. E. F. Redish

- **Theme Music:** U2
  ***Electric Storm***
- **Cartoon:** Pat Brady
  ***Rose is Rose***

**The Equation of the Day**

Electric Field

$$\vec{E} = \vec{F}_q / q$$

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**Physics 131**

## Foothold ideas: Charge – A hidden property of matter

- Matter is made up of two kinds of electrical matter (positive and negative) that usually cancel very precisely.
- Like charges repel, unlike charges attract.
- Bringing an unbalanced charge up to neutral matter polarizes it, so both kinds of charge attract neutral matter
- The total amount of charge (pos – neg) is constant.



## Foothold ideas: Conductors and Insulators

- Insulators
  - In some matter, the charges they contain are bound and cannot move around freely.
  - Excess charge put onto this kind of matter tends to just sit there (like spreading peanut butter).
- Conductors
  - In some matter, charges in it can move around throughout the object.
  - Excess charge put onto this kind of matter redistributes itself or flows off (if there is a conducting path to ground).

# Making Sense of Coulomb's Law

- Changing the test charge
- Changing the source charge
- Changing the distance
- Specifying the direction
- Interpret the sign

$$\vec{F}_{Q\to q} = -\vec{F}_{q\to Q} = \frac{k_C qQ}{R^2}\hat{r}_{Q\to q}$$

?? Which is the test charge and which is the source charge??



# Adding forces for many charges!

$$\vec{F}_q = \vec{F}_{Q_1\to q} + \vec{F}_{Q_2\to q} + \vec{F}_{Q_3\to q} + \vec{F}_{Q_4\to q} + \ldots$$

$$\vec{F}_q = \frac{k_C qQ_1}{r_1^2}\hat{r}_1 + \frac{k_C qQ_2}{r_2^2}\hat{r}_2 + \frac{k_C qQ_3}{r_3^2}\hat{r}_3 + \frac{k_C qQ_4}{r_4^2}\hat{r}_4 + \ldots$$

where

$r_1$ = distance from $Q_1$ to $q$ $\quad$ $\hat{r}_1$ = direction from $Q_1$ to $q$ (mag. 1, no units!)

$r_2$ = distance from $Q_2$ to $q$ $\quad$ $\hat{r}_2$ = direction from $Q_2$ to $q$ (mag. 1, no units!)

...

# Review of Vectors (2-dimensional coordinates)

- We 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 force vector is written

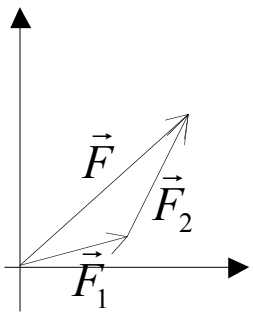
$$\vec{F} = F_x\hat{i} + F_y\hat{j} = (F_x, F_y)$$



# Adding Forces

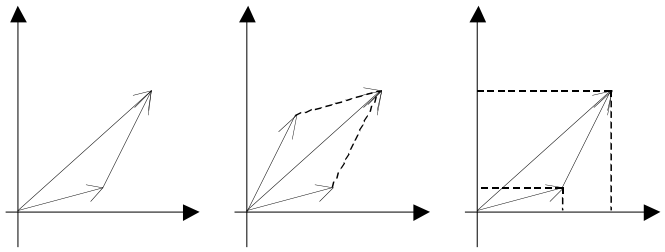
- We define the sum of two vectors as if they were successive displacements.

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



# Adding Vectors: Methods

- There are 3 mathematical ways to add vectors

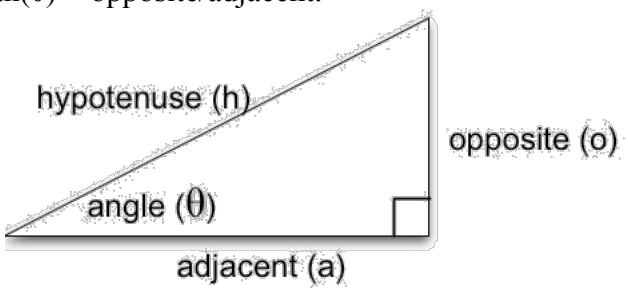


head to tail | parallelogram rule | add components (may use trig)



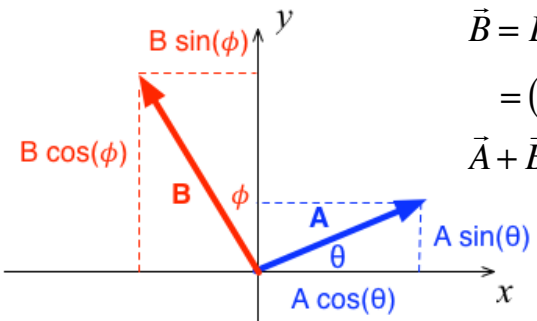
# Trig review

- The ratios of a triangle's sides only depend on θ.
  - sin(θ) = opposite/hypotenuse
  - cos(θ) = adjacent/hypotenuse
  - tan(θ) = opposite/adjacent.



# Vectors with trig – by components

$$\vec{A} = A_x\hat{i} + A_y\hat{j}$$
$$= \left(A\cos(\theta)\right)\hat{i} + \left(A\sin(\theta)\right)\hat{j}$$
$$\vec{B} = B_x\hat{i} + B_y\hat{j}$$
$$= \left(-B\sin(\phi)\right)\hat{i} + \left(B\cos(\phi)\right)\hat{j}$$
$$\vec{A} + \vec{B} = ?$$

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