Sign up with MasteringPhysics.com using the code in the syllabus.

Two preliminary assignments are due soon.

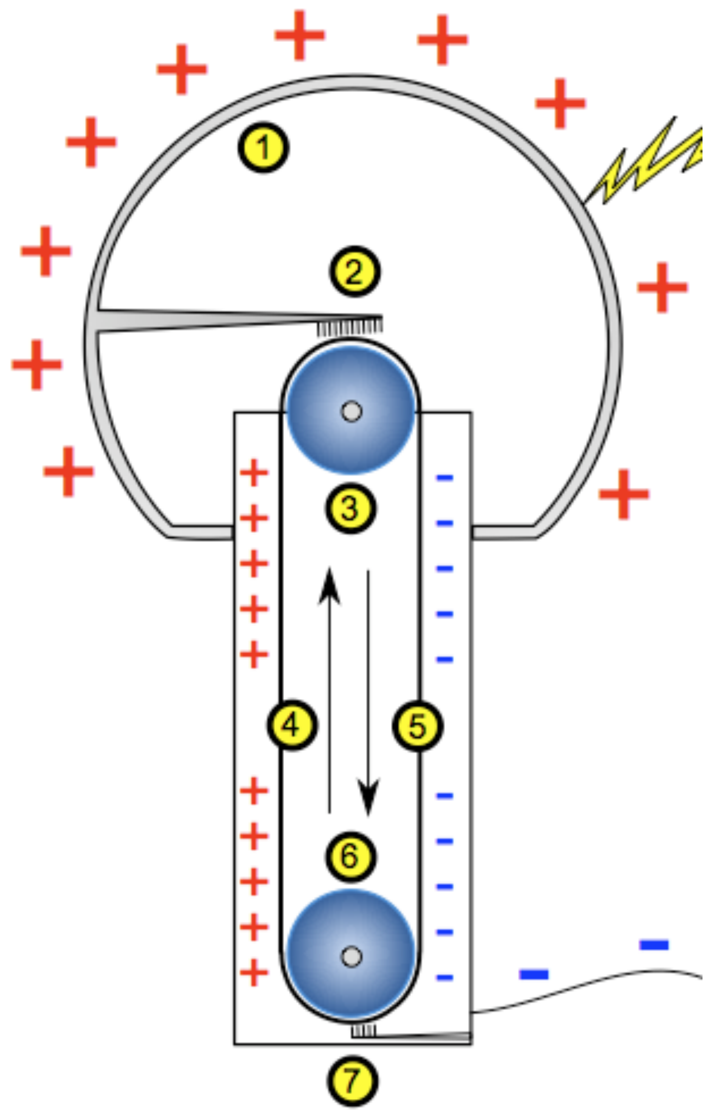
The first graded assignment (Homework #1) due next week.

All Charged Up!

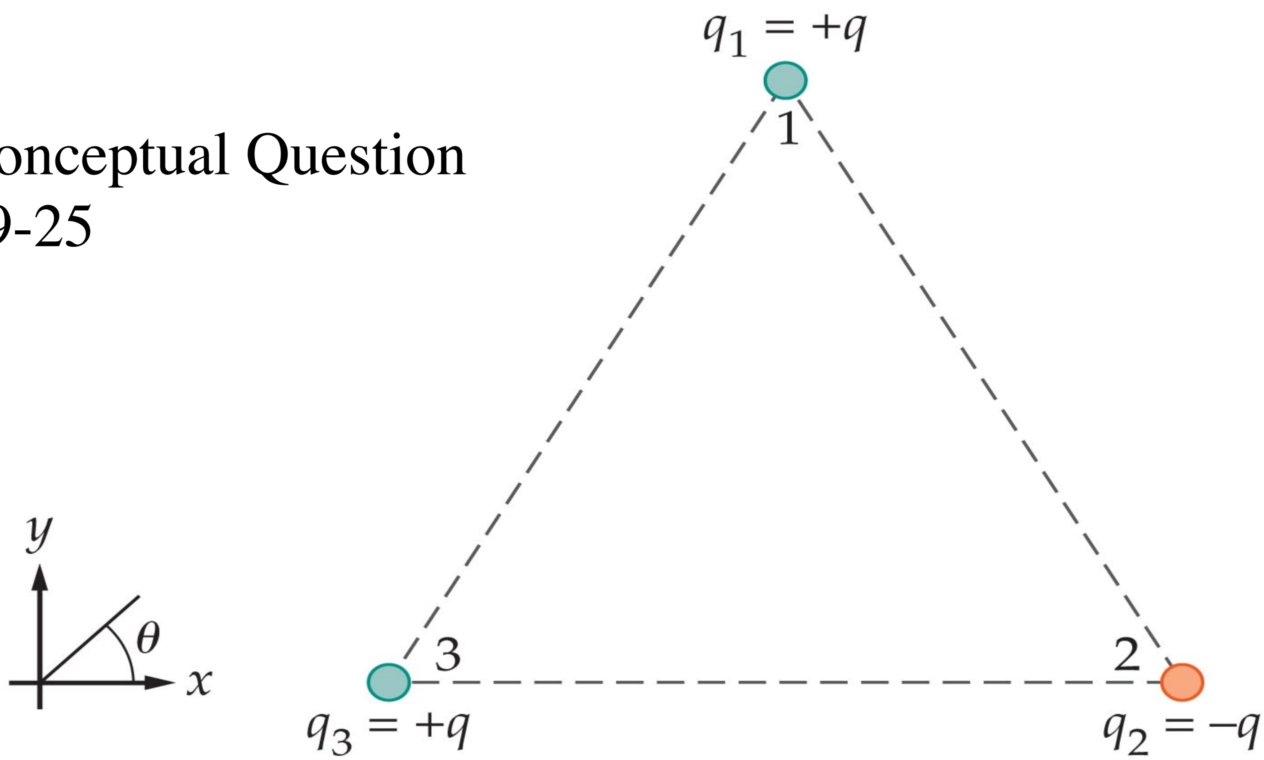
A Van de Graaff generator is a machine that places large electric charge on a sphere.

Like charges on the sphere, move away from each other.

But they are attracted to opposite charges (on a small ball), and can discharge, or arc, through the air, creating a spark.



Conceptual Question
19-25



What is the *Direction* of the **net force** on charge q_1?

What is the *Direction* of the net force on charge q_2?
What is the *Direction* of the net force on charge q_3?

Adding Vectors

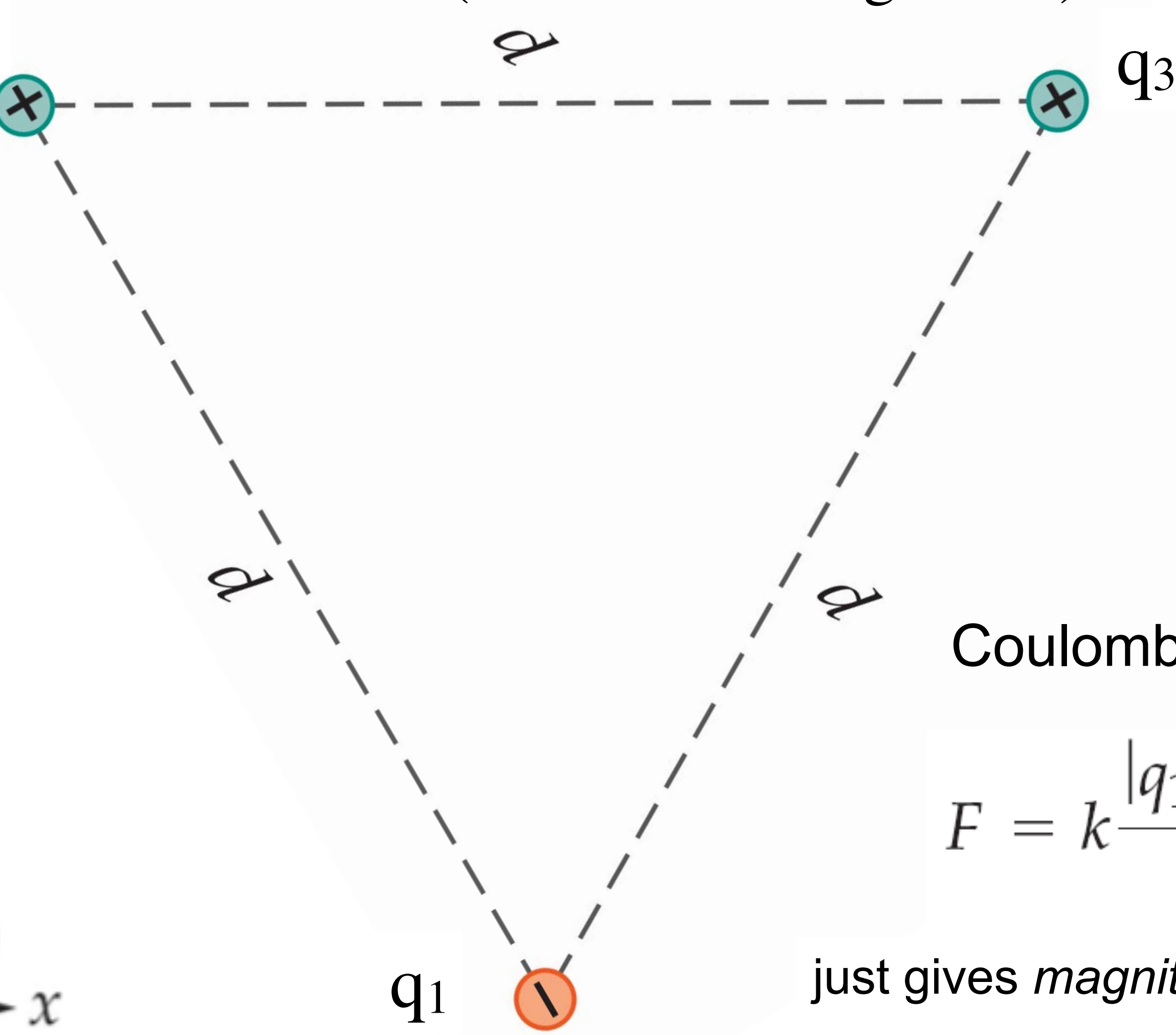
To add vectors graphically, place them head to tail.

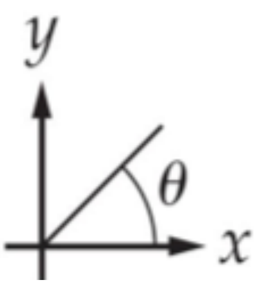
To add vectors numerically, add their x and y components ***separately***.

Note: variables appearing in bold (eg. **F**) are vectors!

Example

If $q_3 = q_2$, what is the Net Force on q_1 ?
(direction & magnitude)

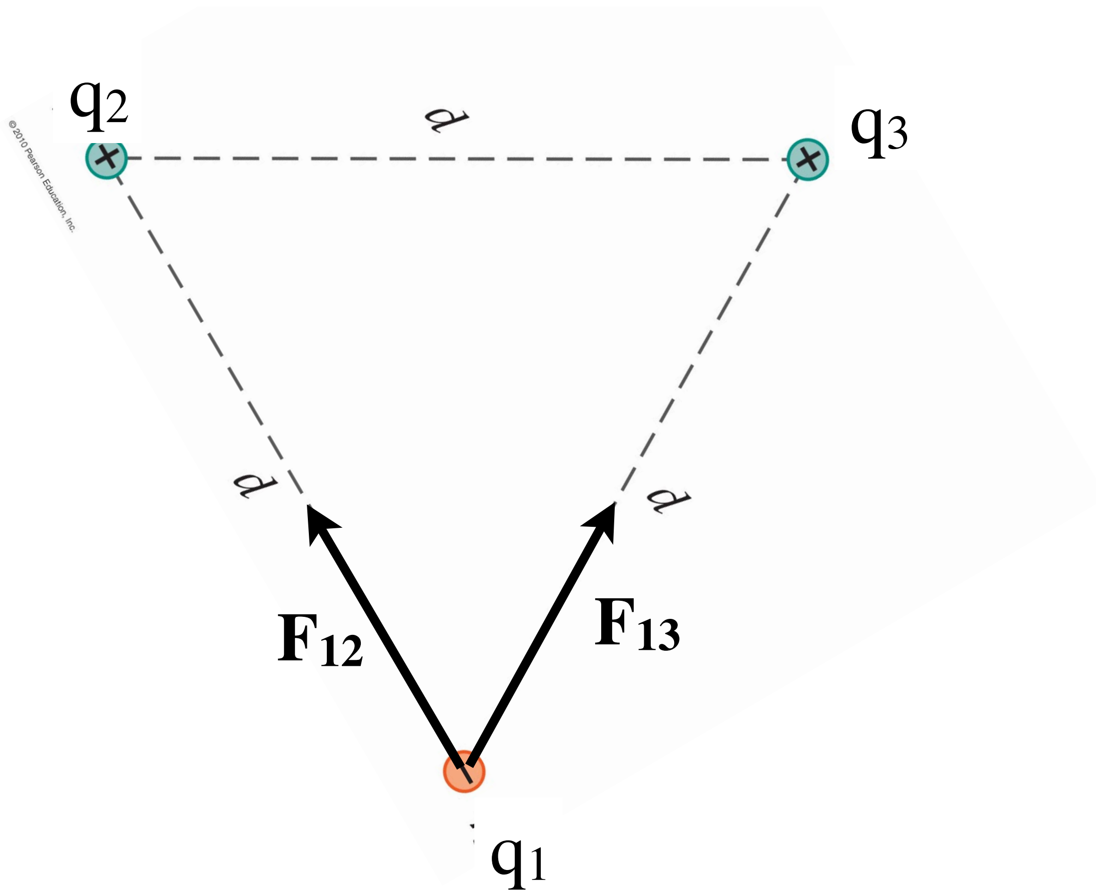




Coulomb's Law

$$F = k\frac{|q_1||q_2|}{r^2}$$

just gives *magnitudes*...



q_2
q_3
d
d
d
$\mathbf{F}_{12}$
$\mathbf{F}_{13}$
q_1
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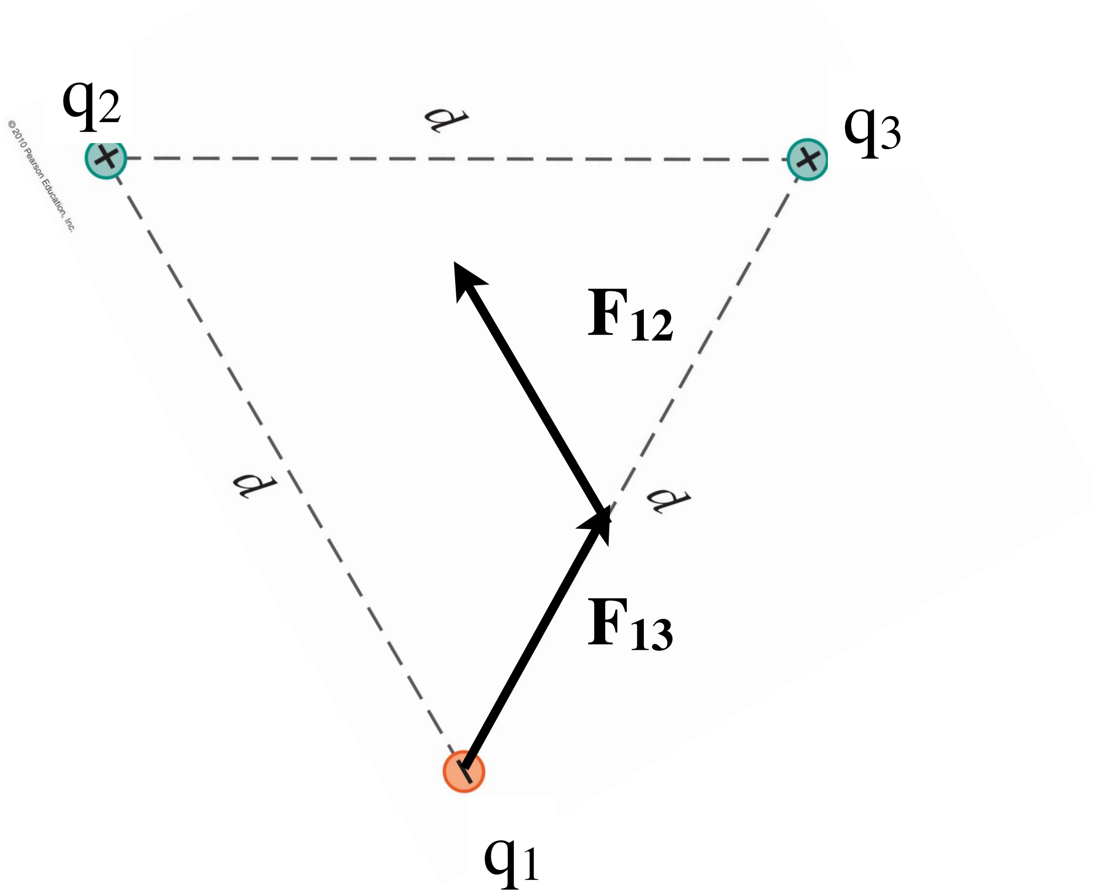
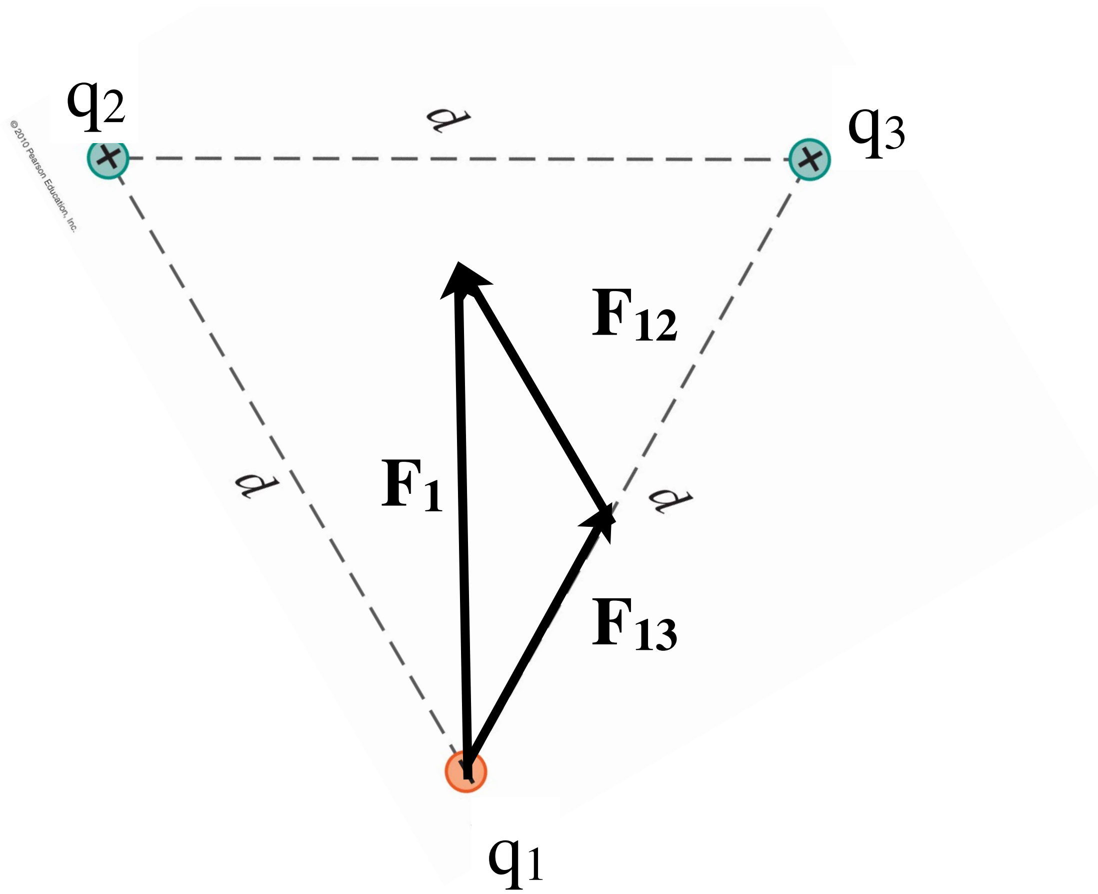


What is the *Net Force* on q_1 ?


q2
d
q3
© 2010 Pearson Education, Inc.
F12
F1
d
d
F13
q1

Adding Vector Components

The Net Force ($\mathbf{F_1}$) on q_1 is the vector sum of the forces due to charges 2 & 3:

$$\mathbf{F_1} = \mathbf{F_{12}} + \mathbf{F_{13}}$$

WARNING: This is a vector equation.

So it is really three equations!!!

$$F_{1,x} = F_{12,x} + F_{13,x}$$
$$F_{1,y} = F_{12,y} + F_{13,y}$$
~~$F_{1,z} = F_{12,z} + F_{13,z}$~~

Our Goal: Find each of these components & add them.

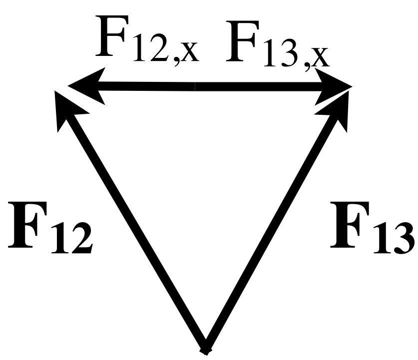
board

Force Components

The force components ($F_{12,x}$ $F_{12,y}$ $F_{13,y}$ $F_{13,x}$) are projections of the vectors $\mathbf{F_{12}}$ & $\mathbf{F_{13}}$ onto the x and y axes.

The *magnitudes* F_{12} & F_{13} are given by Coulomb's Law.

(Here they are equal *since the charges are equal:* $q_3 = q_2$)



The x-components are of opposite sign, and so cancel when we add them:

$$F_{1,x} = F_{12,x} + F_{13,x}$$
$$= F_{12,x} - F_{12,x} = 0$$

The y-components are of the same sign and magnitude: ($F_{12,y} = F_{13,y}$) . So their sum is just double:

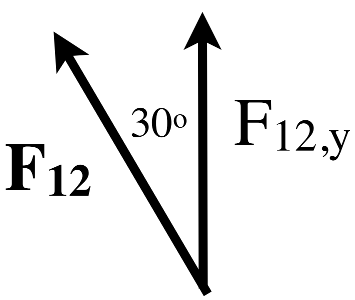
$$F_{1,y} = F_{12,y} + F_{13,y} = 2\ F_{12,y}$$

The entire force is in the y direction and has a value of twice the value of $F_{12,y}$.

$$\mathbf{F_1} = 2\, F_{12,y}\, \hat{\mathbf{y}}$$

($\hat{\mathbf{y}}$ =y unit vector)

Now we only need to find: $F_{12,y}$ (the y-component of F_{12})
--We already have F_{12} from Coulomb's Law--
F_{12} is the hypotenuse of a 30^o triangle.



$F_{12,y} = F_{12} \cos(30^o)$.

So:

$$\mathbf{F_1} = 2 \times F_{12} \cos(30^o)\, \hat{\mathbf{y}} = 1.7\, F_{12}\, \hat{\mathbf{y}}$$

Solution:

The force on particle 1 ($\mathbf{F_1}$):

Has a magnitude: $1.73\ k\ q_1\ q_2/d^2$

And a direction of: 90 degrees from the x-axis
(0 degrees from the positive y-axis)

This force determines how the particle will move.

Key concept:

To get the net force vector, add x- and y- components separately.