Lecture-1

Coulombs law and field intensity,
Electric field due to charge distribution,

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Coulomb's Law

Coulomb's law quantifies the magnitude of the electrostatic force.

Coulomb's law gives the force (in Newtons) between charges q_1 and q_2, where r_{12} is the distance in meters between the charges, and $k=9x10^9$ $N \cdot m^2/C^2$.

$$F_{12} = k\frac{|q_1 q_2|}{r_{12}^2}$$

Force is a vector quantity. The equation on the previous slide gives the magnitude of the force. If the charges are opposite in sign, the force is attractive; if the charges are the same in sign, the force is repulsive. Also, the constant k is equal to $1/4\pi\varepsilon_0$, where $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$.

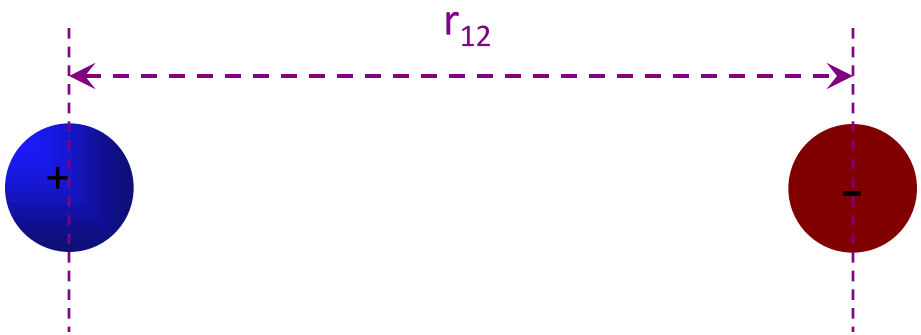
One could write Coulomb's Law like this…

$$\vec{F}_{12} = k\frac{|q_1 q_2|}{r_{12}^2},$$ attractive for unlike

To make this into a "really good" starting equation I should specify "repulsive for like," but that makes it too wordy. You'll just have to remember how to find the direction.

Remember, a vector has a magnitude and a direction.

The equation is valid for point charges. If the charged objects are spherical and the charge is uniformly distributed, r_{12} is the distance between the centers of the spheres.



If more than one charge is involved, the net force is the vector sum of all forces (superposition). For objects with complex shapes, you must add up all the forces acting on each separate charge (turns into calculus!).

We could have agreed that in the formula for F, the symbols $\vec{q}_1$ and q_2 stand for the **magnitudes** of the charges. In that case, the absolute value signs would be unnecessary.

However, in later equations the sign of the charge will be important, so we really need to keep the magnitude part.

On your homework diagrams, show both the magnitudes and signs of q_1 and q_2.

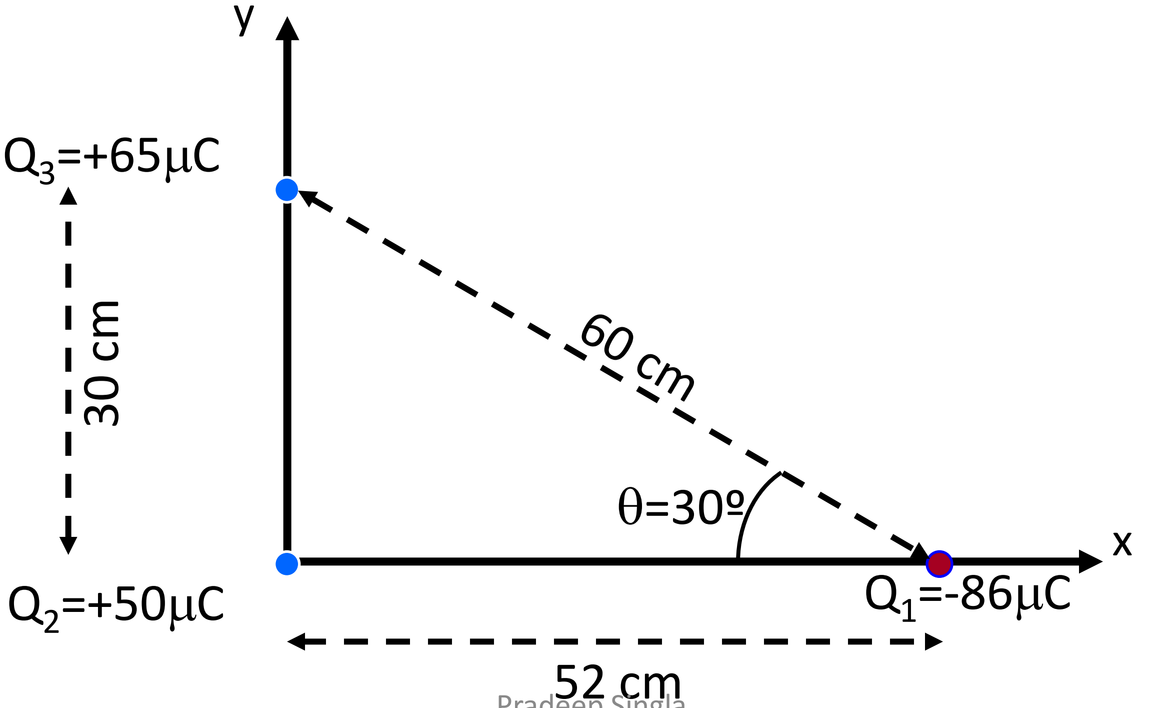
Your starting equation sheet has this version of the equation:

$$F_{12} = k\frac{|q_1 q_2|}{r_{12}^2},$$

which gives you the magnitude F_{12} and tells you that you need to figure out the direction separately.

Solving Problems Involving Coulomb's Law and Vectors

Example: Calculate the net electrostatic force on charge Q_3 due to the charges Q_1 and Q_2.



Step 0: Think!

This is a Coulomb's Law problem (all we have to work with, so far).

We only want the forces on Q_3.

Forces are additive, so we can calculate F_{32} and F_{31} and add the two.

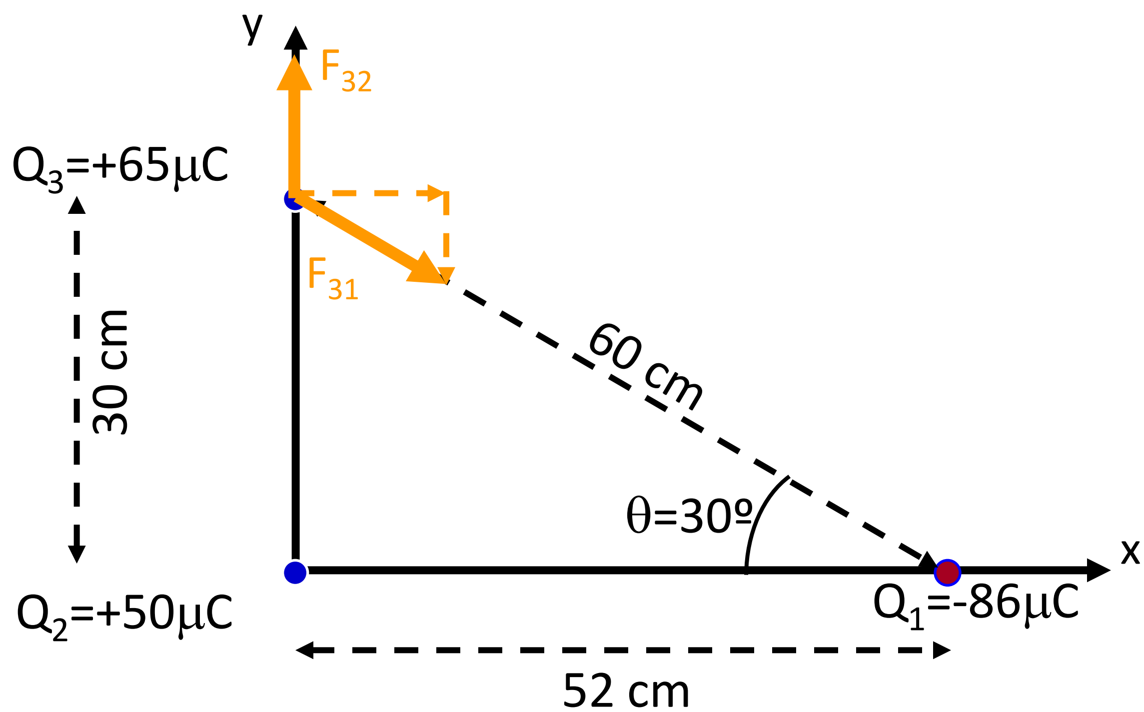
If we do our vector addition using components, we must resolve our forces into their x- and y-components.

Step 1: Diagram

Draw a representative sketch.

Draw and label relevant quantities.

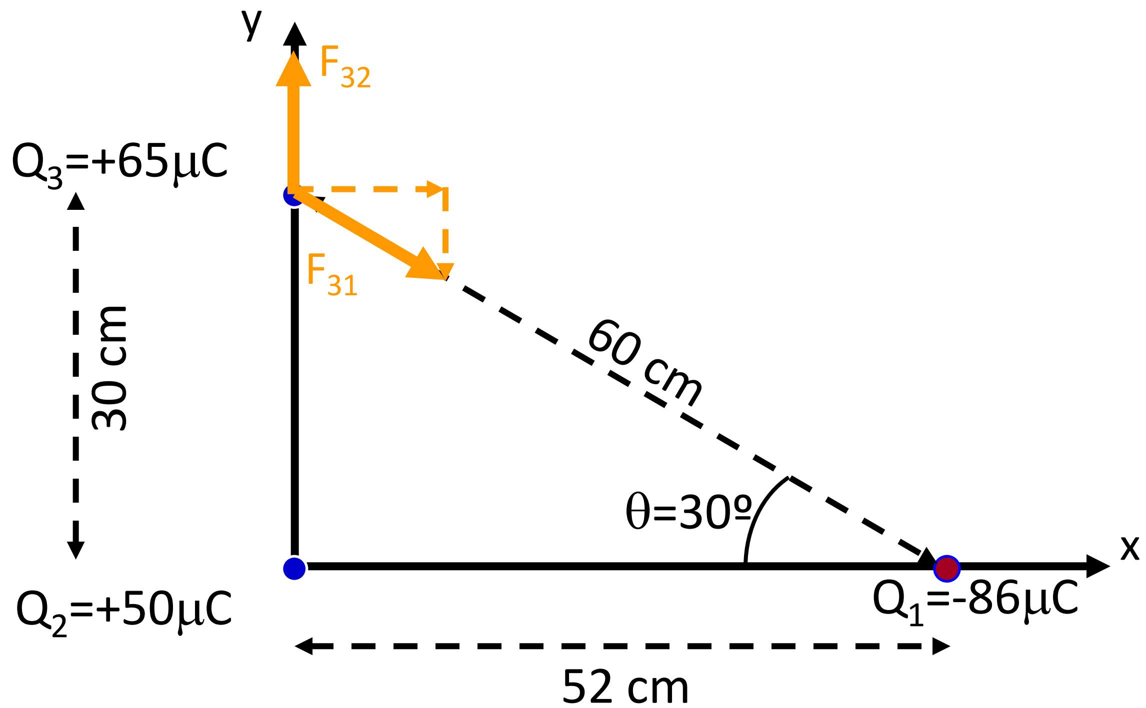
Draw axes, showing origin and directions.



Draw and label forces (only those on Q_3).

Draw components of forces which are not along axes.

Step 2: Starting Equation



$$F_{12} = k\frac{|q_1 q_2|}{r_{12}^2}$$

"Do I have to put in the absolute value signs?"

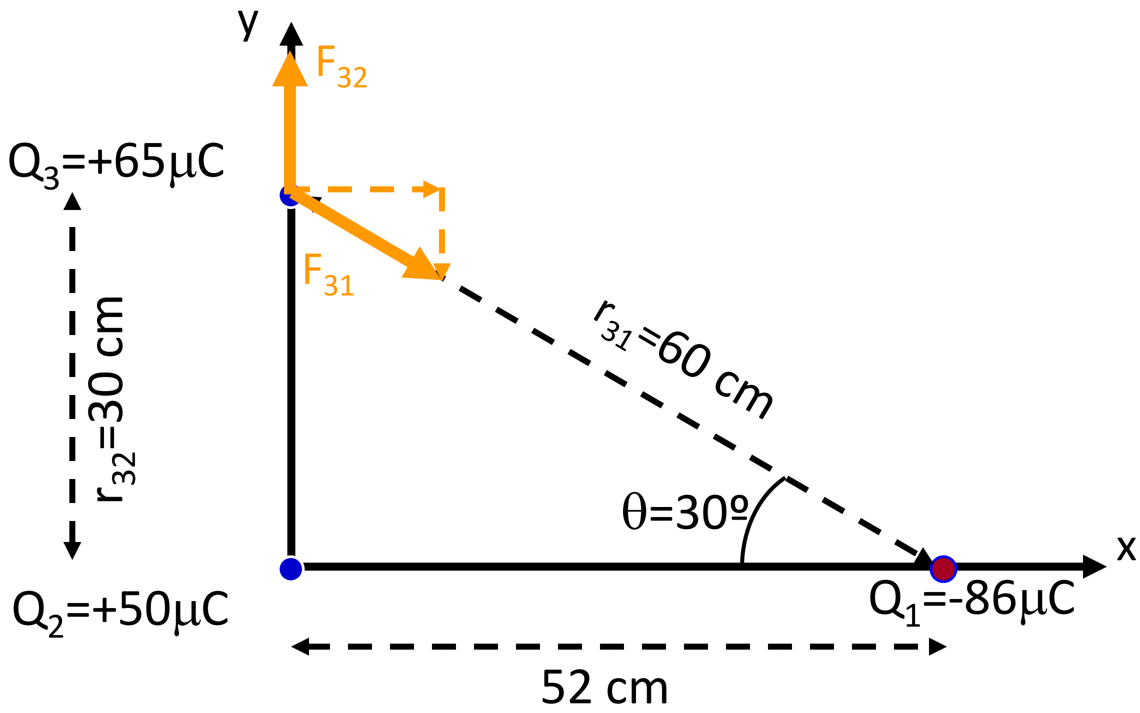
Step 3: Replace Generic Quantities by Specifics

$$\vec{F}_{32} = k\frac{|Q_3 Q_2|}{r_{32}^2},$$

repulsive

$$F_{32,y} = k\frac{|Q_3 Q_2|}{r_{32}^2}$$

$$F_{32,x} = 0$$ (from diagram)



$F_{32,y}$ = 330 N and $F_{32,x}$ = 0 N.

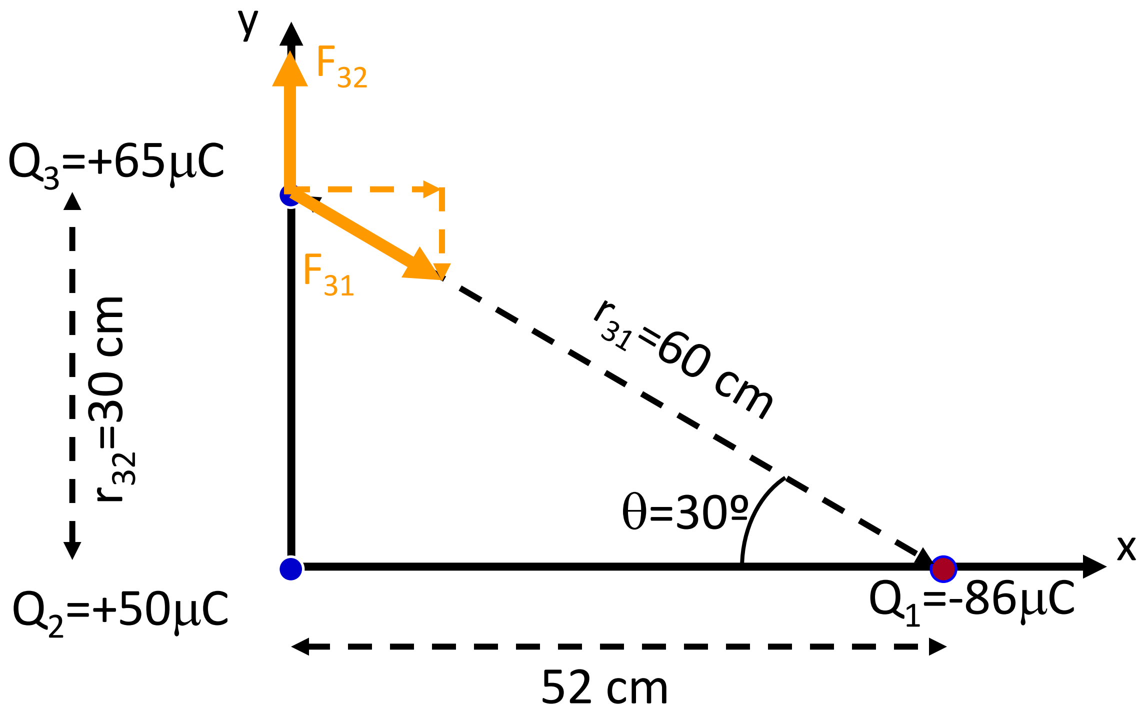
Step 3 (continued)

$$\vec{F}_{31} = k\frac{|Q_3 Q_1|}{r_{31}^2},$$

attractive

$$F_{31,x} = +k\frac{|Q_3 Q_1|}{r_{31}^2}\cos\theta$$

(+ sign comes from diagram)



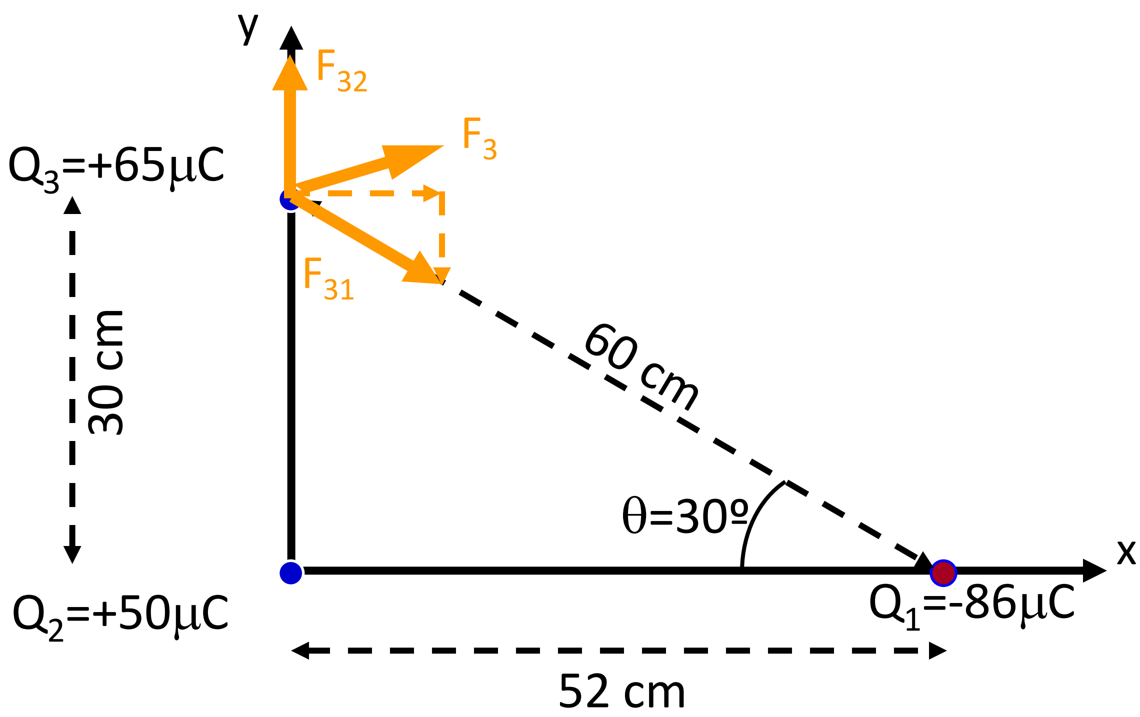
$$F_{31,y} = -k\frac{|Q_3 Q_1|}{r_{31}^2}\sin\theta$$

(- sign comes from diagram)

You would get $F_{31,x}$ = +120 N and $F_{31,y}$ = -70 N.

Step 3: Complete the Math

The net force is the vector sum of all the forces on Q_3.



$F_{3x} = F_{31,x} + F_{32,x}$ = 120 N + 0 N = 120 N

$F_{3y} = F_{31,y} + F_{32,y}$ = -70 N + 330 N = 260 N

You know how to calculate the magnitude F_3 and the angle between F_3 and the x-axis.