Phys122A-Lecture 2
Electric Field

Physics 122 Labs Sections begin on next week

Before your section meets

- Get a copy of the lab manual at the UW Bookstore!
- Read the information on page iii as it has a lot of information related to the course, the course website, WebAssign, etc.
- Get a WebAssign account (Pay by credit card only)

There are 3 components to the labs:

- Pre-Labs: Needs to be completed before each of your lab sessions begin. Pre-labs will be completed in WebAssign
- In-class Experiment: This is your lab section in which you will need your lab manual.
- Post-Labs: Completed after your lab session also on WebAssign

(Lab) Course website:

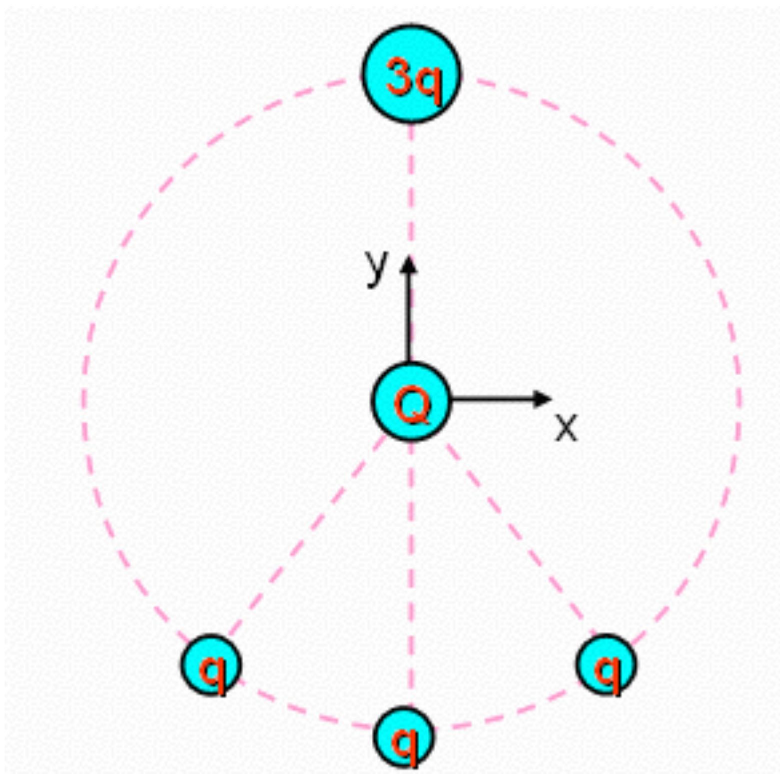
- http://courses.washington.edu/phys122z/index.php
- Please check the Frequently Asked Questions (FAQs) link before you email the Instructor!

“Reading”

Course Schedule:

Phys 122 Autumn 2016									
Week	**Day**	**Date**	**Lec#**	**Lecture topic**	**Text reading**	**FlipItPhysics**	**Tutorial**	**Labs**	
1	W	9/28/16	1	Charge & Coulomb's Law	21-1 to 21-3	1. Coulomb's law	None	None	
	Th	9/29/16		NO CLASS DAY					
	F	9/30/16	2	Electric Field Vectors & Lines	21-4 to 21-5	2. Electric Field			
2	M	10/3/16	3	Electric Fields Act on Charges	21-5 to 21-6		Charge	Electrostatics	

From FlipIt Physics

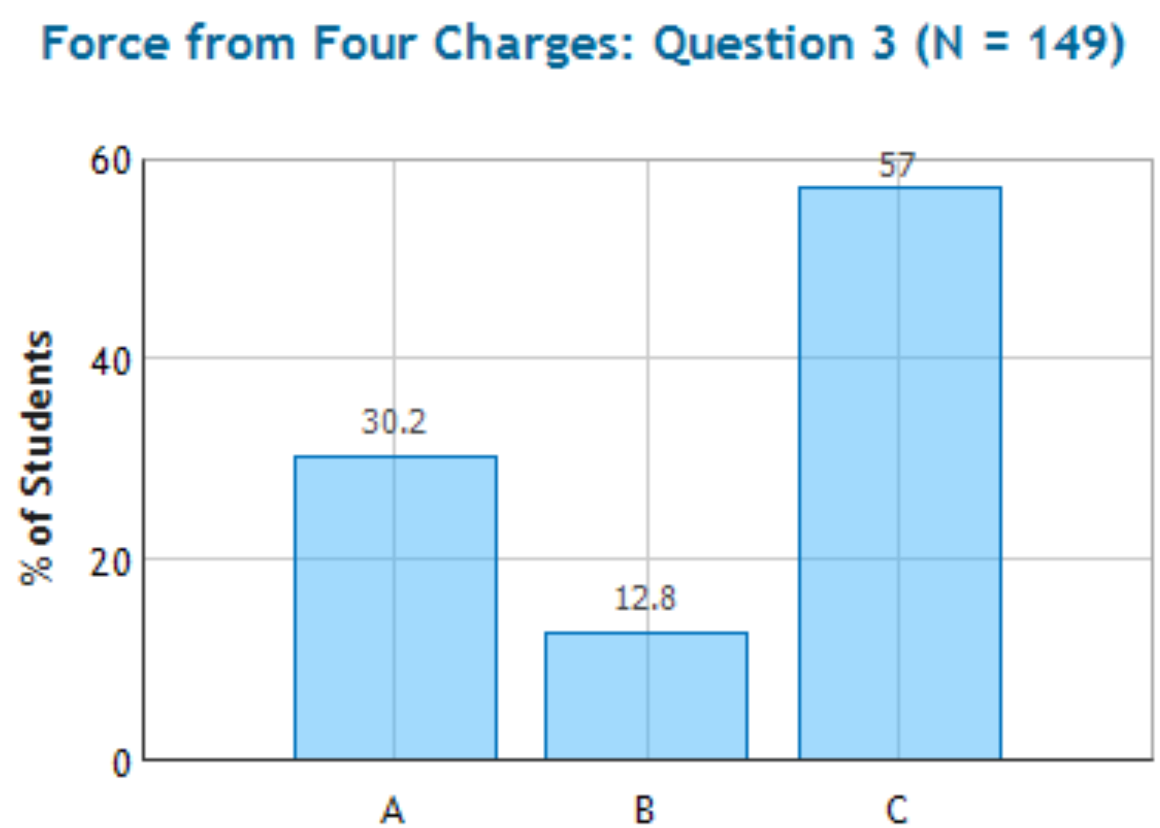


For the collection of charges shown in the above problem, which of the following statements best describes $\mathbf{F}_Y$, the y component of the net force on the charge at the origin

$\mathbf{F}_Y > 0$

$\mathbf{F}_Y = 0$

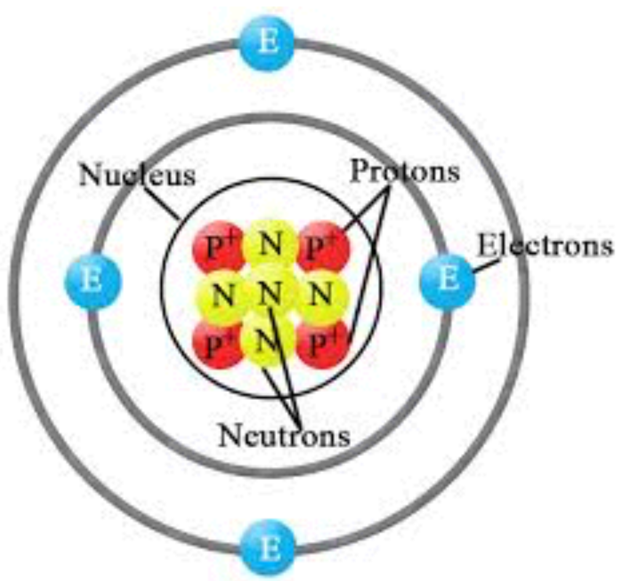
$\mathbf{F}_Y < 0$



"In Force from Four Charges it is unclear whether the angle matters."

From FlipIt Physics

- "What is charge?"
- "Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field."
- "Conserved"
- Units: [Q] = Coulomb (C)



	e	p	n
Q	-e	+e	0

$$e = 1.60217662 \times 10^{-19}\ \mathrm{C}$$

From FlipIt Physics

- “Where are you from?” Born in UK but lived here since I was 0.5 years old.
- “Don’t assign two units!” Sorry.
- Explain why force on electrons and nucleus is equal magnitude. (Newton 3rd Law.)
- Line integral wasn’t explained.

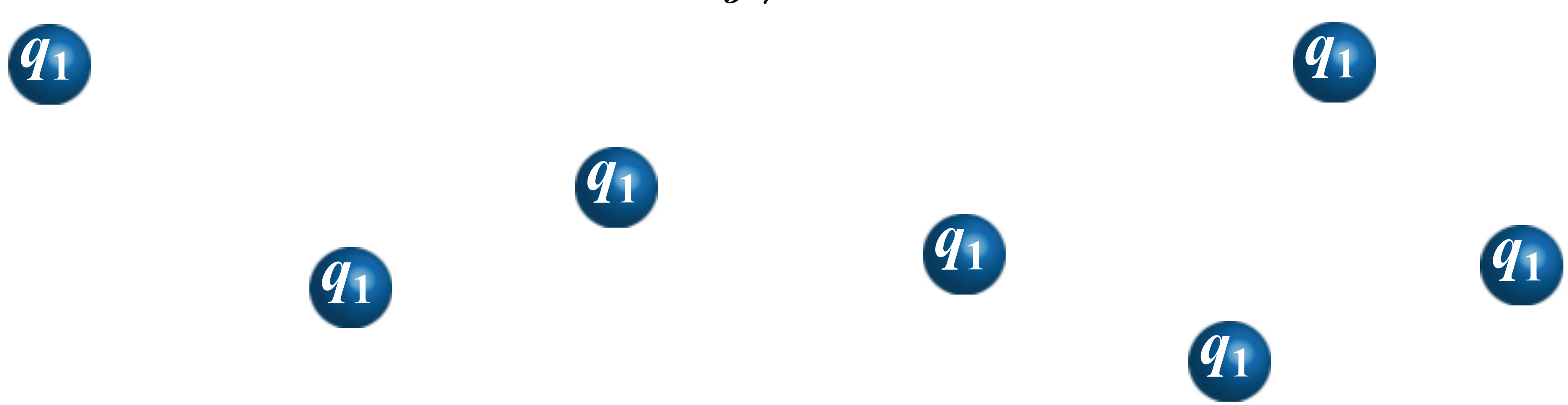
Introduction to the Electric Field…

- Coulomb Law:

$$\vec{F}_{1,2} = \frac{k \ q_1 q_2}{r_{1,2}^2} \hat{r}_{1,2}$$

- Superposition for an collection of *discrete* charges:

$$\vec{F}_{\mathrm{Net},i} = \sum_{j \neq i} \frac{k \ q_i q_j}{r_{j,i}^2} \hat{r}_{j,i}$$



Introduction to the Electric Field…

- Superposition for an collection of *discrete* charges:

$$\vec{F}_{\mathrm{Net},0} = \sum_{j\neq 0} \frac{k\ q_0 q_j}{r_{j,0}^2}\hat{r}_{j,0} = q_0 \sum_{j\neq 0} \frac{k\ q_j}{r_{j,0}^2}\hat{r}_{j,i}$$

- Define the **Electric Field** (q_0 is a test charge):

$$\vec{E} \equiv \frac{\vec{F}_{\mathrm{Net},0}}{q_0}$$

Electric field from a point charge

- **Electric Field** from a point charge (at the origin):

$$\vec{E} \equiv \frac{\vec{F}_{1,0}}{q_0} = \frac{k\,q_1}{r^2}\hat{r}$$

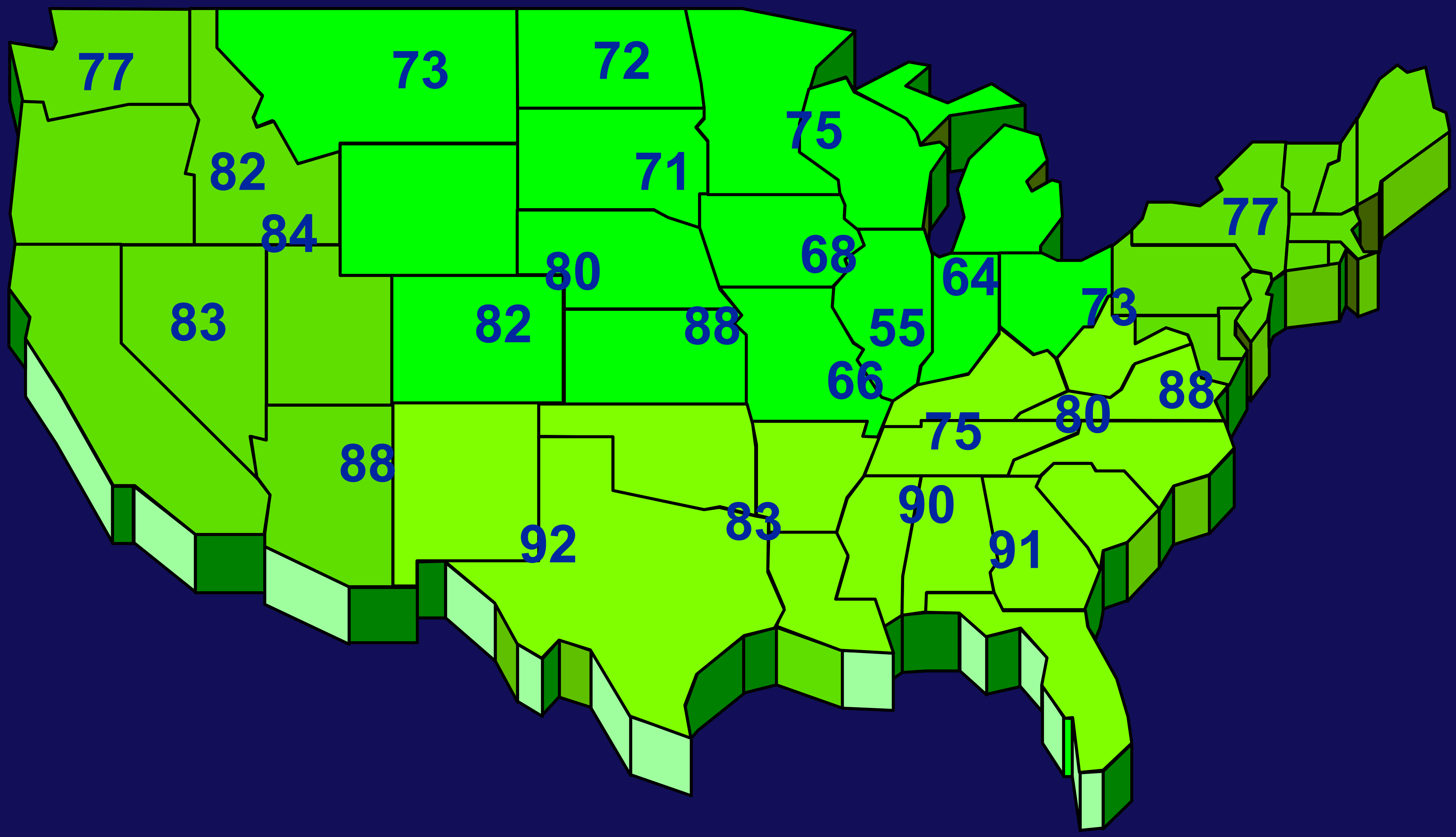
- **Electric Field** from a collection of charges:

$$\vec{E}(\vec{r}_0) = \sum_{j\neq 0} \frac{k\ \ q_j}{r_{j,0}^2}\hat{r}_{j,0}$$

What is a field?

- Scalar, vector (or tensor…) valued function of space (and time).
  - Electric Field (vector) $\vec{E}(\vec{r},t)$
  - Magnetic Field (vector) $\vec{B}(\vec{r},t)$
  - Electric Potential (scalar) $\Phi(\vec{r},t)$

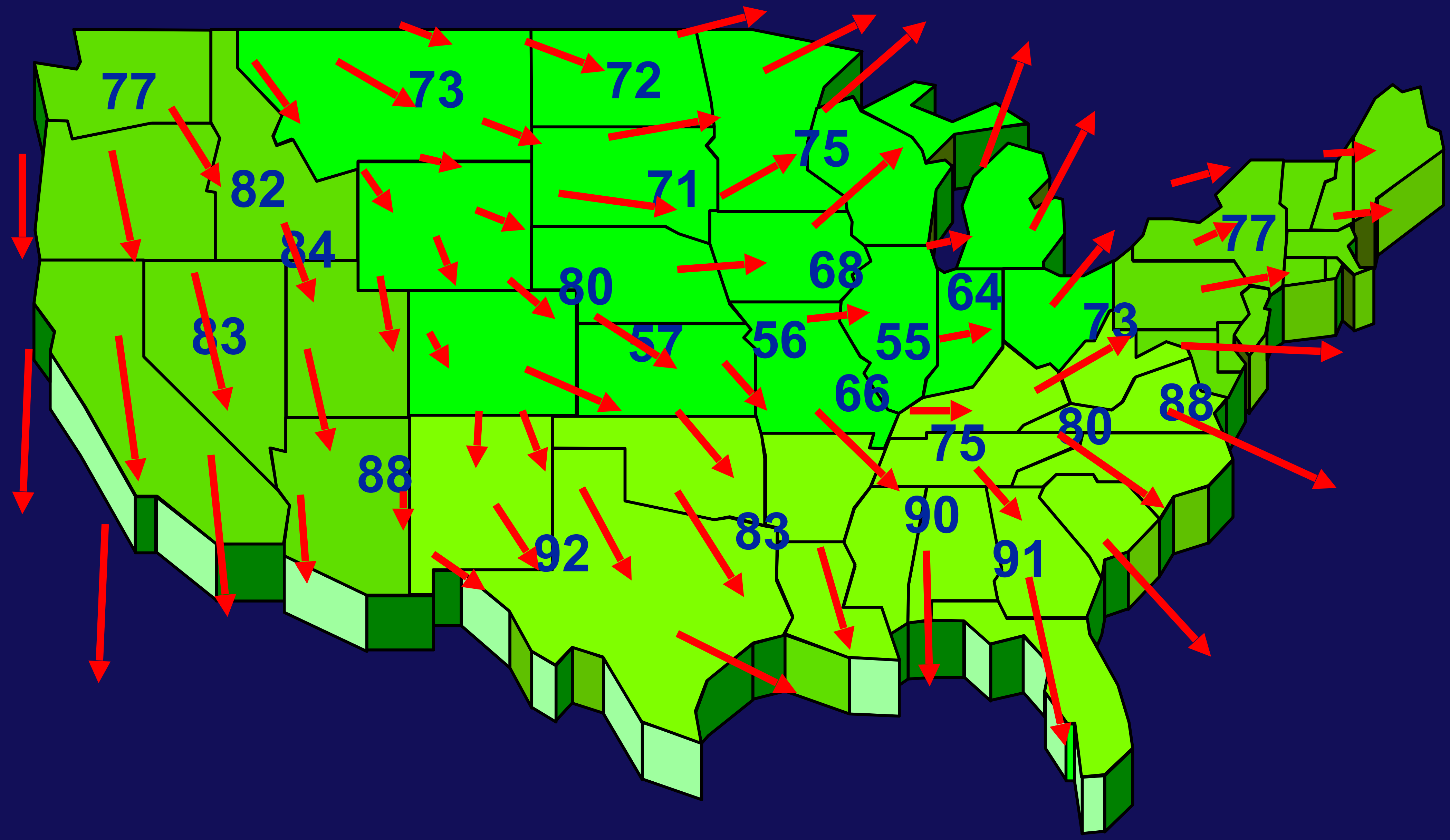
Fields of all kinds...



These isolated Temperatures make up a Scalar Field
(you learn only the temperature at a place you choose)

Fields of all kinds...

It may be more interesting to know which way the wind is blowing …



That would require a VECTOR field.

(you learn how fast the wind is blowing, AND in what direction)

Does the E field really exist?

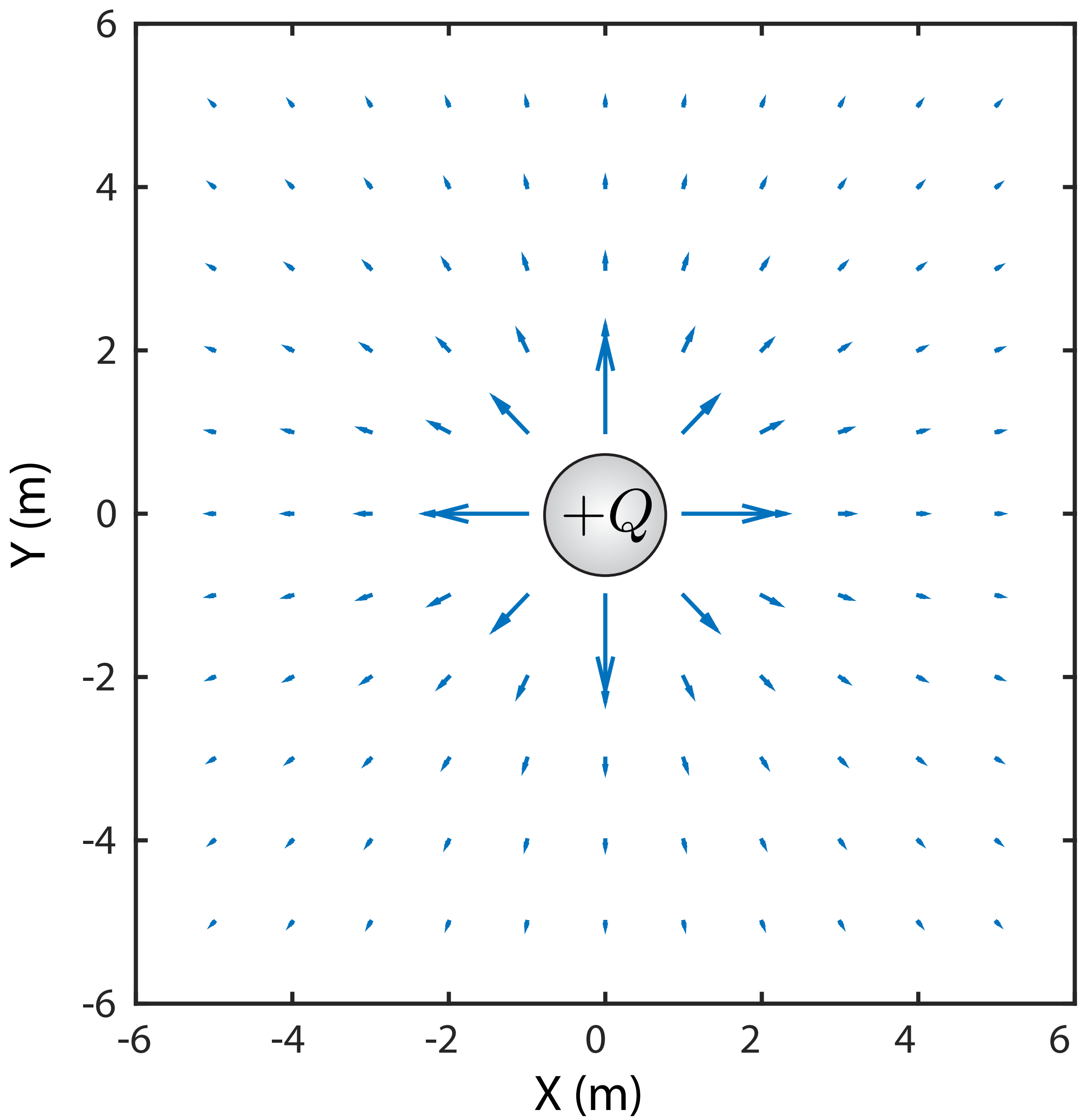
- **Computation tool** or **physical entity**?
- Two unattractive alternatives:
  - Assume E field exists at all locations in space ✔
  - *Assume action at a distance* ✘
- Useful heuristic for understanding physics:
  There is no instantaneous ***action at a distance.***

Visualizing the E field

$$\vec{E}(\vec{r}) = \frac{k\ q_1}{r^2}\hat{r}$$

- **Direction:**
  - Radial
  - Direction of the force on a positive charge
- **Amplitude:**
  - Decreases with distance

Visualizing the E field



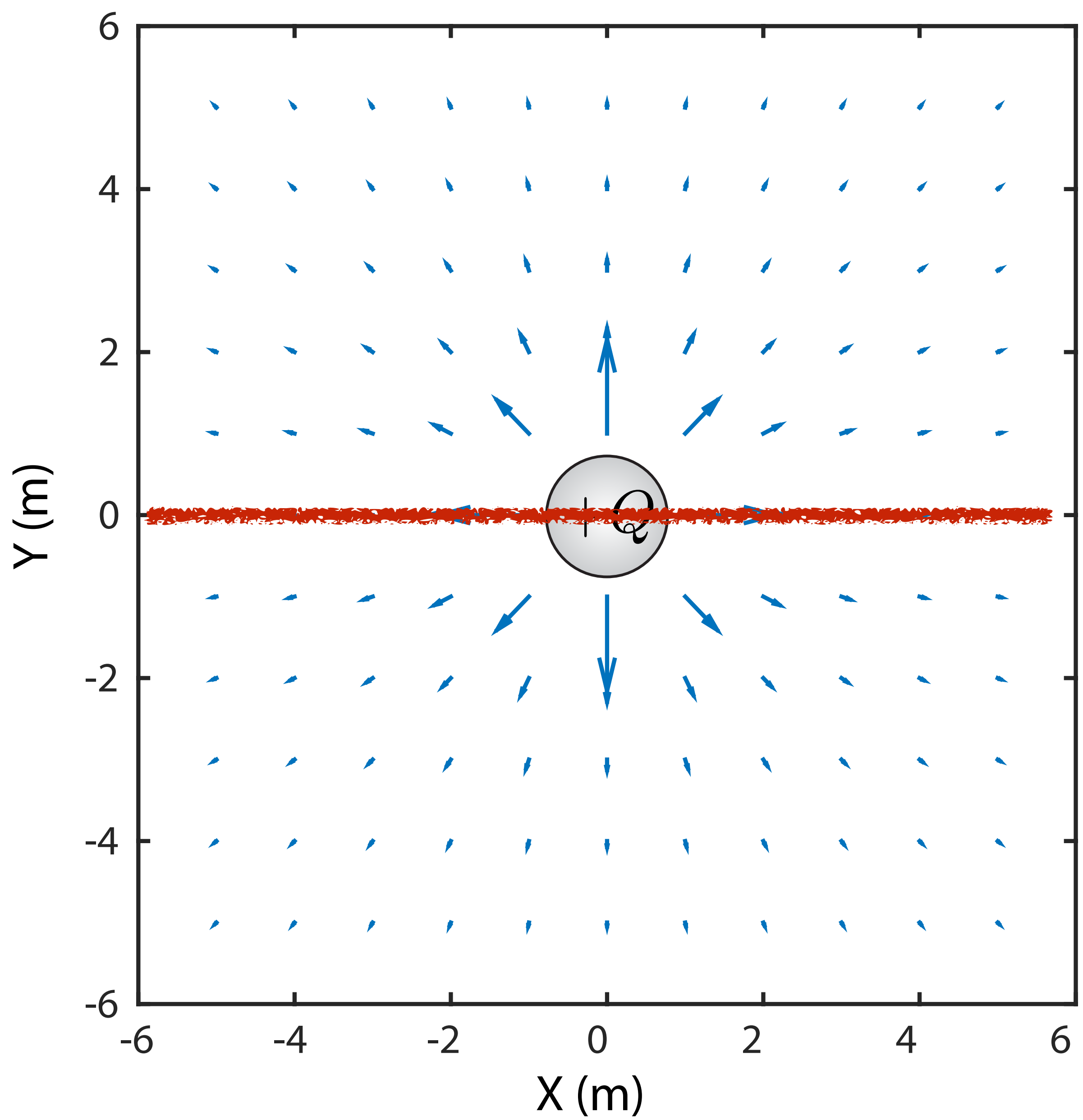
$$\vec{E}(\vec{r}) = \frac{k\ q_1}{r^2}\hat{r}$$

- “quiver” or Velocity Plot
- You almost never see the E field drawn this way!
- General tool for visualizing a vector field.

Visualizing the E field

Field lines … next time.

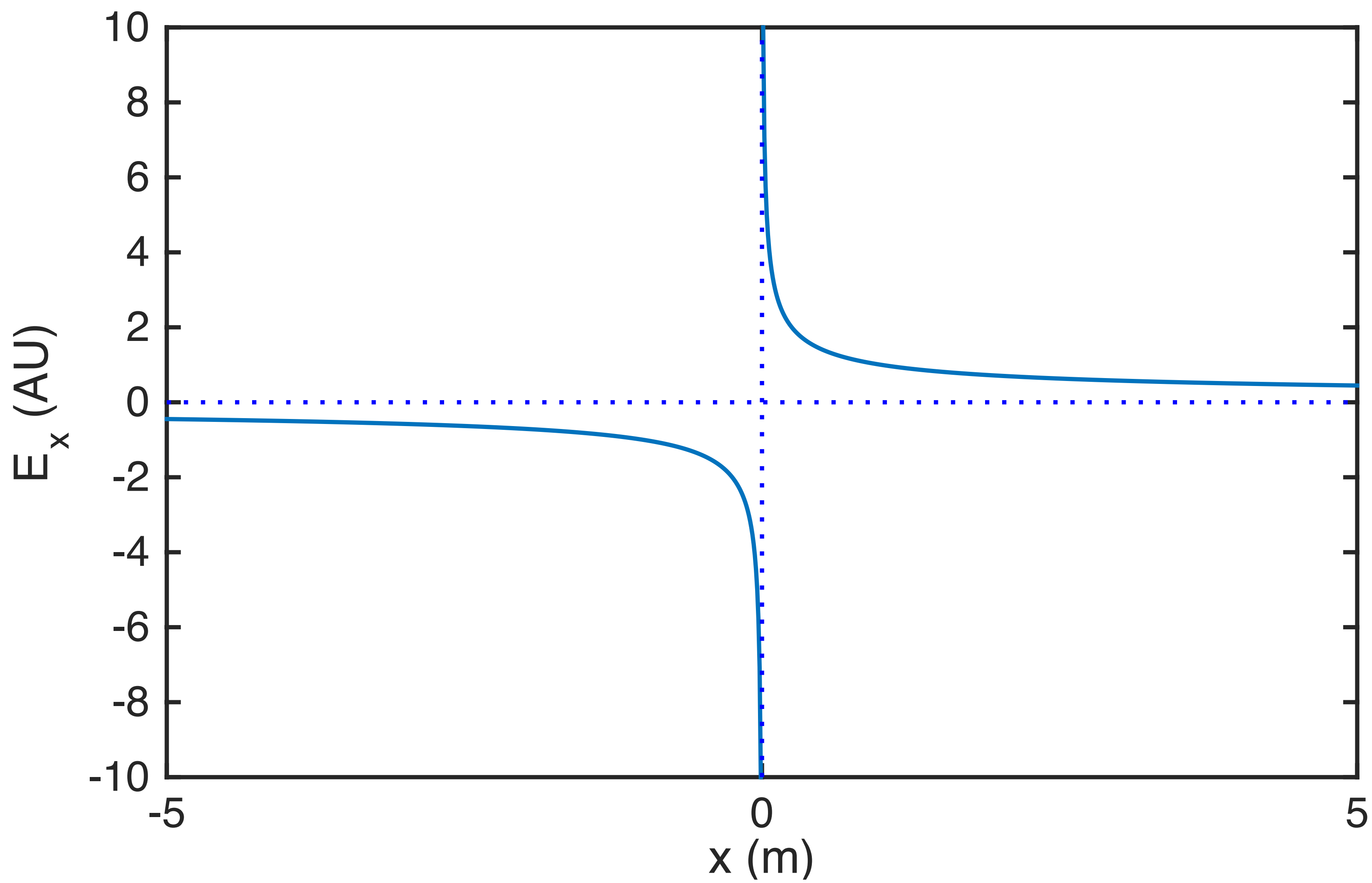
Visualizing the E field



- “quiver” or Velocity Plot
- You almost never see the E field drawn this way!
- General tool for visualizing a vector field.

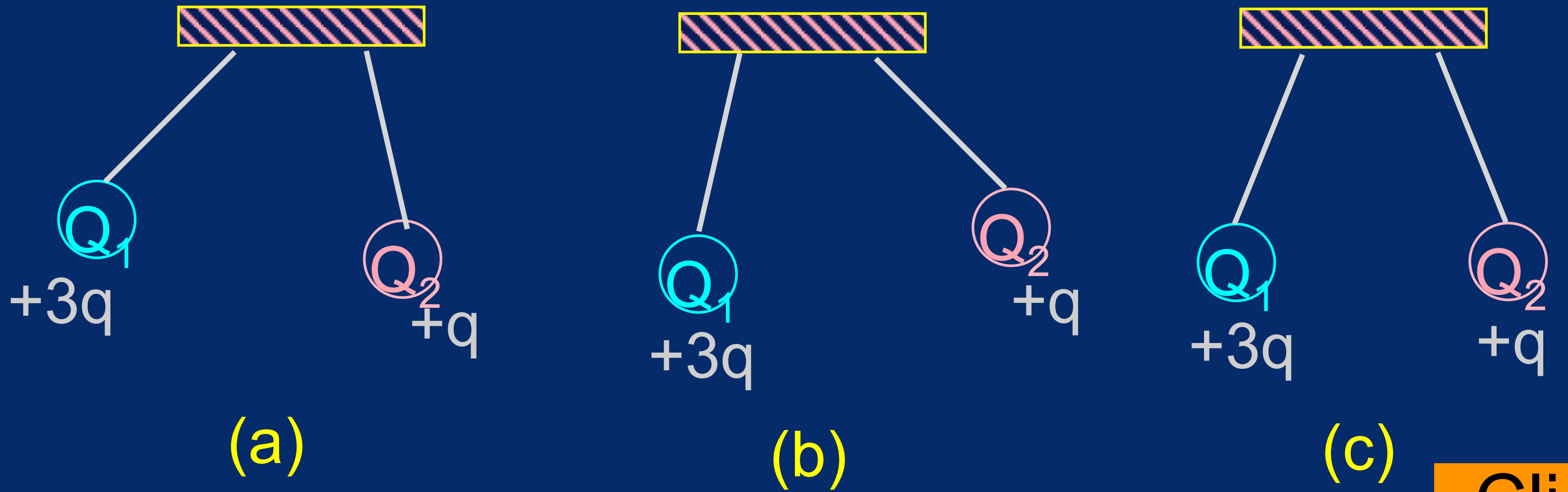
Visualizing the E field

$$\vec{E}(x,y)\Big|_{y=0} = k\ q_1 \frac{x\hat{i}}{|x|^3}$$



Two equal mass balls are suspended from the ceiling with equal length nonconducting threads as shown. Ball 1 has charge $Q_1 = +3q$ and Ball 2 has charge $Q_2 = +q$.

– Which of the following pictures best represents the equilibrium position?



Clicker 2-1

Clicker 2-2

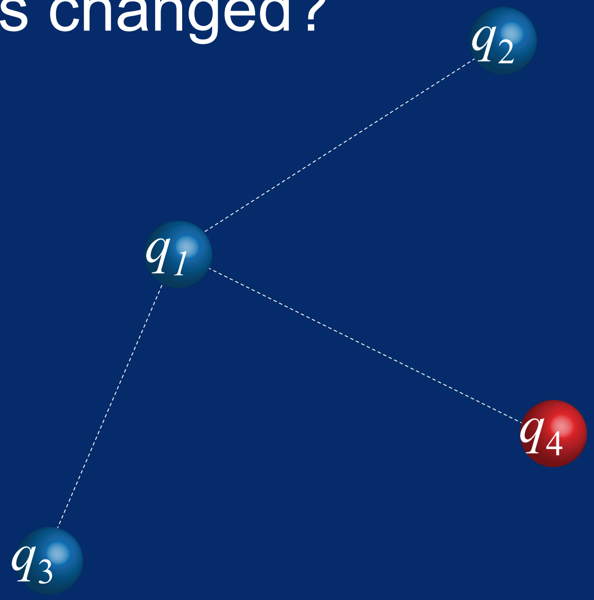
What happens to the Force on q_1 if its sign is changed?

A) $|F_1|$ increases

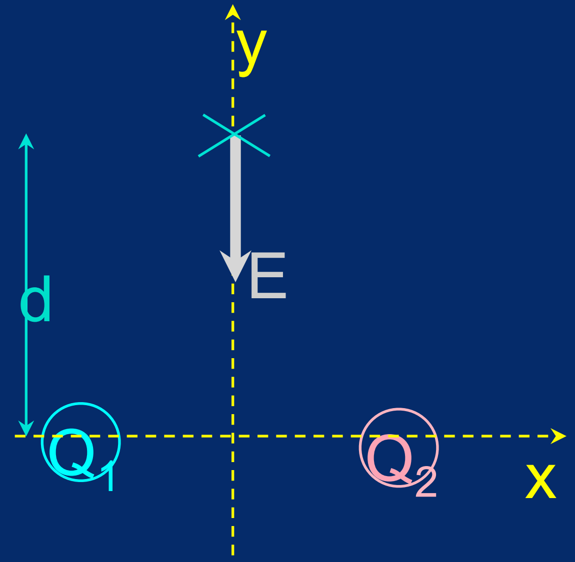
B) $|F_1|$ remains the same

C) $|F_1|$ decreases

D) Need more information to determine



- Two charges, Q_1 and Q_2 , fixed along the x-axis as shown, produce an electric field E at a point $(x,y) = (0,d)$ which is directed along the negative y-axis.
  - Which is true?



(a) Both charges Q_1 and Q_2 must be positive.

(b) Both charges Q_1 and Q_2 must be negative.

(c) The charges Q_1 and Q_2 must have opposite signs.

Clicker 2-3

- Q_1 has charge +Q
- Q_2 has charge +2Q
- They are separated by d.
- Charge q is a distance a away from Q_1

Is there a place – the value for a -- between Q_1 and Q_2 where the force on ANY charge (positive or negative) is zero?

(a) NO

(b) Yes, but I can't find it with all this time pressure.

(c) Yes and my answer is ________ from Q_1. I will volunteer to specify if you ask me

Clicker 2-4

Electric field from a point charge

- **Electric Field** from a point charge (at the origin):

$$\vec{E} \equiv \frac{\vec{F}_{1,0}}{q_0} = \frac{k\, q_1}{r^2}\hat{r}$$

- **Electric Field** from a collection of charges:

$$\vec{E}(\vec{r}_0) = \sum_{j\neq 0} \frac{k\ q_j}{r_{j,0}^2}\hat{r}_{j,0}$$

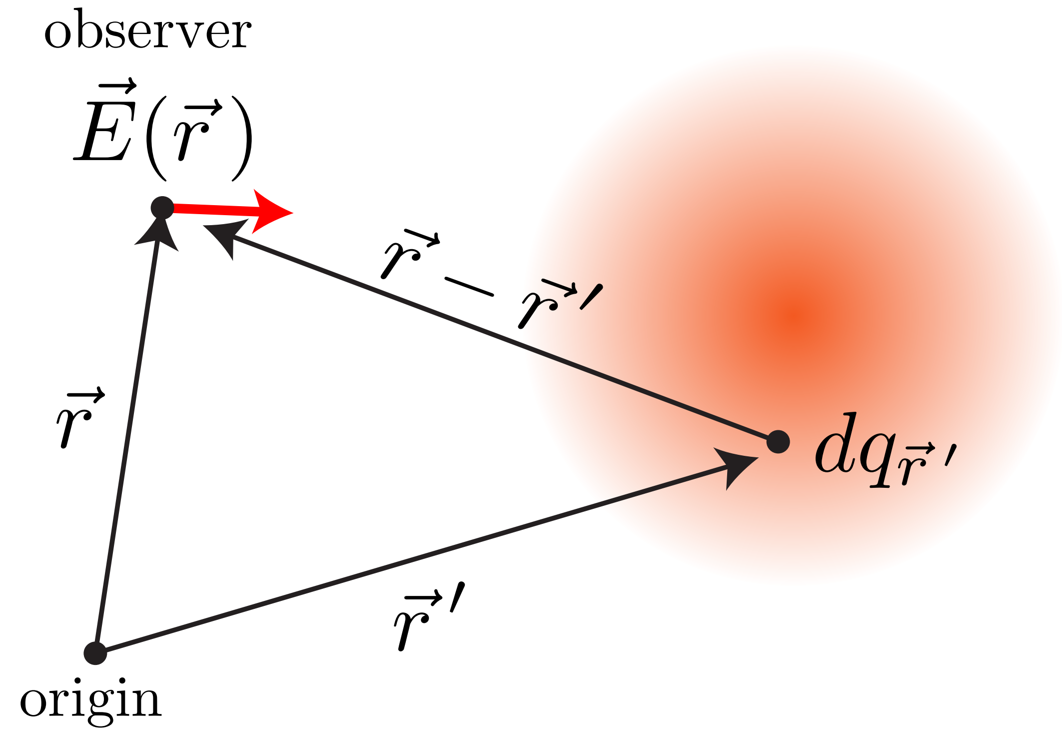
E field from a line charge

- **Electric Field** from a collection of charges:

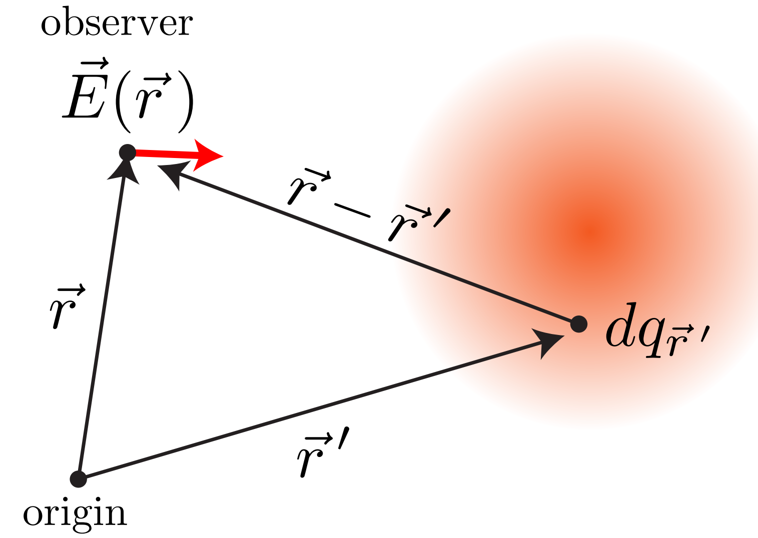
$$\vec{E}(\vec{r}_0) = \sum_{j \neq 0} \frac{k\ q_j}{r_{j,0}^2} \hat{r}_{j,0}$$

- **Electric Field** from a continuous charge distribution:

$$\vec{E}(\vec{r}) = k \int dq_{\vec{r}\,'} \ \frac{\vec{r} - \vec{r}\,'}{|\vec{r} - \vec{r}\,'|^3}$$



E field from a charge distribution



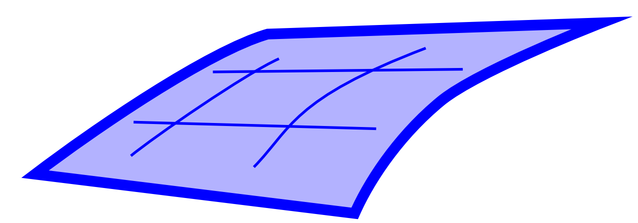
$$\vec{E}(\vec{r}) = k \int dq_{\vec{r}'} \frac{\vec{r} - \vec{r}'}{|\vec{r} - \vec{r}'|^3}$$

- **Electric Field** from a 1D source: [λ] = C/m^1

$$dq_{\vec{r}'} \to d\ell\, \lambda(\vec{r}')$$

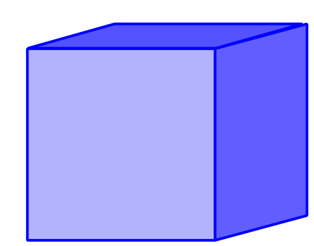
- **Electric Field** from a 2D source: [σ] = C/m^2

$$dq_{\vec{r}'} \to d^2x\, \sigma(\vec{r}')$$



- **Electric Field** from a 3D source: [ρ] = C/m^3

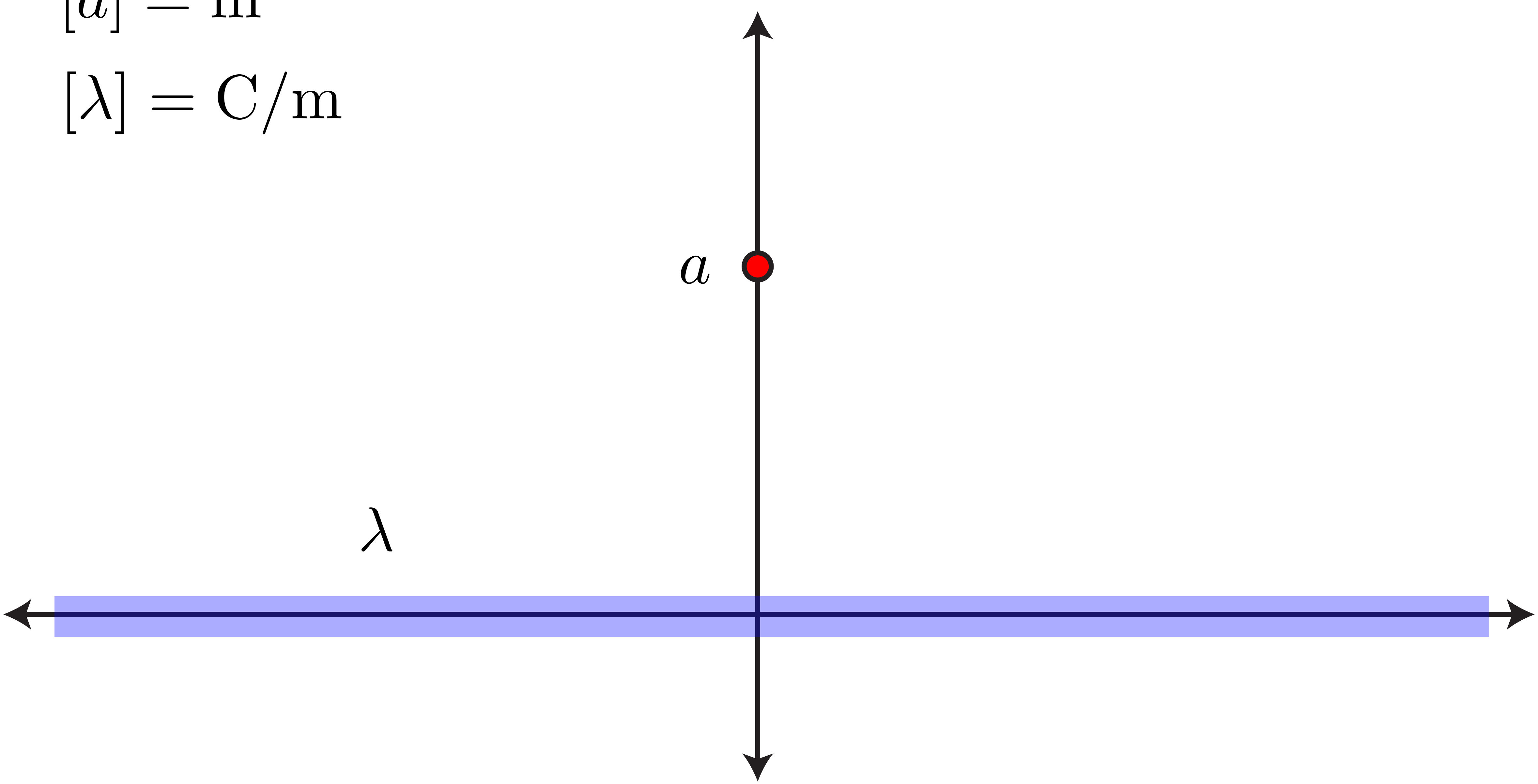
$$dq_{\vec{r}'} \to d^3x\, \rho(\vec{r}')$$



E field from a line charge

$[a] = \mathrm{m}$

$[\lambda] = \mathrm{C/m}$



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Work the integral…