April 6, 2011 Physics 122 Prof. E. F. Redish

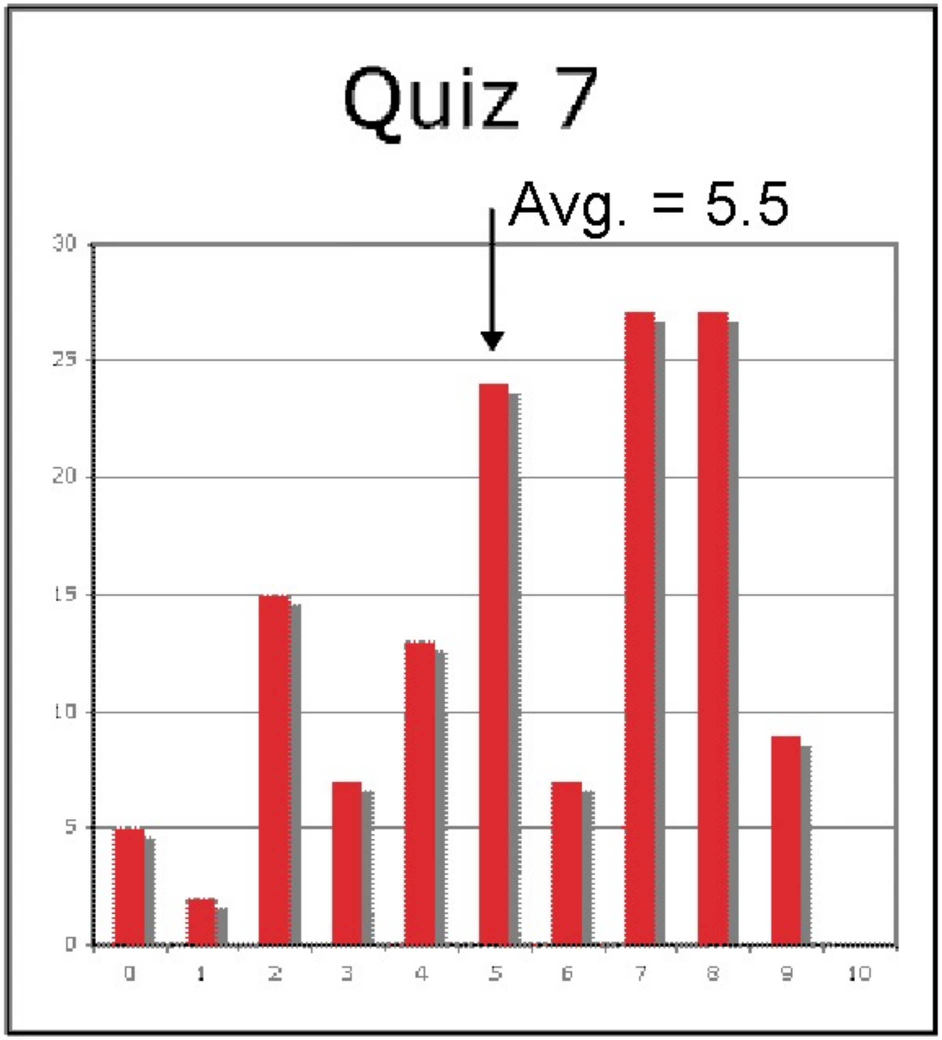
- **<u>Theme Music:</u> Human League**
  Together in Electric Dreams
- **<u>Cartoon:</u> Bill Watterson**
  Calvin & Hobbes

Outline

- Go over Quiz 7
- Fields:
  - Definition
  - Equations
  - Standard examples: points, lines, sheets
  - Multiple sheets

Quiz 7

	7.1	7.2	7.3	7.4
a	6%	3%	7%	7%
b	43%	5%	24%	72%
c	27%	18%	1%	10%
d	4%	6%	63%	3%
e	68%	1%	1%	2%
f	8%	67%	0%	0%
be				4%



In Equations

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

$$\vec{F}_q = \frac{k_C q Q_1}{r_1^2}\hat{r}_1 + \frac{k_C q Q_2}{r_2^2}\hat{r}_2 + \frac{k_C q Q_3}{r_3^2}\hat{r}_3 + \frac{k_C q Q_4}{r_4^2}\hat{r}_4 + \ldots$$

where

$r_1 =$ distance from Q_1 to q

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

$r_2 =$ distance from Q_2 to q

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

...

Making sense

- Notice that F_q/q does NOT depend on q!
- For one source charge

$$\vec{F}_q = \frac{k_C q Q_1}{r_1^2}\hat{r}_1 \qquad \vec{E}_q = \frac{\vec{F}_q}{q} = \frac{k_C Q_1}{r_1^2}\hat{r}_1$$

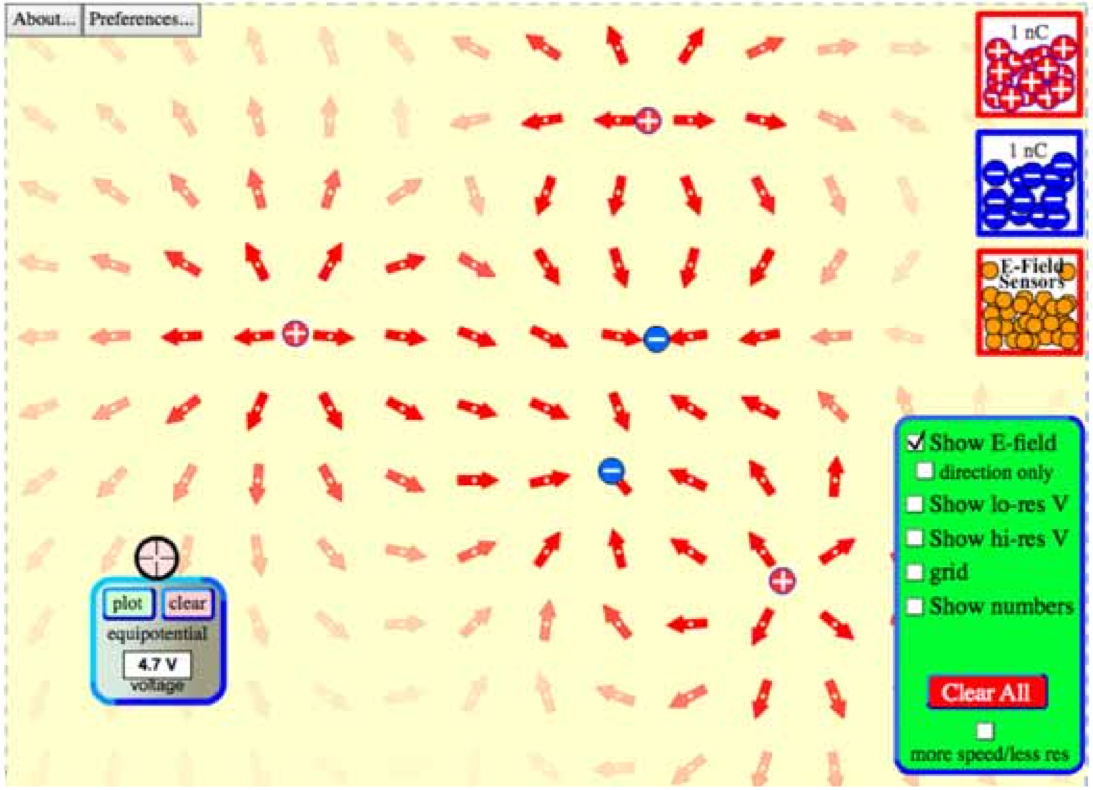
- For many sources

$$\vec{F}_q = \frac{k_C q Q_1}{r_1^2}\hat{r}_1 + \frac{k_C q Q_2}{r_2^2}\hat{r}_2 + \frac{k_C q Q_3}{r_3^2}\hat{r}_3 + \ldots \qquad \vec{E}_q = \frac{\vec{F}_q}{q} = \frac{k_C Q_1}{r_1^2}\hat{r}_1 + \frac{k_C Q_2}{r_2^2}\hat{r}_2 + \frac{k_C Q_3}{r_3^2}\hat{r}_3 + \ldots$$

- Why not? Why did I label E with a q?

Simulation

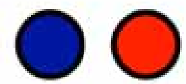
- http://phet.colorado.edu/en/simulation/charges-and-fields



Four standard examples (useful as approximate models)

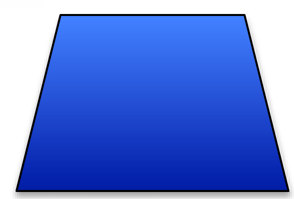
- Point charge

- Dipole



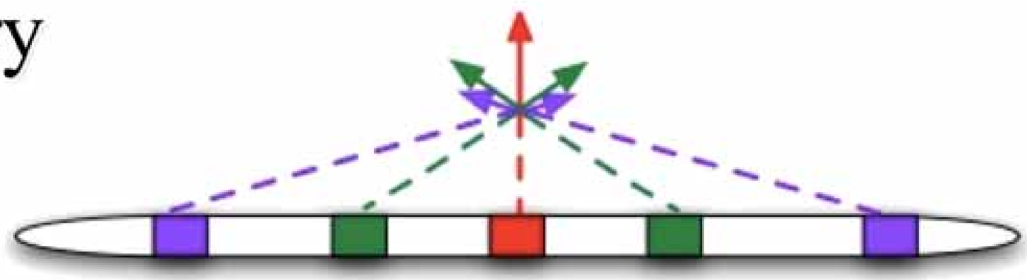
- Uniform long line of charge

- Uniform large sheet of charge



How?

- Geometry



- Different kinds of charge density

$$[\lambda] = \left[\frac{Q}{L}\right] \qquad [\sigma] = \left[\frac{Q}{L^2}\right]$$

- Dimensional analysis

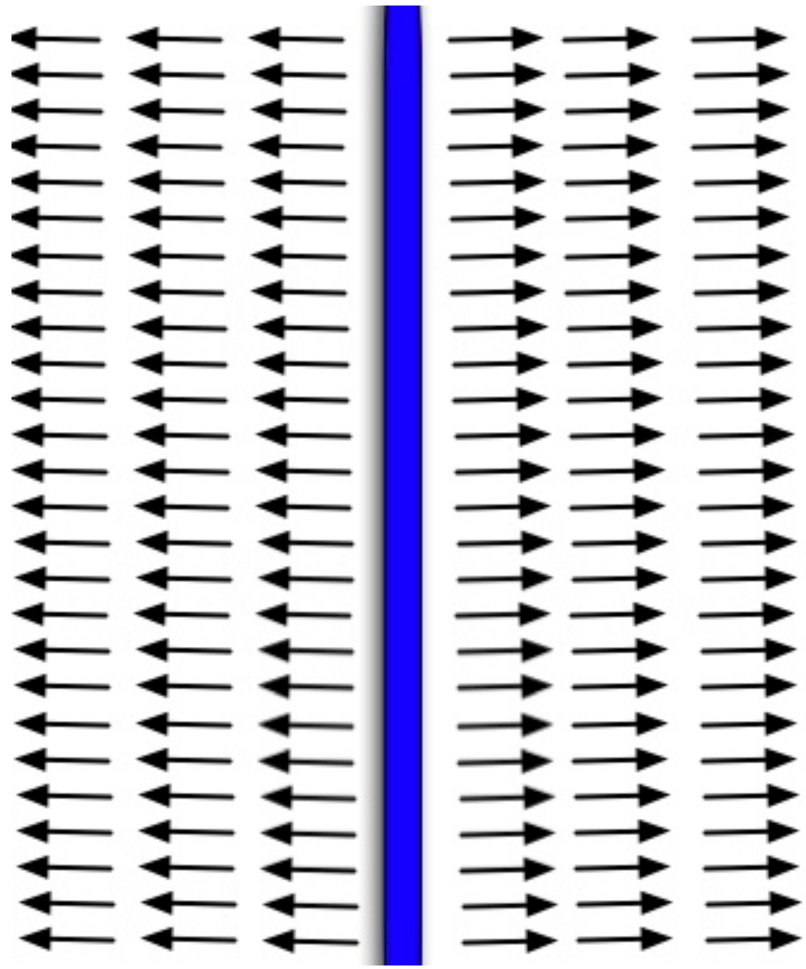
$$[E] = k\left[\frac{Q}{L^2}\right] \qquad [E] = k\left[\frac{\lambda}{L}\right] \qquad [E] = k[\sigma]$$

The dependences

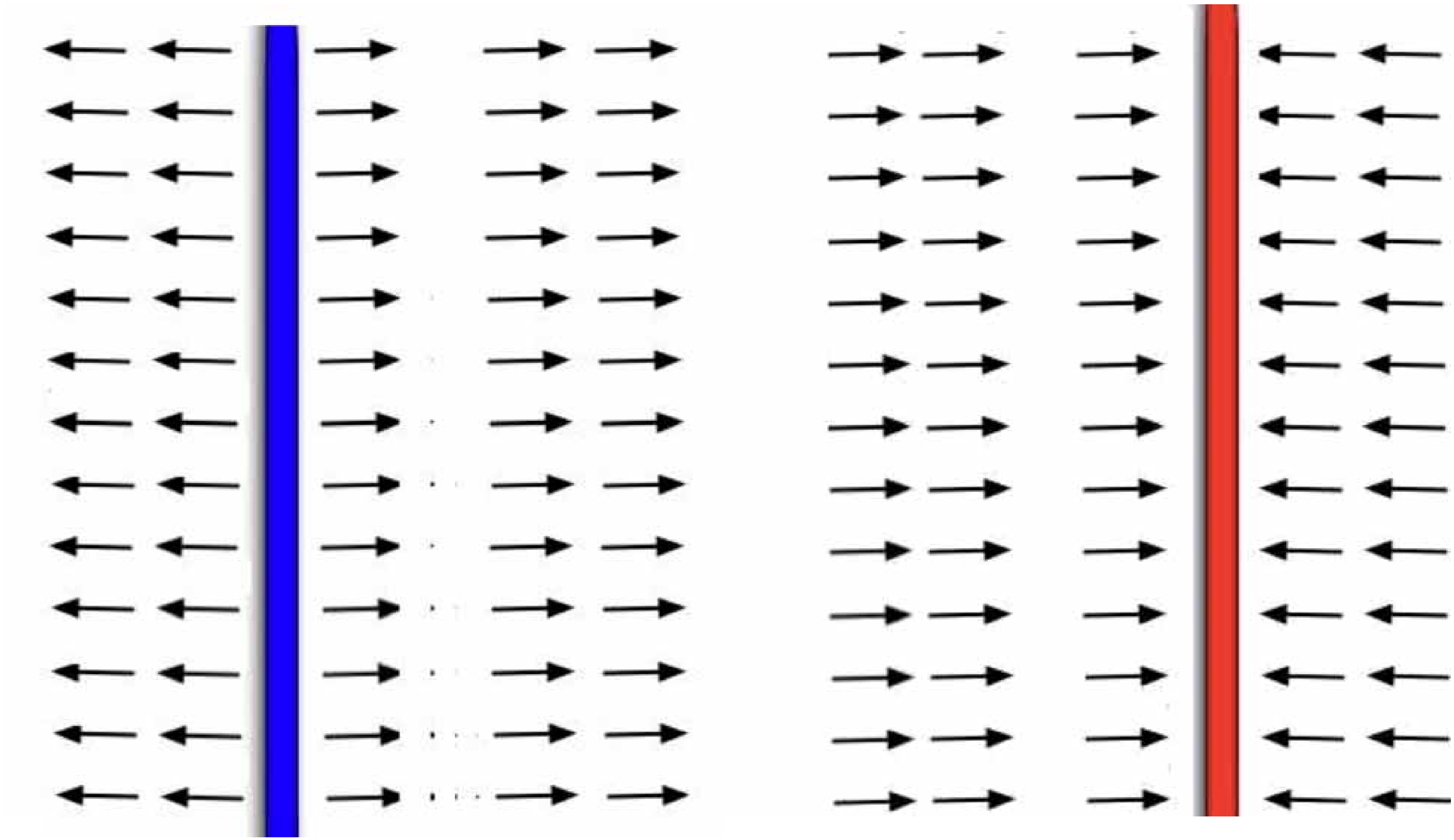
- Point Q [C]: $$E = \frac{k_C Q}{r^2}$$
- Long line λ [C/m]: $$E = \frac{2k_C \lambda}{d}$$
- Flat sheet σ [C/m^2]: $$E = 2\pi k_C \sigma$$

The sheet of charge

- Field is constant, pointing away from positive sheet, towards negative sheet.
- Constant!!?
  How can that be?

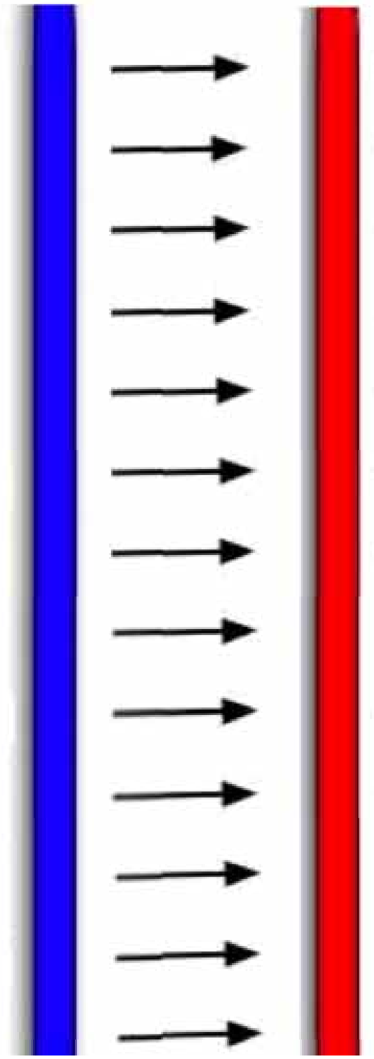


Two sheets of charge



Result

The fields of the two plates cancel each other on the outside.



The fields of the two plates cancel each other on the outside.

The fields of the two plates add on the inside, producing double the field of a single plate.