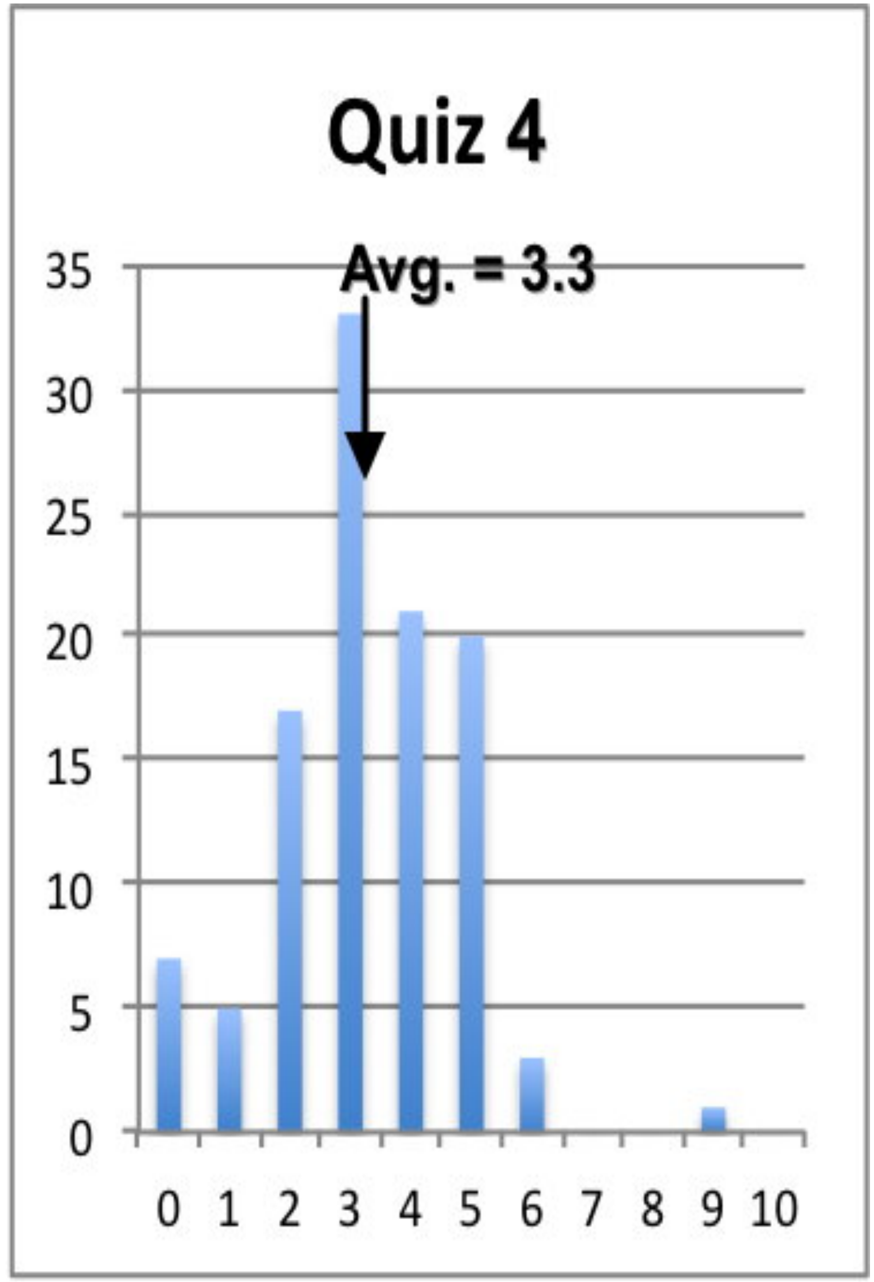
February 24, 2016 Physics 132 Prof. ~~E. F. Redish~~ B. Dreyfus

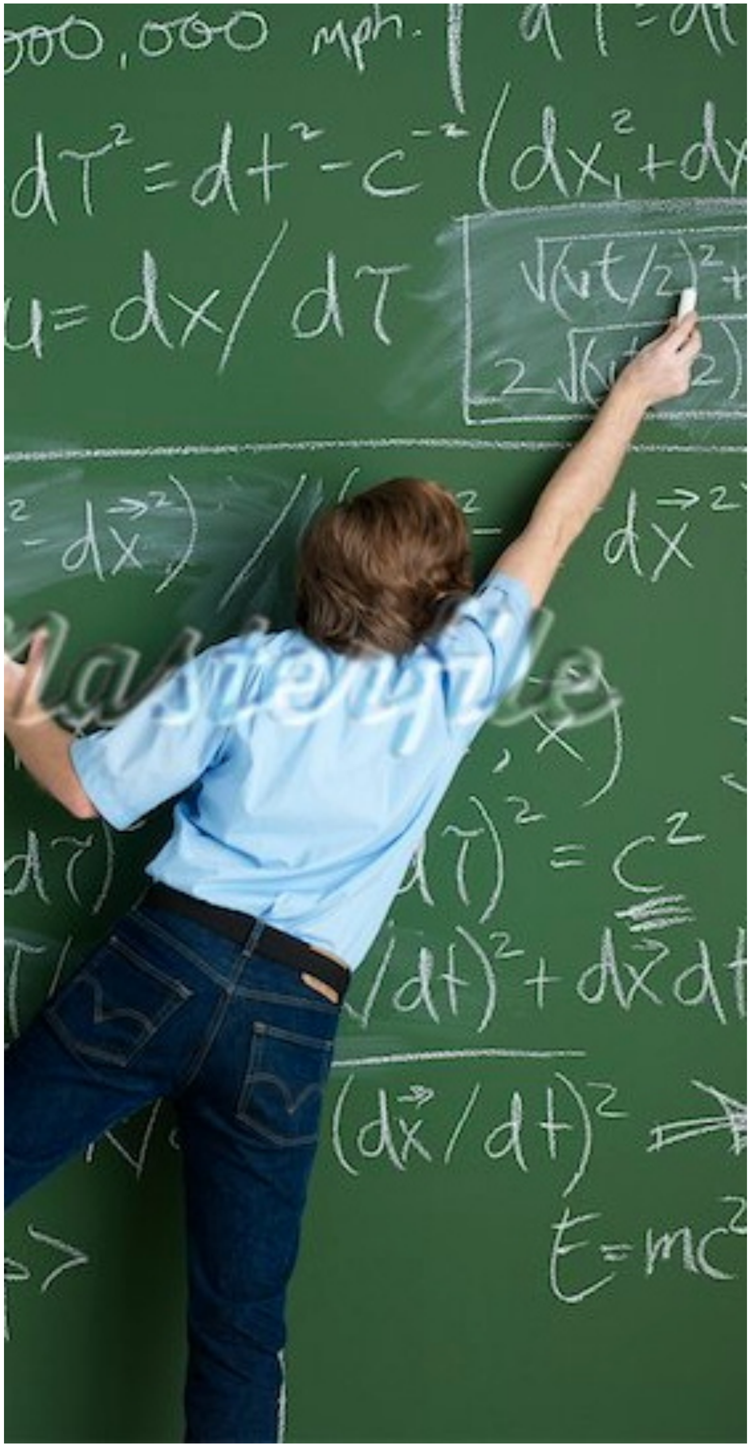
- **<u>Theme Music:</u> Joni Mitchell**
  Electricity
- **<u>Cartoon:</u> Bill Watterson**
  Calvin & Hobbes

Quiz 4

	1
a	7%
b	67%
c	3%
d	41%
e	3%
f	2%
g	31%
h	9%

	2		3.1		3.2
a	75%	a	60%	a	3%
b	20%	b	19%	b	18%
c	5%	c	16%	c	45%
d	0%	ac	0%	d	29%
		bc	2%	e	2%
				f	2%





The Equation of the Day

The Electric Field
in simple
model systems

$$E(\vec{r}) = {k_C q}/{r^2}$$

$$E(\vec{r}) = {2k_C \lambda}/{d}$$

$$E(\vec{r}) = 4\pi k_C \sigma$$

Recap: Vector Fields

- A *field* is a concept we use to describe anything that varies in space. It is a set of values assigned to each point in space (e.g., temperature or wind speed).
- A *force field* is an idea we use for non-touching forces. It puts a force vector at each point in space, summarizing the effect of all objects that would exert a force on a particular object placed at that point.
- A *gravitational*, *electric, or magnetic field* is a force field with something (a "coupling strength") divided out so the field no longer depends on which test object is used.

$$\vec{g} = \frac{\vec{F}_{\text{acting on } m}}{m} \qquad \vec{E} = \frac{\vec{F}_{\text{acting on } q}}{q}$$

Field is the value at a position in space " *r* " assuming that the force is measured by placing the object at *r* .

Recap: Scalar Fields

- A *field* is a concept we use to describe anything that varies in space. It is a set of values assigned to each point in space (e.g., temperature or wind speed).
- An *potential energy field* is the assignment of a potential energy that a test charge would feel (add to the system) if placed at each point in space.
- A *gravitational*, *electric potential* is a potential energy field with something (a "coupling strength") divided out so the field no longer depends on what test object is used.

$$gh = \frac{\Delta U_m^{\text{grav}}}{m} \qquad V = \frac{\Delta U_q^{\text{electric}}}{q} \qquad V(\vec{r}) = -\int_{\text{ref. pt.}}^{\vec{r}} \vec{E}(\vec{r}\,') \cdot d\vec{r}\,'$$

Foothold ideas: Electric potential energy and potential

- The potential energy between two charges is

$$U_{12}^{elec} = \frac{k_C Q_1 Q_2}{r_{12}}$$

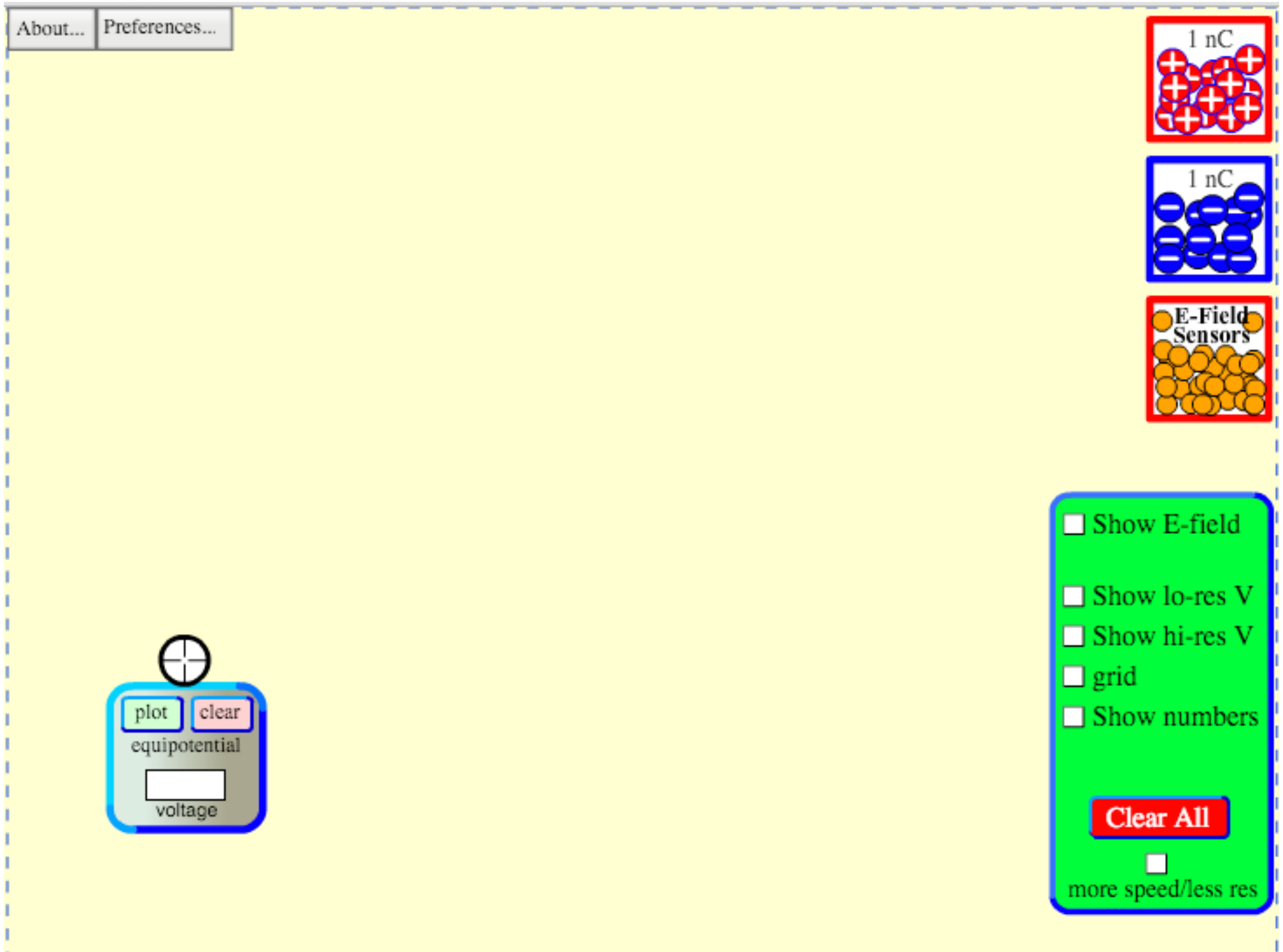
- The potential energy of many charges is

$$U_{12\ldots N}^{elec} = \sum_{i<j=1}^{N} \frac{k_C Q_i Q_j}{r_{ij}}$$

- The potential energy added by adding a test charge q is

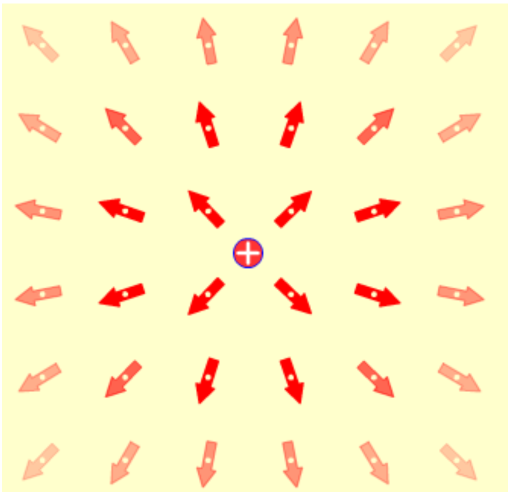
$$\Delta U_q^{elec} = \sum_{i=1}^{N} \frac{k_C q Q_i}{r_{iq}} = qV$$

Explore the potential near a point charge

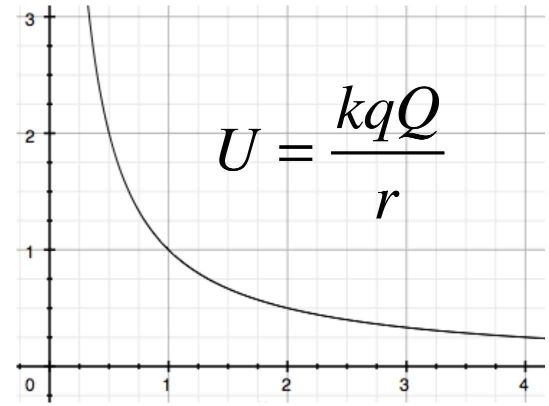


https://phet.colorado.edu/sims/charges-and-fields/charges-and-fields_en.html

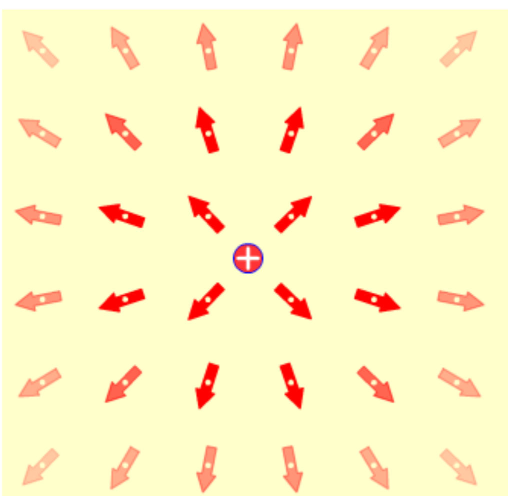
Positive test charge near a single (+) source charge



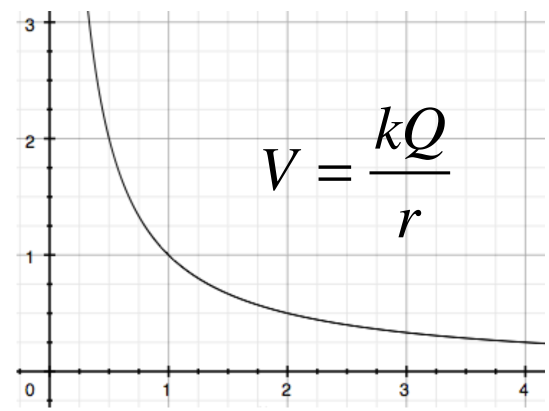
Potential energy
of a positive test charge
near a positive source.



$$U = \frac{kqQ}{r}$$

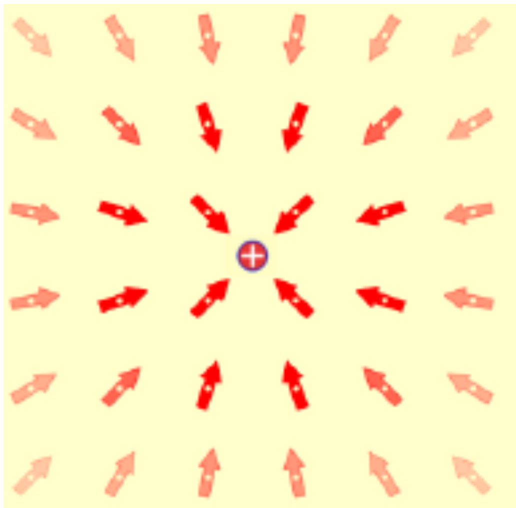


Electric Potential
of a positive test charge
near a positive source.

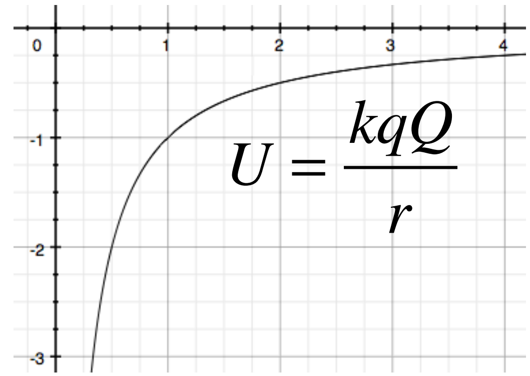


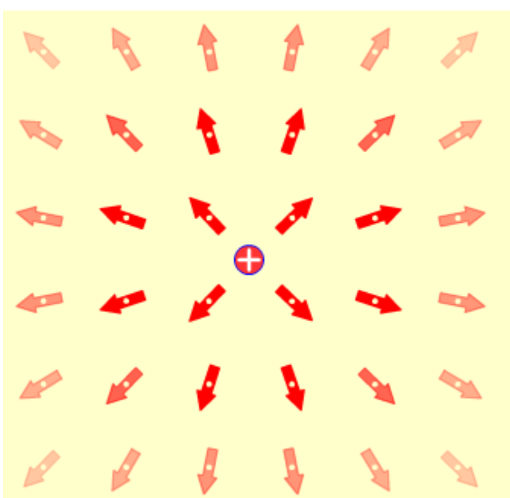
$$V = \frac{kQ}{r}$$

Negative test charge near a single (+) source charge

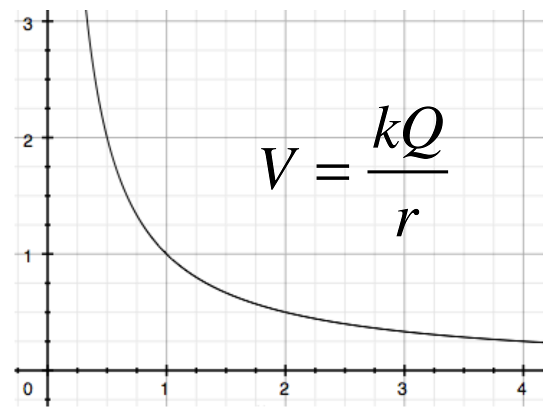


Potential energy
of a negative test charge near a positive source.





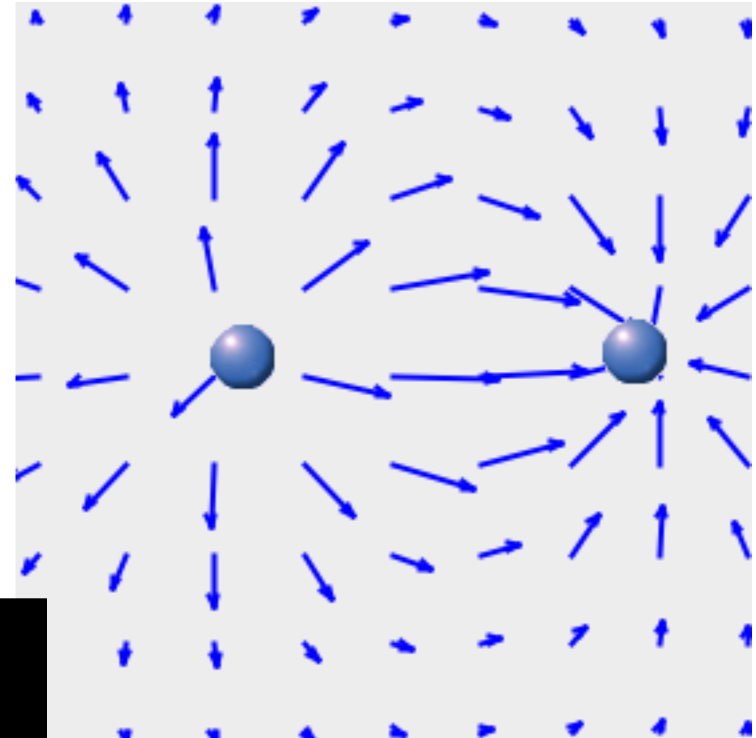
Electric Potential
of a negative test charge near a positive source.

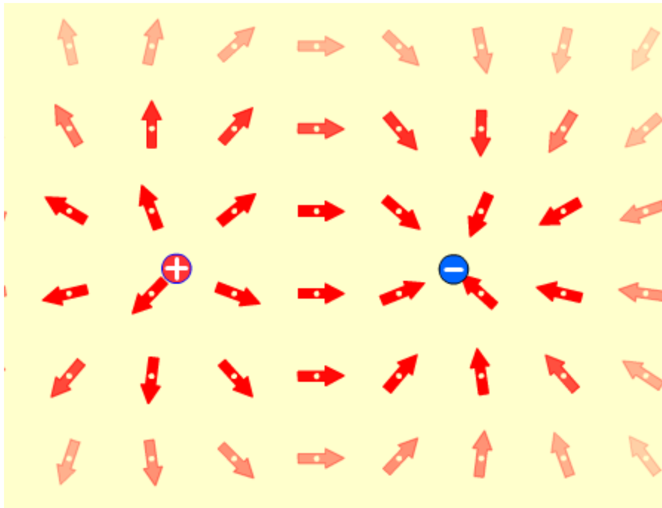


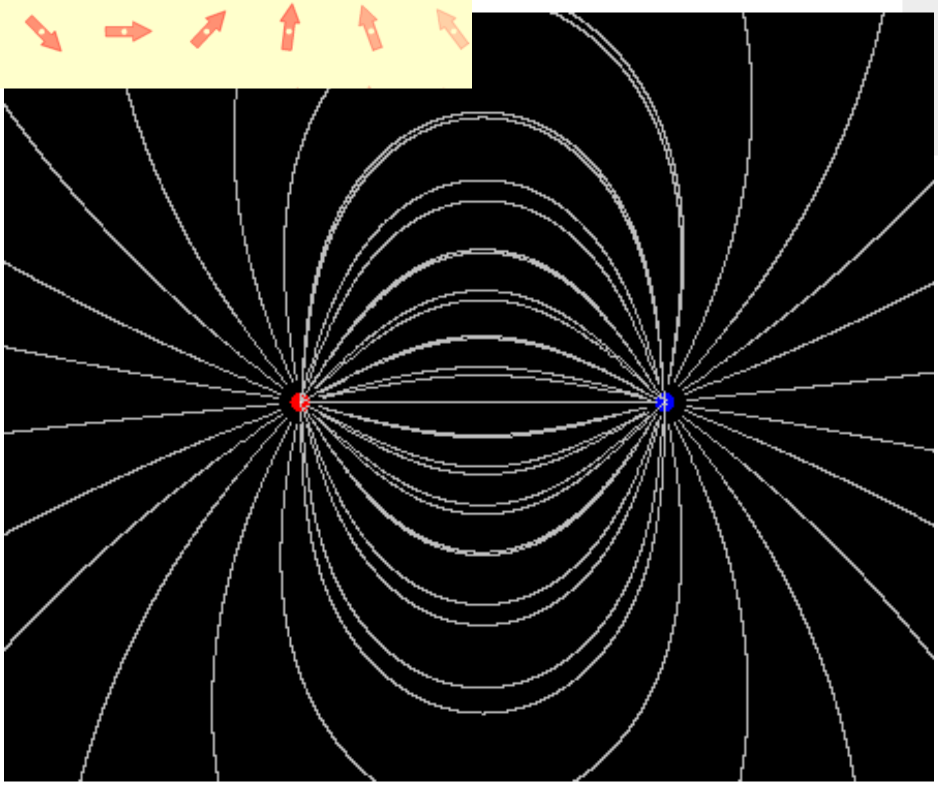
Representations

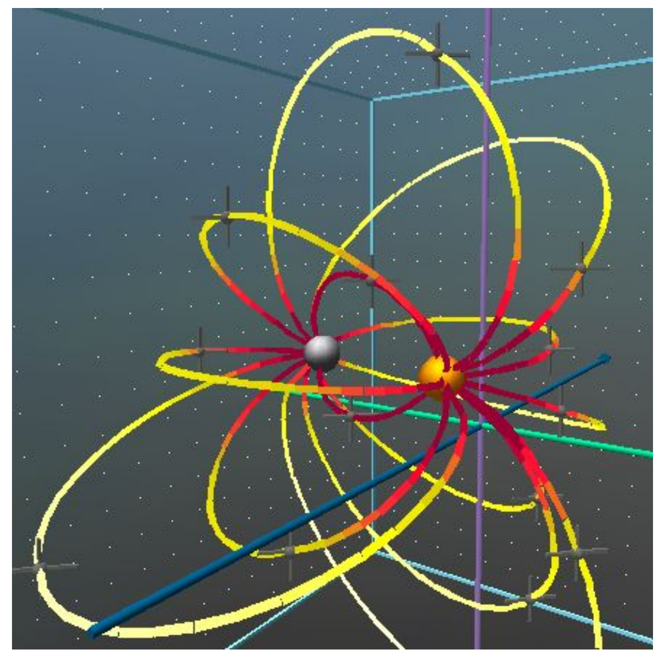
- Representing *E*
  - Arrows (length shows |*E*|)
  - Arrows (fixed length, color or width shows |*E*|)
  - Field lines (show direction only)
  - Field lines (color shows |*E*|)
- Representing *V*
  - 1D: Graph
  - 2D: Isoclines (lines of equal value)
  - 3D: Equipotential surfaces (surfaces of = value)

E field









V