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More Electrostatics 20:3-4 Electric Field, Dipoles, Quiz

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Friday, January 17 2014 Happy Birthday to Zooey Deschanel, Kid Rock, Jim Carrey, Andy Kaufman, Muhammad Ali, and Michelle Obama!



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Review: The Electric Field

The electric field at a point in space is the force per unit charge that a charge q placed at that point would experience:
Right at this point the electric field is

$$\vec{E} = \frac{\vec{F}}{q}$$
 $\frac{N}{C} = \frac{V}{m}$

• The force on a charge q in an electric field \vec{E}

 $\vec{F} = q\vec{E}$

Electric field is analogous to the gravitational field, which gives force per **unit** mass. Right at this point the gravitational field is described by the vector \vec{g} . That means a mass *m* placed here would experience a gravitational force $m\vec{g}$.



 $\overrightarrow{E_1}$

described by the vector \vec{E}_1 . That means a point charge q placed here would experience an electric force $q\vec{E}_1$.



Over here, farther from the charge producing the field, a point charge q would experience a weaker force $q\vec{E}_2$ in a different direction.

The electric field is a continuous entity, so there are field vectors everywhere. We just can't draw them all.

(b)



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is

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(a)

The gravitational field is

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Fields of Point Charges and Charge Distributions

• The field of a point charge is radial, **outward** for a positive charge and **inward** for a negative charge.

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$$\vec{E}_{\text{point charge}} = \frac{kq}{r^2} \hat{r}$$



 The superposition principle shows that the field due to a charge distribution is the vector sum of the fields of the individual charges.

$$\vec{E}_{\text{total}} = \sum_{i} \vec{E}_{i} = \sum_{i} \frac{kq_{i}}{r_{i}^{2}} \hat{r}_{i}$$



Review: Electric Field (of Dreams)

http://phet.colorado.edu/en/simulation/efield

Electric Field of Dreams (1.04)

File Electric Field Help



Electric field points **towards** charge Is the charge negative or positive?

| Ŝ | | Reset All | Add Remove Properties | External Field | |
|---------|--------|------------------|-----------------------------|-----------------------|--------------|
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Review: Electric Field (of Dreams)

http://phet.colorado.edu/en/simulation/efield



Two equal negative charges

$$\vec{E}_{\text{total}} = \sum_{i} \vec{E}_{i} = \sum_{i} \frac{kq_{i}}{r_{i}^{2}} \hat{r}_{i}$$

Note the absence of horizontal electric field in the middle

(But there is vertical magnetic field)



Electric Dipole



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- Here is the field created by two equal and opposite charges
 - Like my H "atom" in the Wednesday lecture
- Electric field lines point away from positive charge, towards negative charge
- But far away (compared to the distance between them), the electric fields cancel
 - (r is very nearly the same for + and – charges)
 - This is an **electric dipole**

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Electric Dipole



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The Dipole: an Important Charge Distribution

- An electric dipole consists of two point charges of equal magnitude but opposite signs, held a short distance apart.
 - The dipole is electrically neutral, but the separation of its charges results in an electric field.
 - Many charge distributions, especially molecules, behave like electric dipoles.
 - The product of the charge and separation is the dipole moment:
 p = *qd*.
 - Far from the dipole, its electric field falls off as the inverse cube of the distance.

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Quiz #1 Equation/Concept Sheet

Charge Units elementary charge $e = 1.6 \times 10^{-19}$ C Coulomb's Law $\vec{F}_{12} = \frac{kq_1q_2}{r^2}\hat{r}$ $k = 9.0 \times 10^9 \text{ N m}^2/\text{C}^2$ **Electric Field** $\vec{E} = \frac{kq}{r^2}\hat{r}$ $k = 9.0 \times 10^9 \text{ N m}^2/\text{C}^2$ Vector Decomposition $A_x = \mathbf{A}\cos\theta$ $A_y = \mathbf{A}\sin\theta$

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 $A^{2} = A_{x}^{2} + A_{y}^{2}$