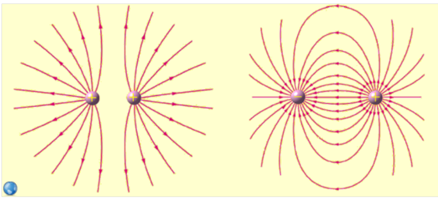
10.3 - Electric Fields



Electric Fields (E-Fields)

The influence a charged object/s has on other charges is called an electric field (like a gravitational field), and is a vector.

$$E = \frac{kq}{r^2}$$	E = Electric Field (N/C) k = 9.0 E 9 Nm^2/C^2 q = source of field (C) r = distance from charge (m)

The direction of E is in the direction of the force a positive 'test charge' at that location (to be discussed) would feel.

E-Field Derivation

The E-field equation is based on a positive 'test charge' (q^+) a distance from another charge q.

The force experienced by the test charge changes as it moves within the field, and is derived:

$$E = \frac{Force\ on\ q+}{q+} = \frac{\frac{kqq+}{r^2}}{q+} = \frac{kq}{r^2}$$

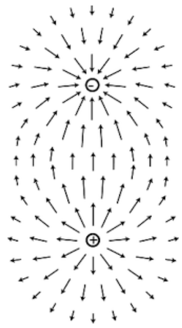
Coulomb's Law Substitution

If multiple forces act on charge:

$$E = \frac{F_{E\ Net}}{q}$$

E-Field Conventions

1. The closer the lines, the stronger the field.
2. Electric force is tangent to field lines.
3. E-field lines start at positive charges and end at negative.
4. The number of lines leaving or entering a charge proportional to charge magnitude.
5. Field lines never cross.



Drawing E-Fields

Charges create E-fields, exerting force on other charges.

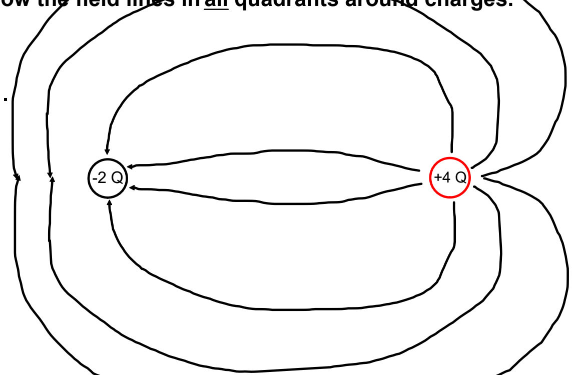
E-fields are mapped using a positive test charge: when placed in the field, it is repelled by positive charges, and attracted to negative charges.

The net force at a point is shown as an arrow: this is repeated field-wide (Demo).

Field Line Examples

Show the field lines in all quadrants around charges.

1.



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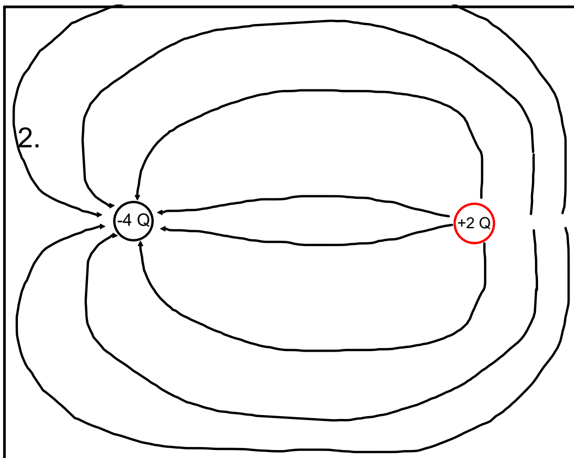

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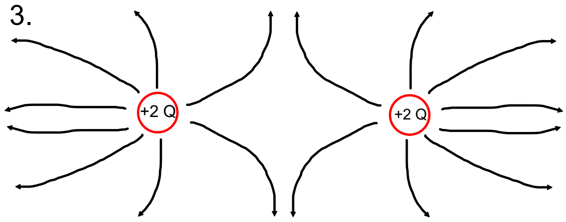

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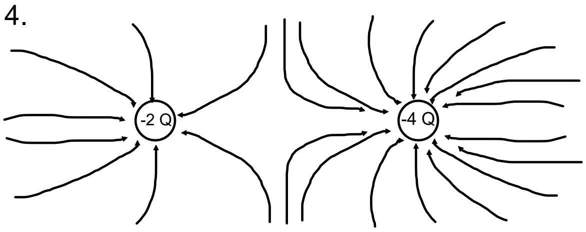
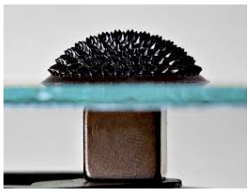


Magnet Analogy

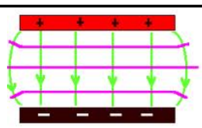
Ex: Magnets and electric charges have similar properties as far as field mapping is concerned.

Watch as the steel filings approach the magnets of opposite polarity.
You will see field lines appear.



Magnet and Ferrofluid!

Parallel Plates



E-fields between parallel plates differ from point charges.

The even distribution of charge on plates yields a uniform field between them (not near an edge).

$E = \dfrac{4\pi kQ}{A}$	E = Electric Field (N/C) k = 9.0 E 9 Nm^2/C^2 Q = charge on ONE plate (C) A = area of ONE plates (m^2)

5. Parallel Plate Example

The E-field magnitude for a storm cloud of area 2.56 E 8 m^2 equals 1.0 E 4 N/C. Find the magnitude of charge on the lower cloud surface.

Parallel Plate Answer:

Set up the problem, isolating Q in your equation:

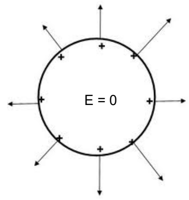
$$E = \frac{4\pi k Q}{A}$$

$$Q = \frac{EA}{4k\pi} = \frac{(1.0E4\,N/C)(2.56E8\,m^2)}{4\pi 9.0E9\,Nm^2/C^2} = 23C$$

General Conductor Rules

Electrostatic Field – resting charges on a conductor.

1. The E-field inside a charged conductor is zero.
2. Excess charge on a conductor is on its surface.
3. The E-field at the surface of a charged conductor is perpendicular to the surface.



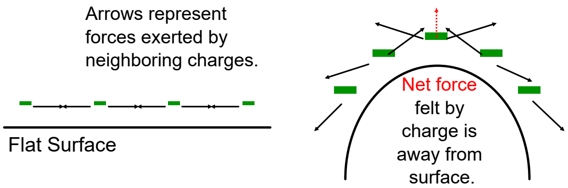
Charges on Surfaces

Charges accumulate at points: E-field is strongest.

Why is this?

Like charges repel: on flat surfaces, forces are parallel between charges.

At points, repulsive force is angled: the parallel force component is smaller: charges can be closer.



Van De Graaf Generator Demo

Watch this! Charges build up on the dome, and discharge when they reach a certain level.

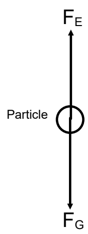
If there's a point on the generator, charges accumulate there, and are discharged more readily.

Look for St. Elmo's Fire!

6. E-Field Example

What E-field must act upon a 7.8 E -6 kg dust particle with a + 5.8 E -6 C charge to make it hover ('defy' gravity)?

Hint: Make an FBD of the particle, showing forces.



6. E-Field Answer

What E-field has to act upon a 7.8 E -6 kg dust particle with a + 5.8 E -6 C charge to make it hover?

Gravitational force:

$$F_G = mg = 7.8E-6\,kg \bullet 9.81\,m/s^2 = 7.652E-5\,N$$

The F_E needed for hovering is opposite to that.

The electric field is that force divided by the charge.

$$E = \frac{F_{E\ Net}}{q} = \frac{7.652E-5\,N}{5.8E-6\,C} = 13\,N/C$$

Homework
10.3 Problems
Due: Next Class.