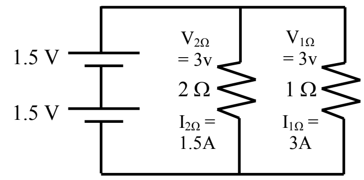
Electric Field Lines; Notes for Electricity 8 (Jan 24 and 25)

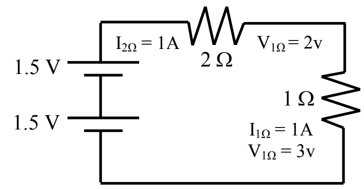
1. V = IR and P = VI so P = (IR)I = I^2R. Or, since $I = \frac{V}{R}$, then $P = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$

On your equation sheet: $P = VI = I^2R = \frac{V^2}{R}$. Just use the easiest one.

2. **Which Light is Brightest?** Remember that for two different light bulbs in series the current is the same, but the one with greatest resistance is brighter. "Brighter" means it is using more power: if $P = I^2R$, then if I is constant P is greater for the greater R; using P = VI, we know that V is greater for the greater R, as well. For two different light bulbs in parallel, the voltage is the same for both, which uses more power? P=VI, so for the same V, the one with greater I is brighter: the smaller R. . Or, using $P = V^2/R$, if V is constant, more R means less P: the bigger resistor is dimmer.



V is equal;
$R_{1\Omega}$ is less;
$I_{1\Omega}$ is greater;
$P_{1\Omega}$ is greater;
1 Ω is brighter.



I is equal;
$R_{2\Omega}$ is greater;
$V_{2\Omega}$ is greater;
$P_{2\Omega}$ is greater;
2 Ω is brighter.

2. **Drawing Electric Fields.**

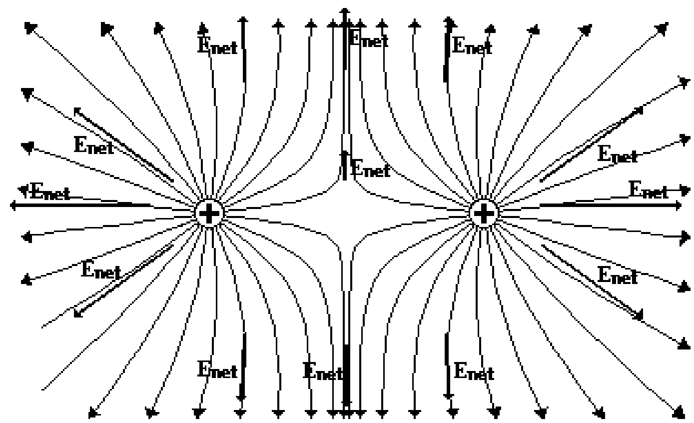
Electric Field lines are drawn to show where charges would move; they show which way the coulomb's force would move a charge.

Drawing Rules for Electric Field Lines:

1) They show the direction a positive charge would move (think of a lot of charges dropped on the page: "where would they go?").

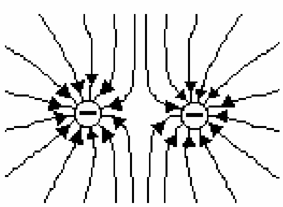
2) The lines never cross (the above charges would want to get next to each other.)

3) They end at infinity or on a negative charge (for us this means that sometimes they go off the page).

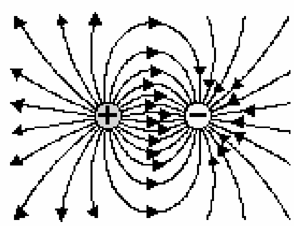


Two Positive Charges: *Notice the lines don't cross and that they are moving away from the positive charges (seeking a negative charge).*

Other Charge Configurations



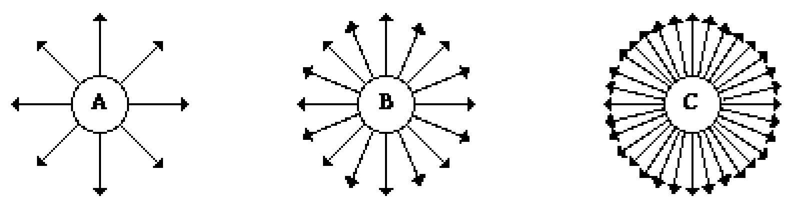
Two Negatively-Charged Objects



A Positively and a Negatively-Charged Object

Density of Lines in Patterns

Density of Line Patterns: closer lines show a stronger electric field (caused by a bigger charge). A stronger field means there will be more force on another charge.

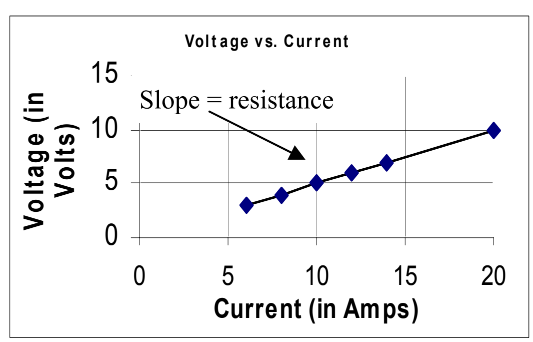


The density of electric field lines around these three objects reveals that the quantity of charge on C is greater than that on B which is greater than that on B.

3. **Ohm's Law**—We usually write Ohm's Law as: V= IR, but this isn't really true. Actually, Ohm's Law is: R = V/I. This says that for a particular circuit (or device, like a resistor), for every voltage you put across the circuit you will impart currents that will always give the same resistance. The table at the right shows that for every voltage and current, the resistance is 2 Ω. We say that this circuit (object or material) is *Ohmic*, meaning it follows Ohm's Law.

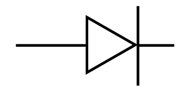
If we graph the voltage vs current we get a **straight line** graph with the resistance as the slope. This is true for any relationship that is a constant. The graph of a Ohmic material is a straight line. A steeper line shows greater resistance.

V (in v)	I (in A)
6	3
8	4
10	5
12	6
14	7
20	10



4. **Non-Ohmic Material**—Not every device or substance follows Ohm's Law. OHMIC materials do, non-ohmic material (like Diodes) do not. The resistance of non-ohmic material may increase or decrease with voltage. A non-ohmic material's graph will not be a straight line.

5. **Diodes**— Diodes allow electricity to flow in one direction and block it in the other direction. Diodes channel electricity, acting as one-way gates. Diodes allow us to convert AC to DC. Devices that run off of batteries (like cell phones) run off of DC. For them to plug into the wall (to run or to charge) the AC current must be turned into DC by the use of diodes (this kind of circuitry is called a rectifier).



Diode symbol

6. **Ways to increase capacitance:**
   1) Decrease distance between plates— (CORRECTION from "Electricity 7 Notes")
   2) Better dielectric (insulator in between the plates) - again, better dielectric = better insulation = more charge.
   3) Increase plate area—more area = more charge can spread out = more charge can be held before it pushes across.

$$C=\varepsilon_o \frac{A}{d}$$

7. **Electron Drift Velocity**—Electrons do not flow through wires very fast. In fact they take a very long time to move, because the electrons are colliding with all the molecules in the wire along the way. It is estimated that an electron can take over an hour to move 1 meter in a wire. Yet we know that electricity seems to work instantaneously in circuits (you don't have to wait for a light to come on). This is because when a voltage is applied to a conductor an electric field is generated almost immediately and each electron moves over slightly, moving all the other electrons in the conductor "chain". Most of the electrons in a circuit come from the wires: they are already there; they just need to be moved.

8. **Why Electric Companies Transmit Electricity at High Voltage**. Electric companies send electricity over very long distances, which we know increases resistance. Since $P = I^2R$ more power is lost through current (it's squared) than resistance. And since $P = IV$, the same power can be sent either by high current (I) or high voltage (V). Since higher current causes more power lost, electric companies send electricity at very high voltages and very low current. These voltages can be 3/4 of a million volts between cities, 4000 voltage inner city, and down to 120 v at your house.

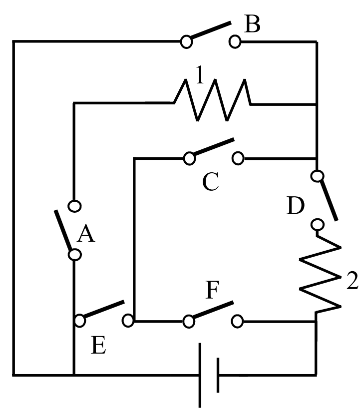
9. **Practice for Electricity Paths**— We are going to use the following diagram to follow current. Remember that for a circuit to be complete (closed) it has to start at the positive side of the battery and end at the negative side. (Answers at the bottom.)

   1) Which switches must be closed for only resistor 2 to work?

   2) Which switches must be closed for resistors 1 and 2 to work?

   3) Which resistor works if E and F are closed?

   4) Which switches must be closed for only resistor 1 to work?



Answers:

1) Switch B and D must be closed for only resistor 2 to work. OR you could close E, C and D.
2) For both resistors to work, switch A and D must be closed.
3) If E and F are closed no resistor works because the form a short circuit back to the battery.
4) For resistor 1 to be on, but not resistor 2, close switches A, C and F. It doesn't matter if D is on or not. If D is closed electricity will still choose to go through the wire connected by switches C and F.