**Electrostatic Force and Electricity Notes**

1 – Charges and Coulomb’s Law

* Matter is made of particles which are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_ charged.
* The unit of charge is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ( )
* Charges are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, meaning that they cannot be…

It is thought that the total charge of the entire universe is constant and neutral.

* Charges are also \_\_\_\_\_\_\_\_\_\_\_\_, meaning that they occur in finite packages.

The smallest unit of charge is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ which is equal to the charge on one proton (+) or one electron (-).

Coulomb determined that the force between two charged objects is proportional to their charges
and inversely proportional to the square of their distances or:

Where: q1 =

 q2 =

 r =

 k =

There are four important things to notice from this equation.

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

There is a very important difference between gravitational and electrostatic forces:

Gravity ALWAYS…

Electrostatic force can…

When solving for electrostatic forces we will NOT…

Instead we will determine the direction of the force based on…

Example:

Two point charges of 1.8x10-6 C and 2.4x10-6 C produce a force of 2.2x10-3 N on each other. How far apart are these two charges?

Example:

Two 85 kg students are 1.0 m apart. What is the gravitational force between them?

If these two students each have a charge of 2.0x10-3 C, what is the electrostatic force between them?

Example:

A charge of 1.7x10-6 C is placed 2.0x10-2 m from a charge of 2.5x10-6 C and 3.5x10-2 m from a charge of -2.0x10-6 as shown.

What is the net electric force on the 1.7x10-6 charge?

1.7x10-6 C

2.5x10-6 C

-2.0x10-6 C

**Electrostatic Force and Electricity Notes**

2 – Circuits

In the last chapter we examined how static electric charges interact with one another. These fixed electrical charges are not the same as the electricity that we use in everyday life, current electricity.

Current electricity is all about…

The number of charges flowing per second is defined by the specific quantity – current.

**Current (I)**: The unit of current is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_ ( ).

However, current will not flow through a conductor unless there is

1. a potential difference (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_).
2. a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Some examples of voltage sources that we use everyday are:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Consider a river. The rate of water flowing down the river is its *current*. Note that we talk about the **rate** of water flowing, not the **speed** that the individual water molecules are moving.
The same is true for electric circuits, where the current represents how many electrons pass a certain point in a certain amount of time.

**Voltage** (**V**):

The units of voltage are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ( )

**Resistance (R)**:

The units of resistance are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ( )

These three quantities are related using
Ohm’s Law:

Electric Current

Consider a circuit of a battery connected to a light bulb.

Which direction does the current flow?

Unfortunately, there are two ways to consider this.

1. Electron Flow: The direction that the electrons actually move. The electrons go from the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. Conventional Current: Flow of positive charge. Positive charges flow from the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Although a little confusing (and more than a little irritating) we need to recall that **electric potential** is defined in terms of moving positive charge. And the **direction** of an **electric field** is defined as the direction that a positive charge will move in that field.

In this class, unless otherwise stated, we will always use \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_!!!

Power

We often talk about the amount of power used by different electrical devices. This is often confused with **voltage** or **energy**.

Recall that power is…

From the definition of power and Ohm’s Law we can derive some formulae to describe **electric power**.

P = W = ΔE and Ep = ΔVq

 t t

Example: An electric fan has a resistance of 12 Ω and requires 0.75 A of current to function properly. What voltage is required to operate the fan?

Example: An electric heater emits 1.00x102 W when connected to a 120 V power line. What is the resistance in the heater?

To draw the various devices that can make up electric circuits, we use on **schematic diagrams** that are…

|  |  |  |
| --- | --- | --- |
| **Schematic** | **Name** | **Function** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

There are two ways that we can attach devices to a circuit.

**(1) Series:**

Ex. Draw a battery of two cells connected to two resistors in series.

**(2) Parallel:**

Ex. Draw a battery of two cells connected to two resistors in parallel.

Measuring Voltage and Current

We can measure the voltage in a circuit using a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and the current in a circuit using a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

We need to connect these two devices in different ways.

A voltmeter must be connected in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This is because a voltmeter measures the voltage drop \_\_\_\_\_\_\_\_\_\_\_\_\_\_ a device.

Ex.

An ammeter must be connected in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This is because an ammeter measures the current \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a circuit.

Ex.

One last note…

There are two types of current. DC (\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) means it flows in one direction such as the current from a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. AC (\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) means that it alternates the direction of flow. In the case of home electric circuits, they alternate at 60 Hz.

As fun as it sounds AC is a little advanced for us just yet so we will be sticking to DC in this course.

**Electrostatic Force and Electricity Notes**

3 – Kirchhoff’s Laws

We have already seen that we can connect devices to a circuit in two ways: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The manner in which we attach components of a circuit can greatly affect the nature of the circuit in particular its \_\_\_\_\_\_\_\_\_\_\_\_\_\_ there are a number of laws that we must use called:

Kirchhoff’s Current Law

**For a series circuit:**

In a series circuit there is only one path so the current must be…

**For a parallel circuit:**

In a parallel circuit the charge can take different paths. Therefore the amount of charge at any point…

**Kirchhoff’s Current Law** can be directly stated as: the sum of currents entering a junction…

IT =

IT =

Kirchhoff’s Voltage Law

Kirchhoff’s Voltage Law is stated as: The sum of the potential differences in a circuit must…

In a way this is simply restating the…

Remember that there is an increase in the potential across the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and that there is a decrease in potential across a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Essentially these increases and drops must add up to zero.

**For a series circuit:**

Since there is only one path, the total voltage increase across the battery must equal the total drop across each resistor.

VT =

**For a parallel circuit:**

Note that the potential difference is…

VT =

Kirchhoff vs Ohm

Kirchhoff does not have a law for resistance. However we can perform an arduous derivation to find the formula using Kirchhoff’s other law and Ohm’s Law.

Instead, let’s just reason it out.

**For a series circuit:**

The total resistance in a series circuit is the \_\_\_\_\_\_\_\_\_\_ of \_\_\_\_\_\_\_\_\_ the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Since each electron must push its way through each resistor, it should make sense that the resistances are cumulative.

RT =

RT =

**For a parallel circuit:**

We already know that as we add resistors in parallel, the total resistance…

If our marching soldiers are forced through one path, then there will be much more friction than if there are multiple paths to choose from. This is true even if the additional pathways are of **higher resistance**.

Let’s recap:

|  |  |  |
| --- | --- | --- |
| Formula | Series | Parallel |
|  |  |  |
|  |  |  |
|  |  |  |

Example:

What are the values of I1, I2

and I3 in the circuit shown?

Example:

What is the value of R2 in

the circuit shown?

Example:

What is the potential difference

supplied by the power source in

this circuit?

What are the values of V1, V2

and R2 in the circuit?

**Electric Circuits Notes**

4 – Electromotive Force

We know that a battery is a source of potential difference (\_\_\_\_\_\_\_\_\_\_\_\_\_\_) or electric energy. When not connected to a circuit there is a potential difference between the terminals.

This voltage is also known as…

Despite the name, this is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ not a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

This dates back to a time when we thought that the two were equivalent.

For example a car battery has an EMF of \_\_\_\_\_\_\_\_\_\_\_ and lithium battery has an EMF of \_\_\_\_\_\_\_\_\_\_\_\_.

However, as soon as a battery is connected to a circuit and current flows through it the potential difference across the terminals is always…

This is due to the fact that every battery has…

Because of this \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the terminal voltage is always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than the EMF of the battery.

Where:

Note: Ir =

Note: If the battery is not connected to a circuit…

Example:

If a 12.0 V battery has an internal resistance of 0.220 ohms, what is the terminal voltage of the battery when a current of 3.00 A flows through the battery?

Consider the following diagram showing a circuit with an external resistance, \_\_\_\_\_\_\_, internal resistance \_\_\_\_\_\_ and EMF \_\_\_\_\_\_\_.

When a battery goes dead it is because…

Example:

A 12.0 V car battery is being charged by an alternator that can supply 15 V. If the internal resistance of the battery is 1.3 ohms, what is the current through the battery?

When a rechargeable battery is being charged an external voltage is applied to the battery. In order to force electrons backwards into the battery the external voltage must be…

In fact the external voltage must be: