Chapter 2

What are We Doing Here?

In Chapter 2 we will: 1) talk a little more about resistors, 2) introduce the topic of clocks, and 3) begin to talk about standard units and conversions.

Before we do that, let's review what we are doing and why we are doing it.

There are a million and one details, little facts and things to remember. When you don't know anything, you don't know how much you don't know. And then when you do see everything, you realize how much you have to learn. Don't panic.

All we doing is introducing you to a few tools, some electronic components, and learning how to draw and build electronic circuits. That is biting off a lot for one semester. So, we are going to start slow, finish in a flash, and then go back and do it all over again, next semester!!!!!

What is an electronic component?

An electronic component is a basic building block of an electronic circuit.

Everyone lives in some kind of house, but all houses look a little different. If we look inside of everyone's house, there will almost always be a kitchens and bedrooms. Every circuit looks different, but they all need some source of electricity, and they nearly always use resistors. So, in the same way that every house is different, but most houses have common features. All electronic circuits are different, but most of them use common components.

We have started out talking about two very important components, batteries and resistors. All by themselves, there isn't much that you can do with batteries and resistors, except learn about them.

There are only a few basic components. We can't talk about them all at once. If you promise not to panic, I will tell you what they are. But don't worry about them yet. We will get there.

The basic components of an electronic circuit are: **power supplies, resistors, capacitors, diodes, transistors, and integrated circuits** Each of these components comes in a variety of different forms. There isn't just one type of any of these components, there are dozens. There are different kinds of resistors, multiple types of capacitors, many kinds of diodes and transistors. If we put just one type of each integrated circuit in your bedroom... there wouldn't be any room left for your bed. In fact there wouldn't be any room in your house, and your yard would fill up pretty fast as well.

Obviously, we can only get a tiny taste of what is actually out there in the huge world of electronics.

What are the tools? You have used some of them already. Your multimeter is a tool. We will be drawing circuits, and we will be using ImageJ as a tool to help us draw. We will be exploring and demonstrating basic concepts and basic circuits with the Propeller micro-controller. So, right now, we are using the Propeller as a tool.

That's is really it in a nutshell. Nothing very complicated, and a huge amount of fun.

More About Resistors

In the lab section, you learned how to measure resistors with a multimeter. You learned that the unit of measurement was the ohm, Ω, And you learned how to read the color codes on a resistor. Then you found that the resistors you are using are 1/4W, 1/4Watt.

What does this mean?

1/4 W is the **power rating** of the resistor.

From **Ohm's Law**, if we know the voltage and resistance in a circuit, we can determine the current flowing through that circuit. We also know that every circuit generates heat. As electrons flows through your resistors, the resistors will heat up. Usually, resistors will heat up in such a minimal way that you can't really feel the difference.

The amount of heat **dissipated** by a resistor has been found to be directly related to the Voltage across the resistor multiplied by the Current flowing through the resistor.

V X I, (Volts x Amps, V X A) is such an important calculation that we give it a name, the **Watt**.

! Watt of power is said to exist when 1Amp of current flows through an electric potential of 1V.

Again we have a very convenient unit, because if there is one 1 Amp flowing and there is one volt causing that current, then we have 1 Watt. Heat occurs at the point of resistance.

But we have 1/4W resistors. So, if we allow current through 1 Ohm resistor which is attached to 1Volt battery, we are going to have 1W. Our resistor will exceed its power requirements, become very hot and might be destroyed.

So, what the 1/4 W power rating on the resistor means is that if you want to use that resistor and you do not want to have any problems, then when you measure your circuit, your Voltage multiplied by your Current must be 1/4 (0.25) or less. That isn't very much.

Let's practice a little.

If we have 5 Volts and a 100 Ω resistor, what is the current and how many Watts are we making.

Amps = V/R = 5/100 = .02 Amps or 20 milli-Amps.

Watts = V X Amps 5V X .02Amps

Watts = 0.1

0.1W = 1/10 W

0.1 is less than 0.25. This means that your 1/4W resistor is safe.

If we had 9 volts and a 100Ω resistor, we would have 0.09 Amps or 90 milli-Amps of current. Again, to calculate watts we multiply Amps times Volts. So,
.09Amps X 9Volts = 0.81W

.81 W is far greater than .25 W, So this combination of Voltage, Resistance and Current would be associated with so much heat that our Resistor would eventually fail, because of heat.

What could we do, if we really needed 9 V and .09 Amps?

We could use four 400Ω resistors, each of which can handle 1/4 W. We would then have a big resistor equal to 100Ω and a total heat capacity of 4 X 1/4W = 1W.

What?

Can we really add 4 four 400 Ohm resistors and end up with the same thing as a resistor with four times the capacity to handle heat?

Yes, we can, but exactly why this works is not obvious. We are going to have to either remember the Law of Resistors, which we t

Consider This:

If you had four 400Ω resistors and you added them together, you would expect to get 1600Ω of resistance. And you would be right. But there are two basic ways to hook four resistors together!!! One of those ways produces a resistance just as you suspect. But the other way that you can hook four 400Ω 1/4 W resistors together, actually does produces one big 100Ω 1W resistor. We will see this in the next lab.

Remember **resistors have no polarity**. One end of a resistor is exactly the same as the other.

A Few Words About Clocks
more to follow....

You have always been fascinated by time, clocks and calendars. So you will be happy to learn that we will be using a clock every time we use our Propeller. This introduction to clocks isn't just about the Propeller, but we are going to use the Propeller, because it has an excellent clock and we will use that clock to make other clocks.

In school, when the bell rings, the entire school is being time **synchronized**, because the entire school is being told that it is time to do something. If everyone in the school didn't use the same clock, teachers wouldn't stop talking at the same time, and they wouldn't dismiss classes at the same time. Imagine the confusion, if one teacher always talked longer than another. While he was talking, students would be waiting in the halls for his last class to end and for their class to begin. Students of the slow talking teacher would get out of his class late and by the time they got to their next class, that class would have already started. Things would get worse all day long. Because the slow talking teacher took longer to give his classes, students would be standing in the hall even longer to get into his next class. And his students would be even later for their next class. That is why we have a master clock in the school.

In electronics the word, **Clock**, with the usual meaning. A clock helps us keep an orderly relationship between what we want to happen and when we want it to happen. The word, **Clock**, also has a specialized meanings in the world of electronics. We refer to a clock, but we can also clock something. When we clock an integrated circuit, we basically send a signal every time we want the integrated circuit to do something. The clock signal has only one purpose and that is to tell the chip that it is time to do something again. Integrated circuits can also produce a clock, in which case, the clock signals tells us that we need our micro-controller to do something.

In school, we clock our classes. In electronics, we clock our devices and they clock us!!!!

In the lab, we will look at how we can create a standard clock using a Propeller and a light emitting diode. Then we will see how to use a Prop-Strobe to actually measure the cycles per second of our DC motors.

The Propeller chip can be clocked 80,000,000 times per second. That is 80MHz, which we say "80 MegaHertz." So, saying "80MHz" is the same as saying "80 million Hertz."

That means that that an 80MHz clock divides one second into 80,000,000 equal parts... let's put this into our calculator: 1/80000000.

You should see that we have .0000000125, which has a unit of seconds. But what you see is 1.25E-8. In scientific notation, the E stands for "exponent of ten." In this case the exponent of 10 is -8. So, have 1.25 X 10 ^(-8). A nanosecond is equal to E-9 seconds. A nanosecond is one billionth of a second. If you divide one second in one billion equal parts, you have a nanosecond. So, we micro-controller that requires about 12.5 nanoseconds between clock signals.

What this means is that the Propeller can do something, and then 12.5 nanoseconds later, it can do something else. And it doesn't do anything until we tell it to--->:)   A charming, almost fact.

How long is 12.5 nanoseconds?

In 12.5 nanoseconds, light can travel a little more than 12 feet in a vacuum. That means that in a big room, the Propeller can do something, such as turn on a light, and before that light has the chance to travel across the room and back again, the Propeller can do something else. That is pretty fast.

As you can see, making a regular clock using a Propeller should be easy and it should be pretty accurate. It should also be possible to make a calendar. If we can make a clock and a calendar, we can make an alarm clock, etc. That is for the future. For right now... back to the basics.

Introduction
to
Units of Measurement, Units of Scale, and Standard Conversions

In this chapter we are going to **begin discussing** units of **measurement** and **scale**. A unit of measure can only exist when there is a standard, commonly accepted, well understood, and clearly defined method for making a measurement.

The establishment of units and the conversion between them is a scientific matter that is always given due consideration and merit. In our country, these matters have official status and are regulated by the National Institute of Standards and Technology, NIST. The NIST website is a fascinating place. Once you are done studying, take a look at http://ts.nist.gov/WeightsAndMeasures/index.cfm. Or Google NIST and find a link.

You won't understand most of what you see. But over time, little by little, as you gain experience, you will find the NIST information to be very interesting.

Among the "things" that we measure are time, distance, weight, volume, velocity, frequency, wavelength, current, voltage, resistance, power, capacitance, induction, magnetic fields, electric fields, radio fields, and money. Some of these you know, some of the others you will read about for the first time in this book. Many will remain in the outer recesses of obscurity--->)

We use units of **measurements** and **scale** and perform **standard conversions** everyday. Everyone does. You already know a lot about measurements and conversions.

In fact, we use units of measurement and scale and perform standard conversions so often that we don't even think about it most of the time.

For example, if I ask you how much you weigh, all you have to do is step on your digital scale and you will come back with an answer. Let's say that at some particular time you weigh 176.5 pounds. Then you go to your doctor, and the nurse weighs you and tells you that you weigh "one hundred seventy six and one half pounds." Which measurement is correct?

You know that both are correct, because you can convert fractions into decimals. There are **standard methods** for converting fractions to decimals, which you learned a long time ago. In fact you might not even notice the fact that you are doing a **conversion** to make a **comparison** between your scale and the doctor's scale.

If anyone else asked you how much you weighed, you probably wouldn't go back to the scale, you would just give the last value you saw. You would use either fractions or decimals, and you would know that it does not make any practical difference whether you use fractions or decimals.

You also know that if you weigh yourself repeatedly throughout the day, your weight would slowly vary (change) all day long. You don't really have a single weight. On any particular day, your weight will be somewhere within some **range**. In the morning it might be 176.5 pounds and throughout the day, it might go slightly up or slightly down, depending upon how much you put in your mouth, how much comes out the other end, and what you are doing.

If you are asked how your weight changes throughout the day you might simply describe the **range** of values. You could say, "I weigh between 176.5 and 178.3 pounds, depending upon the time of day."

You know how to make a graph, and you could easily make a graph, with the time of day on the x axis and weight on the y axis. The name of your chart could be "Time vs. Weight." If you did this, you would see that there is some relationship between your weight and the time of day... but it wouldn't necessarily tell you what that relationship is because **time**, itself, **doesn't cause** the **change** in weight, it is something related to time that is causing the change.

We have just discussed the use of **standard measurements** and **conversions**, the concepts of **range**, **time**, and **causality**. We haven't said anything that you didn't already know. We simply used words and concepts in a slightly different way.

Why is your scale digital and your doctor's not digital?

Both measure weights, but the two types of scales use different methods. Your doctor's scale is actually a sophisticated balance. When your weight exactly balances the movement of another weight inside of the scale, you read your weight from the scale.

At home you use a digital scale, which doesn't have big weights or a complicated balancing system. Your scale uses electronic components, which are sensitive to the force that your weight creates when you stand on the scale. Digital scales use **electronic components**, which change **current**, **resistance**, or **voltage** in response to the force that you create by standing on it. Those electronic measurements are then converted into a weight measurement. There is no standard method for converting those electronic measurements into weight measurement. This kind of conversion depends upon the electronic components, which are used, and the manner in which they are used. The company that makes the scale has the responsibility to make sure that the conversion is reasonably accurate.

Question:

How many measurements would you have on the "time" axis of your graph?

Answer:

That depends on how long and how often you made measurements. If you measure your weight every 15 minutes, you would have 4 measurements per hour. Let us imagine that you started measuring at 8 AM and stopped at 8 PM. You would have 12 hours of measurements and every hour you would have 4 measurements. So, you would have 48 measurements (12 hours X 4 measurments/hour.

Obviously, if you made measurements every 10 minutes, you would have 6 measurements per hour for twelve hours ... or 72 measurements.

How frequently you make measurements and how long you make measurements determines the number of measurements you will have on the time axis. How often you make measurements is called the **measurement frequency** and how long you take to make all of your measurements is called the **period of observation**.

Again we haven't said anything that you cannot understand, but we have discussed some things that you might not have thought about before. And we have defined some new terms: **measurement frequency** and **period of observation**.

The concept of frequency is so important that there is a specially defined unit for frequency, called the **Hertz**, **Hz**.

A measurement frequency of one measurement per second is called a measurement frequency of **1 Hertz** or **1 Hz**.

In fact, anything that happens once per second can be thought about as happening at a frequency of 1Hz. If something happens 100 times per second, we can say that the frequency is 100Hz.

The second hand on a clock can be thought of as changing position at a frequency of 1Hz.

Units of scale are used with **units of frequency**. We describe sound using frequency. A sound can have a frequency of 1000Hz, in which case we can use unit of scale, a Kilo, K, and call it 1KHz sound. The K indicates thousands. 1KHz is 1000Hz. 2KHz is 2000Hz. 2.5KHz is 2500Hz.

Consider the **RPM** gauge in the car. RPM is a standard measurement. RPM is an abbreviation for **revolutions per minute**. This is a measurement of how many times per minute that the drive shaft of your motor rotates around back to the exact same place. There is another way of referring to anything that changes in this same way, we can say, "when the motor shaft makes one complete rotation, the shaft is going through one complete **cycle**."

At idle, the RPM gauge starts out around 1000 RPMS. As you press on the gas pedal, the RPM indicator goes from 1000 to 2000 and then from 2000 to 3000 RPM. Let us say that the gauge reads 3600 RPMs and I ask you to convert that number into **Cycles Per Second**, **CPS**. One cycle per second is also a frequency of 1 Hz. What would you do?

In every minute, there are 60 seconds. So, to convert RPM to cycles per second, **CPS**, we simply divide 3600 by 60... giving us 60 revolutions per second, which is the same as saying that the motor is rotating at 60 cycles per second. or that the frequency of rotation is 60 Hz.

Why does this work?

We have Revolutions Per Minute...mathematically we write this: 3600 revolutions / 1 minute. That is a lot to write, so we just write:

3600 Revs/min.

1 minute is identical to 60 seconds... mathematically we write this as "one minute per 60 seconds," or "1 min/ 60 seconds"... so we can multiply our RPMs by this **identity.**

x =3600 revs/min
x = 3600*(rev/min)*(1m/sec)

x=60Revs/sec

Which is the same as 60 CPS

The frequency of rotation is 60 Hz.

I RPS = 1 CPS = 1 Hz

Notice that 1 minute equals 60 seconds, but 60 seconds also equals one minute--->:)

Question:

How do we know that we are supposed to multiply by 1 min/60 sec and NOT by "60sec/min?"

Answer:

Well... you could just remember the standard conversion...**OR** you could remember that we are trying to get rid of the minutes and end up with seconds where the minutes used to be. The only way to get rid of minutes on the bottom is to multiply by something with minutes on top.

You will suffer from "**conversion confusion**" every time you have to do a conversion until the standard method becomes clear. You will learn by doing.

Let's do another standard conversion.

On the package of your 9 Volt DC motor, you will find the motor speed, in terms of RPMs. We really need to know what that means in terms of CPS. Give it a try.

We will have lots of conversions to do. By the time you are done, you won't have to think about it.

Frequently, what we are measuring can be described by the concept of frequency.

In the Lab, we saw that **a DC motor can also act as a generator**. We actually measured the voltage potential across the motor terminals as we turned the shaft of the motor. And we saw that if we used another motor to turn the shaft of our generator motor, then we could measure a constant voltage.

If you look at the book that came with your multimeter, you will see that the multimeter reports reports voltage a few times a second. This is a pretty slow measurement frequency. In the time that the multimeter makes a measurement, the motor will have turned many times. In one of our future lab sessions, we will see how to use a Propeller micro-controller to measure the same voltage potential at 25 times the speed of the motor.

The concept of frequency can be used to describe both what we are measuring, and how we are measuring it.

If something happens once a second or if we make a measurement once a second, we have a standard unit...**1 Hertz**, abbreviated as 1 Hz We commonly use measurements frequencies of 1 Hz. But if what we are measuring changes at 100Hz, and we are measuring at 1Hz, we are going to be missing a lot of information.

The Hz is a unit of frequency, named after **Heinrich Hertz**, who demonstrated **UHF** and **VHF** radio waves in 1887.

Let us imagine that you could magically see electrons as they are traveling through a wire. Let us imagine that not only can you see electrons, but something within you allows you to actually count electrons moving in a wire. This is very hard work, so you decide to only count for 1 second. So, you decide to look at a single place and count the electrons as they are moving passed that place for one second.

That's a lot of imagining... but imagine one more thing. Imagine that when you do this, you find that the number of electrons moving past that little place on your wire is exactly ....

6241509629152650000 electrons,

which is more than a quadrillion:)

Let's break this huge number up into groups of three.

6 241 509 629 152 650 000

Now it is much easier--->:)

When the reporter from Fox News comes to report on your achievement, you have to tell him the number. You take a deep breath and you say... "the number is 6 quintillions, 241 quadrillions, 509 trillions, 629 billions,152 millions, and 650 thousands"

The reporter is quiet for a moment and then asks you a question:

"Isn't that a **Coulomb**?"

IT IS!!!!!!

A **Coulomb**, is a measurement of electric charge, and is named to honor **Charles Augustin Coulomb**. The Coulomb is abbreviated, **C**. We have to be careful when we read, because "C" can also mean degrees centigrade. Charles Augustin Coulomb was a French scientist who substantially changed and advanced science during his lifetime.

It is easier to say, "one Coulomb" than it is to read that huge number. So, we use the Coulomb as a standard unit to indicate a huge quantity of electric charge. When we have a Coulomb of charge moving passed a point in one second, we define the standard unit of current, the Amp. 1 Amp = 1C / 1s, which means: "One Amp of current is equal to one Coulomb of charge moving passed a point in one second."

One Amp is the amount of current flowing in a wire, when 1 Coulomb of electrons flows through that wire in one second of time.

There is just one little problem with this. At the time that Coulomb lived, the electron had not been discovered. Although we can now calculate this number, it was unknown to Coulomb! Coulomb believed that the fundamental unit of charge was thousands of times bigger than it actually is.

Question:

Imagine that you have a wire that is very thin and allows only one electron to pass a point at any instant in time. What is the frequency, in terms of Hz, of electrons passing in front of your eyes in one second? Assume that you have a current of 1 Amp.

In this case, you need an extra sharp imagination, because there is absolutely no way that this could happen.

Answer:

6241509629152650000 Hz

We have 1 Amp of Current. So we know that we have 1 Coulomb of electrons passing your imaginary observation point each second. And we know that one Coulomb is 6241509629152650000 electrons.

6241509629152650000 * 1 electron/sec ....

but 1 electron/sec = is 1 Hz

So, in this case, we simply substituted **Hz** for the "per second."

Do you remember Ohm's Law?

Ohm's law states a relationship between, current, resistance and voltage of a circuit. This relationship can be stated in any one of three ways.

1. **Voltage = Current X Resistance**,

Volts = Amps X Ohms,

V = I X R...

2. **Current = Voltage / Resistance**

Amps = Volts / Ohms

I = V / R

3. **Resistance = Volts / Current**

Ohms = Volts / Amps

R = V / i

All of these equations refer to just one relationships and state just one law, 3 different forms of the same equation and 3 different ways to name the quantities. If you remember just one of the nine different forms of Ohm's Law you can always work your way to any other of the nine forms.

Which form should you use? It doesn't really matter. In order to use Ohm's Law, you have to know two values to find the third. So, usually, you put what you don't know on the left and then find that value by putting the two values, which you do know, into the right side of the equation.

Do you remember Ohm's Law now? Remember just one form... and you remember it all.

Anywhere that you see a reference to current, as either "Amps" or "I", you can substitute one Coulomb per second for either the A or I, which represent the same thing... current. "One Coulomb per second" is the same thing as 1C/s. Ohm's Law allows you to directly relate the current, which we measure in Amps, to Resistance, which we measure in Ohms, to Voltage, which we measure in Volts. With the Coulomb, we can calculate the actual numbers of electrons flowing in a wire during any particular period of time. This fact is incredibly useful. This fact helped bring mankind into the modern age. More important to us is the fact will Ohm's Law will let us create circuits that actually work.

Question:

How many electrons flow passed a point in a circuit in two seconds, if that circuit has a source equal to 1V, a current equal to 1 A and a total resistance equal to 1 Ohm?

Answer:

Easy... One Coulomb of charge flows through a circuit in one second if that circuit has a current of 1 amp. So, one C of charge flows in one second.... how many Coulombs will flow in 2 seconds?

The answer had better be = 2 X C.

What is 2 X C?

6241509629152650000 x 2

That huge number that we talked about above... multiplied by 2.

In the lab section, we found that the current flowing in our thermocouple was around 2 micro Amps, $2\mu A$.

μ is a Greek letter, pronounced "Mu." "mew".... not "moo." No fair making cow sounds.

The Mu, μ, is a unit of scale.

Some keyboards don't have a convenient way to type a μ... so sometimes you just see "u" or "uA." We use mu, to represent the unit of scale that means "one million-th". If we divide a volt into one million parts, one of those parts is a microvolt, μv. If one volts represents the electrical potential required to do some "thing" then 1 microvolt, is that amount of electrical potential divided by 1,000,000.

So, 2μA is 2A/1,000,000= .000002A. Your multimeter doesn't have enough digits to display .000002,

We read 2.0 and in the scale indicator on the screen, we saw μ... indicating a microAmp scale.

Notice that we are talking about two different kinds of units. First, we have units of measurement, "how many, how much, how long," etc. And then we refer to units like mu, μ, in front of volt, micro-volt, in front of an Amp, μAmp, and in front of a second, μSec. Micro, mu, μ, is a unit of scale.

Question:

Why do we have units of scale?

Answer:

We have units of scale for reasons of practicality, communication, cost, and convenience.

Notice that the screen on your multimeter can only hold 5 digits. The largest number that it can display is 99999 and the smallest number that it can display is 00001, If all of the quantities that your multimeter could measure had values between 1 and 99999, then the multimeter would not need units of scale.

But that isn't the case, your multimeter does have units of scale... and if you don't pay attention to the units of scale on your multimeter, then you are not going to know if you have a resistor that is 10 Ohms, 10K Ohms, or 10M Ohms.

Imagine if we didn't have a unit like the Amp or Coulomb. Every time we wanted to represent a Coulomb of charge we would be forced to use the number 6 241 509 629 152 650 000. That number would be written down every day, in millions of places, by millions of people from now until the end of the time. We would eventually need millions of trees just to create the extra paper required to print that number----->:)

The Amp is a unit of measurement, the μ is a unit of scale. They both saves trees---->:)

We measured a current of 2 micro-amps from a thermocouple. That current is equal to some number of electrons flowing in one second through a wire. How many?

6241509629152650000 x 2 is the number of electrons in 2 coulombs

We want to know the number of electrons in 2 μC.

we take the number

6241509629152650000 x 2 and then

we divide it ....

by....

1,000,000

So, if we have a 2μA current in our thermocouple, the number of electrons flowing in one second is

2μC = (6241509629152650000 x 2) / 1,000,000

Get out your calculator and try it--->:)

If you have a good calculator, you should see

what you should see is
12483019258305.3

But what you actually see is
1.24830192583053E+13

Cheap calculator--->:)

What does all of this mean?

2μC is some number of elemental charges... it is a lot easier to remember and talk about 2μC than to talk, using numbers in the form of 1.24830192583053E+13... but they actually are the same number.

There is a problem with using the Coulomb as a unit. The number of electrons is somewhat arbitrary. Right now this is not important, so don't worry about it.

Here is the story: In 1811, about five years after Coulomb died, Amedeo Avogadro, stated an hypothesis, which became a Law. This Law helped to established a new unit of scale, which is used as part of various units of measurement. That unit is called a mole. This unit, which is called a mole, is just a number, $6.02214179(30)\times10^{23}$.

The number, $6.02214179(30)\times10^{23}$, is called Avogadro's number.

By definition, a mole of any thing contains $6.02214179(30)\times10^{23}$ of those things. A mole of electrons is $6.02214179(30)\times10^{23}$ electrons. When we talk about Avogadro's number and electrons... it is just like talking about a Coulomb... except Avogadro's number is bigger than a Coulomb... much bigger.

Michael Faraday almost immediately suggested that a new constant should be adopted, which today we understand would allow the flow of electrons to be expressed as moles of electrons moving passed a point in one second. We have no need for Faraday's constant right now or for Avogadro's number either. But you should know that they exist. Avogadro's number is usually rounded off to 6.02 X 10^23. One mole of things is approximately 6.02 X 10^23 things.

You should memorize Avogadro's number, it is the password to chemistry--->:)

The mole allows us to precisely relate chemical processes to electrical processes. And the mole allows us to do far more. So, the mole is a very big deal. Even though you don't understand any of this very well yet, I cannot resist telling you that one mole of electrons has the same electric charge as approximately 96,485.3399 Coulombs. This number is called the Faraday's Constant, F.

F = 96,485.3399 C

Faraday didn't know the exact value of his own constant! What he did know was that we needed this number, and he knew how this number could be used.

But this isn't much fun, you don't need to know most of this right now(or ever). So, for now we are going to drop the mole like a dead rat--->:) Don't worry about it. I am sorry I mentioned it. You don't have to know it.

Huge numbers... more huge numbers... units....more units...famous dead scientists, with weird names, and moles... this is enough to exhaust a guy.

Take a break.

Have some fun.

Let's go to the Lab!!!!!