Diploma of Audio Production **Name_______________**

Analogue Fundamentals

Module 1

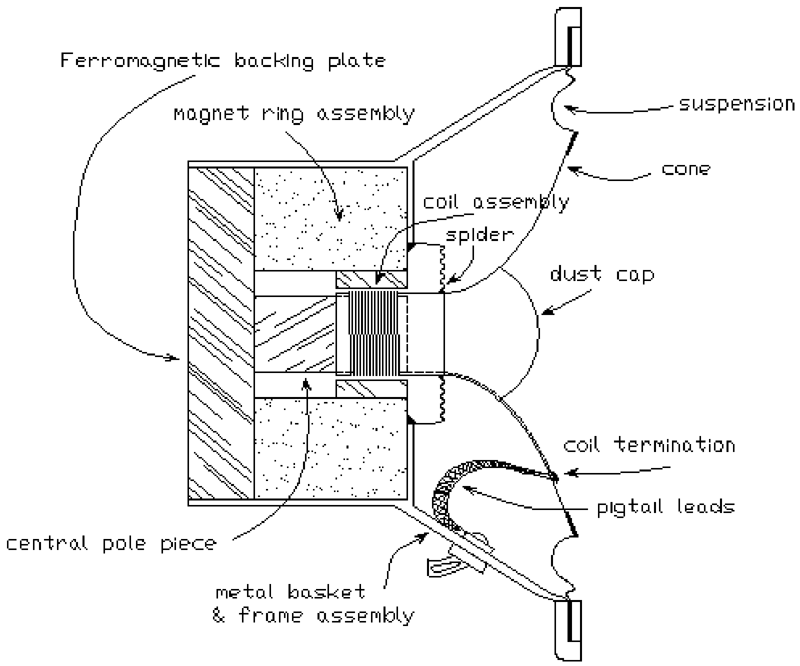
Fundamentals of Electricity.

Well what's this got to do with music and in particular music reproduction?

Everyone here has listened to music on a loudspeaker. But how does a loudspeaker work? Yes the "cone" of the speaker is vibrating or "pumping" in rhythm to the music and in doing so it moves the air particles. This in turn moves our eardrums and we have the sensation of hearing. The loudspeaker cone actually "compresses" and "rarifies" the air particles which causes our eardrums to move in and out.
But what is it that causes the speaker cone to pump or move in and out?

Answer. ____

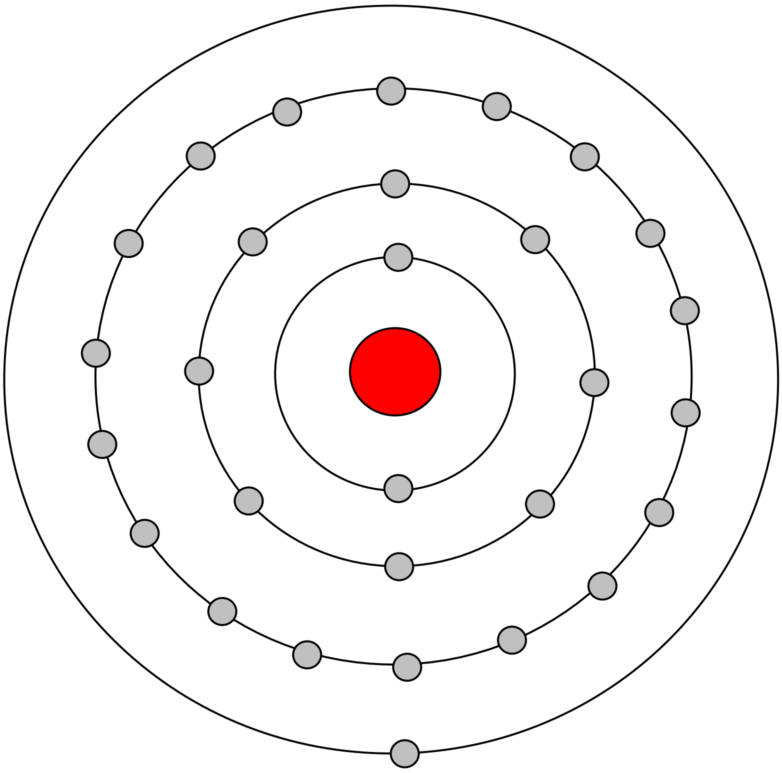
OK so now that we have established that it is indeed and electric current that "drives" the speaker we need to now look at what we need to produce this "current". We also need to define what constitutes an electric current or simply what is an electric current?

What makes a loudspeaker move and produce sound?	'Compressions' and 'Rarefactions' of the air created by the movement of the cone. The Cone is driven by the electric motor effect of the coil of conductive wire reacting against the magnetic field inside the speaker pole piece. This happens because the ***flow of current*** through a conductor produces a magnetic effect – more on this later.	

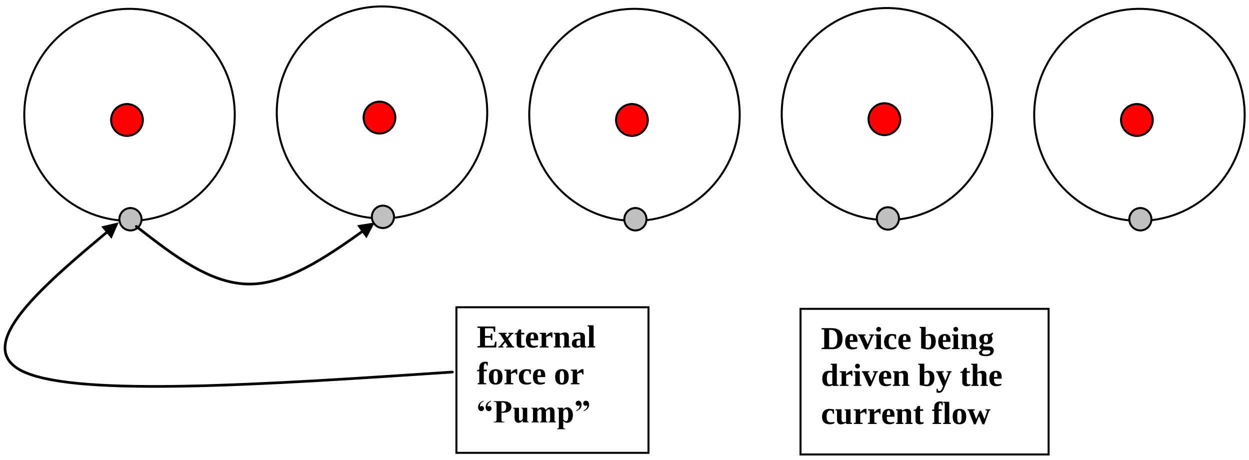
Lets do the 2nd thing first: What is an electric current?

By definition it is a **movement of electrons** through a conducting medium or conductor. A conductor can simply be a piece of copper wire, which is made up of trillions of copper atoms. An ‘atom’ consists of a nucleus and orbiting electrons. Bear in mind that this picture is largely a “convenient” mathematical/quantum model, which suites the observed characteristics of matter. It does not mean that if we were small enough we could actually “see” the atom like this. Sometimes electrons behave like ‘waves’, not particles. An element such as copper has 29 electrons orbiting around the nucleus containing 29 protons and 34 neutrons. Now electrons and protons have an opposite charge to each other, the proton is said to be positively charged and the electron negatively charged. The neutron has no charge or is neutral. Now we are only interested in the electrons because it is the sequential movement these small particles that provide an electric current. A copper atom has 4 shells or rings of electrons orbiting the nucleus. It is the characteristics of the outer shell that make copper an excellent conductor of electricity.

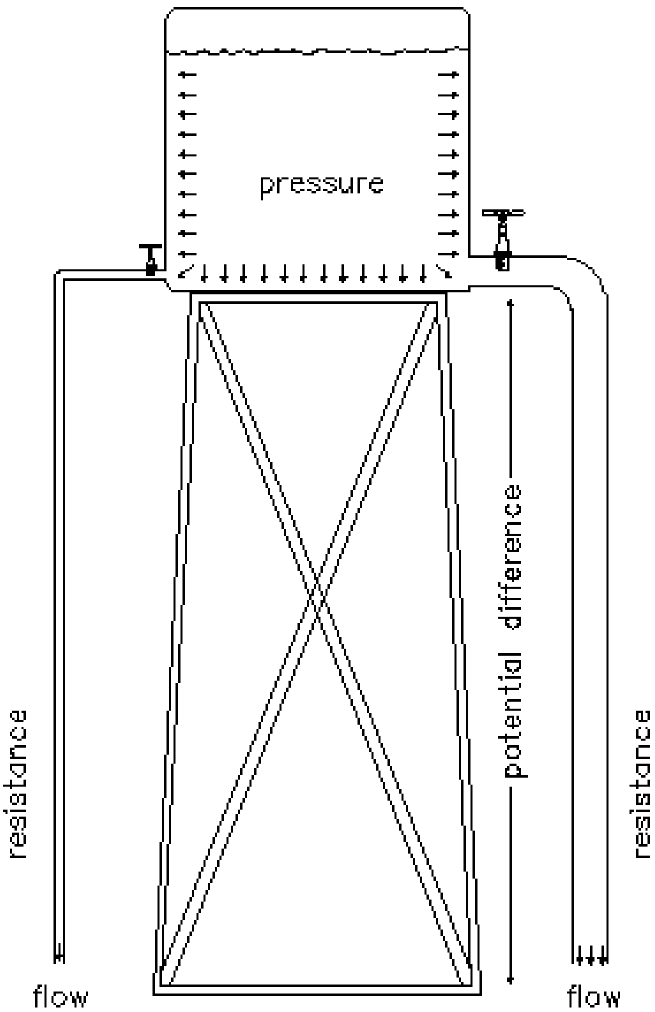
A picture would help….



Note that the outer shell has only one electron and as such is easily moved to another atom with the application of an external force. Remember that like charges repel and unlike charges attract, a bit like magnetism with north and south poles. So an electron is repelled by another electron moving towards it. This is what constitutes an electric current.



The flow of electricity and the force which drives it can be likened to a water supply. Think of the electrons as the water in the tank, the EMF or voltage as the pressure, caused by the 'Potential Difference' due to gravity (in this case), and the amount of electricity flowing (the 'current') as the amount or quantity of water. The bigger pipe offers less ***resistance*** to the flow, and so has more water through-put even though the static pressure in the system is the same.



A Closed Circuit

The requirements for producing an electric current are;

1/. A source of power such as a battery or power supply. This is our external force or pump, often called “Electro Motive Force” or EMF.
The battery is our source of energy or “supply of electrons”

2/. A circuit made of a conductor such as copper or aluminium.

3/. The device we wish to operate with the flow of current. Put differently, a device which we desire to *perform some sort of work* for us. This could simply be a lamp or light globe. In electronic terms this is known as the resistance or load, which opposes the flow of current.

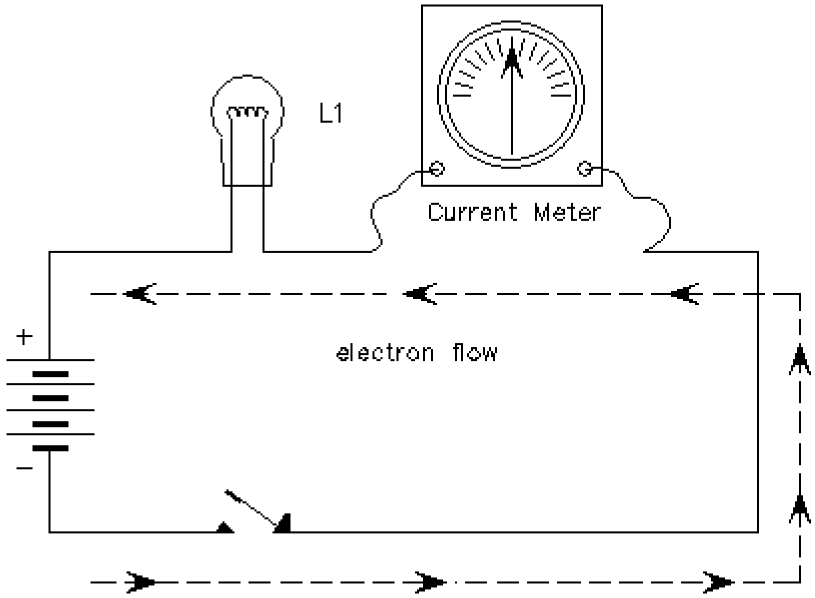
In order to make an electric current works for us, we need something to ***resist*** the flow of electrons. It is this ‘resistance’ to the flow of current that allows the electron flow to do the desired work for us.

Now what is a battery and what are the important characteristics that we need to be aware of?

Well a battery can be considered to be a store of electrons or current carriers capable of doing some work. The battery has a positive terminal and a negative terminal.
We could say that the negative terminal has a surplus of electrons while the positive terminal has a deficiency of electrons. This unbalance of electrons is produced by a chemical reaction inside the battery. It the “pressure” exerted on an external circuit by the electrons at the negative terminal wanting to get to the positive terminal that results in an electric current.

The voltage, or ***potential difference*** along with the capacity of the battery are other important characteristics we need to know.
eg. 1.5 Volts, 6 Volts, 9 Volts etc. and the physical size of the battery usually determines how much current the battery can provide.

An Electric circuit.



Battery and lamp

Note: The current flowing in the circuit (when the switch is closed) is known as “Direct Current” or “DC” as it is always flowing in one direction only as opposed to “Alternating current” or “AC” which flows back and forth or alternates direction. Batteries provide DC while “the 240 Volt mains” provides AC.

Question:
Is the audio signal that comes out of a CD player AC or DC?? ___________________

Why ?____

So in any functioning circuit we have the source of energy, the battery, conductor to carry the current and a “Resistance” which opposes the flow of current.

Question:
What happens to the lamp when it endeavors to oppose the flow of current?
____

Speaking of conductors;

List say 4 materials you think are good conductors of electricity.

1. ________________________
2. ________________________
3. ________________________
4. ________________________

The opposite of conductors are called 'insulators'. These are materials that will not allow the flow of current, and are so because there outer electron shell is stable and complete and usually consists of 8 electrons.

List 4 materials you think will make good insulators.

1. ________________________
2. ________________________
3. ________________________
4. ________________________

So now we have the three most important properties of any electric circuit.

1/. The **Voltage (V)** (or applied voltage). This is the 'electrical pressure'. This can be provided by a battery, power supply or an amplifier with an audio signal. This is measured in **Volts.**

2/. The resulting **current** flowing around the circuit. This is essentially the quantity of electricity. This is measured in **Amperes** or **Amps (A)**.

3/. The **resistance** to the flow of current and this is measured in **"OHMS". (Ω)**

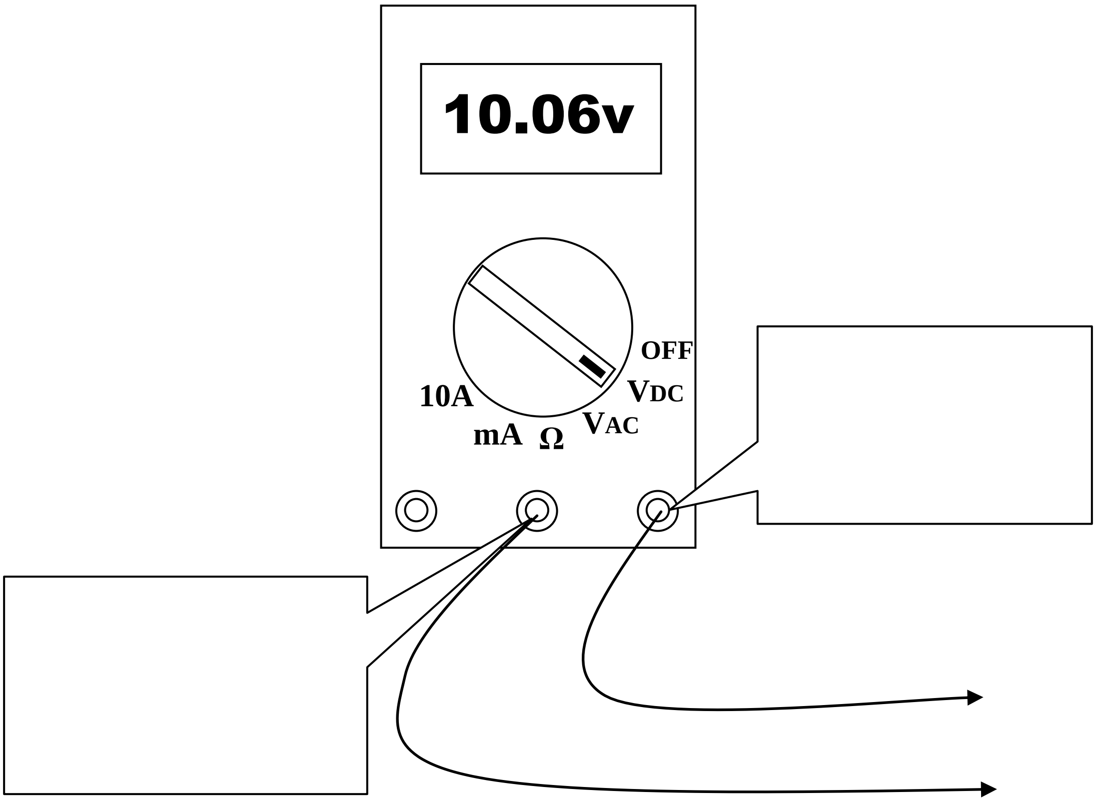
The abbreviations for the above are **Voltage = V**, **Current = A** and **Resistance = R** or **Ω** (omega). The **mathematical** symbols for the above are **V** for Voltage, **I** for Current and **R** for resistance.
The action of these three properties are described in the following formula.

Current = $\mathbf{Voltage}/\mathbf{Resistance}$ or $\mathbf{I} = \frac{\mathbf{V}}{\mathbf{R}}$

This is the formula known as "OHMS" law named after its discoverer, George Ohm.

The formula tells us that if the **voltage increases** the **current will increase** but if the **resistance increases** the **current will decrease**.
Now we can measure all of these properties using a device known as a "Multimeter" and most modern meters are of the "Digital" variety and are known as a "Digital Multimeter" or "DMM"

Example:



What can an electric current do? or better still what are the possible effects of an electric current.

1. Can produce heat.
2. Can produce a magnetic field (Electromagnetism)
3. physiological effect (Worst case – electrocution)
4. Chemical effect (electroplating etc.)

What about some examples of the above effects!!

Heating effect.
1. ________________________
2. ________________________
3. ________________________
4. ________________________

Magnetic effect.
1. ________________________
2. ________________________
3. ________________________
4. ________________________

Chemical effect.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Physiological effect.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Time for some practical work.

Aim:

DMM familiarization.

Lets measure the voltage of some batteries using the DMM on the V__ Scale and also measure the resistance of some loudspeakers using the DMM on the Ω scale

Results:

Battery 1 ____________ Volts

Battery 2____________ Volts

Speaker 1 __________ Ω or ohms

Speaker 2__________ Ω or ohms

Next I want you to measure your own body resistance from one hand to the other. Hold the probes reasonably tight and your reading will be somewhere between 100,000Ω to many millions of ohms depending on a number of factors such as "sweaty" hands etc.

Question: If your body measures resistance can an electric current pass through it?

Answer: ____

____

Experiment:

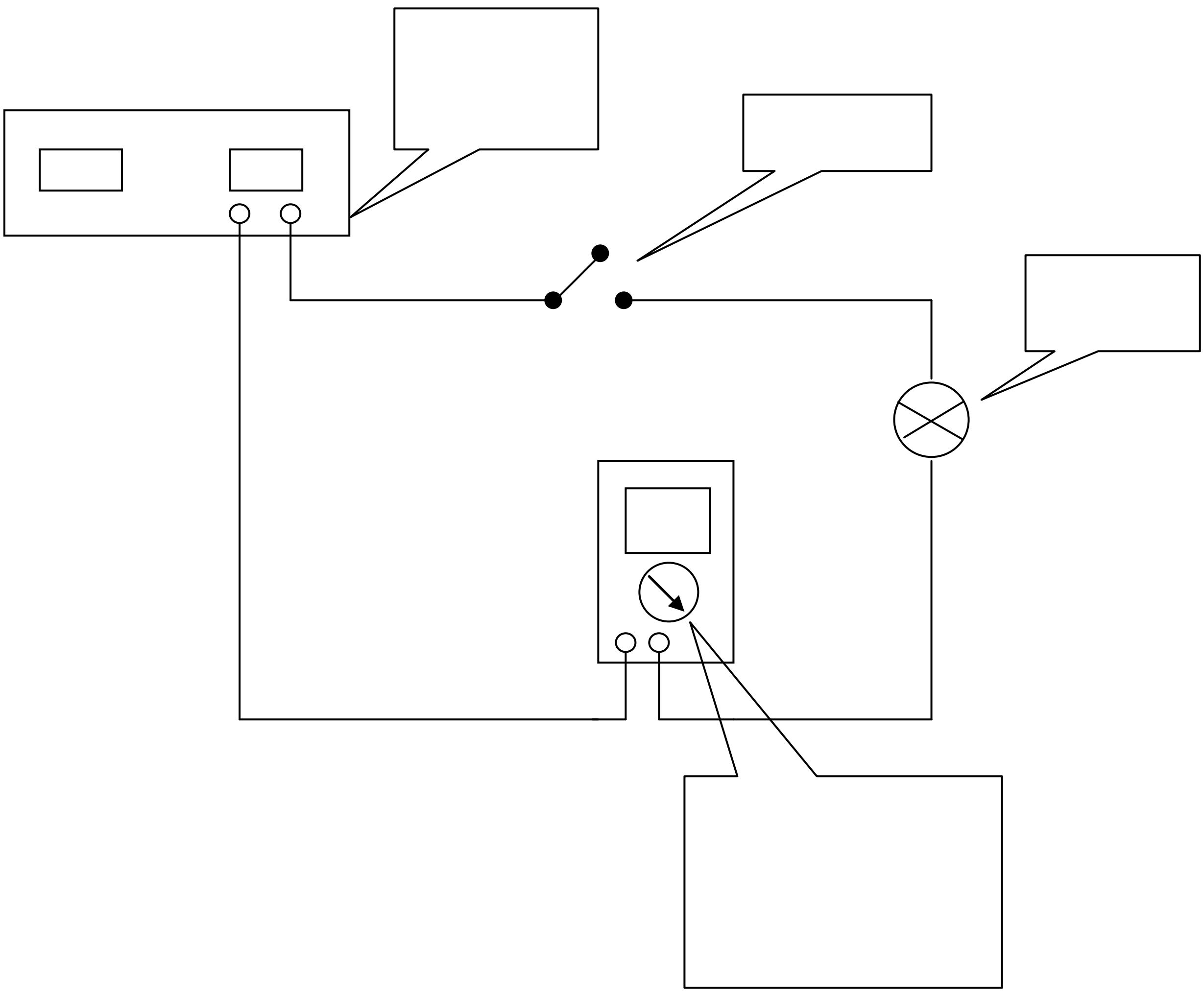
Aim: **To measure electrical current and voltages in and around a circuit**

Procedure:

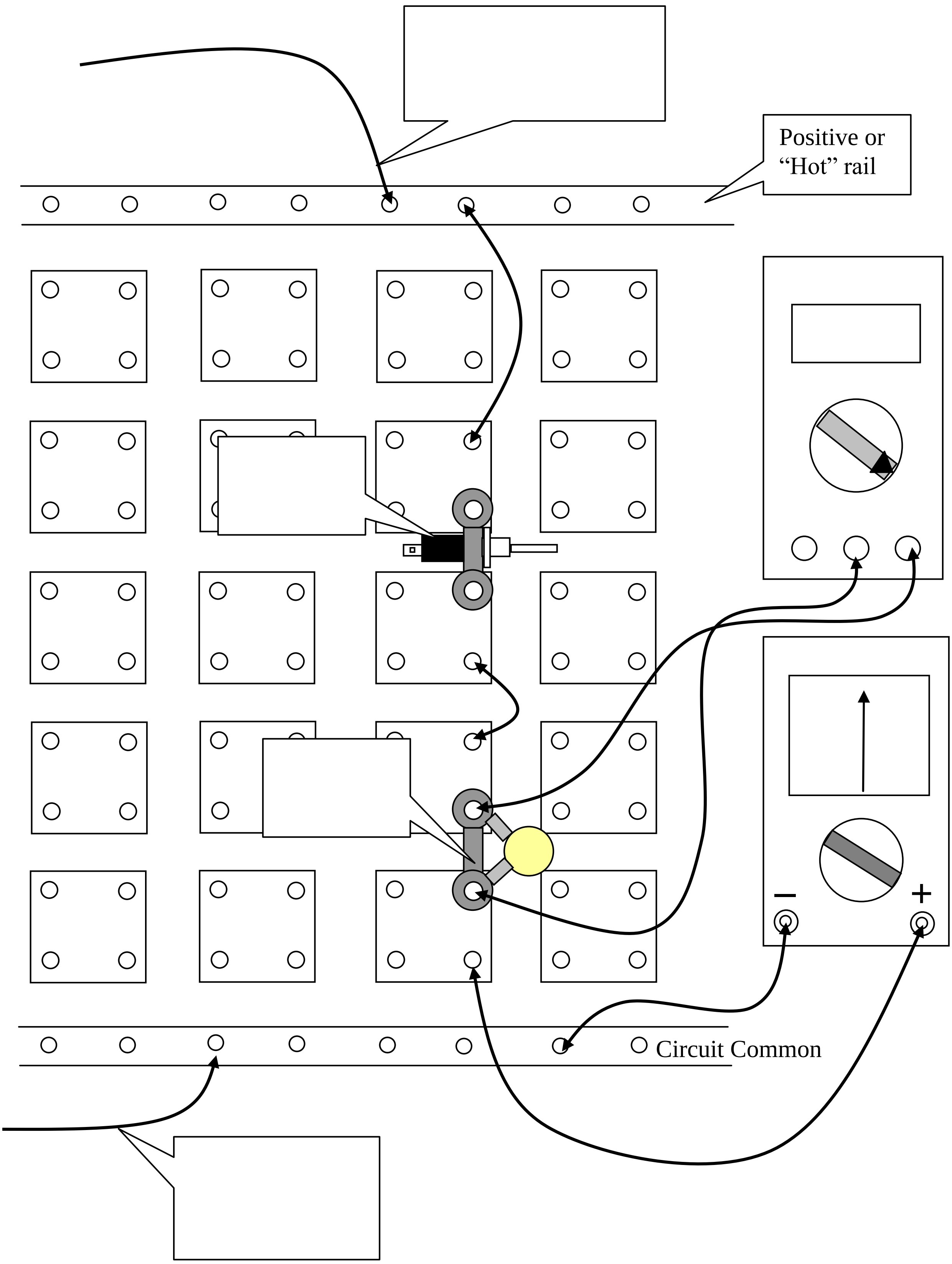
1. Using the Digital Multimeter, set the output voltage of the power supply (battery eliminator) to 12 Volts.

2. Connect up a circuit consisting of a lamp, switch, current meter, cables and power supply as shown below.

The circuit.



Layout on matrix board:



1. Does the lamp Illuminate?
2. Operate the switch, so that the lamp switches on and off.
3. What current flows through the circuit with the lamp off?
4. Measure the current through the circuit with the lamp on. Record this current.____________________________________
5. Using the DMM measure the voltage across the lamp and switch with the lamp operating. Record these readings.
6. Lamp__________________Switch__________________
7. With lamp off Repeat point 5.
8. Lamp__________________Switch___________________
9. Using Ohms law, Calculate the resistance of the lamp when illuminated. Below we have re-arranged Ohms Law to enable us to calculate resistance from the current flowing, and the known voltage:

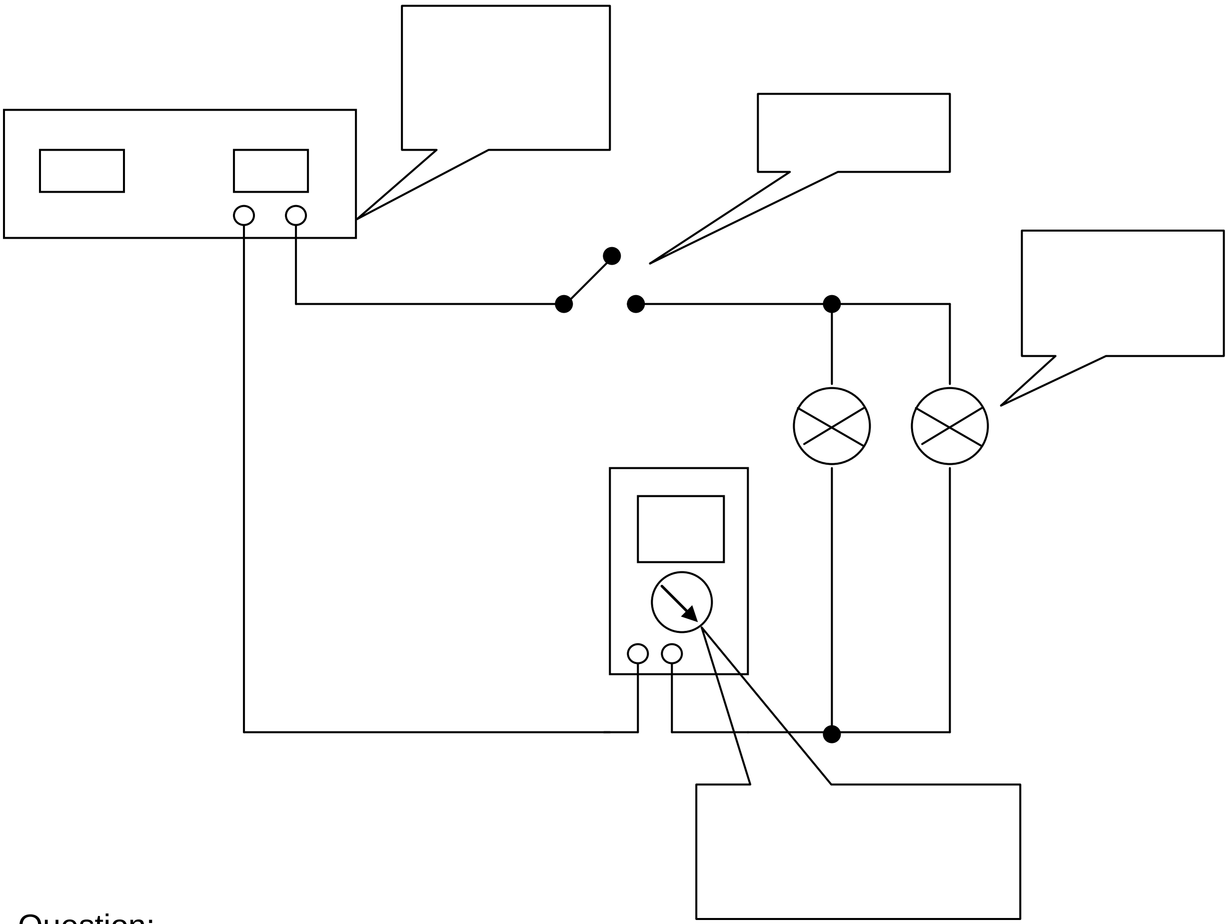
$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{R}} \text{ \& therefore => } \quad \mathbf{V} = \mathbf{I} \times \mathbf{R} \text{ \& therefore => } \quad \mathbf{R} = \frac{\mathbf{V}}{\mathbf{I}}$$

Therefore the resistance offered to the supply voltage is equal to the **voltage divided by** the measured **current**.

Calculations:

____
____
____
____
____
____

Rewire the circuit as shown below and Modify the component layout over the page. Then repeat steps 1 through to 7 above.



Question:

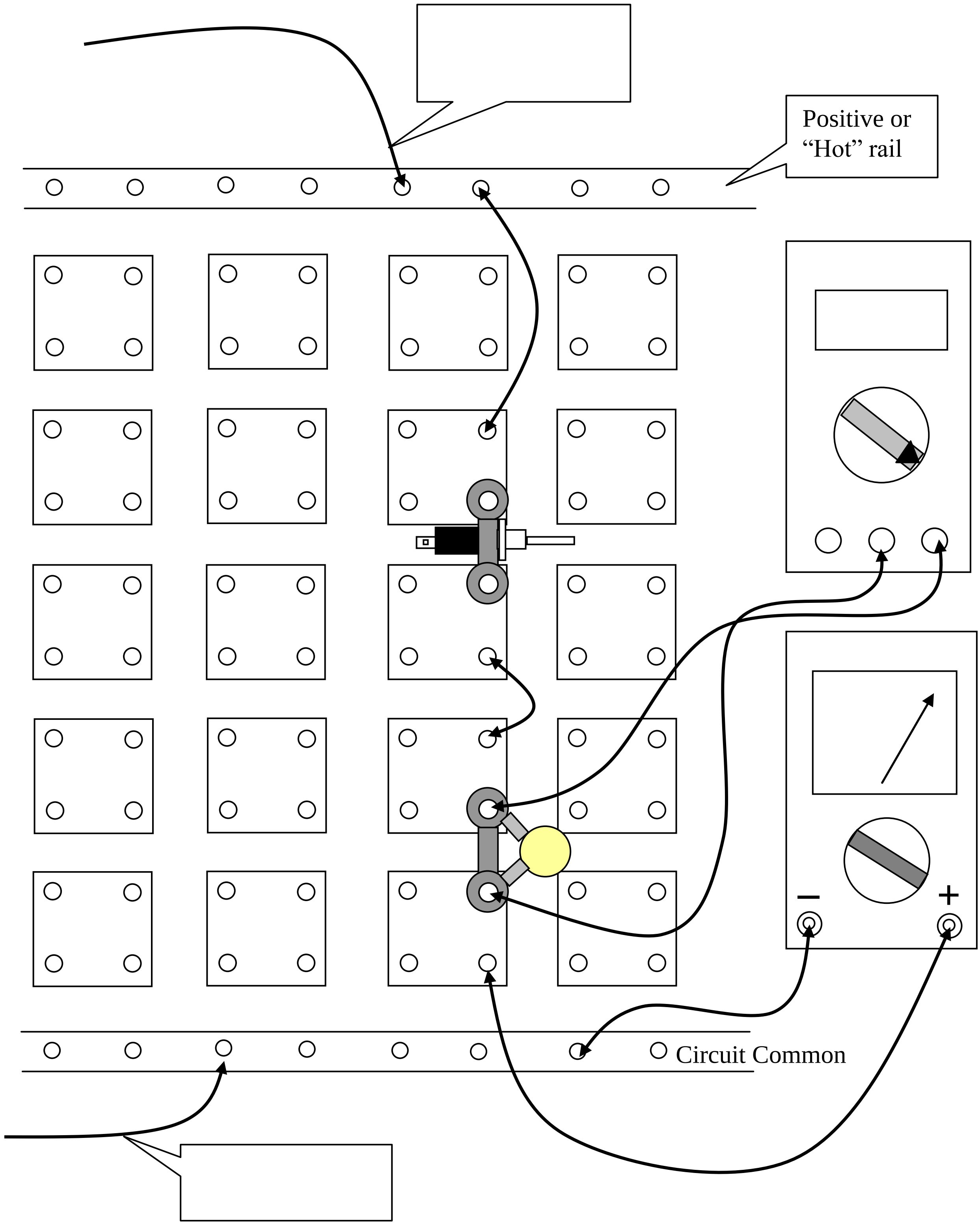
1. What happened to the current flowing around the circuit with the addition of the 2nd lamp?

   Did it increase or decrease? ___________________

2. Therefore the “Total” resistance offered to the power supply must have_________________

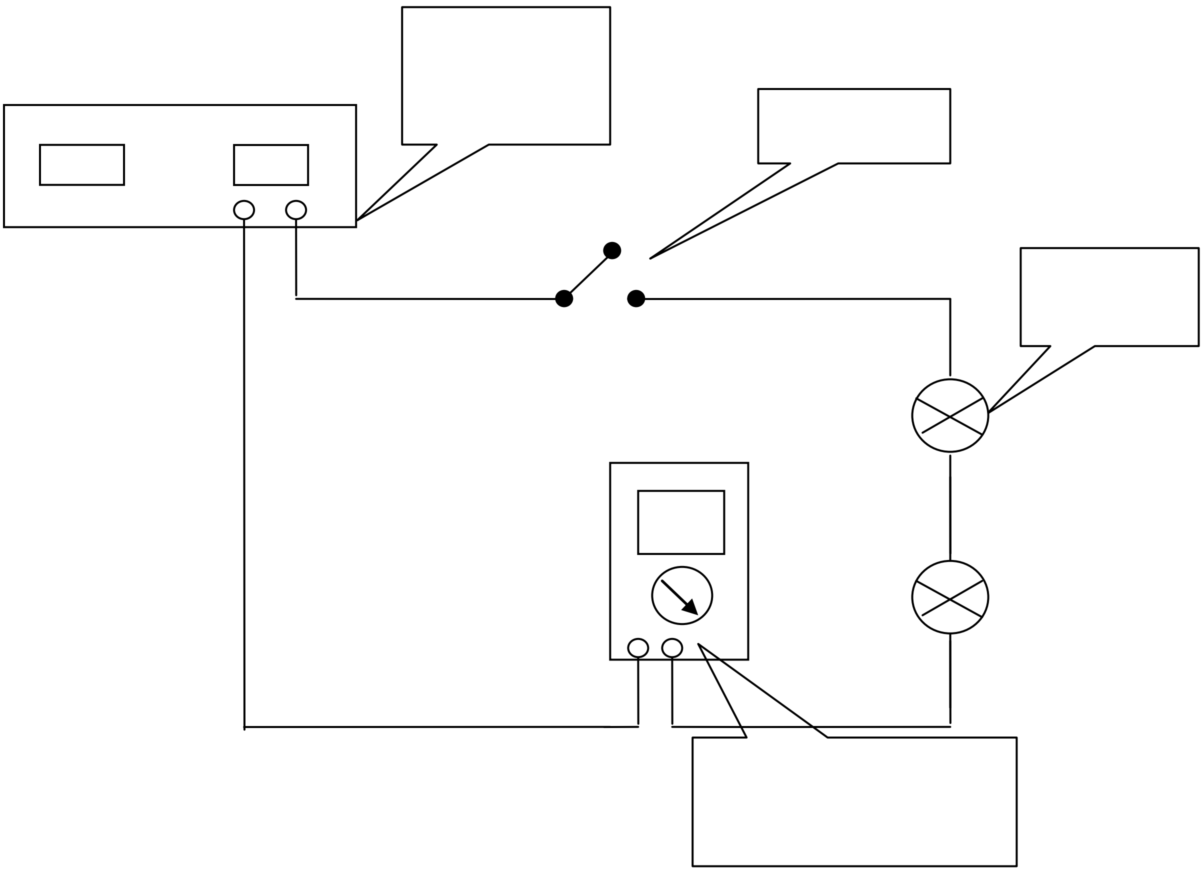
   Calculate the actual value of resistance using ohms law

   Calculations


Positive or
“Hot” rail
Circuit Common
−
+

This circuit is known as a parallel circuit. *<u>The current increases with the addition of each lamp or resistance.</u>*

Note that the resistance of each lamp is still the same as is the current passing through each lamp. So with parallel circuits, the “total” resistance offered to the power supply is less therefore allowing greater circuit current to flow!! Rewire the circuit as shown below and repeat steps 1 through to 7 as set out on page 3.



The circuit above is known as a “series” circuit. <u>The current *decreases* with the addition of each lamp or resistance.</u>

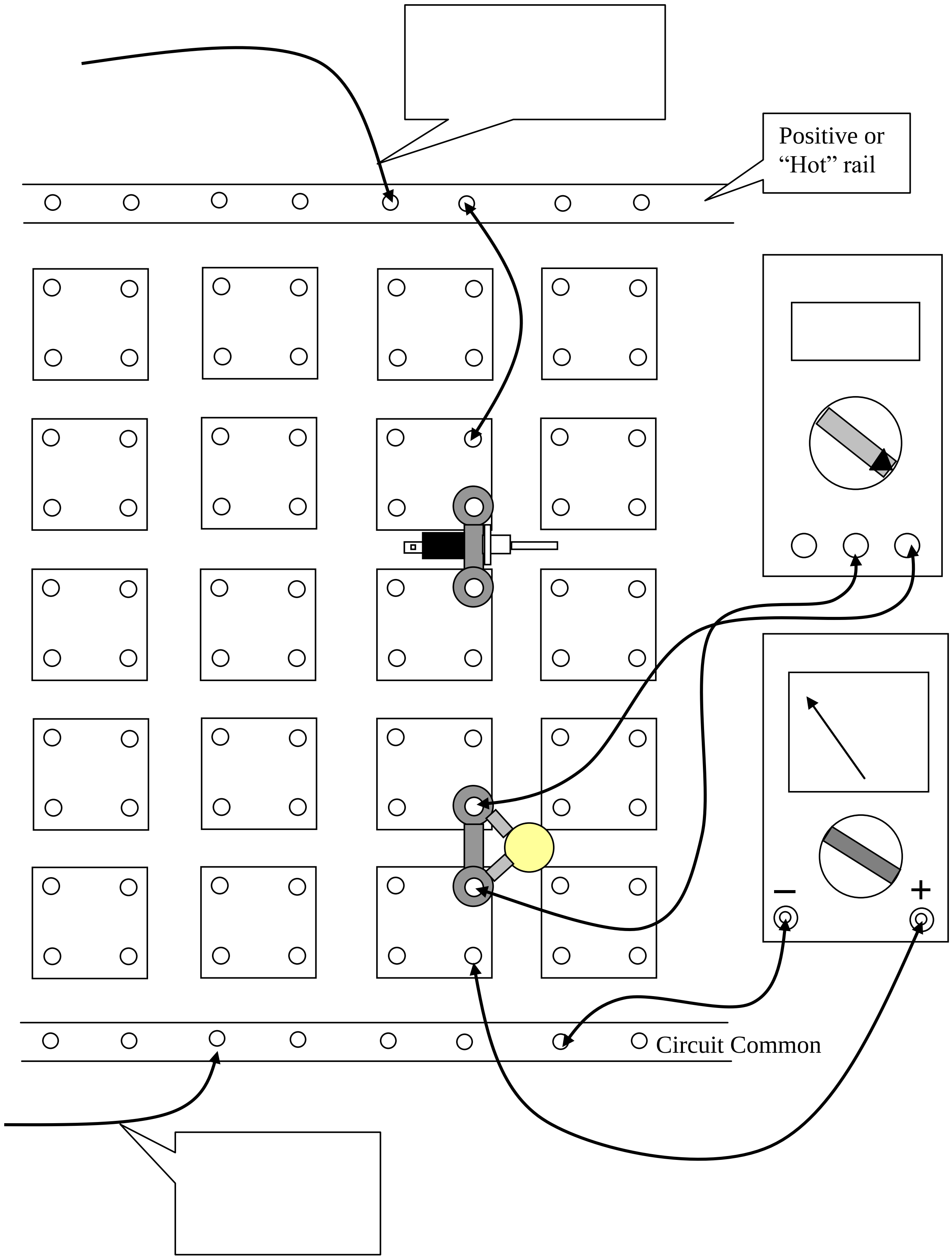
1. Measure the voltage across each lamp and record.

   Voltage lamp 1____________
   Voltage lamp 2____________

2. Measure and record the circuit current.

   Current_________________

   Has it increased or decreased? _____________________


Positive or
“Hot” rail
Circuit Common

Using OHMS Law, Calculate the total resistance offered to the power supply in the series circuit.

Calculations.

Conclusion:

See if you can come up with a conclusion to this experiment.

