Black Box Experiments

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"Whenever I met one of them who seemed to me at all clear-sighted, I tried the experiment of showing him my Drawing Number One, which I have always kept. I would try to find out, so, if this was a person of true understanding. But, whoever it was, he, or she, would always say: "That is a hat." Then I would never talk to that person about boa constrictors, or primeval forests, or stars. I would bring myself down to his level. I would talk to him about bridge, and golf, and politics, and neckties. And the grown-up would be greatly pleased to have met such a sensible man." The Little Prince, Antoine de Saint Exupéry

Teacher's Notes:

Teaching the scientific method involves more than just experimentation. The understanding and use of the scientific method have many components: the reflective, the interactive and the manipulative. A Black Box experiment is a great teaching tool to introduce the scientific method as a generic protocol for problem solving. "Black Box experiments" are problem-based situations the teacher creates that offer a hypothetical mystery (hence, the "Black Box"). The problem is easily researched, observable and is very straightforward. Students then use what they observed to create a hypothesis, design and implement a test to explore their hypothesis, collect data and make a conclusion. In many cases Black Box experiments do not model real life science research and experimentation, yet, it does offer a good opportunity for students to experience the scientific method on their own scale. For older and more advanced learners, it's also an opportunity reflect and critique its simplicity and to go deeper into the complexity of real scientific problems.

Many physics and chemistry discoveries in the history of modern science can count as black box experiment, Mendeleev's periodic table, Rutherford's gold foil, Millikan's oil drops were predicted and calculated without actually seeing the tested object,

The most popular black box is the sealed shoebox with mystery items inside. Without opening the box, students need to determine its contents by using their senses. This lesson plan offers a unique yet simple design and twist to a Black Box mystery.

Part I – The Mass of a single Balora (or Balorum?)

Equipment, costs and instructions:

- 10-20 identical boxes can be used plastic jars of peanut butter or any other as long as you can get identical ones.
- Marbles 60 – 200 (depends on number of boxes) (200 are sold for ~$10 on amazon. Including S&H) – can make it cheaper using other available items like paper clips, washers, screws or nails.
- Letter size paper, about 40 sheets.
- Digital scales accuracy of 0.1 grams (Triple beam scale works as well, but measuring time will be longer)
- Millimetric graph paper, or computers with excel software, or internet access and google spreadsheet.

Preparation:

- Insert different amounts of marbles along with spacing paper (same amount of sheets to each box), the purpose of the paper is to muffle the sound of marbles.
- Mark boxes with different symbols, create a key of symbols vs. number of marbles.

Class Instructions:

Scientists had found that these blocks contain different amounts of Balora. We do not how many Balora in a box, or what is the mass of a single Balora.

1. In your group, devise a method of measurement and write down an experiment protocol.
2. Execute your experiment, analyze the data and prepare to present your results to the class.
3. Other than not opening the box any way of trying to figure out how many Balora in the box is valid.
4. You are not allowed to open a box under no circumstances!
5. All the boxes contain Balora, there are no empty boxes.

Activity time – 45 min Presentation Discussion 30-45 min

Optional:

1. Tell the students that the boxes contain a consecutive number of Balora.
2. Remove 2-3 samples from the middle of the sample, so students will get to parallel lines, but shifted. (The missing elements of Mendeleev)

Part II – Electrical Black Boxes

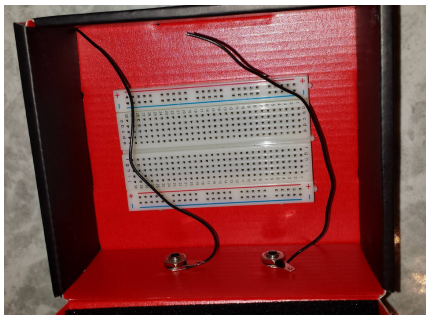
In this part we give the students a closed box with two terminals. Inside each box there is an electrical circuit, constructed by us, or the students.

The students require to conduct a(n) I vs. V, (or V vs. t, or I vs. t if they suspect a capacitor is involved). It is recommended that the students will be familiar with characteristics of graphs of different components.

Components might be (but are not limited to):

- Resistor
- Capacitor
- Light bulb or incandescent wire
- Diode
- Or any combination of the above.
- Battery.

Neat boxes can be created using "Banana Jack Sockets" and breadboards that can be ordered in www.dx.com for ~$4 for 20 banana sockets, and ~$4.50 for a pair of breadboards. Simpler boxes can be created with 2 wires that stick out of a closed box.



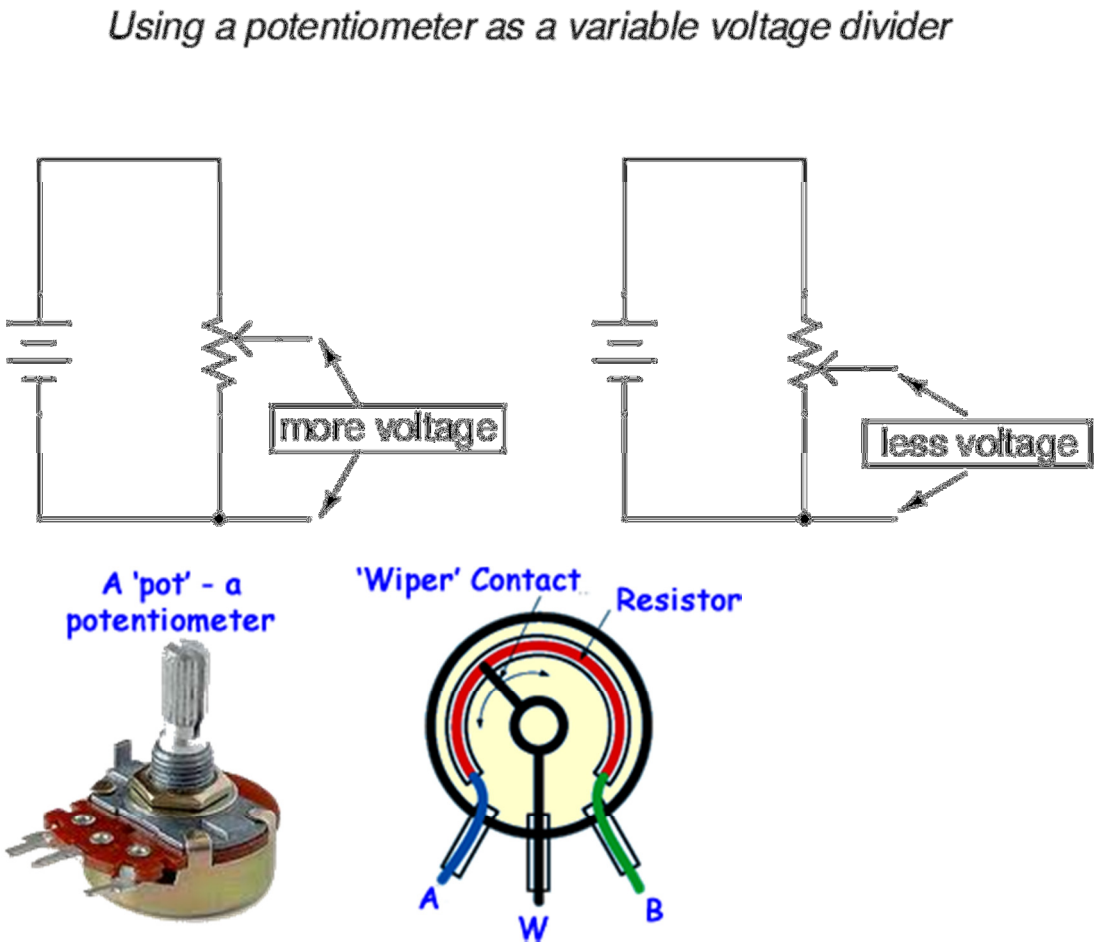
The breadboard makes it easy to prepare the electrical circuits.

Other equipment:

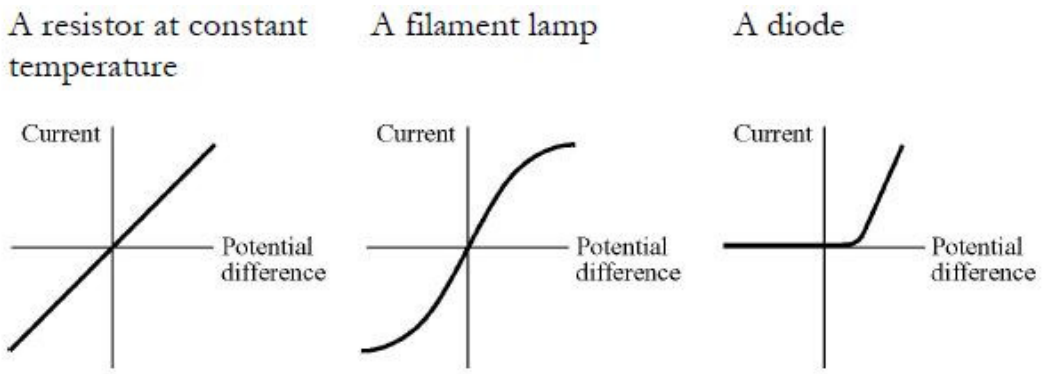
1. Power supply with current and voltage display.
2. Any other adjustable power supply + voltmeter and ammeter
3. Battery, meters and potentiometer that functions as a voltage divider.
4. When using capacitors, high capacity capacitors are required in order to be able to measure I or V vs t with a stopwatch, unless using LoggerPro with proper sensors. 1Farad capacitors are expensive if using standard science equipment suppliers (~$30 apiece) on dx.com they are available for ~$1 (if you buy a lot of 5).

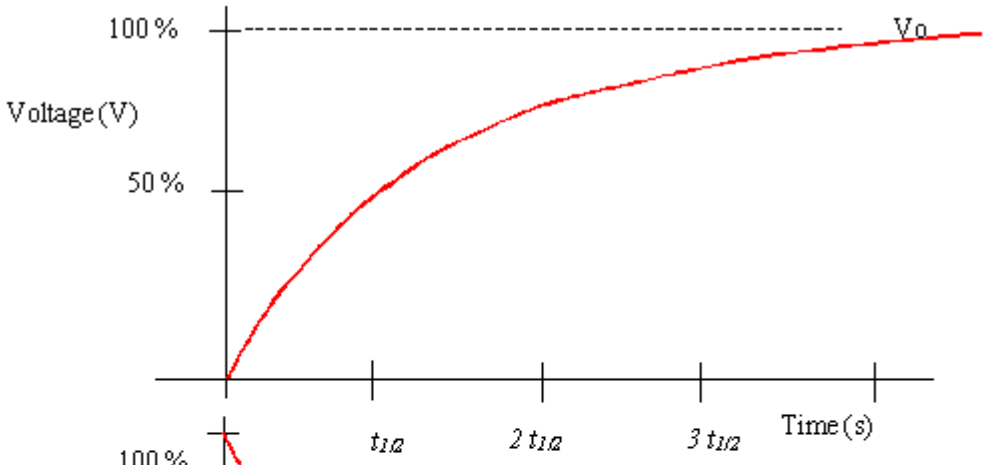
5. Safety warning for capacitors – you can get ZAPPED and injured by a charged capacitor even when it is not connected to the circuit, make sure you discharge the capacitors after the experiment. Always treat a capacitor as if it is charged.
6. Safety warning for other electrical equipment – although low voltage is used, a short circuit may cause smoke and even flame if not protected by the power supply fuse. Students might wrongly connect wire and create a short circuit – check their circuits before turning the power on.
7. Some capacitors and other components are limited to a maximum voltage, do not exceed this level.

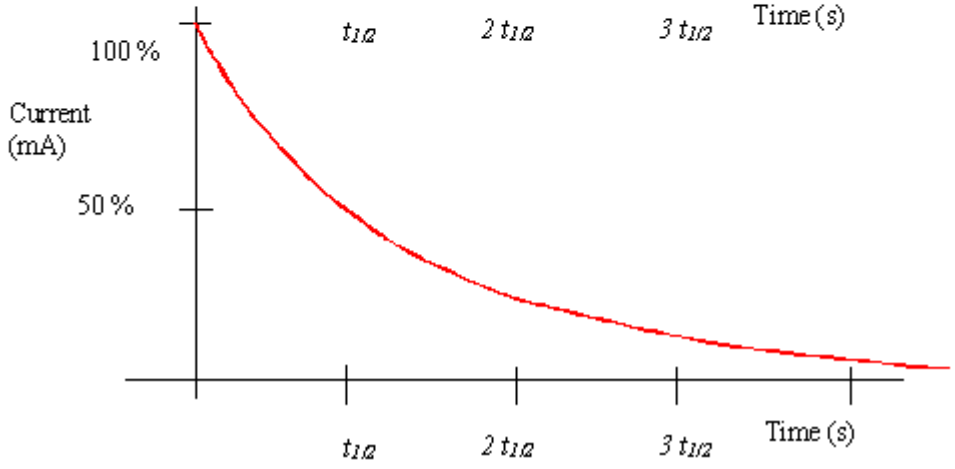
Using Potentiometer as a voltage divider



Characteristics of Electrical Components







Class Activity:

Option One:

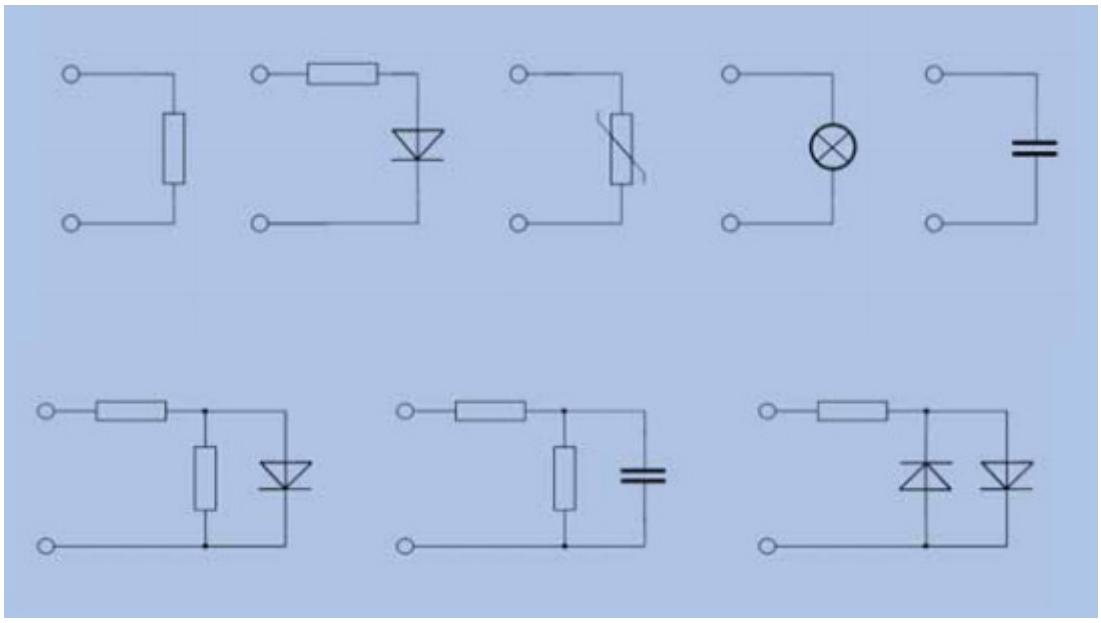
1. The teacher construct the circuits for the students, distribute the boxes.

Option two:

2. Each group of students construct a circuit, groups exchange boxes.

3. Each group has to conduct measurements to determine the circuit components inside the box, and its characteristics. Resistance for resistors, Capacity for capacitors, etc.
4. Easy circuits may contain a single resistor or capacitor.

Ideas for circuits:



Resources:

Virtual black boxes:

http://blackboxpuzzles.workroomprds.com/