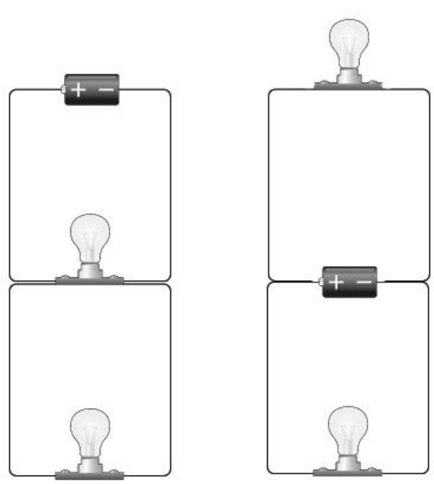
Laboratory 5 Pre-Lab (value: *2 marks*)

Submit to your lab instructor ***by 4pm the day BEFORE*** your scheduled lab period.

1. Draw all 3 possible combinations of two charges, marking which case(s) attract & which repel.

2. Two lamps with the *same* resistance R are connected *separately* to batteries with voltages V and $2V$. (a) How does the current flowing through each lamp compare? (b) How does the power used by each lamp compare? Justify your answers.

3. How are the lamps connected in each of the diagrams below (*series*? *parallel*?)? Explain.



(a) (b)

Laboratory 5: Charge & Circuits

Experiments are to be completed on the provided laboratory sheets below; any supporting material (eg. graphs) should be attached. Make sure your name and your partners name(s) are clearly indicated on the front page of your lab. **Neatness and clarity count!** Explain your answers clearly and concisely. If an equation is to be used in a calculation, *write the equation down* and then insert numbers and solve. Report your final answer to the appropriate significant figures.

The lab write-up is due by the end of the lab. Late labs will not be accepted.

APPARATUS

Ebonite and acrylic (or glass) rods, wool cloth, pith ball, electrophorous, and electroscope; power supply, two lamps, a switch, connecting wires, and a digital multimeter (voltmeter).

OBJECTIVE

1. To investigate and demonstrate the basic principles of static electricity.
2. To investigate series and parallel electrical circuits.

THEORY

Static Electricity

1. A *neutral* (or *uncharged*) object contains equal amounts of *positive* & *negative* charge.
2. A neutral object that *gains electrons* has a *net negative charge* (becomes *negatively charged*); one that *loses electrons* has a *net positive charge* (becomes *positively charged*).
3. *Similar charges repel* each other while *opposite charges attract* each other.
4. In *electrical conductors* (such as metals) electrons are free to move. An ungrounded conductor will experience a (temporary) *separation of its positive & negative charges* while in the presence of a charged object; this separation is referred to as (*induced) polarization.*
5. *Conductors* may be charged by contact with a charged object (*charging by conduction*) or indirectly if 'grounded' close to (but not touching) a charged object (*charging by induction*).
6. In *electrical insulators* (such as plastics) innate OR any added electrons are bound; insulators are typically *charged by friction* (*"triboelectric effect"*) when rubbed against another material.

Current Electricity

The current, I, flowing through a resistance R is given by

$$I = \frac{\Delta V}{R} \tag{1}$$

where ΔV is the voltage change across the resistance. This relationship also holds for a complete circuit *if* ΔV is the *net voltage* and R is the *net or effective resistance* of the circuit.

The electrical power, P, consumed by a device is given by

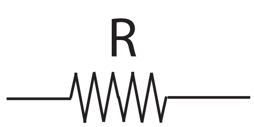
$$P = I\,\Delta V \tag{2}$$

where I is the current flowing *through* the device and ΔV is the voltage change *across* the device.

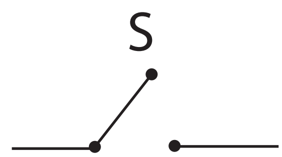
The greater the power consumed by a lightbulb, the brighter that lightbulb will appear to the eye.

Some **standard symbols** used in electrical ***circuit diagrams (CD)*** are shown below.

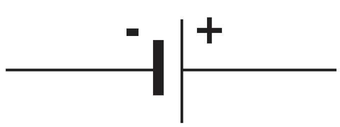
resistance (i.e. a lamp)



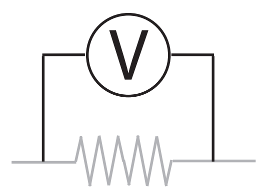
switch



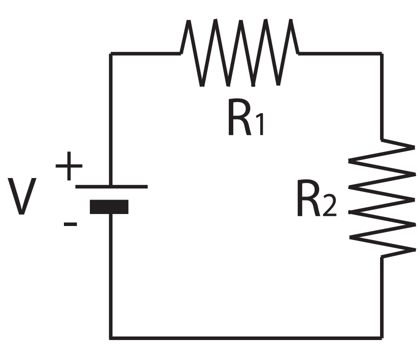
voltage source
(i.e. power supply)



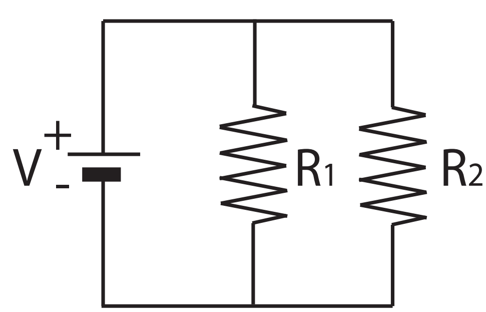
voltmeter
(connected to resistor)



Circuit diagram for
2 lamps connected in series



Circuit diagram for
2 lamps connected in parallel



NAME:
DATE: PARTNER:

Laboratory 5: Charge & Circuits

Static Electricity

Part A: Pith Ball

1. [***2 marks***] Rub the clear acrylic rod vigorously with the wool cloth (electrons are transferred FROM the rod TO the wool cloth). Approach the uncharged pith ball with the rod but DO NOT allow it to touch *** NOTE: ** the pith ball is very light & moves very suddenly so approach it SLOWLY with the rod.* **Is the pith ball attracted or repelled by the acrylic rod? Why? Draw a labelled diagram of the charge distribution on the pith ball & nearby rod.**

What is the *net charge* on the pith ball when the rod is brought near? Explain.

2. [***1 mark***] Recharge the rod and allow the pith ball to touch it. **What is the *net charge* on the pith ball now? Is the pith ball attracted or repelled by the (charged) acrylic rod *after* contact? Explain.** *** NOTE: ** You may need to recharge the pith ball frequently by contact with the (charged) clear acrylic rod, especially in damp weather when the humidity is high.*

3. [***1 mark***] Charge the pith ball with the clear acrylic rod as in step 2. Rub the black ebonite rod vigorously with the wool cloth to charge the rod. Bring the rod close to (but WITHOUT touching) the (charged) pith ball. **Is the pith ball attracted or repelled by the (charged) ebonite rod? What can you deduce about the net charge on the ebonite rod? Explain.**

Part B: Electrophorous

1. [***1 mark***] Rub the plastic baseplate of the electrophorous with the wool cloth (electrons are transferred FROM the cloth TO the baseplate). **What charge does the baseplate now have?**

2. [***2 marks***] Holding the metal plate of the electrophorous by its *insulating* handle, place it on the charged baseplate. With an electrophorous, *no charge is transferred from the insulating plastic plate to the metal plate.* **What happens to the charges in the conducting metal plate as a result? What can we conclude about the net charge on the metal plate? Explain.**

Draw a labelled cutaway side view (OR a 3D view) of the apparatus, illustrating the distribution of charges once the metal plate is placed on the charged plastic baseplate.

3. [***2 marks***] While the metal plate is resting on the (charged) plastic base plate, touch its upper surface with your finger. **What is the charge of the metal plate *after* you touch it? Explain.** Lift the metal plate by its insulated handle and confirm your answer above by bringing the metal plate close to a charged pith ball (see step 2). **Describe what you observe and indicate *how* this confirms your conclusions about the net charge on the metal plate.**

Part C: Electroscope

1. [***2 marks***] Rub the clear acrylic rod with the wool cloth and bring the rod near (*but WITHOUT touching*) the top of the electroscope. **Do the gold leaves attract or repel each other? Why? Draw a diagram of the charge distribution on the electroscope with the rod nearby.**

What happens if you move the rod away? What is the net charge on the electroscope?

2. [***2 marks***] Charge the clear acrylic rod as before, then touch the top of the electroscope with the rod. **What happens? What is the net charge on the electroscope now? What happens now when you move the rod away? Why is it different than before?**

3. [***1 mark***] Touch the top of the (charged) electroscope with your finger. **What happens? What is the net charge on the electroscope now? Explain.**

Current Electricity

1. IF the power supply has NOT been set up, connect the voltmeter to the '+' and '-' outputs of the power supply, turn the power supply on, and adjust the voltage control on the power supply until the voltmeter reads 4.0 V. Leave the power supply at this setting for the remainder of the lab.

*** NOTE: ** A (potentially dangerous) SHORT CIRCUIT occurs when an electrical circuit contains a conducting path connecting one terminal of a battery to the other terminal such that all loads/resistances in the circuit are bypassed. This creates a very low (nearly 'zero') resistance path between two points of differing voltage. As a result, very large currents may flow, causing excessive heat and the potential of a fire or explosion. In the lab, if the power supply detects a short circuit it may signal this by emitting a high-pitched tone and/or turning off. While not damaging to the power supply, avoid constructing circuits which contain such paths.*

2. [***1 mark***] Connect one lamp to the power supply.

Measure the voltage difference across the light bulb using the voltmeter. *This value will be our reference voltage.* **Observe the lamp's brightness.** *This brightness will be the reference brightness* used for comparison with the observed brightness of lamp(s) in the circuits which follow.

Reference voltage = ______________

What do you notice about the *reference voltage* compared to the *power supply voltage*?

**** Draw a FULLY LABELED circuit diagram for ALL steps marked with "(CD)". ****

Part D: Series Circuits [*6 marks*]

3. a) *Based on diagrams in the Theory*, connect two lamps to the power supply *in series* **(CD)**.

b) **Disconnect ONE light bulb by unscrewing it from its socket. What happens? Replace that bulb & unscrew the *other* bulb. What happens now? Does the outcome depend on *which* bulb you disconnect? Explain.** Replace the bulb so both are lit again.

c) **Measure the voltage difference across *each* of the bulbs & compare to step 2.**

light bulb 1 voltage = ______________ *light bulb 2 voltage =* ______________

How does the current through *each* lamp compare with step 2? Explain.

d) **How does the power usage of *each* lamp compare with step 2? Explain.**

How do the bulbs compare in brightness to each other? To the reference brightness from step 2? Is the power usage (above) consistent with these observations? Explain.

e) **Connect a switch so it controls both bulbs (CD).** *DO NOT short circuit the PS!*

f) **Connect a switch so it controls ONLY one bulb (CD).** *DO NOT short circuit the PS!*

Part E: Parallel Circuits [***6 marks***]

4. a) *Based on diagrams in the Theory*, connect two lamps to the power supply *in parallel* **(CD)**.

b) **Disconnect ONE light bulb by unscrewing it from its socket. What happens? Replace that bulb & unscrew the *other* bulb. What happens now? Does the outcome depend on *which* bulb you disconnect? Explain.** Replace the bulb so both are lit again.

c) **Measure the voltage difference across *each* of the bulbs & compare to step 2.**

light bulb 1 voltage = ______________ *light bulb 2 voltage =* ______________

How does the current through *each* lamp compare with step 2? Explain.

d) **How does the power usage of *each* lamp compare with step 2? Explain.**

How do the bulbs compare in brightness to each other? To the reference brightness from step 2? Is the power usage (above) consistent with these observations? Explain.

e) **Connect a switch so it controls both bulbs (CD).** *DO NOT short circuit the PS!*

f) **Connect a switch so it controls ONLY one bulb (CD).** *DO NOT short circuit the PS!*

5. [***1 mark***] **Is lighting in homes connected in *series* or *parallel*? Explain.**