

Topic 12: Direct Current Circuits

- Source: *Conceptual Physics* textbook, lab book and CPO textbook and lab book
- Types of Materials: Textbooks, lab books, worksheet, lab/activity, demonstration, websites/videos and good stories
- Building on: Circuits are the practical application of the electric forces, electrical potential, and current and resistance topics. Applied theory checks and confirms the student's understanding of previous topics. As more electrical devices are understood, like capacitors, inductors, diodes, transistors, IC's full-wave rectifiers, and so on, the imagination of the student becomes the only limitation to possible circuits. Students can gain talent from simply wiring a lamp to designing computer chips, with MUCH further study!
- Links to Physics: Many physical apparatus incorporate electronic circuits into their workings. A few include the optical microscope (for lighting), a car door power lock (electrical power needed to physically lift and lower the lock), directing electrons in old TV sets (electromagnets vary the magnetic field to direct beam), and so on.
- Links to Chemistry and Biology: Often, the only electronic understanding needed in chemistry and biology is the operation of equipment. This list could be anything such as in medicine. High-tech medical equipment includes the MRI, the CAT scan, the ultrasound and the nuclear stress test.
- Materials:
- (a) Hewitt
 1. Sparky the Electrician
 2. Ohm Sweet Ohm
 3. Parallel and Series Circuits
 4. Getting Wired
 5. Cranking Up
 - (b) Hsu
Electric Circuits
 - (c) My Lab
Resistance Using Series and Parallel Circuits with:
 1. Light Bulbs (Series 01, 02 and 1 combination circuit)
 2. Resistors in Series and Parallel

(d) Worksheet
Circuits

(e) Demonstration
3-Way Light Switch

(f) Videos and Websites

www.glenbrook.K12.il.us/gbssci/phys/Class/BBoard.html

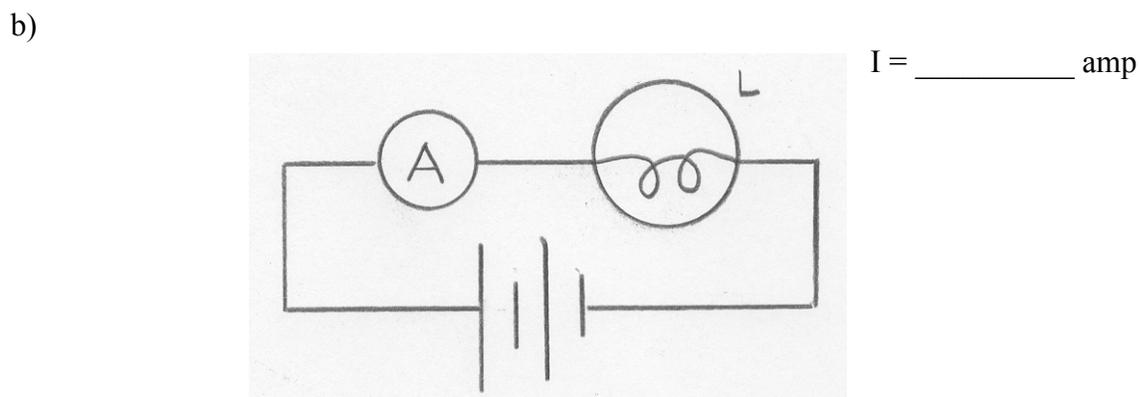
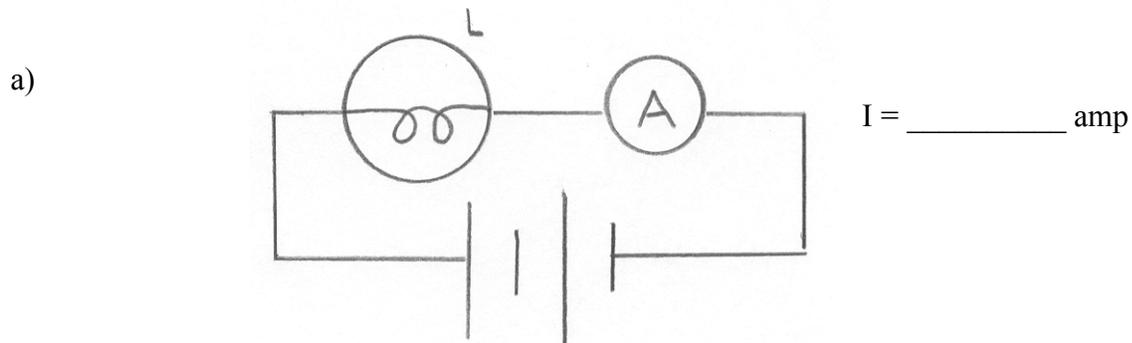
(This site covers most physics topics as abbreviated theory followed by questions about the sketches and discussion that introduced the topic—answers provided; interactive over the web.)

(g) Good Stories*

Topic 12: Electrical Circuits – Series 01

Things you need: Power supply (1)
Lamp (1)
Connectors (3)
Ammeter (0-2 amp)

Assemble the circuits below and record your observations.



Is the current in circuit a) (less than, equal to, greater than) the current in circuit b)?

Is the brightness of the lamp in circuit a) (less than, equal to, greater than) the brightness of the lamp in circuit b)?

Conclusion: What does the current and brightness tell you about a series circuit?

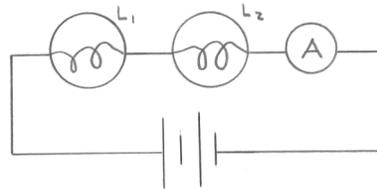
Topic 12: Electrical Circuits – Series 02

Things you need: Power supply (1)
Lamps (2)
Connectors (4)
Ammeter (0-2 amp)

Assemble the circuits below and record your observations.

a)

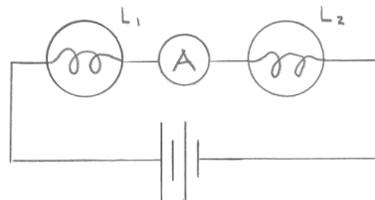
I = _____ amp



Is the brightness of L1 (less than, equal to, greater than) the brightness of L2?

b)

I = _____ amp

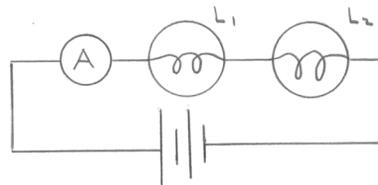


Is the brightness of L1 (less than, equal to, greater than) the brightness of L2?

Is the lamp brightness in b) (less than, equal to, greater than) the brightness in a)?

c)

I = _____ amp



Is the brightness of L1 (less than, equal to, greater than) the brightness of L2?

Is the lamp brightness in c) (less than, equal to, greater than) the brightness in b)?

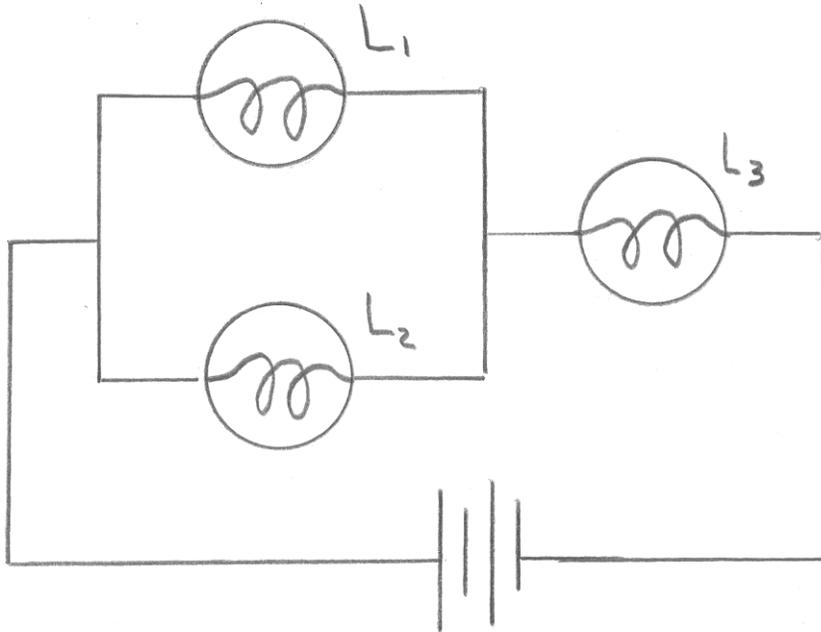
How does the lamp brightness of the Series 02 lamps compare to the brightness of the Series 01 activity?

Conclusion:

Topic 12: Electrical Circuits – Combination Circuit

Things you need: Power supply (1)
Lamps (3)
Connectors (8)

Assemble the circuit below and record your observations.



- 1) Is the brightness of L1 (less than, equal to, greater than) the brightness of L2?
How could you explain this?
- 2) Is the brightness of L3 (less than, equal to, greater than) the brightness of L1?
How could you explain this?
- 3) What does the brightness of the lamps tell you about the current through L1 and L2?
- 4) What does the brightness of L3 tell you about the current through L3?
- 5) Any other observations?

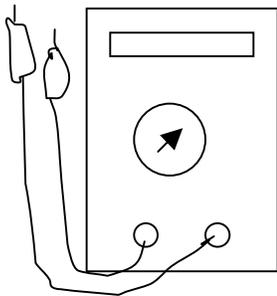
Topic 12: Resistors in Series and Parallel

Purpose: To experimentally determine how resistors combine when connected in series and parallel.

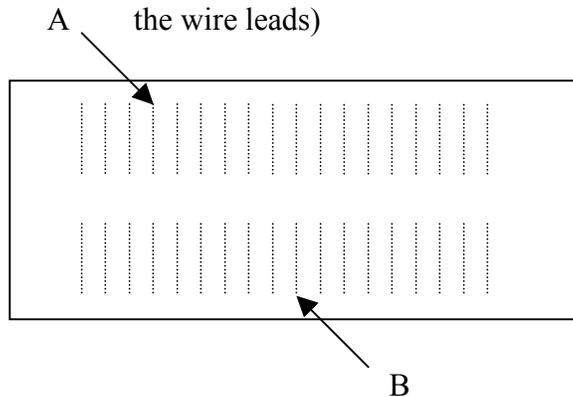
Background: Electric resistance is opposition to electric charges moving through a substance. Metal offers little resistance and glass offers a lot of resistance. Mathematically, Ohm's law relates potential difference measured in Volts (V) to charge movement called current (I) measured in Amperes (A) as the Ohm (Ω) that is symbolized with the letter (R). George Ohm, a high school physics teacher, discovered the relationship and thus has this relationship named after him. The math relationship is therefore, $R = V/I$, which is not used in our investigation.

Materials:

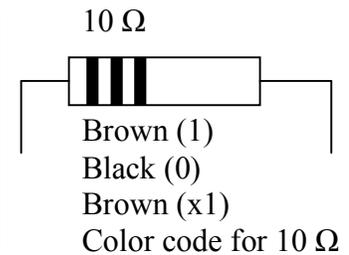
Ohmmeter
(Measuring device to do resistance)



Breadboard
(Device to easily connect resistors without twisting the wire leads)

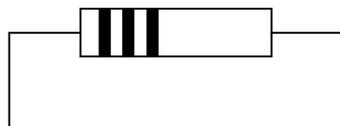


Carbon Resistor
(Inexpensive device to limit charge flow)



Each column of holes, like A, is interconnected so any wire lead inserted will be electrically connected to each other. Column B is also interconnected, but it is NOT connected to A or any other column.

In this lab only three 10- Ω resistors will be used. Bend the leads on each resistor to look like this:

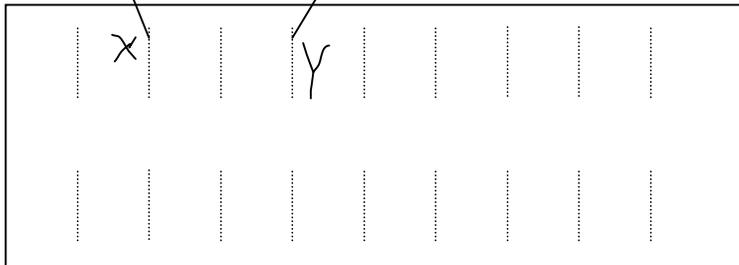
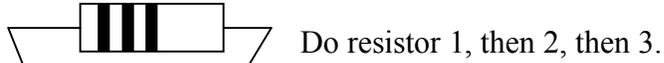


This shape will allow the student to easily insert the leads into the breadboard.

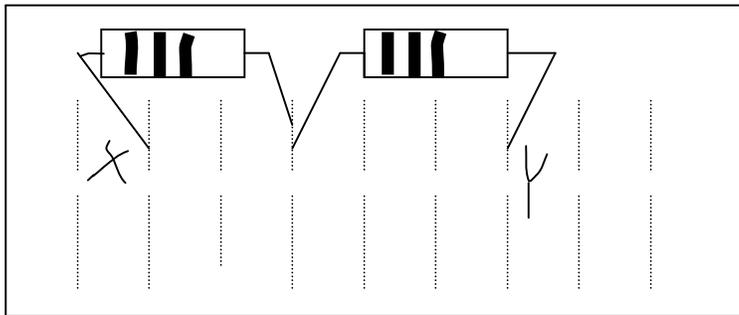
(A) Purpose: To determine how resistors combine when connected in series.

Procedure (a):

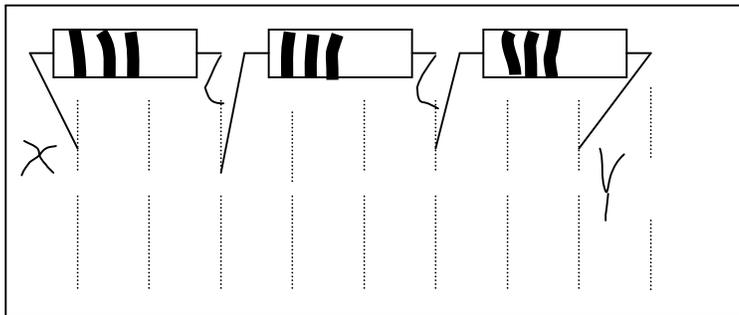
1. Select the proper range on the ohmmeter.
2. Place the two leads of the resistor in two separate columns.
3. Touch the two probes of the ohmmeter to the two ends of the resistor at X and Y.
4. Record value in table.
5. Repeat for resistor 2.
6. Repeat for resistor 3.



(a)



(b)



(c)

Each Resistor	Ω Value
1	
2	
3	

Procedure (b):

1. Connect resistors 1 and 2 in series on the breadboard (see sketch).
2. Measure the combined resistance of the two resistors in series.

SERIES CONNECTION

Resistors 1 and 2	Ω Combined Value
1 + 2	

Procedure (c):

1. Connect resistors 1, 2 and 3 in series on the breadboard (see sketch).
2. Measure the combined resistance of the three resistors in series.

SERIES CONNECTION

Resistors 1 and 2	Ω Combined Value
1 + 2 + 3	

SERIES

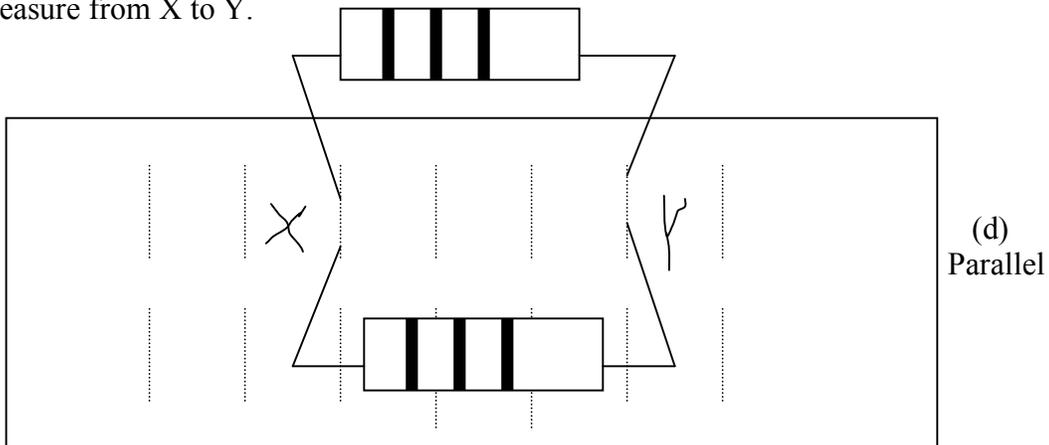
Conclusion: Looking at the individual resistance values and the combined value, I conclude that:

(B) Resistors in Parallel

Procedure (a):

1. Connect resistor 1 and 2 in parallel as shown in sketch (d).
2. Measure the resistance of both resistors when hooked in a branch. (Consider a branch as providing more than one path for the charges to follow; if a road forks, you choose which road to take.)

Measure from X to Y.



(a)

Resistors 1 and 2	Ω Combined Value
1 + 2	

Compare the individual resistances of 1 and 2 to the combined resistance of 1 and 2 when in parallel. Can you give a physical reason?

Procedure (b):

Repeat the parallel procedure with three resistors (no sketch (e) drawn for this one).

(b)

Resistors 1, 2 and 3	Ω Combined Value
1 + 2 + 3	

Compare the individual resistances of 1, 2 and 3 to the combined resistance of 1, 2 and 3 when in parallel. Can you give a physical reason?

PARALLEL

Conclusion: How do resistors in parallel combine?

Topic 12: Resistors in Parallel Answer Sheet

(b) Conclusion to Resistors in Parallel Lab

Sample Data:

(A) SERIES

(a)

Each Resistor	Ω Value
1	10.0
2	10.0
3	10.0

(b)

Resistors 1 and 2	Ω Combined Value
1 + 2	20.0

(c)

Resistors 1, 2 and 3	Ω Combined Value
1 + 2 + 3	30.0

SERIES CONCLUSION:

As resistors are connected in a row, one after another, the series combination is the sum of each resistor. Add resistors in series to obtain the total resistance.

(B) PARALLEL

(a)

Resistors 1 and 2	Ω Combined Value
1 + 2	5.0

Compare: The resistance of the parallel branch went down. Since charges have a choice of two paths, the resistance decreases.

(b)

Resistors 1, 2 and 3	Ω Combined Value
1 + 2 + 3	3.3

Compare: The resistance with a third path went down even more. Now that charges have three options, opposition is less to move through the branch.

PARALLEL CONCLUSION:

When more paths are offered across a parallel branch, the resistance becomes smaller and smaller. The actual relation of

$$\frac{1/R_{\text{Total}}}{\text{Total}} = \frac{1/R_{\text{One}}}{\text{One}} + \frac{1/R_{\text{Two}}}{\text{Two}} + \dots$$

might be recognized by some mathematically-minded students since we have used an easy set of resistances, 10.0 Ω , three times.

Topic 12: Activity – “3-Way Light Switch”

Purpose: To give students a “practical challenge” in wiring that has meaning

Materials:

(Two) 3-way light switches

Ohmmeter

SAFE DC or AC low-voltage power supply (like 6V or 12V - DO NOT USE 120 VAC— TOO DANGEROUS.)

3, 4, 5 or 6 connecting wires

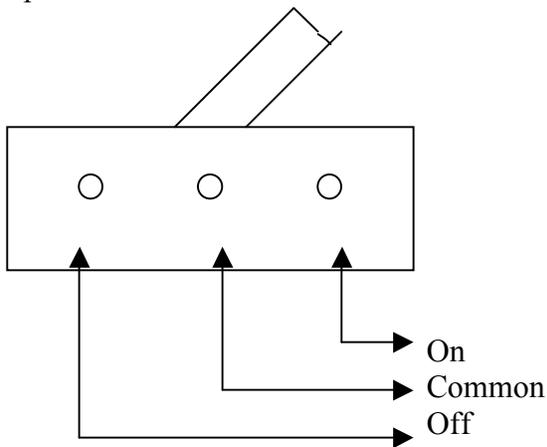
Screwdriver

Task: This is the type of challenge that should use the “inquiry” approach. The student assignment could be:

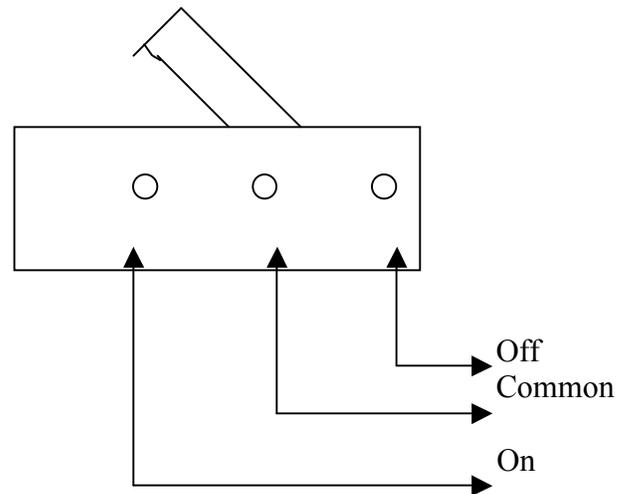
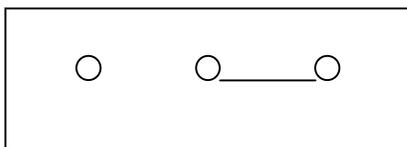
- Experiment with the provided materials to connect a circuit that SIMULATES a switch at the bottom of a stairway and one at the top of a stairway so the light can be turned on or off from either the top or bottom of the stairway and
- Sketch all possible circuits.
- Show your completed circuit to the teacher.

Results:

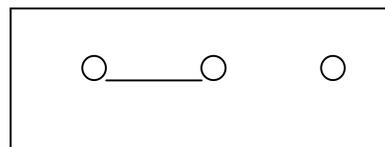
Simplified Switch:



ON right



ON left



Four Possible Connections:

