LAB 6 - SERIES AND PARALLEL CIRCUITS(TPL2)

Objectives

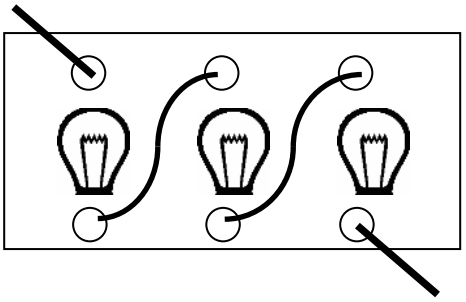
- To learn to design and wire simple circuits using a power supply, wires, and resistors.
- To interpret draw circuit diagrams.
- To understand the use of a multimeter for measuring current, voltage, and resistance.
- To understand the differences between the currents and voltages in series circuits and parallel circuits.

It would be very helpful to look at the online help page for this lab.

Part 1 - Series and Parallel - Bulbs and Brightness

We will be creating series and parallel circuits from small white bulbs and a power supply. The bulbs should be wired as shown to the right (in this case a "series" configuration):

We will be connecting the power supply to combinations of these bulbs, to see how the circuit configuration affects the brightness of the bulbs. The two main circuit types we will be studying are Series and Parallel.

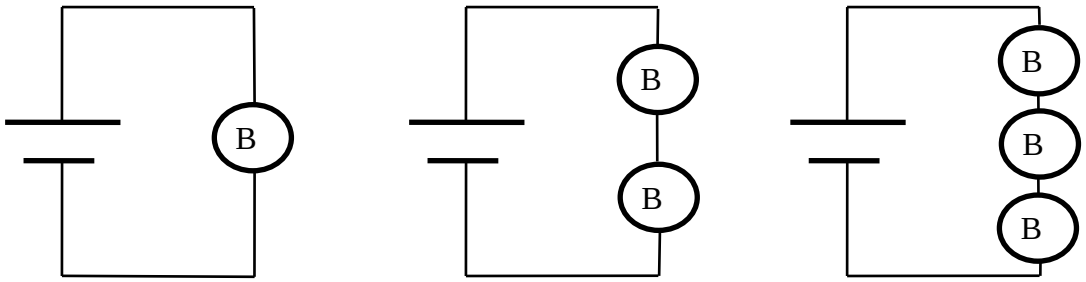


Three bulbs wired in series

Series Circuits

Prediction Answer this on the Data/Question sheet:
Look at the diagrams below ... Suppose you connected the power supply to one, two, or three bulbs in a series configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the dimmest?

1. Circuit connections. Connect a red and black lead to the 5-volt power supply. Connect one of the bulbs to the power supply leads. How bright is that bulb? Now connect it to two bulbs in series, and then three in series (look at the circuit diagrams below or above).



Bulb configurations for Series circuits

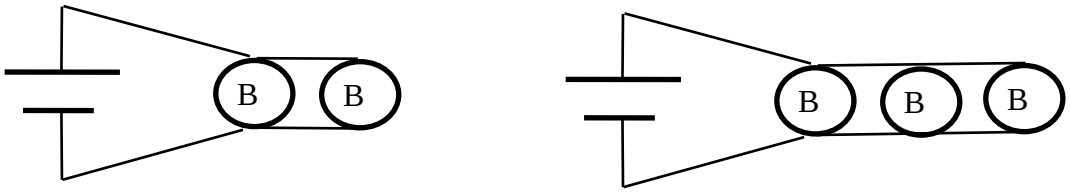
Question Answer this on the Data/Question sheet:
Did your observations match your predictions? If not, why? What have you learned from this?

Parallel Circuits

Suppose you connected the bulbs in a parallel configuration instead of series. Parallel circuits have multiple paths for the current to flow.

Prediction Answer this on the Data/Question sheet:
Look at the diagram below ... Suppose you connected the power supply to two or three bulbs in a parallel configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the dimmest?

1. Circuit connections. Now connect the bulbs as shown in the circuit diagrams below:



Circuit connections for Parallel circuits

Question Answer this on the Data/Question sheet:
Did your observations match your predictions? If not, why? What can be learned from this?

Part 2 - Series circuits - Current and voltage

For this section, we will be measuring the currents and voltages in a series circuit made up of resistors.

1. Multimeter. We will be using the multimeter to measure the voltages across and currents through the resistors, as well as the resistance of the different resistors. Be VERY sure that you are on the right meter setting, and you have it connected the correct way – so we can protect the meters!

Basic connections/modes for the multimeter:

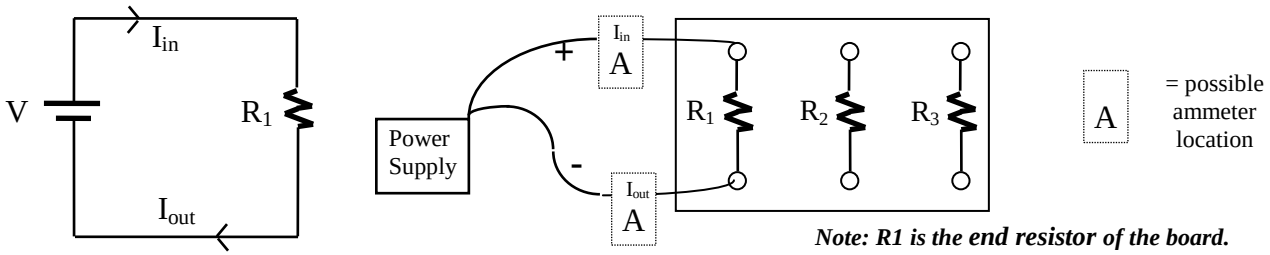
- Ammeter – should be "IN" the circuit (i.e., current has to flow through the meter – if the meter would not be there, the circuit would be open)
- Voltmeter – should be "ACROSS" an element (i.e., the current should be flowing in the circuit, the meter is not repairing a break – it is reaching across an element)
- Ohm-meter – just connect it across the leads of the resistor with no power supply connected – the resistor to be measured should be separate from any circuit …(with only the meter connected to it).

2. Measure resistance. The first step is to measure the resistance of the various resistors that we will be using. Connect some banana leads to the multimeter in the common plug (COM-black lead) and the ohm plug (Ω-red lead). Measure each of the resistors we are using (R_1, R_2 and R_3) and record these readings on the Data/Question sheet.

Single series circuit -

1. Circuit connections. Connect the power supply and resistor R_1 as shown in the diagram below: A red lead to the 5V +terminal, and a black lead to the negative terminal of the power supply. I_{in} measures

the current into R_1, I_{out} measures the current out of R_1. The 'A' socket of the meter is always to the '+' side of the circuit and the 'COM' socket is always to the '-' side of the circuit.



Note: R1 is the end resistor of the board.

The ammeter is to be placed in one position while the other has only a wire making the connection.

Circuit configuration for simple series circuit

Prediction Answer this on the Data/Question sheet:
Do you think there will be more current going into the resistor, or coming out, or will they be the same?

2. Measuring the voltage. With the multimeter, use the DC-Voltage dial setting and the V and COM sockets to measure the voltage across the resistor. Connect a lead to the 'V' socket and a second to the 'COM' socket, then connect the 'V' lead to the upper terminal of R_1 (above, + side) and the 'COM' lead to the lower terminal of R_1 (above,- side). Record your answer on the Data/Question sheet.

Caution: When measuring the current with the ammeter (the multimeter), the meter should be placed IN SERIES with the circuit (such as by replacing a wire, or an open connection). This way, the current flows through the meter, as it should.

NEVER CONNECT THE MULTIMETER **ACROSS** AN ELEMENT WHEN IT FUNCTIONS AS AN AMMETER!

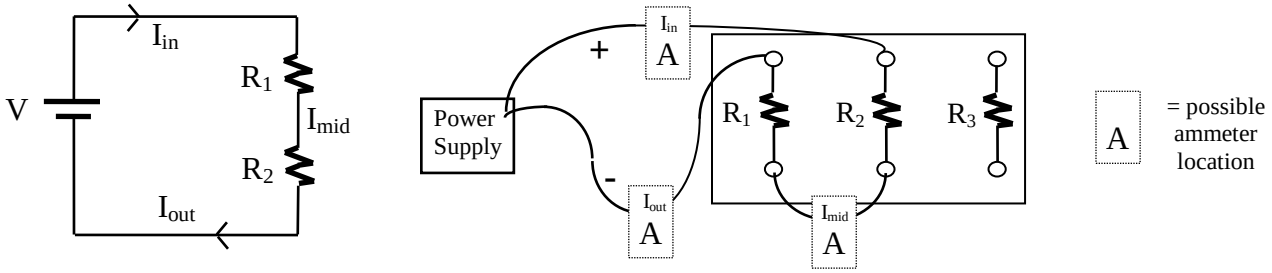
3. Measuring the current. With a multimeter, use the DC-Current dial setting the COM and A sockets and measure the current into the resistor and out of the resistor as shown in the figure above. Remember, the ammeter is placed **in the circuit** - so the current goes **through** the ammeter. In order to connect the ammeter to measure I_{in}, the wire lead to the upper terminal (the figure above) of R_1 must be removed and placed in the 'A' socket of the meter and a second lead connected between the 'COM' socket of the meter and the upper terminal of R_1. To measure I_{out}, the lead at R_1 is disconnected and plugged into the 'COM' side of the meter, a lead is then used to connect R_1 to the 'A' socket of the meter. Record your answers on the
Data/Question sheet.

Question Answer this on the Data/Question sheet:
What did you observe for the currents; how well did your prediction match your observation?

4. Calculate the resistance to check our measurements. To test our understanding, calculate the resistance from the voltage and current measurements and record on the Data/Question sheet.

Two element Series Circuit -

1. Wiring circuit. Connect two resistors (R_1 and R_2) together in series, as shown below :



Circuit configuration for double series circuit

We will be measuring the voltage across the two resistors and the current flow through the resistors.

Predictions Answer these on the Data/Question sheet.

a) What is the relationship among the currents in the two-resistor circuit?

b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

2. Measure the voltage. Switch the meter to the voltage configuration and measure the voltage across each resistor, V_1 and V_2 (for the multimeter, make sure the red lead is connected to the "high voltage", (indicated by the '+' above), side of the resistor – keeps the voltage reading positive). For V_{total}, place the meter so that both R_1 and R_2 are included between the meter's leads. Record your answer on the Data/Question sheet.

3. Measure the current. Switch the meter to the current configuration and measure the incoming current, the current between the resistors, and the current going back into the power supply (For the connections, see **Single Series Circuit. 3** above.). Record your answer on the Data/Question sheet.

Questions Answer the following on the Data/Question sheet:

a) Did the voltages add up to the main voltage? (Was that what you predicted?)

b) Were the currents all the same in the circuit?

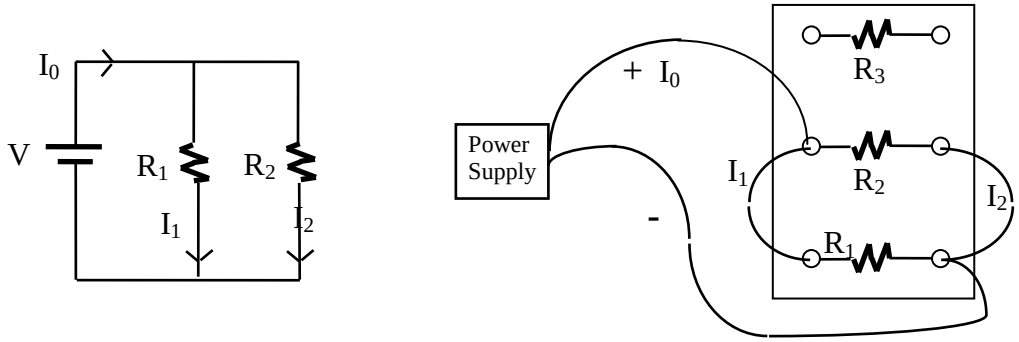
4. Testing the results. To test our understanding of the system, check to see if your data basically agrees with the ideas on the Data/Question sheet.

5. Finding the Equivalent Resistance. Follow the instructions on the Data/Question sheets.

Part 3 - Parallel Circuits - Current and Voltage

Two resistor parallel circuit -

1. Circuit connections. Connect the power supply and resistors R_1 and R_2 as shown in the diagram.



Circuit configuration for two resistors in parallel

Note: The wire configuration above is chosen to allow easy measurement of the currents.
Let's investigate the current in the circuit. Will there be more current going into one branch or the other, i.e. through R_1 or R_2? We will measure the two currents and compare them.

Predictions Answer these on the Data/Question sheet:

a) What is the relationship among the currents in the two-resistor circuit?

b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

2. Measure the voltages. With the multimeter, measure the voltage across each resistor then across the combination. Record these values on the Data/Question sheet.

3. Measure the currents. With the multimeter, measure the main current, I_o, and the individual currents, I_1 and I_2, in each resistor. (For I_0, disconnect the power supply lead from R_2 and plug it into the 'A' terminal of the meter. Then use a second lead from the 'COM' terminal of the meter back to R_2. For I_1, disconnect the single lead from R_1 (on the left in the figure above) and connect it to the 'A' terminal of the meter. Use a second lead to reconnect the 'COM' of the meter to R_1. For R_2, disconnect the single lead from R_2 (on the right in the figure above) and connect it to the 'COM' of the meter. Use a second lead to reconnect the 'A' terminal of the meter to R_2.). Record these values on the Data/Question sheet.

Questions Answer on the Data/Question sheet.

a) How did the voltages compare to the main voltage? (Was that what you predicted?)

b) Did the currents add up to the main current?

4. Testing the results. To test our understanding of the system, does your data basically agree with the ideas listed on the Data/Question sheet.

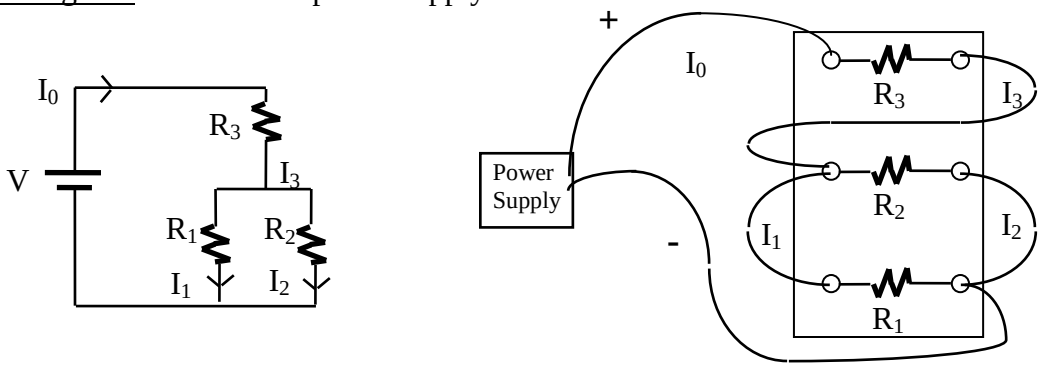
5. Finding the Equivalent Resistance. Follow the instructions on the Data/Question sheet.

Part 4 - Series/Parallel Combination Circuits

For this section, we will be measuring the currents and voltages in a circuit made up of resistors in series and parallel **combinations**. *Resistors R_1 and R_2 are in parallel, and that set is in series with Resistor R_3.*

Combination circuit -

1. Circuit diagram. Connect the power supply and the resistors as shown below:



Circuit configuration for Series/Parallel combination circuit.

Note: The wire configuration is chosen to allow easy measurement of the currents.
Let's investigate the current in the circuit. Will there be more current going into one branch or the other? We will measure the two currents and compare them.

Predictions Answer these on the Data/Question sheet.
a) How will the currents through the parallel resistors compare to the main current in the circuit.
b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

2. Measure the voltage. Switch the meter to the voltage configuration and measure the voltage across each resistor. (For the voltage measurements, just plug the meter leads into the terminals for each resistor and then the terminals of the power supply.) Record your values on the Data/Question s

3. Measure the current. Switch the meter to the current configuration and measure the currents through all of the resistors. (Follow the directions in **Part 2** and **Part 3** to measure the currents indicated.) Record your values on the Data/Question sheet.

Questions Answer these on the Data/Question sheet.
a) How did the voltages compare to the main voltage? (Was that what you predicted?)
b) Did the currents add up to the main current? If not, how do they add up?

4. Finding the Equivalent Resistance. Follow the instructions on the Data/Question sheet.

DATA/QUESTION SHEET FOR LAB 6 SERIES AND PARALLEL CIRCUITS

Part 1 - Series and Parallel - Bulbs and Brightness

Prediction Suppose you connected the power supply to one, two, or three bulbs in a series configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the dimmest?

_____

_____

1. Circuit connections.

Question Did your observations match your predictions? If not, why? What have you learned from this?

_____

_____

Parallel Circuits

Prediction Suppose you connected the power supply to two or three bulbs in a parallel configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the dimmest?

_____

_____

1. Circuit connections.

Question Did your observations match your predictions? If not, why? What can be learned from this?

_____

_____

Part 2 - Series circuits - Current and voltage

2. Measure resistance.

Resistor $\mathbf{R_1}$ = _____ Ω Resistor $\mathbf{R_2}$ = _____ Ω Resistor $\mathbf{R_3}$ = _____ Ω

Single series circuit -

Prediction Do you think there will be more current going into the resistor, or coming out, or will they be the same?

_____

_____

2. Measuring the voltage. V_{total} = _____ V

3. Measuring the current. I_{in} = _____ A I_{out} = _____ A

Question What did you observe for the currents; how well did your prediction match your observation?

_____

_____

4. Calculate the resistance, to check our measurements. To test our understanding, calculate the resistance from the voltage and current measurements and record below.

$R_1 = V_{total}/I_{in}$ _____ Ω % difference (with **R_1**) = _____ (**R_1** from Part 2.2 above)

Question How close does your calculated resistance match with the resistance value you measured with the multimeter? What factors could affect this?

_____

_____

Two element Series Circuit -

Predictions a) What is the relationship among the currents in the two resistor circuit?

_____

_____

b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

_____

_____

2. Measure the voltage.

V_{total} = _____ V V_1 = _____ V V_2 = _____ V

3. Measure the current. Measure the current coming from the power supply, the current between the resistors, and the current going back into the power supply.

I_{in} = _____ A I_{middle} = _____ A I_{out} = _____ A

Questions a) Did the voltages add up to the main voltage, V_{total}? (Was that what you predicted?)

_____

_____

b) Were the currents all the same in the circuit?

_____

_____

4. Testing the results. To test our understanding of the system, check to see if your data supports the following ideas:

Does $V_1 + V_2 = V_{total}$? _____
Does $I_{out} = I_{in} = I_{middle}$? _____

5. Finding the Equivalent Resistance.

In theory $R_{eq} = R_1 + R_2$ R_{eqcal} = _____Ω (Use the values from Part 2.2)

From measurements $R_{eqmeas} = V_{total} / I_{in}$ R_{eqmeas} = _____Ω

% Difference (with R_{eqcal} and R_{eqmeas}) = _____

Part 3 - Parallel Circuits - Current and Voltage

Two resistor parallel circuit -

Predictions: a) What is the relationship among the currents in the two-resistor circuit?

_____

_____

b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

_____

_____

2. Measure the voltages.

V_{total} = _____ V V_1 = _____ V V_2 = _____ V

3. Measure the currents.

I_0 = _____ A I_1 = _____ A I_2 = _____ A

Questions a) How did the voltages, V_1 and V_2, compare to the main voltage V_{total}? (Was that what you predicted?)

_____

_____

b) Did the currents, I_1 and I_2, add up to the main current I_0?

_____

_____

4. Testing the results. To test our understanding of the system, does your data basically agree with these ideas:

Does $I_1 + I_2 = I_0$? _____

Does $V_1 = V_2 = V_{total}$? _____

5. Finding the Equivalent Resistance.

In theory $R_{eq} = R_1 * R_2 / (R_1 + R_2)$ R_{eqcal} = _____Ω (Use the values from Part 2.2)

From measurements $R_{eqmeas} = V_{total} / I_o$ R_{eqmeas} = _____Ω

% Difference (with R_{eqcal} and R_{eqmeas}) = _____

Part 4 - Series/Parallel Combination Circuits

Combination circuit -

Predictions a) How will the currents through the parallel resistors compare to the main current in the circuit.

_____

_____

b) Will the voltages across the resistors be equal or unequal - what is their relationship to the currents?

_____

_____

2. Measure the voltages.

V_{total} = _____ V V_1 = _____ V

V_2 = _____ V V_3 = _____ V

3. Measure the currents.

I_0 = _____ A I_1 = _____ A

I_2 = _____ A I_3 = _____ A

Questions a) How did the voltages compare to the main voltage? (Was that what you predicted?)
Does $V_1=V_2$? Does $V_3=V_1$ or V_2? Does $V_{total}=V_3+V_1$? Does $V_{total}=V_3+V_2$?

_____

_____

b) Did the currents add up to the main current? If not, how do they add up?
Does $I_0=I_3$? Does $I_3=I_1 + I_2$?

_____

4. Finding the Equivalent Resistance.

In theory $R_{eq} = R_3 + [\ R_1 * R_2 / (R_1 + R_2)\ ]$ R_{eqcal} = _____Ω (Use the values from Part 2.2)

From measurement $R_{eqmeas} = V_{total} / I_o$ R_{eqmeas} = _____Ω

% Difference (with R_{eqcal} and R_{eqmeas}) = _____

a) How do the two values compare? _____
b)

_____

_____

Questions/Suggestions → James Nolta - jnolta@LTU.EDU