

LESSON 1: Circuits Exploration

Activity 1: Circuits in Series

Series Circuit - There is a single path for electrons to flow when electrical components are connected in sequence. The current is the same through each resistor.

Build Project 1 – Electric Light and Switch

- a. This is an example of a _____ (series or parallel) circuit.
- b. When the circuit is open, the light is _____ (on or off).
- c. What is the voltage supplied in this circuit? (look at batteries) _____

Build Project 2 – DC Motor and Switch

Note: Confirm the motor is placed in the same direction as the diagram. The negative terminal of the battery goes toward the negative terminal of the motor. This controls the direction the motor is spinning.

- a. Describe the energy transformation that is occurring when the circuit is closed.

_____ → _____ → _____ + _____ + _____

Build Project 11 – An Extension of Project 2

Note: This is the same circuit as Project 2 except the direction of the motor is switched

- a. What is difference between Projects 2 and 11? _____
- b. Why does this happen? _____

Note: Try adding a second battery set in series. Compare the flight of the fan with a single battery set.

- c. The total voltage of both battery sets = _____ volts
- d. Describe the height of the fan with one vs two battery sets. _____

Build Project 5 – Lamp and Fan in Series

- a. This is an example of a _____ (series or parallel) circuit. Explain why? _____

- b. Compare the brightness of the bulb in this circuit with the fan ON the motor vs the fan OFF the motor.

- c. Compare the speed of the motor with the fan ON the motor vs the fan OFF the motor.

- d. The voltage from the batteries is divided between the light and motor. Which load will use more voltage? _____

- e. Without the fan, the motor spins faster and requires more voltage. That means there is _____ (more or less) available to the light.
- f. Can you get the fan to launch? _____ Why or why not? _____
- g. What would happen if you removed the snap that connected the lamp with the switch? _____ Why? _____
- h. Change the position of the light and motor. Do you get the same results? _____ Why? _____

Activity 2: Circuits in Parallel

Parallel Circuit – If there is more than one complete path for the electrons to flow it is a parallel circuit. The current divides into two or more paths before recombining to complete the circuit. Each load connected in a separate path receives the full circuit voltage, while the total circuit current is equal to the sum of the individual branch currents.

Build Project 6 – Fan and Lamp in Parallel

- a. This is an example of a _____ (series or parallel) circuit.
- b. Compare the brightness of the bulb in this circuit with the fan ON the motor and with the fan OFF the motor. Describe your results. _____
- c. The voltage from the batteries in this circuit is _____ volts. What is the voltage applied to each device? _____
- d. In this circuit, will the fan launch? _____
- e. Remove one of the snaps (wires) connecting the lamp. Describe what happens to the motor when the lamp is disconnected. _____

Extension: Build Project 19 – Space War

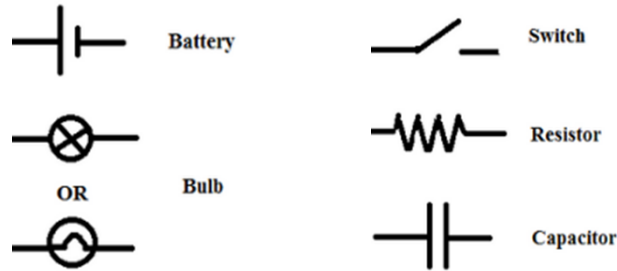
U3 Space Wars IC is an integrated circuit. An integrated circuit is made of interconnected electronic components, such as transistors, capacitors and resistors. They are etched or imprinted onto a tiny slice of a semiconducting material, such as silicon or germanium. An integrated circuit, which can be smaller than a fingernail, can hold millions of circuits. They complete a specific job such as to produce or amplify a sound.

- a. Does the circuit produce sound when the slide switch (S1) is turned on? _____
- b. Turn off the slide switch (S1) and push the press switch (S2). Is the sound the same? _____
- c. Turn on the slide switch (S1) AND the press switch (S2). Describe the sounds. _____

- d. In parts B and C, are the sounds the same as you alternate between switches? _____
Why does this occur? _____
- e. The switches are wired in a _____ (series or parallel) circuit.

Activity 3: Design Challenge

- Using two bulbs (L1 and L2), a switch (S1 or S2), snap connectors and a battery set, make a circuit in both series and parallel.
- Using the symbols below, draw the schematics for each.



SERIES

PARALLEL

LESSON 2: Introduction to Resistance

Activity 1: Resistors in Series & Parallel

Build Project 7 – Light Emitting Diode

- Turn on the switch and describe the brightness. _____
- Build Project 8. Reverse the direction of the LED (D1) in the circuit. What happens to the light?
_____ Explain why? _____
- Replace the LED (D1) with a lamp (L1). Turn on the switch. Describe what happens. Explain the result.

Which uses more electric power (watts) a LED or incandescent light? _____
- Replace the lamp (L1) with the LED (D1). The resistor in this circuit is _____ Ω . Remove the R1 resistor and replace it with the 10K Ω resistor (R4). Describe what happens to the light when the switch is turned on. Compare it to the brightness from part A. _____
Why does this happen? _____

Build Projects 98 & 99 – Simple Water Alarm & Simple Salt Water Alarm

- Build the circuit but leave the jumper wires out of the cup. What happens when you turn on the switch?
_____ Why? _____
- Place the jumper wires in a cup of water. The circuit is now _____. (open or closed)
- Based on this activity, is water an insulator or conductor? _____
- Add about 1 teaspoon of table salt to the cup of water and stir. Insert the ends of the jumper wires. Compare the sounds from the speaker WITHOUT the salt and WITH the salt in the water. _____

Activity 2: Resistors in Series & Parallel

At times, you may not want the full amperage or voltage to your load. Just as a faucet can control the flow of water, an adjustable or **variable resistor** can control the flow of electrons in a circuit.

Build Project 110 – Adjustable Tone Generator

The project demonstrates how resistor values can change the frequency of an oscillator.

- Turn on the slide switch. Describe the sound you hear. _____
- Is the LED on or off? _____ Is the LED bright or dim? _____
- Slide the switch on the variable (adjustable) resistor. Describe what happens to the tone? _____
_____ Describe what happens to the LED brightness. _____
- If a faucet controls the flow of water, a resistor controls the flow of _____.

Build Project 172 – Red and Green Control

Describe what happens in each part:

- With the slide switch **on** and the variable resistor set to the **left**, which LED is illuminated?

- With the same set up as in part A, describe what happens when you also turn **on** the press switch (S2)?

- With the slide switch (S1) **on** and the press switch (S2) **on**, describe what happens when you slide the variable resistor to the **right** side? _____
- Turn **off** the slide switch (S1) and turn the press switch (S2) **on**. With the variable resistor slide on the **right**, describe what happens to the green LED. _____
- When the variable resistor is on the **left** and the slide switch (S1) is **on**, explain why the red light brightens. Use the terms *current* and *resistance* in your answer. _____

- Describe a place in your home where you may find a variable resistor in a circuit. _____

Activity 3: Photoresistors

Some materials, such as cadmium sulfide, change their resistance when light shines on them. Electronic parts made with these light-sensitive materials are called **photoresistors**. Their resistance decreases as the light becomes brighter.

Build Project 272 – Photoresistor Control

- With the switch on, describe the brightness of the LED. _____
- Describe the brightness of the LED when you limit the light entering the photoresistor with your finger.

- Shine a flashlight directly on the photoresistor. What happens to the brightness of the LED?

- What is happening to the resistance and current as you cover the photoresistor? _____

Build Project 107 – Automatic Street Lamp

In this project, you will use a variable resistor AND a photoresistor. You will also use parts Q1 PNP and Q2 NPN. These pieces are transistors. A **transistor** can be described as a current amplifier. It uses a small amount of current to control a larger amount of current. They allow current to flow in one direction, like in an LED. The arrows on the parts Q1 and Q2 indicate the direction of current flow.

- Press the press switch (S2) on and set the variable resistor the lamp (L2) is barely lit. Slowly cover the photoresistor with your finger. Describe what happens to the lamp. _____
- Explain what is happening to the current to the lamp when the photoresistor is covered. _____

Street lamps work on this principle. They turn off to save electricity during the day but turn on at night or during a storm for safety.

Extension: Build Project 276 – LED Fan Rotation Indicator

- Is this circuit wired in series, parallel or both? _____
- Which way (clockwise or counter clockwise) does the fan turn when you turn on the slide switch (S1)?
_____ The positive side of the battery is connected to the positive side of the motor. The polarity of the motor determines the way it rotates.
- Why does only one LED light turn on? _____
- Push the press switch (S2). The motor rotates _____ (clockwise or counter clockwise) and the _____ (red or green) LED lights up.
- Now place the fan on the motor and turn on one of the switches but not both. One of the lamps is lit as the motor spins, but now the LED is dim. The motor needs a lot of current to spin the fan but only a small amount of current without it (less resistance). In this circuit, a lamp is lit when the motor current is high, and a LED is lit when the motor current is low. Which has a higher resistance, the LED or lamp?

Extension: Build Project 173 – Current Controllers

Note: Electricity will take the path of least resistance.

- a. With the circuit complete, turn on the slide switch (S1). Describe the brightness of the LED.
_____ This circuit is in series. The 5.1K Ω (R3) controls the resistance.
Trace the path of the electrons with your finger.
- b. Turn off the slide switch (S1) and turn on the press switch (S2). Compare the brightness of the LED with just the press switch (S2) on. _____ Trace the path of the electrons in this circuit with your finger.

Placing resistors in series increases the total resistance, so the current is decreased to the LED.

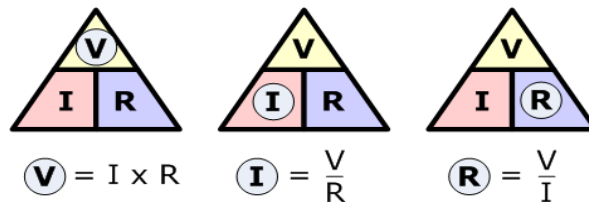
$$R_1 + R_2 = \text{Resistance}_{\text{series}} \text{ or in this circuit, } 1\text{K}\Omega + 10\text{K}\Omega = 11\text{K}\Omega$$

- c. Turn on both switches. Compare the brightness with both switches on compared to only one switch.

Placing resistors in parallel decreases the total resistance, so the current is increased to the LED.

$$\frac{1}{R_1} + \frac{1}{R_2} = \text{Resistance}_{\text{parallel}} \text{ or in this circuit, } 1/1\text{K}\Omega + 1/5.1\text{K} = 1.2 \text{ k}\Omega$$

When you decrease the resistance, you increase the current. In this parallel circuit, the LED is brighter. The relationship between voltage, current and resistance is Ohm's Law.



LESSON 3: Meters

Activity 1: Amp Meter & Volt Meter

- The meter has a + and - polarity marking to indicate which direction the current will move the pointer.
- Always keep the switch on LOW unless told to do so in the instructions.
- The meter will measure current (amps) when connected in a series circuit.
- If the current is higher than 300 μ A in the low setting, the higher current may be measured by connecting a low value resistor in parallel.

Build Project 323 – 3mA Meter

- Turn on slide switch (S1) with the meter (M2) on low. The meter reads _____ mA.
- The resistor that is in parallel with the meter is _____ Ω . Placing the 100 Ω resistor in parallel with the meter increases the meter's range 10 times.
- Extension: Remove the vertical 3-snap connector (first layer-left side of the board) linking the 1K Ω resistor to the horizontal 3-snap connector (second layer-bottom of the board). Replace it with the red LED (D1-arrowing pointing toward the bottom of the grid.) The reading on the meter (M2) is now _____ mA. Why? _____

Build Project 324 – 0-3V Voltmeter

The meter will measure voltage when connected in parallel in a circuit. It can measure voltages up to .3V, but higher voltages may be measure by connecting it with a high value resistor.

- Set the meter (M2) to low. Insert the battery holder between points A and B. The reading on the meter is _____. If you use new batteries, you can use this reading for a comparison
- Find an old set of batteries and repeat the project.

Activity 2: Meters with Adjustable Resistors & Photoresistors

Build Project 325 – Function of Adjustable Resistor

An adjustable resistor is a normal resistor with an additional arm contact. The arm moves along resistive material and stops at the desired resistance. It controls the amount of current (amps) flowing through the circuit.

- The meter (M2) reading at the lowest point is _____. Highest point is _____.
- Describe what happens to the meter (M2) as you change the position of the slider on the variable resistor (RV). In this circuit, as the _____ increases the _____ decreases.

Build Project 486 – Simple Illumination Meter (Light Meter)

The amount of light changes the resistance of the photoresistor, which affects the current through the meter.

- Set the variable resistor (VR) to the far **left**. Turn on the slide switch (S1). The meter (M2) reading is _____
- The photoresistor (RP) is very sensitive to light. Describe what happens to the needle on the meter (M2) as you wave your hand over the photoresistor. _____

- c. Move the variable resistor (VR) to the far **right**. Turn on the slide switch (S1). The meter (M2) reading is _____
- d. Describe the difference in the meter (M2) reading when you wave your hand over the photoresistor (RP). _____

Activity 3: Measuring the Resistance of Different Loads

Build Project 494 – Resistor Measurement

- a. Set the meter (M2) to the **low** setting. Attach **one** jumper wire to points A & B. Adjust the slide on the variable resistor (VR) so the meter points to 10. Remove the wire.
- b. Test the 100 Ω resistor. The meter (M2) reading is _____.
- c. In a circuit, any load also acts as a resistor. Test other resistors from your kit and record results in the table below.

| Type of Resistor | Meter Reading |
|----------------------------------|---------------|
| Speaker (SP) | |
| 5.1K Ω resistor (R3) | |
| Music IC (U1) | |
| 100K Ω resistor (R5) | |
| LED (D1) arrow pointing to right | |