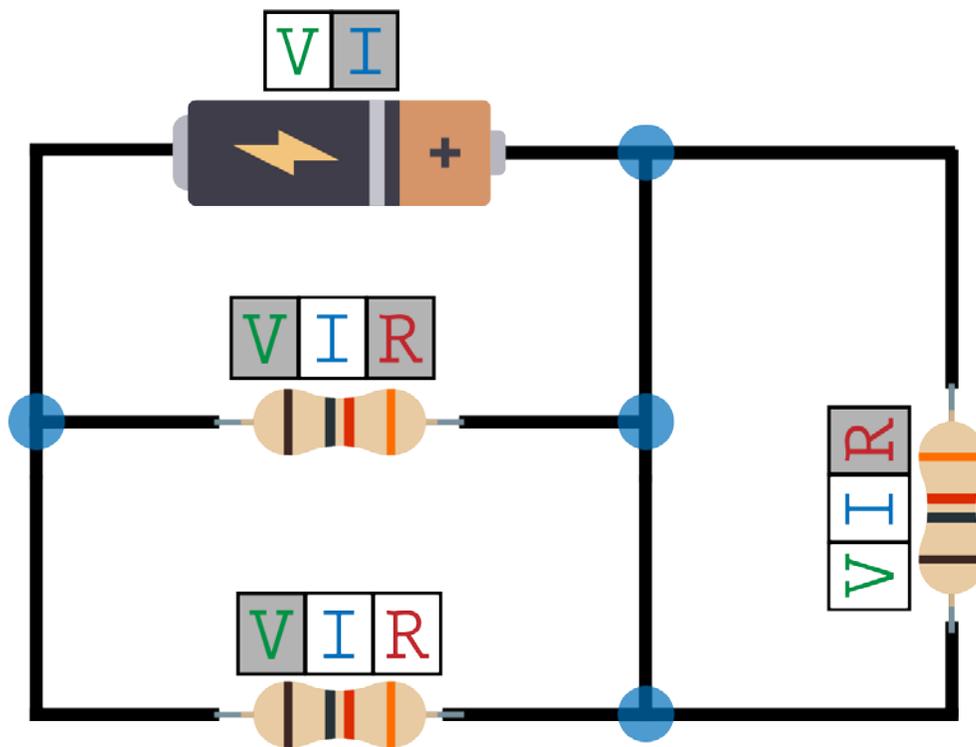


# Circle Kirch Instructions: Player 1

## Intro

Circle Kirch is a 2-player competitive game about electrical circuits. Don't worry if this is new to you! Just by playing the game, you will learn the basic procedures involved in analyzing schematics.

To help you learn the rules, short, single-player mini-games are included throughout the instructions. Make sure you and your opponent play these on your own *before* playing the full game together.



# The Board

## Components

The game board is made up of 2 basic components:

Batteries

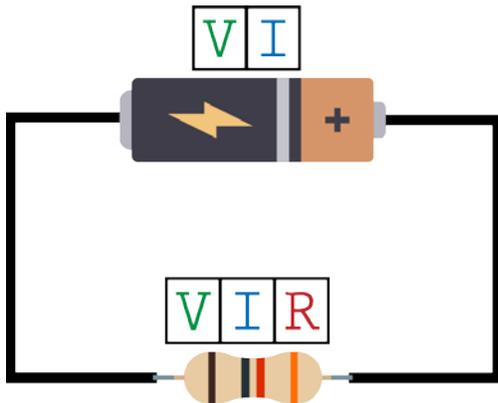


Resistors



## Connections

These components are connected by wires, like this:



## Ratings

You'll notice that each component has two or three ratings:

Voltage



Current



Resistance



Both batteries and resistors have **Voltage** and **Current**, but only resistors have **Resistance**.

# The Goal

In the game board, certain ratings are known and others are unknown.

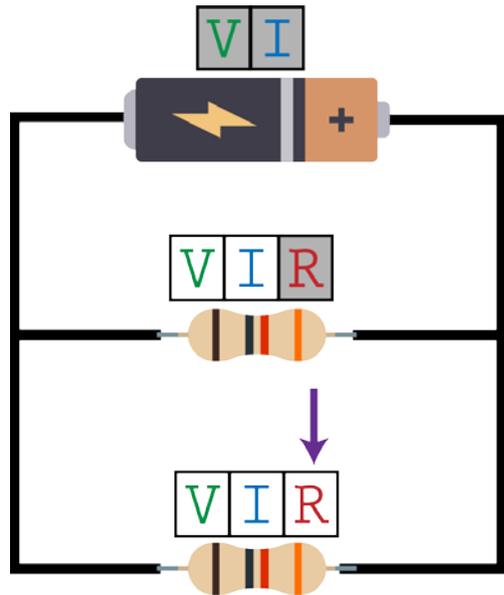
Known ratings are shaded in gray: 

Unknown ratings are in white: 

In this example, **Current** and **Resistance** are known and **Voltage** is unknown:



In a full board, one unknown value will have an **arrow** pointing to it. The goal of the game is to reveal this unknown value (make it known) before your opponent does:



# The Moves

A “move” means revealing an unknown value. There are 3 moves you can make.

When you make a move, place one of your tokens on the rating to show which unknown you have revealed.

## Move 1: Ohm’s Law

If exactly 2 of the ratings for a resistor are known, you can reveal the 3<sup>rd</sup> one for that resistor.



Can reveal **Resistance**  
(place a token on the **R**)

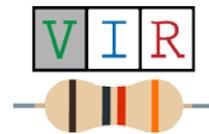


Can reveal **Current**  
(place a token on the **I**)



Can reveal **Voltage**  
(place a token on the **V**)

Careful! You **cannot** use Ohm’s Law here because less than 2 ratings for the resistor are known.



This move applies *only to resistors*. Batteries do not have **Resistance**, so you can’t use Ohm’s Law with them.

## Ohm’s Law Mini-Game

Let’s play a short game to make sure you understand the Ohm’s Law move. Take **Board 1** and place it in front of you. There are 2 circuits on this board. Use the Ohm’s Law move to reveal the indicated unknown values. After you’ve tried this, flip to the next page to see if you did it correctly.

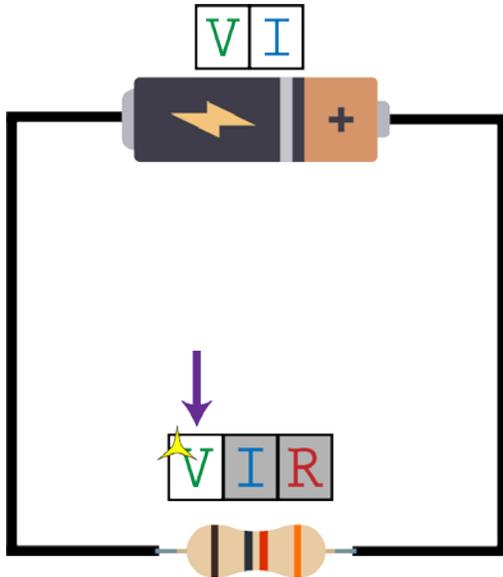


Don’t turn the page until you have completed this mini-game with **Board 1**!

## Ohm's Law Mini-Game – Solution

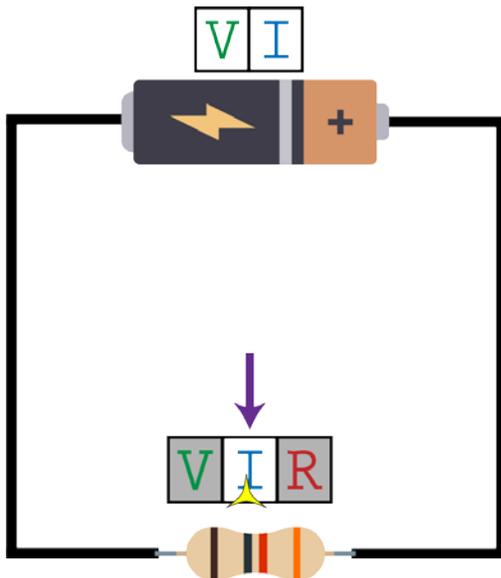
### Left Circuit

Place a token on the **Voltage** on the resistor to reveal it.



### Right Circuit

Place a token on the **Current** on the resistor to reveal it.



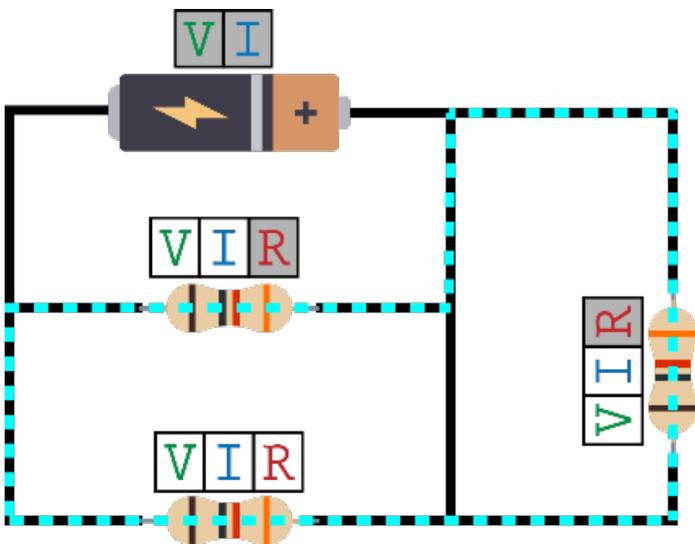
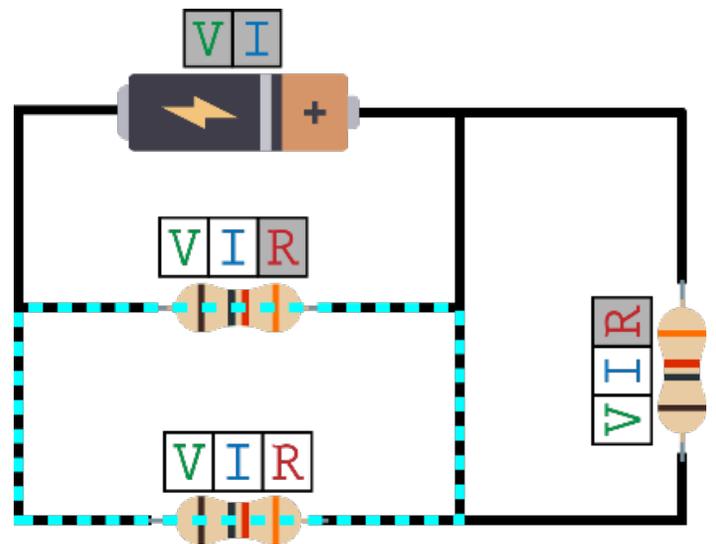
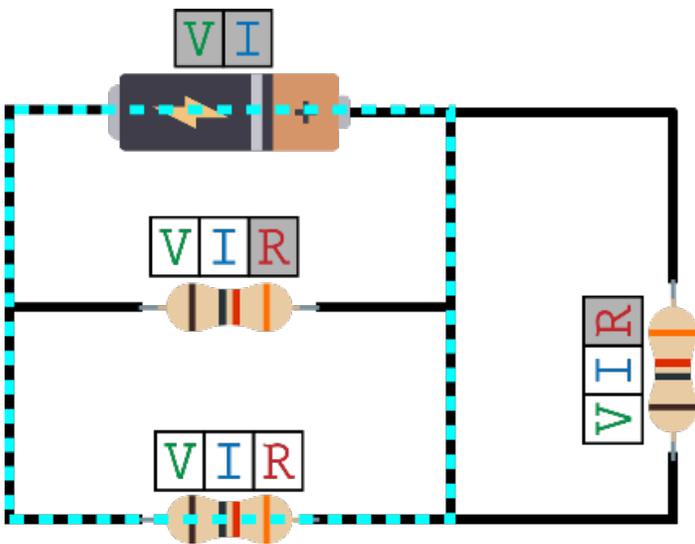
Not too bad, right? The Ohm's Law move is a straightforward, but essential move in this game.

## Move 2: Kirchhoff's Voltage Law

To make this move, first find a Kirchhoff Loop. A Kirchhoff Loop is any path in the circuit that

- (i) starts and ends in the same place AND
- (ii) never crosses its own path.

The dashed blue lines show some examples of valid Kirchhoff Loops:



 Kirchhoff Loop



## Kirchhoff's Voltage Law Mini-Game

Let's play a mini-game to make sure you understand this move. Take **Board 2** and place it in front of you. There are 2 circuits on this board. Use Kirchhoff's Voltage Law to reveal the unknown values. You may also need to use Ohm's Law. After you've tried this, flip to the next page to see if you are correct.

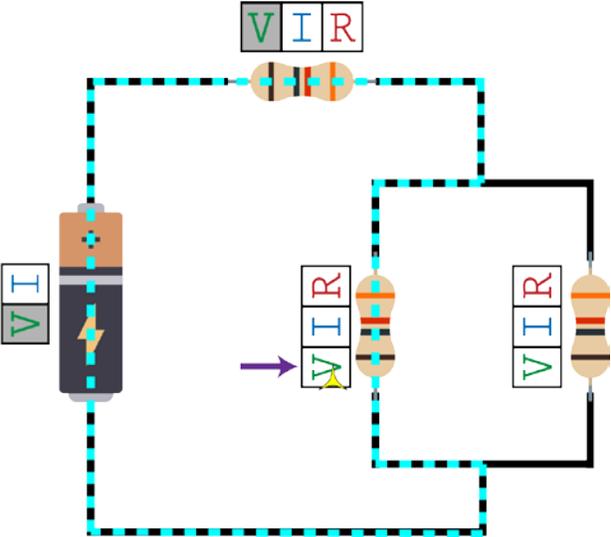


Don't turn the page until you have completed this mini-game with **Board 2**!

# Kirchhoff's Voltage Law Mini-Game – Solution

## Left Circuit

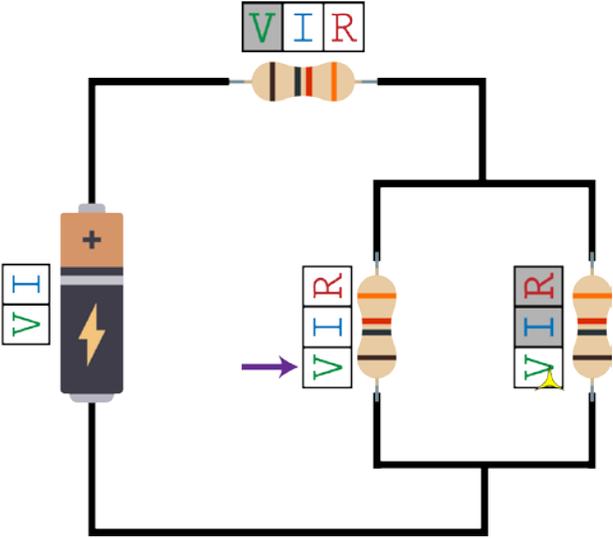
First, note that the highlighted path below is a valid Kirchhoff Loop. In this loop, the **Voltage** is known for all components except for one, so we can reveal that unknown **Voltage**.



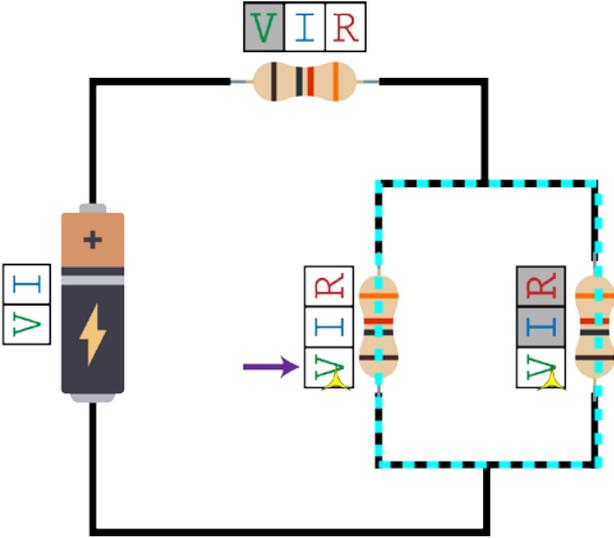
## Right Circuit

This one requires two steps:

First, use Ohm's Law to reveal the **Voltage** of the resistor all the way on the right.



Then, use Kirchhoff's Voltage Law with the highlighted loop to reveal the indicated **Voltage**.



## Move 3: Kirchhoff's Current Law

Instead of explaining this move upfront, let's play one more mini-game. Take **Board 3** and try to reveal the indicated unknown. You'll see a new symbol on this board—a blue dot. Just ignore them for now. Once you've tried it out, go to the next page to see the answer.

This one might be tricky, so don't spend more than 2 minutes trying to figure it out.



Don't turn the page until you have completed this mini-game with **Board 3**!

## Kirchhoff's Current Law Mini-Game – Solution

Did you get stuck? Player 2 learned about the Kirchhoff's Current Law move in the other set of instructions. After both of you have made an attempt to play through **Board 3** on your own, work together to try to reveal the indicated unknown. Player 2 may need to ask you about Kirchhoff's Voltage Law!

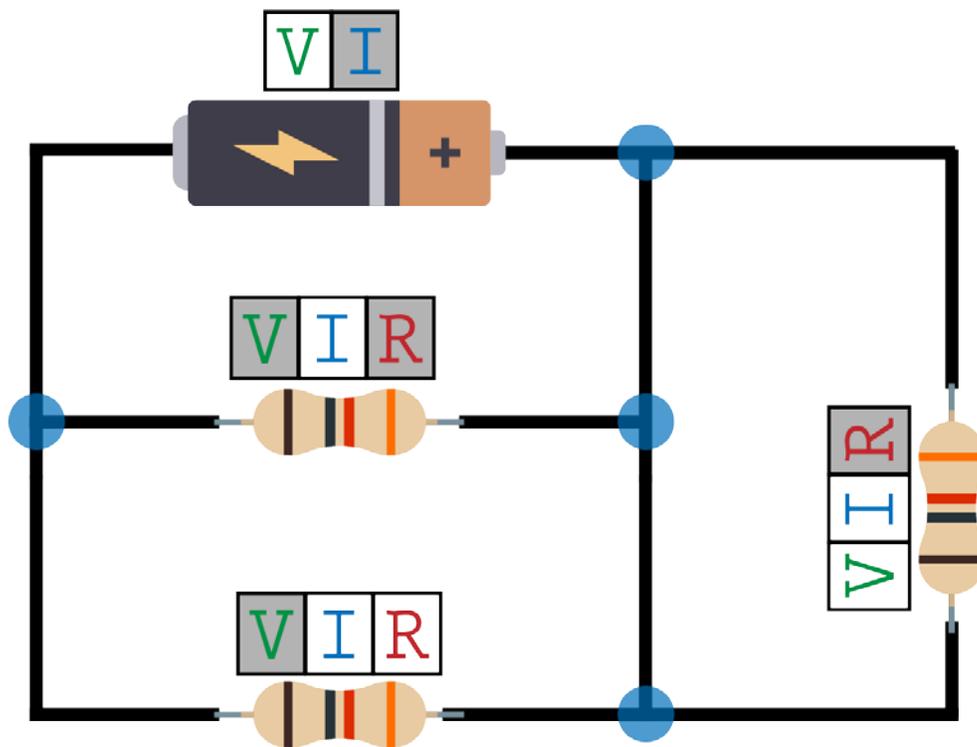
The actual solution to the **Board 3** mini-game is in the "Both Players" instruction set. After you've worked together on **Board 3**, take a look at it to make sure you both understand the 3 moves.

# Circle Kirch Instructions: Player 2

## Intro

Circle Kirch is a 2-player competitive game about electrical circuits. Don't worry if this is new to you! Just by playing the game, you will learn the basic procedures involved in analyzing schematics.

To help you learn the rules, short, single-player mini-games are included throughout the instructions. Make sure you and your opponent play these on your own *before* playing the full game together.



# The Board

## Components

The game board is made up of 2 basic components:

Batteries

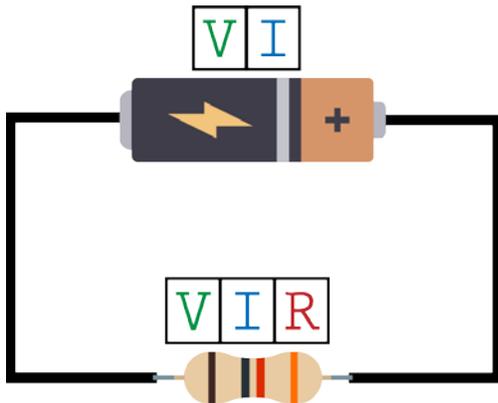


Resistors



## Connections

These components are connected by wires, like this:



## Ratings

You'll notice that each component has two or three ratings:

Voltage



Current



Resistance



Both batteries and resistors have **Voltage** and **Current**, but only resistors have **Resistance**.

# The Goal

In the game board, certain ratings are known and others are unknown.

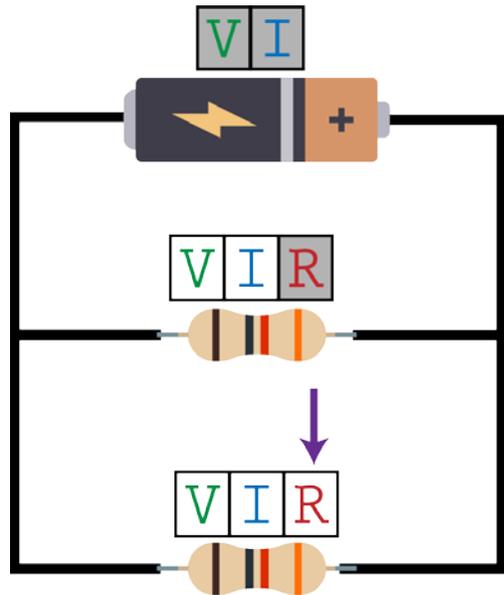
Known ratings are shaded in gray: 

Unknown ratings are in white: 

In this example, **Current** and **Resistance** are known and **Voltage** is unknown:



In a full board, one unknown value will have an **arrow** pointing to it. The goal of the game is to reveal this unknown value (make it known) before your opponent does:



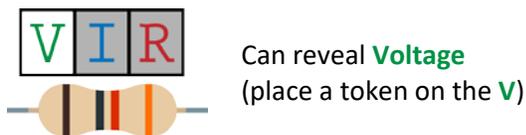
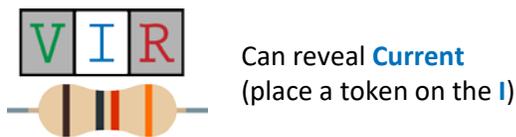
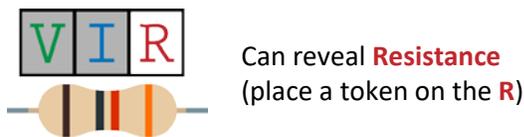
# The Moves

A “move” means revealing an unknown value. There are 3 moves you can make.

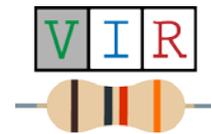
When you make a move, place one of your tokens on the rating to show which unknown you have revealed.

## Move 1: Ohm’s Law

If exactly 2 of the ratings for a resistor are known, you can reveal the 3<sup>rd</sup> one for that resistor.



Careful! You **cannot** use Ohm’s Law here because less than 2 ratings for the resistor are known.



This move applies *only to resistors*. Batteries do not have **Resistance**, so you can’t use Ohm’s Law with them.

## Ohm’s Law Mini-Game

Let’s play a short game to make sure you understand the Ohm’s Law move. Take **Board 1** and place it in front of you. There are 2 circuits on this board. Use the Ohm’s Law move to reveal the indicated unknown values. After you’ve tried this, flip to the next page to see if you did it correctly.

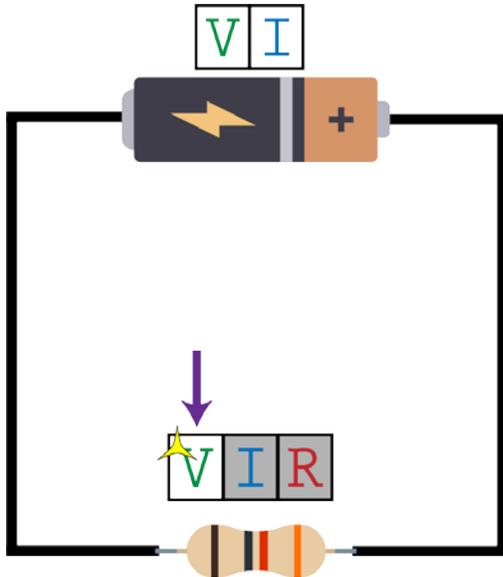


Don’t turn the page until you have completed this mini-game with **Board 1**!

## Ohm's Law Mini-Game – Solution

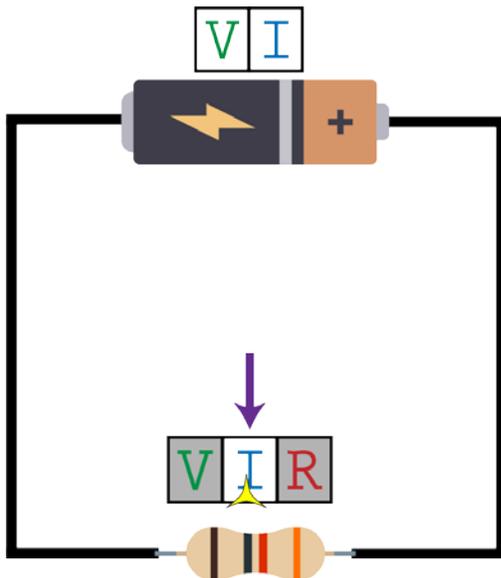
### Left Circuit

Place a token on the **Voltage** on the resistor to reveal it.



### Right Circuit

Place a token on the **Current** on the resistor to reveal it.

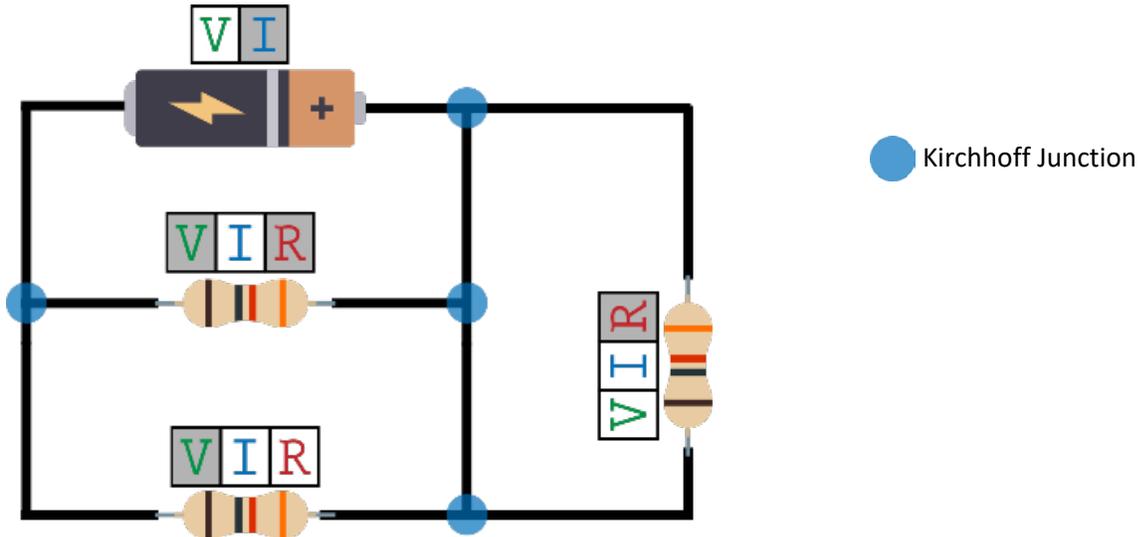


Not too bad, right? The Ohm's Law move is a straightforward, but essential move in this game.

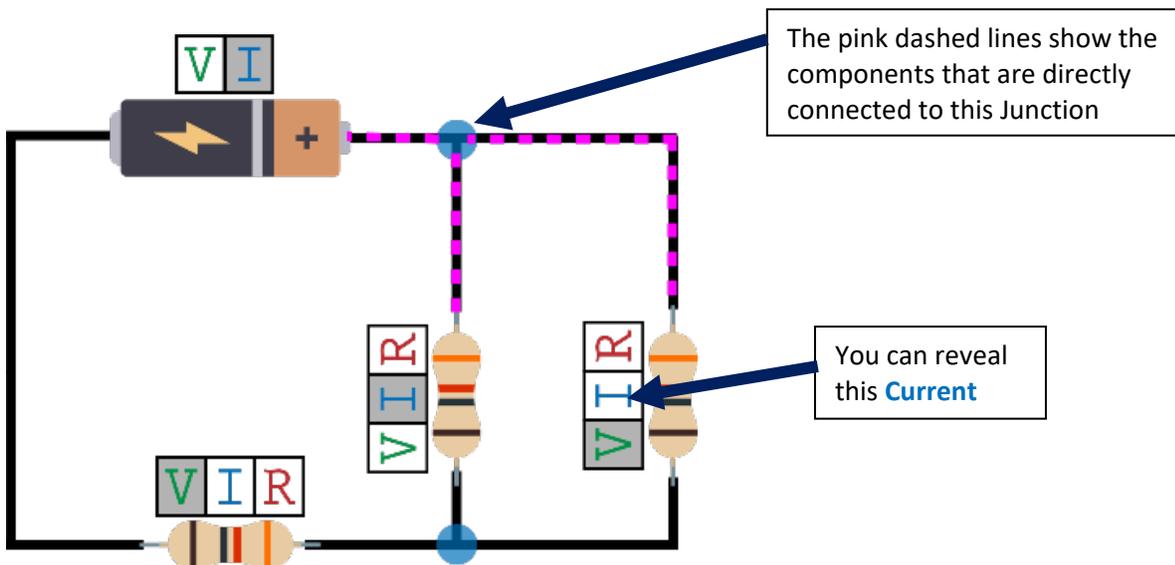
## Move 2: Kirchoff's Current Law

To make this move, first select a Kirchoff Junction. A Kirchoff Junction is any point on the circuit where the wires branch into more than one possible direction.

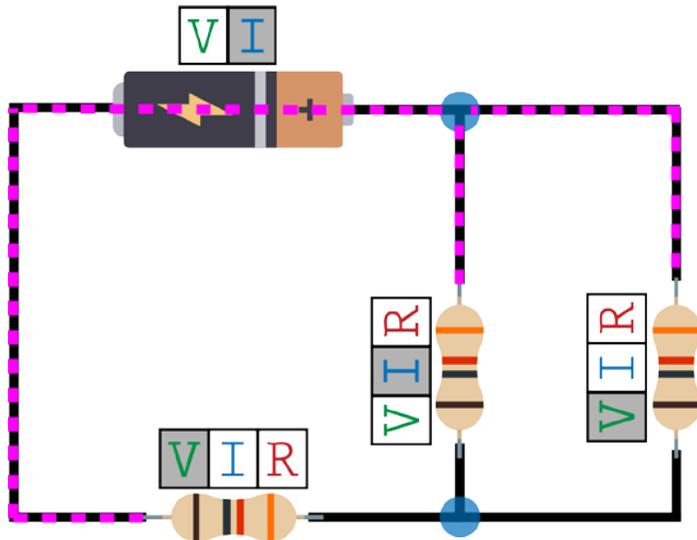
Kirchoff Junctions are marked in blue dots on the board:



Once you've selected a Kirchoff Junction, identify the components that are *directly connected* to that junction. For the components that are directly connected to the junction, if you know the **Current** for all components except for one, then you can reveal that unknown **Current**.



Careful! Say you have selected the Kirchhoff Junction at the top of this circuit. The following is an **INVALID** use of Kirchhoff's Current Law:



**INVALID: This resistor is not directly connected to the Kirchhoff Junction at the top**

### Kirchhoff's Current Law Mini-Game

Let's play a mini-game to make sure you understand this move. Take **Board 4** and place it in front of you. There are 2 circuits on this board. Use Kirchhoff's Current Law to reveal the unknown values. You may also need to use Ohm's Law. After you've tried this, flip to the next page to see if you are correct.

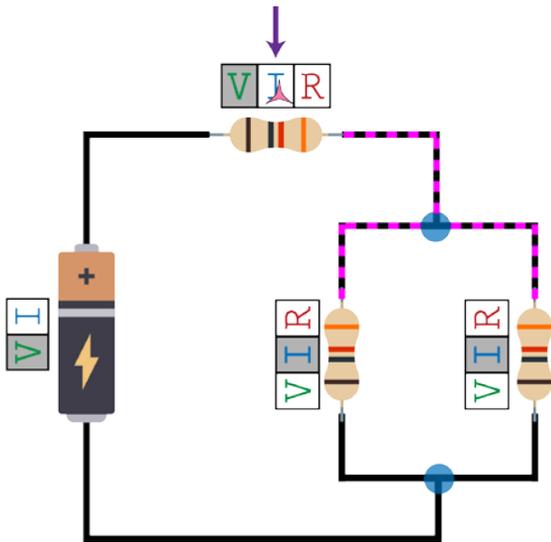


Don't turn the page until you have completed this mini-game with **Board 4**!

## Kirchhoff's Current Law Mini-Game – Solution

### Left Circuit

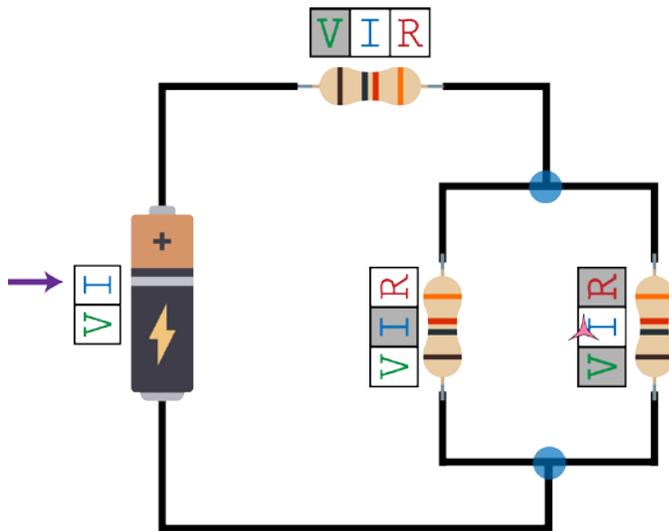
First, note that the dashed pink lines show the components that are directly connected to one of the Junctions. For these three components, the **Current** is known for all except for one, so we can reveal that unknown **Current**.



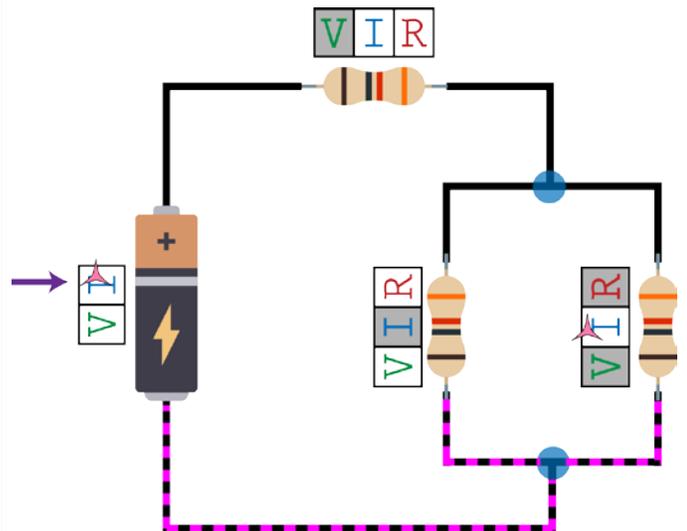
### Right Circuit

This one requires two steps:

First, use Ohm's Law to reveal the **Current** of the resistor all the way on the right.



Then, use Kirchhoff's Current Law with the bottom junction to reveal the **Current** of the battery.



## Move 3: Kirchhoff's Voltage Law

Instead of explaining this move upfront, let's play one more mini-game. Take **Board 3** and try to reveal the indicated unknown. Once you've tried it out, go to the next page to see the answer.

This one might be tricky, so don't spend more than 2 minutes trying to figure it out.



Don't turn the page until you have attempted this mini-game with **Board 3**!

## Kirchhoff's Voltage Law Mini-Game – Solution

Did you get stuck? Player 1 learned about the Kirchhoff's Voltage Law move in the other set of instructions. After both of you have made an attempt to play through **Board 3** on your own, work together to try to reveal the indicated unknown. Player 1 may need to ask you about Kirchhoff's Current Law!

The actual solution to the **Board 3** mini-game is in the "Both Players" instruction set. After you've worked together on **Board 3**, take a look at it to make sure you both understand the 3 moves.

# Circle Kirch Instructions: Both Players

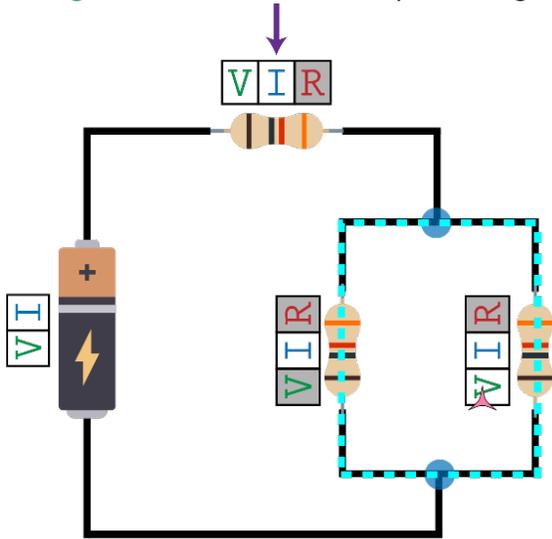
## IMPORTANT!

Do not read these instructions right away! Before you turn to the next page, choose one player to be Player 1 and the other to be Player 2. You two should independently read your own set of instructions (*Circle Kirch Instructions: Player 1* or *Circle Kirch Instructions: Player 2*) and play through the mini-games on your own before coming together again.

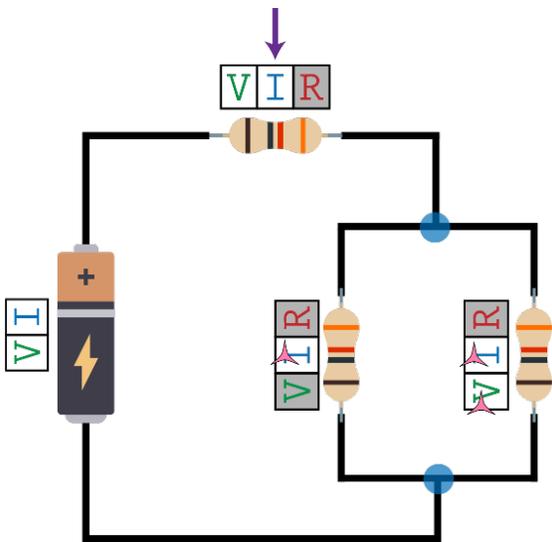
## Board 3 Solution

Before reading this page, make sure that both players have worked together to complete the Board 3 mini-game.

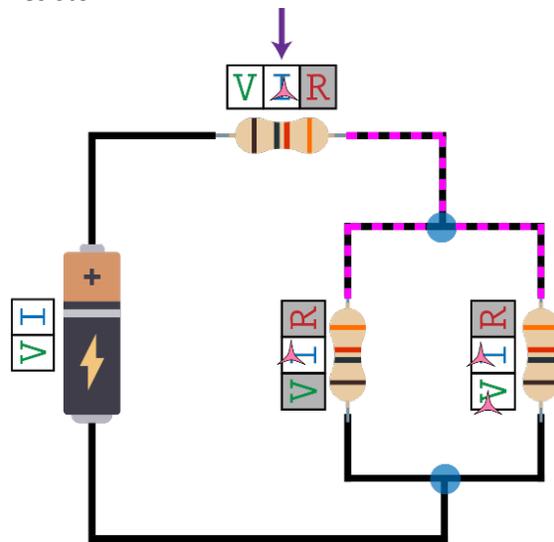
First, use Kirchhoff's Voltage Law to reveal the **Voltage** of the resistor all the way on the right.



Then, use Ohm's Law to reveal the **Voltage** of the two lower resistors.



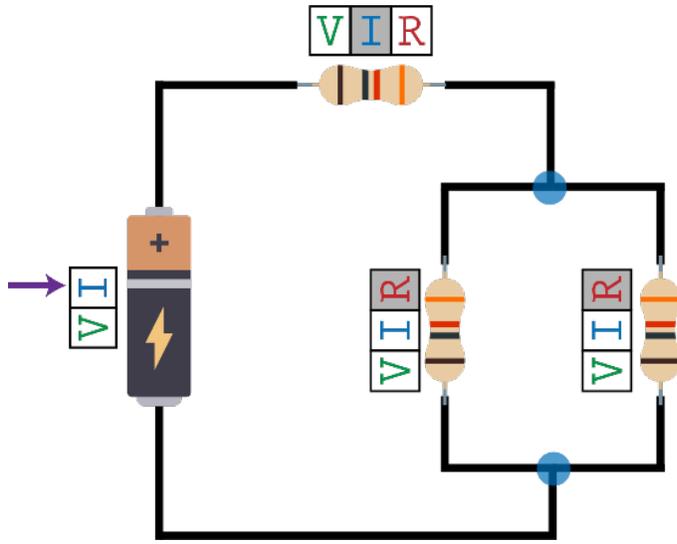
Finally, use Kirchhoff's Current Law with the top junction to reveal the **Current** of the top resistor.



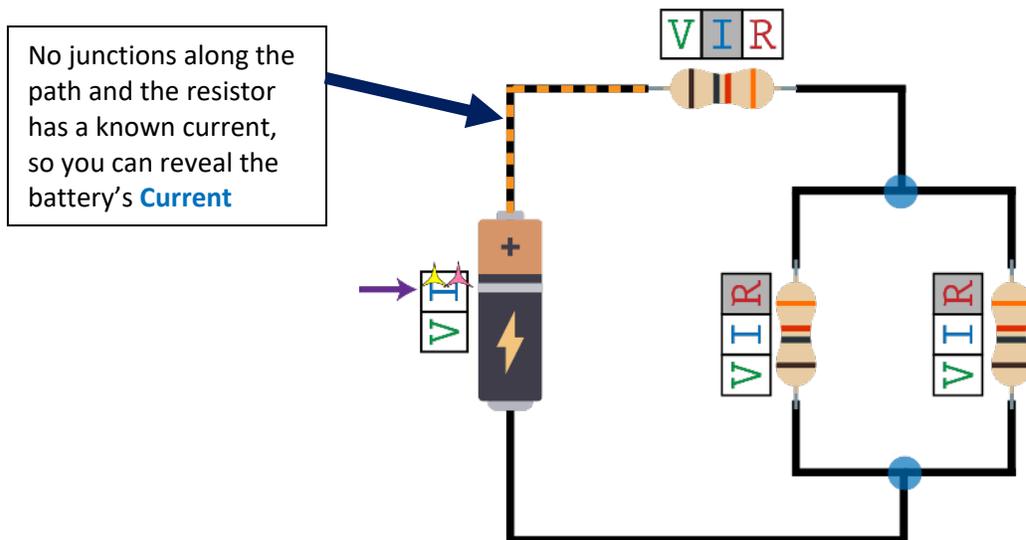
## Same-Wire, Same Current

There's just one more move to learn—the “**same-wire, same-current**” move.

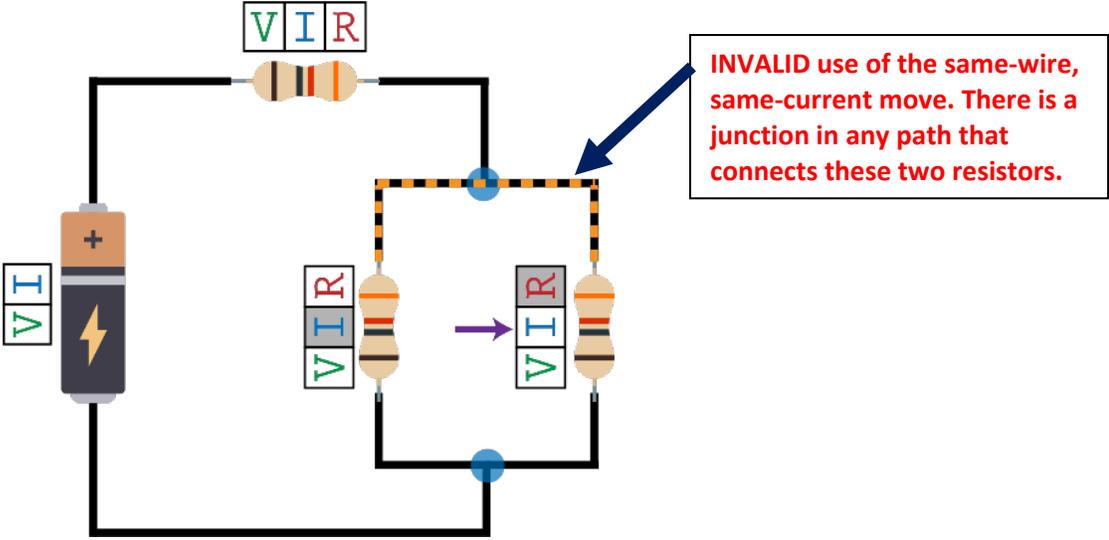
In the circuit below, the **Current** for the top resistor is known. You can immediately reveal the **Current** of the battery, but not the **Current** of the other two resistors. Why do you think this is the case?



The reason is that there are **no junctions** along the path that connects a component with a known **Current** to a component with an unknown **Current**.



In the circuit below, you **cannot** use the same-wire, same-current move to reveal the **Current** of the resistor on the right.



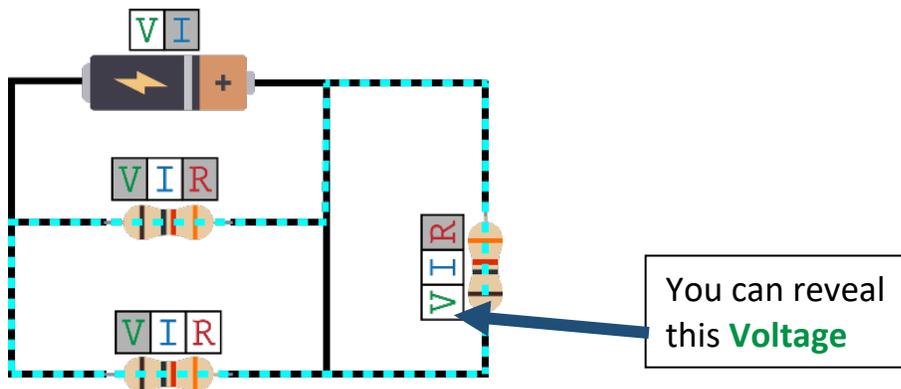
## Review of the 4 Moves

### Ohm's Law

If exactly 2 of the ratings for a resistor are known, you can reveal the 3<sup>rd</sup> one for that resistor.

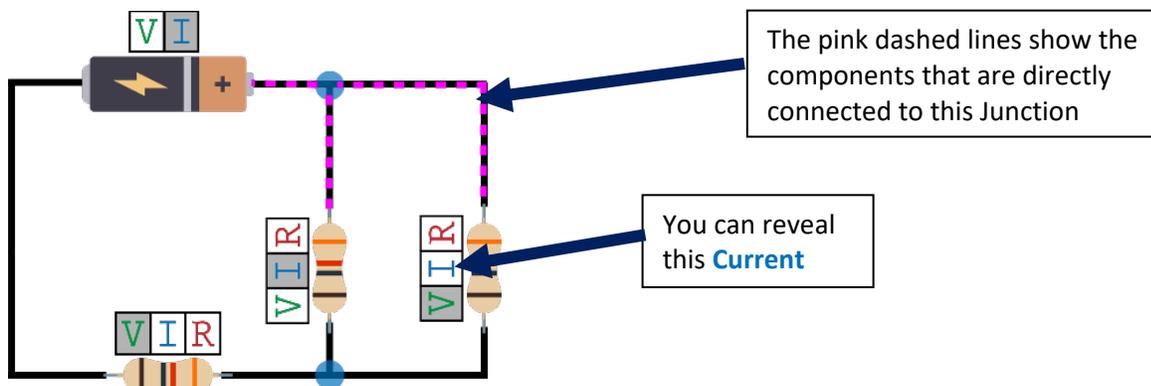
### Kirchhoff's Voltage Law

Within a valid Kirchhoff Loop, if you know the **Voltage** for all components except for one, then you can reveal that unknown **Voltage**.



### Kirchhoff's Current Law

For the components that are directly connected to a Kirchhoff Junction, if you know the **Current** for all components except for one, then you can reveal that unknown **Current**.



### Same wire, same current

If there are no junctions along the path that connects a component with a known **Current** to a component with an unknown **Current**, you can reveal the unknown **Current**.

## Competitive Game Rules

Both players have now mastered the possible moves you can make. We're ready to learn the rules of the competitive game!

One player uses the yellow tokens and the other uses the pink tokens. Choose one player to go first. Take turns revealing ratings until one of you reveals the rating with the **arrow**.

On a single turn, you can:

- Use the Ohm's Law move as many times as you want
- Use the same-wire, same-current move as many times as you want
- Use either Kirchhoff's Voltage Law or Kirchhoff's Current Law **only once**

When you reveal a **Voltage**, **Current**, or **Resistance**, place one of your tokens on the rating to show that it is now known to you.

*A rating that is revealed by one player is not automatically known to the other player. If Player 1 reveals a certain **Current**, Player 2 cannot use that **Current** as a known value (until Player 2 reveals it on a later turn).*

The first player reveal the rating with the **arrow** wins! Play again on the next board, and switch who goes first.

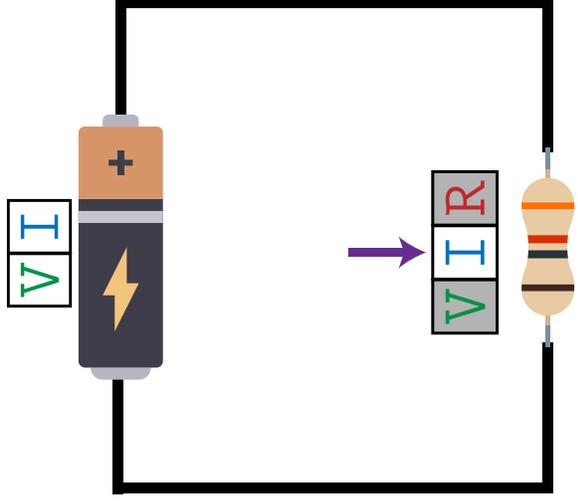
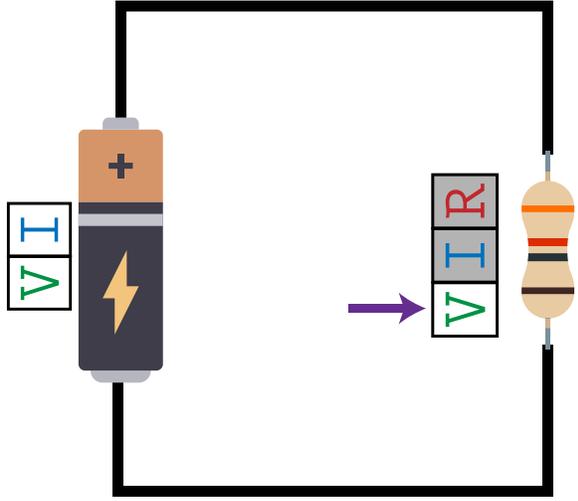
Some clarifications about what you can do on a single turn:

- You **cannot** use both Kirchhoff's Voltage Law and Kirchhoff's Current Law in the same turn. Whichever Kirchhoff move you choose to use, you can only use it once on that turn.
- You can use Ohm's Law as many times as you'd like, before and/or after you use one of the Kirchhoff moves.
- You can use "same-wire, same-current" as many times as you'd like, before and/or after you use one of the Kirchhoff moves.

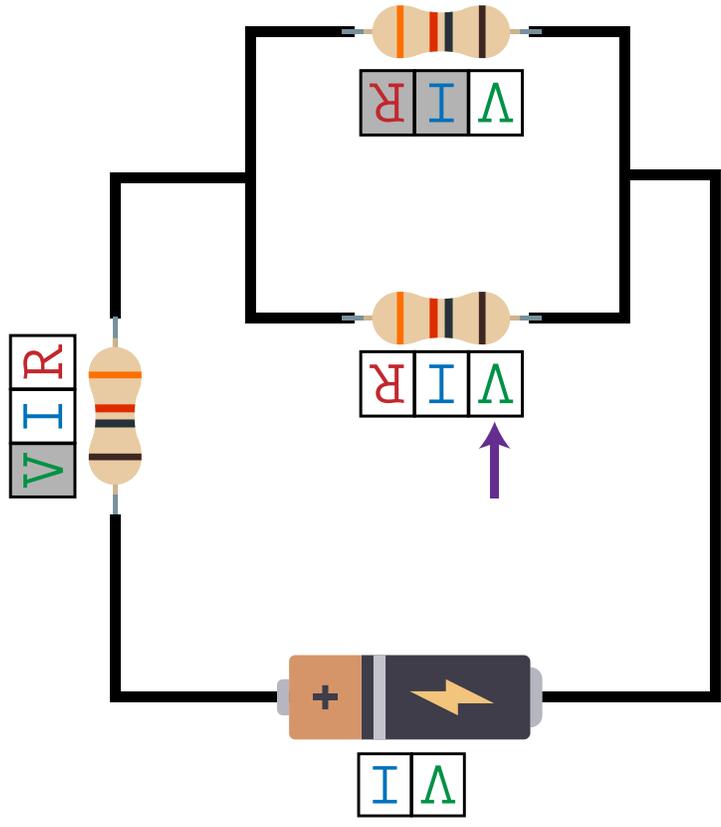
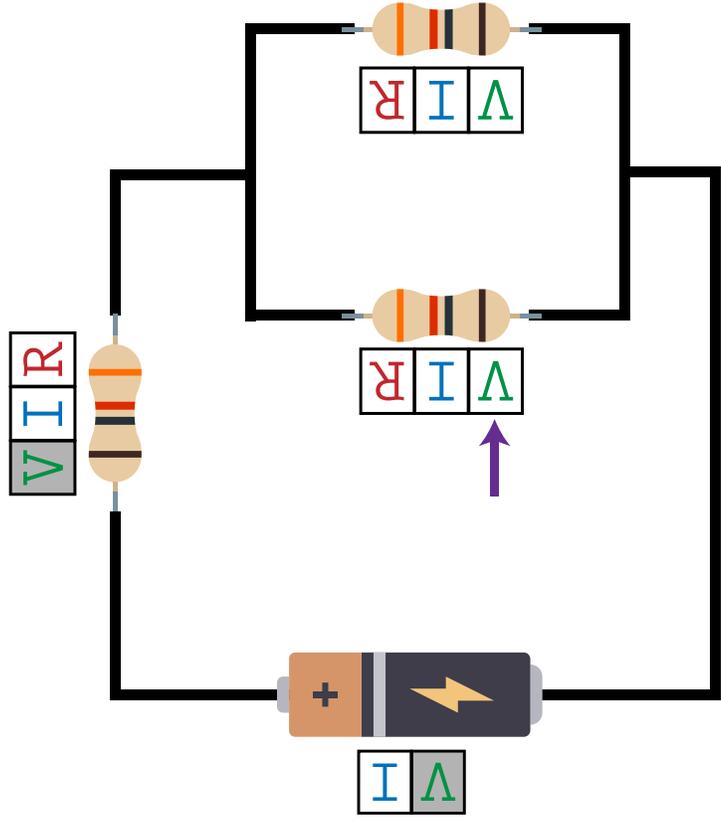
We suggest you play the competitive boards in this order:

- **Board 5** – Player 1 goes first
- **Board 6** – Player 2 goes first

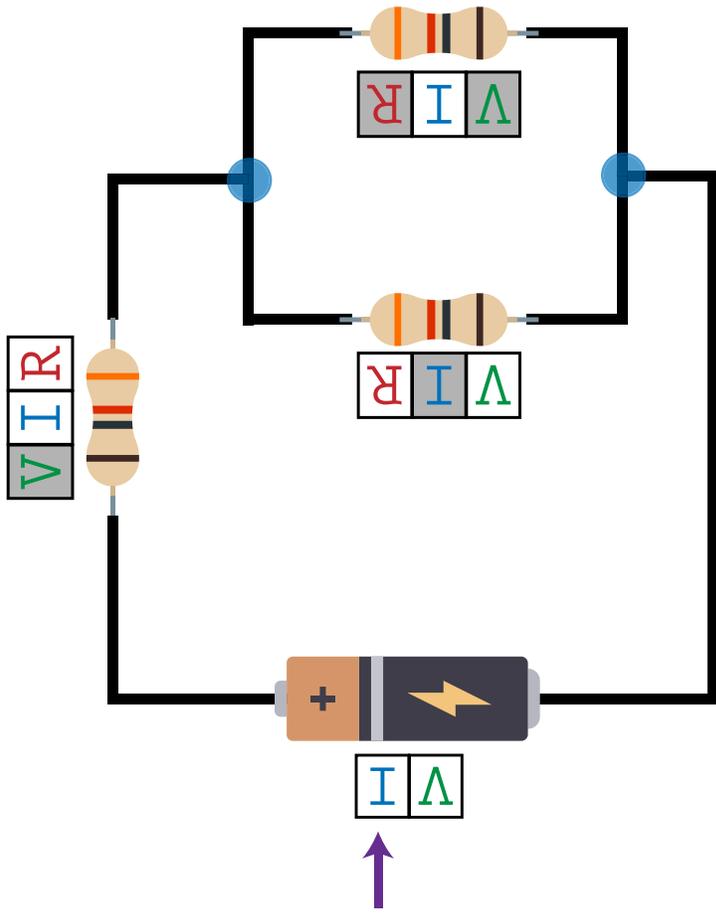
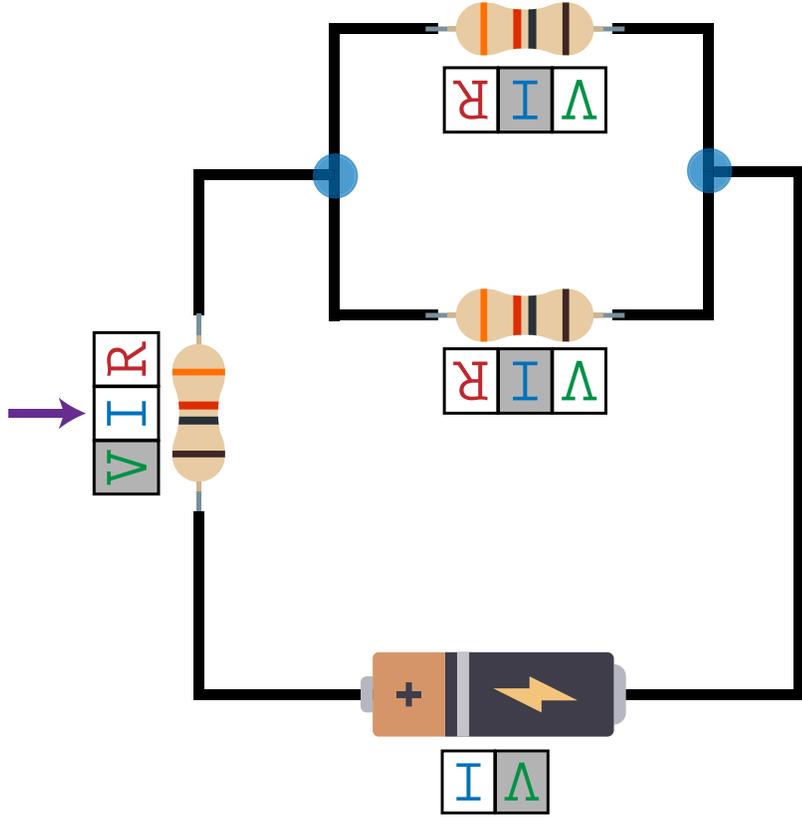
# Board 1: The Power of Ohm



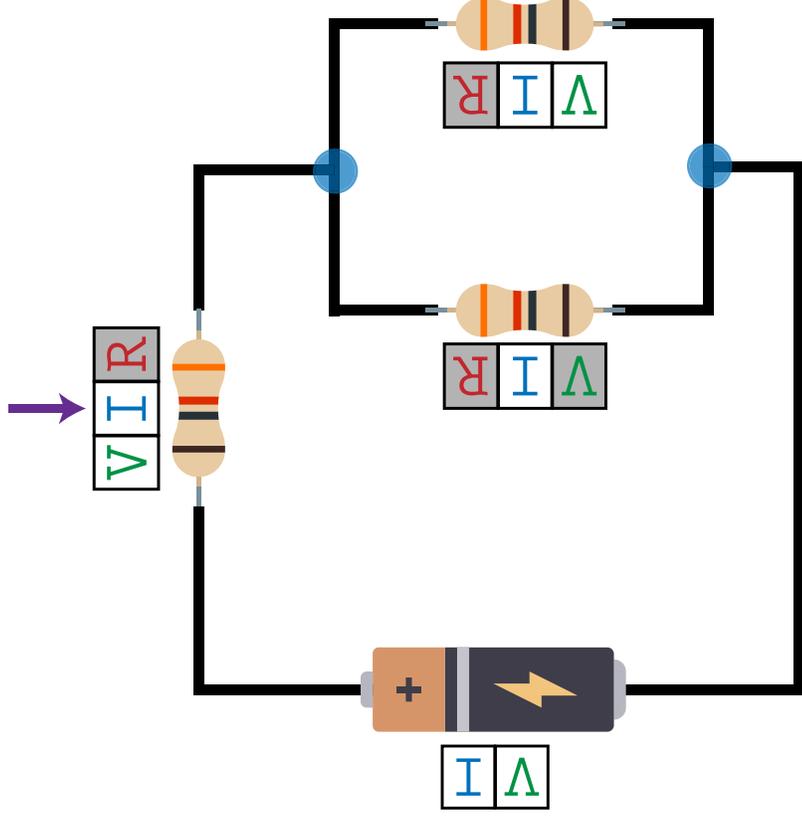
# Board 2: Loopy Loop



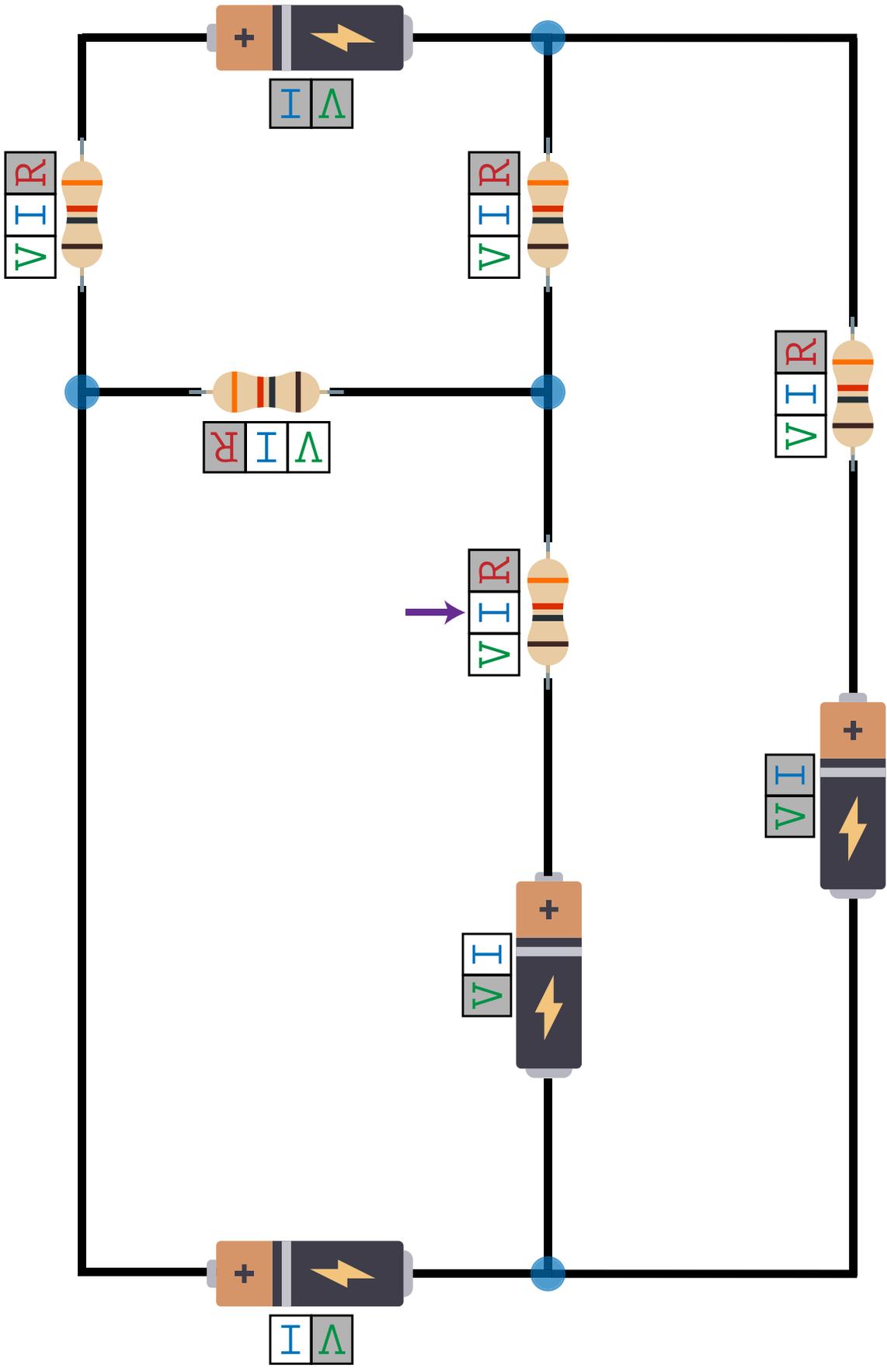
# Board 4: Funky Junction



# Board 3: Get Jiggy With It



# Board 5: Glowbones' Lament



# Board 6: CENATION

