Intro Screen
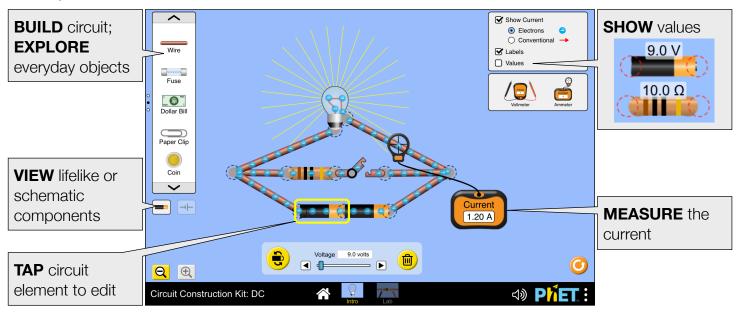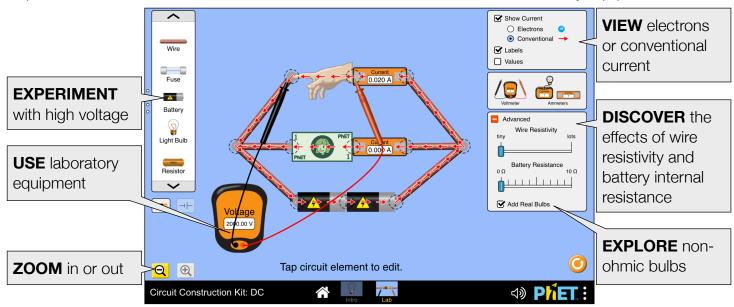
Build circuits with batteries, light bulbs, resistors, and switches. Explore the relationship between voltage, current, and resistance.
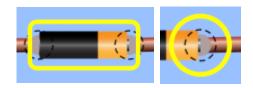
BUILD circuit; **EXPLORE** everyday objects

VIEW lifelike or schematic components

TAP circuit element to edit

SHOW values

MEASURE the current

Lab Screen

Experiment with conductors and insulators, and take measurements with laboratory equipment.

EXPERIMENT with high voltage

USE laboratory equipment

ZOOM in or out

VIEW electrons or conventional current

DISCOVER the effects of wire resistivity and battery internal resistance

EXPLORE non-ohmic bulbs

Complex Controls

- The delete key can be used to delete a selected circuit component or cut a selected vertex.

Customization Options

The following query parameters allow for customization of the simulation, and can added by appending a '?' to the sim URL, and separating each query parameter with a '&'.

Query Parameter and Description	Examples

`schematicStandard` - displays schematic circuit components using IEEE (default), IEC, or British standards.	`schematicStandard=ieee`
	`schematicStandard=iec`
	`schematicStandard=british`

`showCurrent` - specifies the initial state of the Show Current checkbox. (Default is true.)	`showCurrent=false`
`currentType` - specifies the initial current representation: electrons (default) or conventional.	`currentType=conventional` `currentType=electrons`
`moreWires` - increases the number of wires from 25 to 50. Not recommended for slower devices.	`moreWires`
`addRealBulbs` - enables non-Ohmic bulbs on startup (checks "Add Real Bulbs" checkbox).	`addRealBulbs`

`screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center.	`screens=1`
	
	`screens=2,1`

`supportsPanAndZoom` - when true, enables panning and zooming of the simulation using pinch-to-zoom or browser zoom controls.	`supportsPanAndZoom=false`

Model Simplifications

- Both the electrons and conventional current representations are *cartoon-like* and do not perfectly model the current in the circuit. Their speed and density are an approximation, and should not be taken literally. The current animation will pause while a circuit element is dragged.
- The fire graphic denotes a short circuit or very high current (greater than 15 amps). When the current is very large, the simulation cannot properly animate the current, so the simulation speed will be reduced and an on-screen warning will appear.
- Wires are not ideal (minimum resistivity of 10^{-5} $\Omega \cdot m$) and long wires can affect the current in the circuit, as resistance is proportional to length. To find the resistance for any wire segment within a complete circuit, measure the current and voltage and use Ohm's Law to calculate the resistance.
- If a short is introduced in parallel, internal resistance is added to the battery. This is done so that the current through the other branch(es) of the circuit is more realistic. Note that this internal resistance will not be displayed when "Values" is turned on.
- Non-contact ammeters (such as an AC/DC current clamp) exist, though are usually used to measure ~1-1000 amps. For convenience, the probe can read on top of all circuit elements, including the *lifelike* boundaries of the batteries and bulbs. The Virtual Lab version of this sim does not include a non-contact ammeter.

Rouinfar, January 2022

- When the current is (0 A, 0.02 A], a third decimal place will be added to the ammeter readout.
- The voltmeter probes read anywhere within a component's vertices. At times, this may create the illusion that the probes are not in contact with the conductive portions of the component.
- Batteries with internal resistance are modeled as a battery and resistor in series. Therefore, the voltage drop across the battery in a complete circuit will be zero (unless wire resistivity is high).
- The colored bands on the resistors accurately represent the resistance within ±5%, as indicated by the gold tolerance band.
- The pencil has a resistance of 25 Ω, which considers its **core** (graphite/clay), not its wooden casing.
- The dog has a resistance of 100000 Ω, but to avoid electrocution, it will bark and disconnect from the circuit if the voltage across it exceeds 100 V.
- The standard and high-resistance light bulbs behave Ohmically. A non-Ohmic bulb can be accessed on the Lab screen by checking the "Add Real Bulbs" checkbox (or by running the sim with the `addRealBulbs` query parameter, see Customization Options above).
- The light bulb brightness is proportional to the power through the bulb ($P=V^2/R$), and maximum brightness is achieved at 2000 W.
- When fuses are connected in series and the current suddenly exceeds the highest rating (e.g. increasing voltage while switch is open), one fuse will randomly blow regardless of current rating.

Suggestions for Use

Sample Challenge Prompts
- Build a circuit to turn on a light bulb.
- Predict what will happen to the brightness of a light bulb when the voltage is changed.
- Discover a way to connect two light bulbs in a circuit so that: (a) if one bulb is disconnected both bulbs go out, and (b) if one bulb is disconnected the other bulb will remain lit.
- Compare a circuit with two resistors connected in series to a circuit with two resistors connected in parallel. Describe what happens to the current and voltage across each resistor.
- Design an experiment to determine which objects are insulators and which are conductors.
- Determine how to increase the electron speed or reverse the direction of motion. Explain your method.
- What does the fire represent?
- Predict what happens to the current in a circuit when battery resistance or wire resistivity is changed.

See all published activities for Circuit Construction Kit: DC here.
For more tips on using PhET sims with your students, see Tips for Using PhET.