PhET Tips for Teachers — Circuit Construction Kit: AC

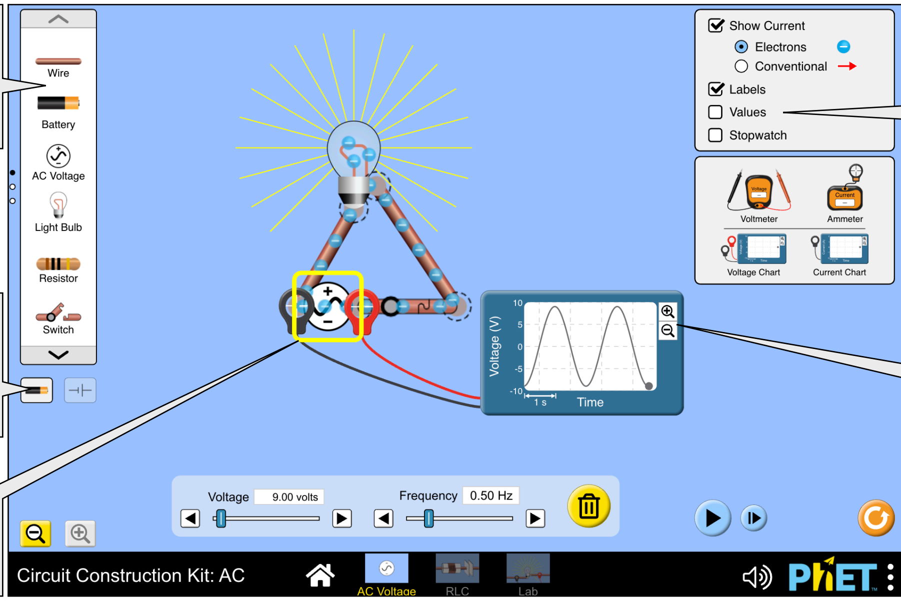
AC Source Screen

Build AC and DC circuits with AC sources, batteries, light bulbs, resistors, and switches. Discover the relationship between voltage, current, and resistance.

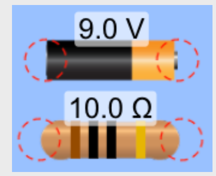
BUILD circuit; **EXPLORE** everyday objects

VIEW lifelike or schematic components

TAP circuit element to edit



SHOW values

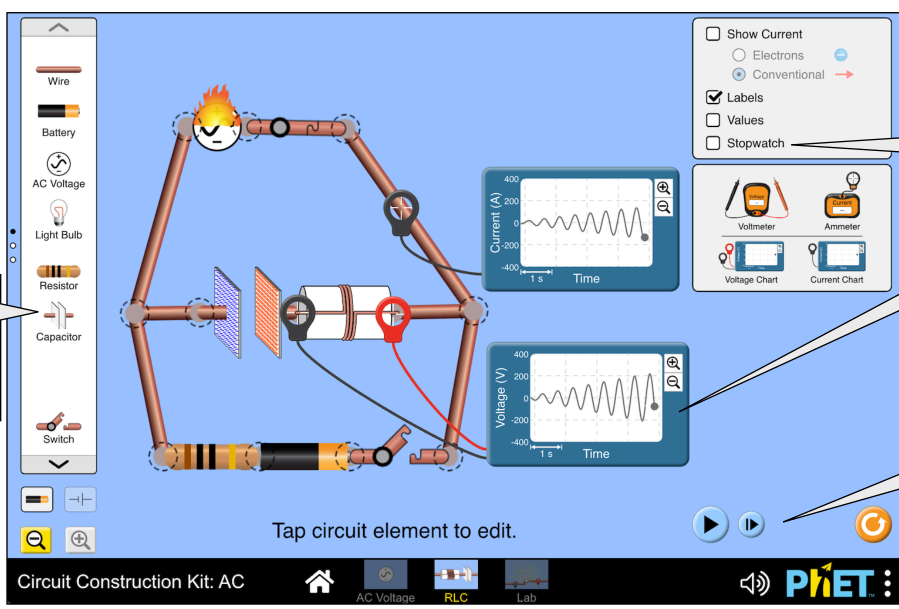


MEASURE the voltage; **ZOOM** to re-scale charts

RLC Screen

Experiment with RC, RL, and RLC circuits. Measure the time constant, determine the factors that affect it, and create resonant circuits.

EXPERIMENT with capacitors and inductors



DETERMINE time constant experimentally

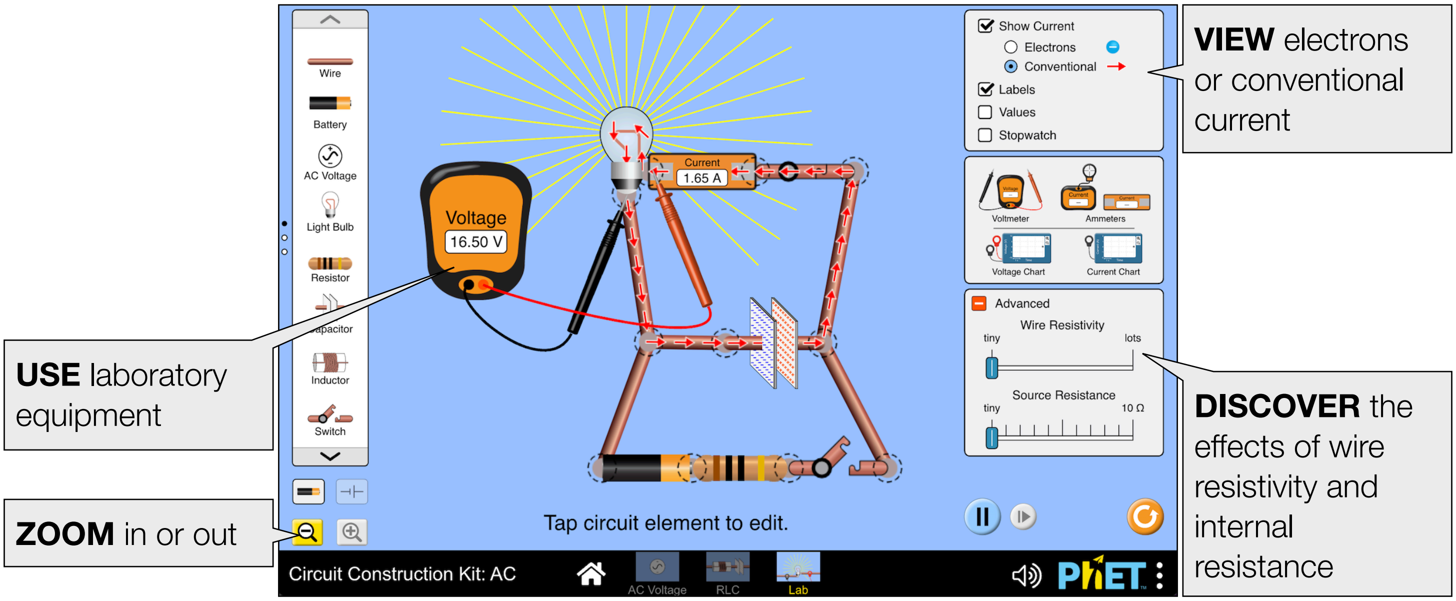
BUILD resonant circuits

PAUSE and **STEP** to explore dynamics

Rouinfar, January 2022

Lab Screen

Explore the effects of wire resistivity and source resistance. Experiment with phase shifts in AC sources.



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`

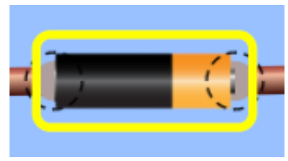
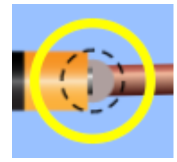
`showCurrent` - specifies the initial state of the Show Current checkbox. (Default is true.)	`showCurrent=false`
`currentType` - specifies the initial current representation: electrons (default) or conventional.	`currentType=conventional` `currentType=electrons`
`ammeterReadout` - displays magnitude (default) or signed readout, see Model Simplifications below.	`ammeterReadout=magnitude` `ammeterReadout=signed`
`moreWires` - increases the number of wires from 25 to 50. Not recommended for slower devices.	`moreWires`
`moreInductors` - increases the number of inductors from 1 to 10. Use with caution, see Model Simplifications below.	`moreInductors`

`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`

Rouinfar, January 2022

Query Parameter and Description	Examples
`audio` - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	`audio=muted` `audio=disabled`
`supportsPanAndZoom` - when true, enables panning and zooming of the simulation using pinch-to-zoom or browser zoom controls.	`supportsPanAndZoom=false`

Complex Controls

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

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 (≥15 A). When the current is very large, the simulation cannot animate the current in real time, so the animation speed will be reduced and an on-screen warning will appear.
- The components are not ideal and have a small internal resistance to accurately model the dynamics.
  - Wires: minimum resistivity 10^{-10} Ω·m
  - Batteries & AC sources: minimum internal resistance 10^{-4} Ω
  - Capacitors and Inductors: 10^{-4} Ω
- 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.
- When the current is (0 A, 0.02 A], a third decimal place will be added to the ammeter readout.
- The ammeter displays magnitude by default. To explore negative currents, use the `ammeterReadout=signed` query parameter described in the Customization Options section above. For AC circuits, the ammeter readout will be negative when the voltage is negative. For DC circuits, the current is positive by default and the sign clears whenever the current through an element becomes zero. When an element is connected to a circuit, its current polarity will match the rest of the circuit. If there isn't already a defined polarity, the sign will be positive. This means that opening and closing a switch may reset the sign to positive. The current within a DC circuit will be self-consistent, but won't necessarily be consistent between separate circuits.
- 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.
- Voltage sources with internal resistance are modeled with an invisible resistor in series. Therefore, the voltage drop across the voltage source 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 light bulbs behave Ohmically. To experiment with non-Ohmic bulbs, use Circuit Construction: DC.
- 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.
- Ideal inductors will oscillate if suddenly disconnected. To avoid this, inductors will immediately dissipate any stored energy when disconnected from a circuit which may lead to a spike in the voltage and current charts.
- We do not recommend using multiple inductors in the same circuit. It is possible to create perpetual currents or other nonphysical behavior, especially at low resistances. For this reason, we have chosen to only include one inductor by default. To access additional inductors, use the `moreInductors` query parameter described in the Customization Options section above.
- Capacitors may behave poorly if the resistance in the circuit is less than 0.1 Ω.
- When there is a sudden change to the circuit, spikes may appear in the voltage and/or current charts. This can happen when an inductor is suddenly disconnected, the phase of an AC source is shifted, or when a capacitor is shorted.
- When the sim is paused, the model will step forward by 10^{-6} s when the sim is interacted with, such as when a slider is adjusted or circuit components are connected to one another. However, some dynamics still require the model to be manually stepped forward while paused to take effect, such as the barking dog (voltage exceeds 100 V) or tripped fuse.

Suggestions for Use

Sample Challenge Prompts

- Build a circuit to turn on a light bulb.
- Compare and contrast the behavior of a light bulb connected to an AC source and a light bulb connected to battery.
- 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.
- Determine how to increase the electron speed or reverse the direction of motion. Explain your method.
- What does the fire represent?
- Predict what will happen in an RC circuit if the resistance, capacitance, or initial voltage is changed.
- Build an RLC circuit and determine the conditions necessary for resonance.
- Predict what happens to the current in a circuit when source resistance or wire resistivity is changed.

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