# Introduction to AC Circuits

**March 25, 2020**

The world mostly works on Alternating Current (AC) circuits, in which the voltage and current vary periodically. Your household voltage (and current) goes through 60 full cycles per second (Hertz or Hz). Radio waves are broadcast at frequencies of kilohertz or megahertz, and the electronics that generate those radio waves and detect them must operate at those frequencies.

The fundamental components of AC circuits are resistors (which you worked with in our DC circuit unit in January), capacitors (which we discussed a bit during the electrostatics unit) and "inductors" (actually self-inductors – which I'll discuss below).

It makes intuitive sense that resistors play a role in AC circuits as they do in DC circuits. But capacitors are simply two conducting plates (or something equivalent) that don't connect. How could they play a role in a circuit when charge can't flow between the plates? In an AC circuit, the charge sloshes back and forth, and so in such a circuit each plate in a capacitor plays a role by first becoming positively charged and then negatively charged. In fact, in an AC circuit a capacitor plays a role a little like a resistor and takes on a property called "reactance" that is analogous in some ways to resistance. (And yes, that will be a focus of this week's work)

An "inductor" is simply a solenoid – a wire wound around a core of some type. In a DC circuit, a solenoid produces a magnetic field (as you measured in our last physical class). In an AC circuit, the magnetic field in the solenoid – and thus the magnetic flux through the solenoid – is constantly changing. And because the magnetic flux is constantly changing, the inductor generates an EMF that affects the flow of current just as the AC power supply does. An inductor has a "reactance" – a resistance-equivalent-sort-of – just like a capacitor does.

Not only do capacitors and inductors have reactances, but they also do screwy things with the relationship between the phases of the voltage and current.

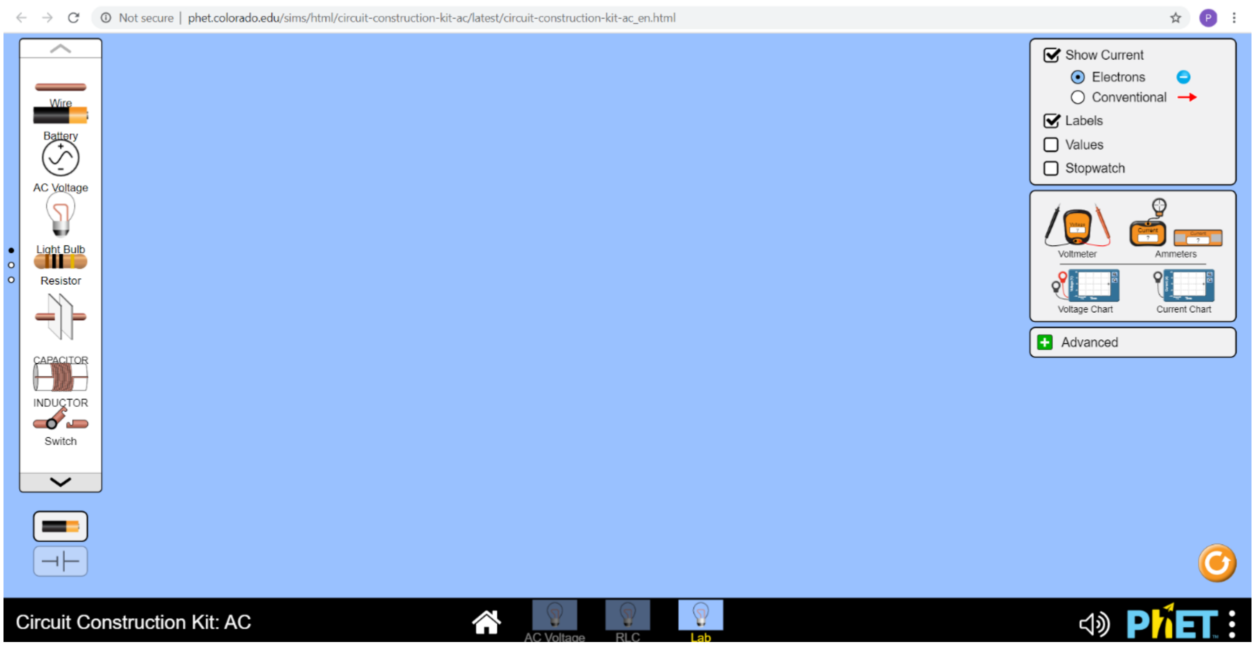
We will get to all of that.

But first, we are going to get used to using the PhET AC circuit simulation. This simulation was released by the University of Colorado folks just a few weeks ago to meet the needs of students like you during this difficult time. One of the scientific staff members of the PhET team is a bachelor's degree graduate of the FSU Physics Department who went on to earn a Ph.D. in Physics Education Research at Kansas State University. I contacted her during our last week of physical classes and asked her if PhET had any simulations that were not yet released but were ready for beta testing that they could release to us. PhET responded by releasing this sim and several others to the national education community. So when I tell you they were thinking of students like you when they decided to release this sim, I mean they were actually thinking of you in particular – Studio Physics students at FSU.

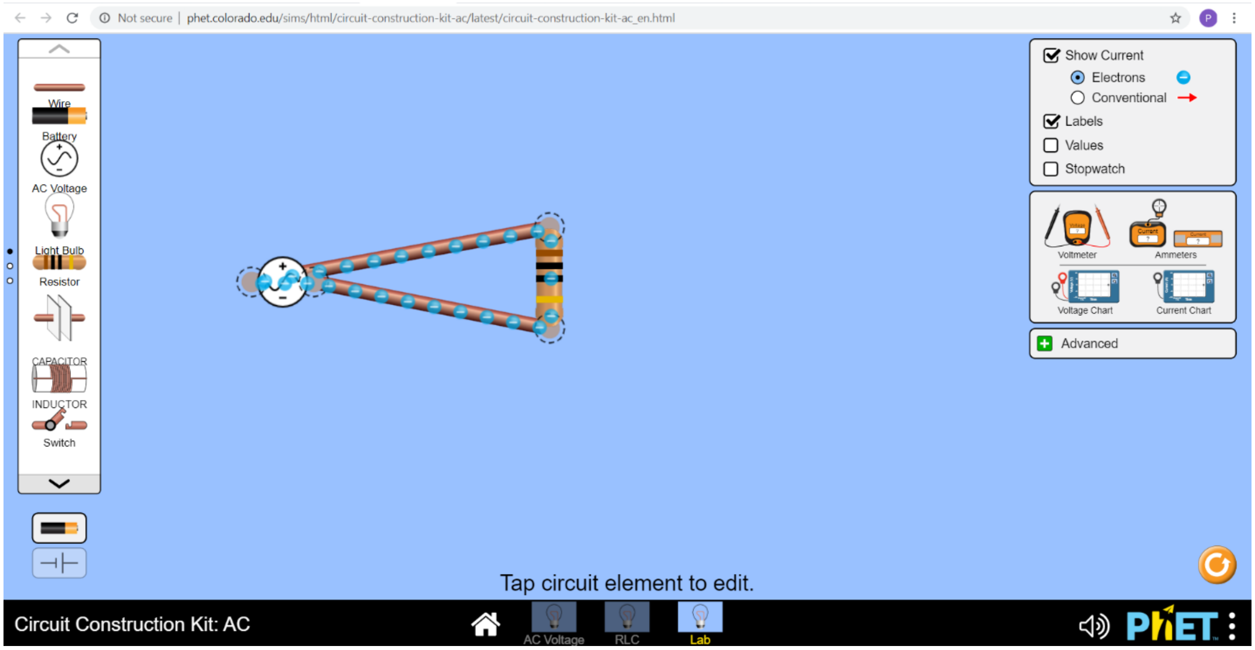
Start here:

http://phet.colorado.edu/sims/html/circuit-construction-kit-ac/latest/circuit-construction-kit-ac_en.html

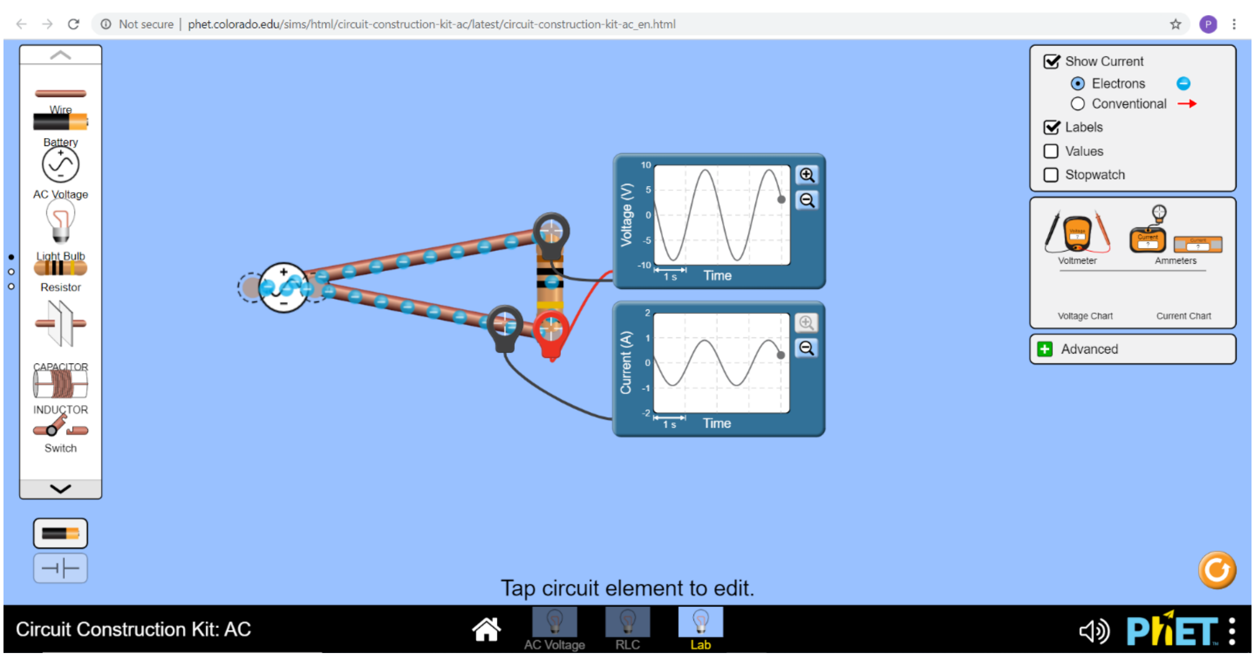
There will be a light bulb icon that says “Lab” underneath. Click on that twice to get this:




Now move an AC voltage source into the blue part of the screen by dragging it from the white component box on the left. Move a resistor out into the blue part as well, and then connect the AC source and resistor with two wires – also dragged from the white component box. When the connections are made, electrons (!) will appear in the circuit and they will wiggle back and forth.




Next set up the “Voltage Chart” and “Current Chart” to read what is going on in the circuit and to see the dependence on time. To use the voltage chart, connect the two contacts across a component. To use the current chart, just place the contact at a point in the circuit. Arrange your screen as shown below:




Notice that I have placed the voltage chart and current chart on top of each other. You can see that the voltage and current are rising and falling together, as you’d intuitively expect for a circuit with a power supply and a resistor. You can adjust the scale of the current and voltage charts with the little magnifying glasses on the right sides of the charts.  We say they are “in phase” – that is, the sinusoidal functions of the voltage and current have the same phase angle.

Now read the amplitudes of the voltage and current, and click on the resistor to see its resistance.  You might (or should) remember Ohm’s Law from January.  Is the relationship between the resistance, the amplitude of the voltage and the amplitude of the current consistent with Ohm’s Law?

You can change the resistance to see if it changes the relationship between the amplitudes of the voltage and current.

Now click on the AC source and look at the frequency setting.  Is the period of the oscillations of the voltage and current consistent with the frequency setting?

In the next lab module, we will add a capacitor to the circuit and see what happens.