1 The Basics

Kirchoff’s Laws are just expressions of the conservation of charge and energy. Kirchoff’s Junction Law (a.k.a. Kirchoff’s Current Law) states that the currents into and out of a junction must be equal.

\[ \sum I_{in} = \sum I_{out} \]

Kirchoff’s Loop Law (a.k.a. Kirchoff’s Voltage Law) states that as you go around a loop, the total of the voltage differences must equal zero.

\[ \sum_{\text{loop}} \Delta V = 0 \]

2 Application

In applying Kirchoff’s Laws, use the following steps:

2.1 Label the currents in each branch.

Draw a labeled arrow on the schematic for each branch in which there is current. Don’t worry about the direction too much, if the actual current goes opposite to the label, that current will just turn out negative.

2.2 Write Kirchoff’s Junction Laws

For each junction, write out the junction law, placing the currents on the correct side of the equation for the directions of the arrows you used.

2.3 Write Kirchoff’s Loop Laws

This is the tricky part. Write out the loop law for each small loop. Don’t bother with the large loop around the outside unless it’s particularly convenient (in which case, leave out a hard loop in the middle). As you go around each loop, remember the following:

- For a battery, going from negative to positive is \( +E \).
- For a resistor, going with the current is \(-IR\).
- For a capacitor, going from positive to negative is \(-Q/C\) (Here, the current increases the charge, so \( I = dQ/dt \)).
- For an inductor, going with the current is the \(-L dI/dT\)

2.4 Solve the equations.

There should be as many equations as unknowns. Make sure they’re not redundant, and add a different junction equation if necessary.