Class 20 More Kirchhoff’s Rule

About Kirchhoff's Rules

1. There are two Kirchhoff rules – Kirchhoff's current rule (junction rule) and Kirchhoff's voltage rule (loop rule).

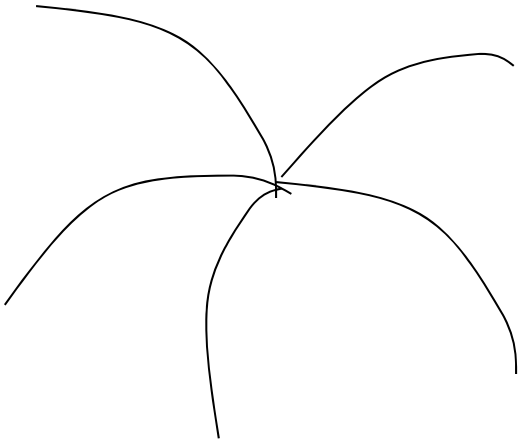
2. More complex circuits cannot be broken down into parallel and series units. The two Kirchhoff's rules allow us to solve for any circuits, no matter how complex it is (at least theoretically).

Kirchhoff's Current Rule (Junction Rule)

Kirchhoff's current rule is a result of conservation of charges:

At any junction, the sum of currents must equal zero.

$$\sum_{\text{junction}} I = 0$$



Junction formed by twisting many wires together.

Kirchhoff's Voltage Rule

Kirchhoff's voltage rule is a result of conservation of energy:

The sum of the potential differences across all elements around any closed circuit loop must be zero.

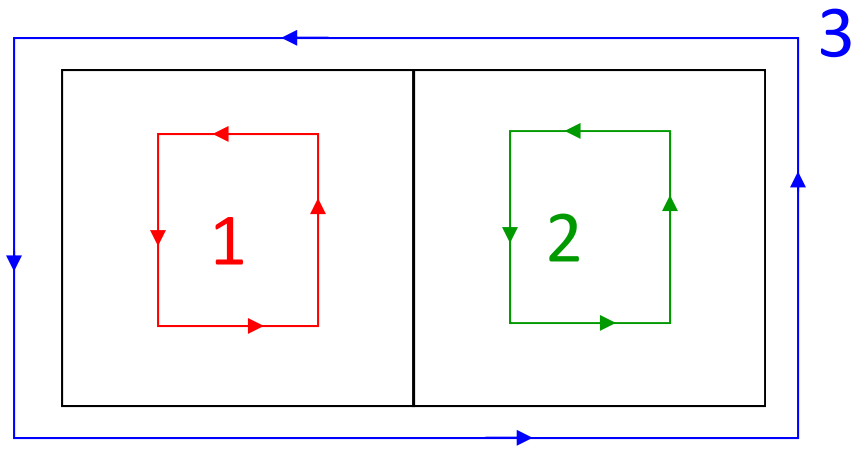
$$\sum_{\text{closed loop}} \Delta V = 0$$

Conservation of energy:
Work done by battery = Energy stored in conservative elements (e.g. capacitors) + Energy dissipated by resistive elements (e.g. resistors)

Dependence in Kirchhoff's Loop Equations

You can write down Kirchhoff's voltage equations for any closed loop you have chosen. However, the Kirchhoff's voltage equations you have written may be dependent of each other.

Example:



You can write Kirchhoff's voltage equations either for loops 1 and 2, or loops 1 and 3, or loops 2 and 3, but not 1, 2, and 3 because these three equations are dependent of each other.

Strategy in using Kirchhoff's Rules

1. Go through every junctions in the circuit. Insert current as unknown variables (unless it is given) for every branch forming the junction. You may have to assume current directions. Make use of the Kirchhoff's Current Rule and try to use as little of variables as possible.

2. Write down Kirchhoff's Voltage Rules. Choose the loops that can make the solution easier.

3. Solve the simultaneous equations for the answers.