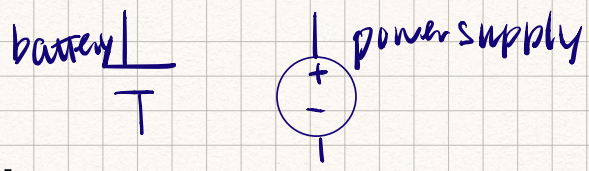
Electronics Basics

Let us start with different components to build a circuit!

Power: where it stores electrical energy to drive the circuit to run — for example, a voltage supply or a battery-

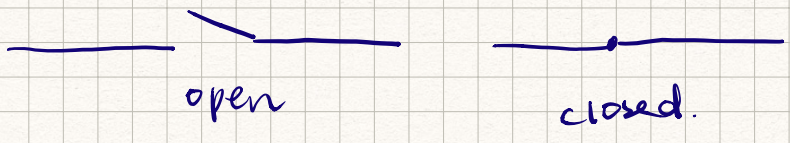


Ground: a necessary component to complete a circuit - you can think of it as somewhere the current wants to return to.

Resistor: **Unit: Ohm (Ω)**

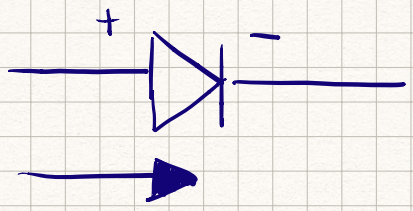
a component that provides a "resilient force" when the current is running in a circuit

Switch: a component that can switch the circuit on/off



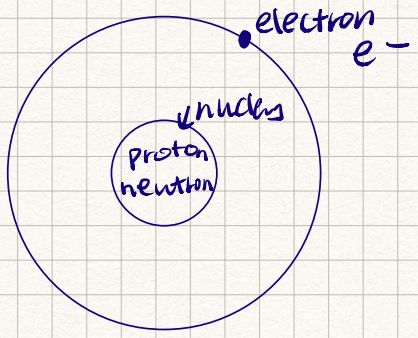
Diode: One example of a diode is LED - Light Emitting Diode that generates light

We will talk more on LED in the later discussion :)



How does a circuit work exactly? Let us start with looking into electrons!!!

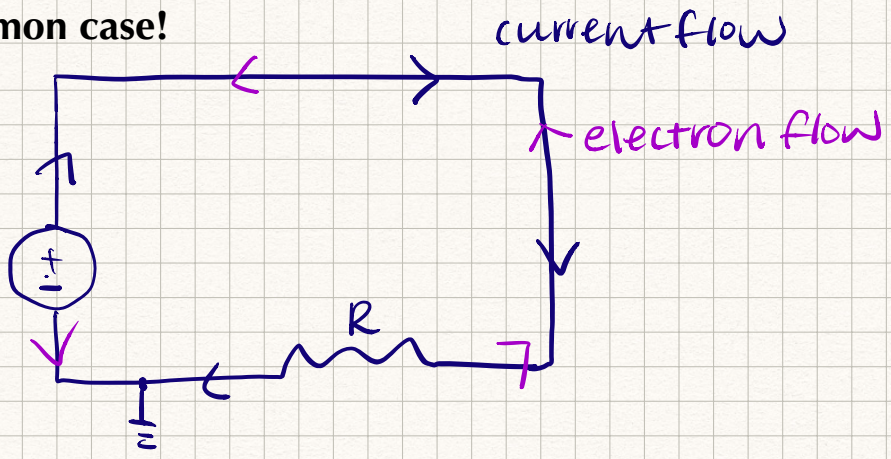
All matter is made from atoms, which consists of nucleus, a positive charged core, and electrons(negatively charge) that flow around the nucleus to neutralize the entire atom. Because electrons are moving around the outermost shell, it is relatively easier to force electrons to leave or fill the valence shell of an atom.



A circuit is simply electrons flowing in a loop to bring energies to different components to make them work ! Current is a way of us humans measuring the "flow" of electricity. Note that the direction of a current is opposite of the flow of electrons!!! Why? It's because when scientists first define current they didn't know that electron is negatively charged!

So the most basic circuit will have at least a voltage supply, a ground, and an another component that consumes energy. In the diagram

shown below a resistor acts as such component, which is also the most common case!



Ohm's Law

The current is proportional to voltage and inversely proportional to resistance

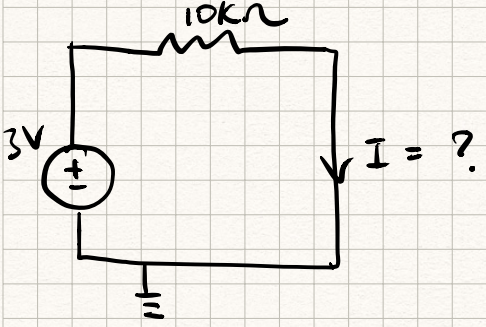
V = I x R

Volts = Amps x Ohms

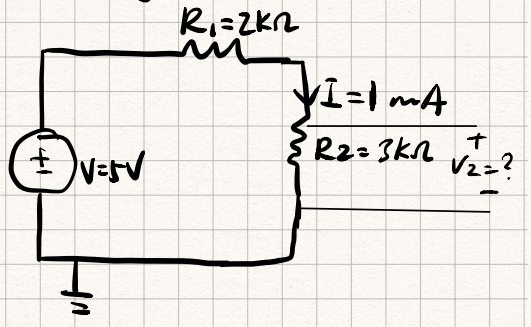
$$I = \frac{V}{R} \quad \text{or} \quad R = \frac{V}{I}$$

Practice Problems

① We know the battery is 3V, the resistance of the resitor R is 10kΩ, Find the current.



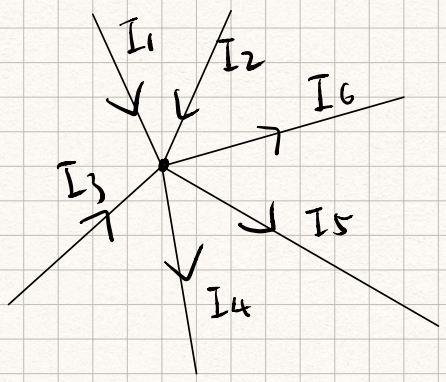
② We know the current passing R_2 is 1.00mA, R_2 = 3kΩ, Find the voltage across.



Kirchhoff's Current and Voltage Law

-Kirchhoff's Current Law (KCL)

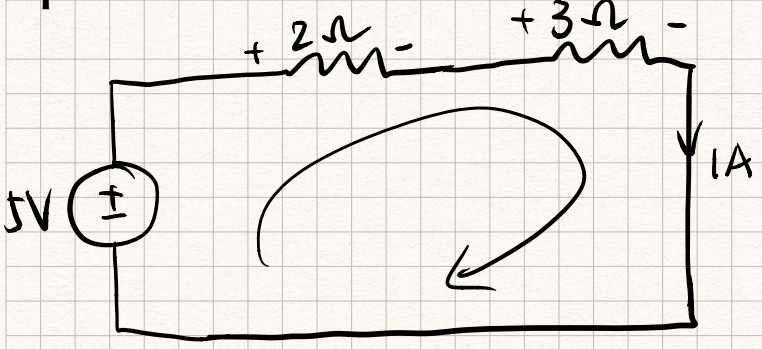
Current flowing into a node must be equal to the current flowing out of it.



$$I_1 + I_2 + I_3 = I_4 + I_5 + I_6$$

Kirchhoff's Voltage Law (KCL)

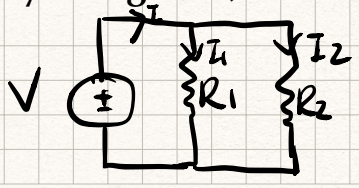
The sum of all voltages around any close loop in a circuit must equal zero.



$$-5V + 2\times1 + 3\times1 = 0$$

Using KCL & KVL:

-Parallel Circuit: in a parallel circuit the voltage across each parallel resistor is the same.(can be proven by using KVL) The total current is equal to the sum of current passing through each branch.(can be proven by using KCL)

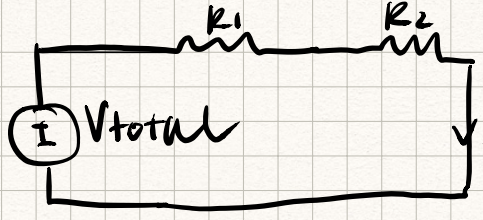


$$V_1 = V_2 = V$$

$$I = I_1 + I_2$$

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$

-Series Circuit - current going through an in series circuit is the same in anywhere in the circuit. Each resistor acts as a voltage divider - the voltage across each resistor is a portion of the total voltage depending on its resistance and other resistors in the circuit.



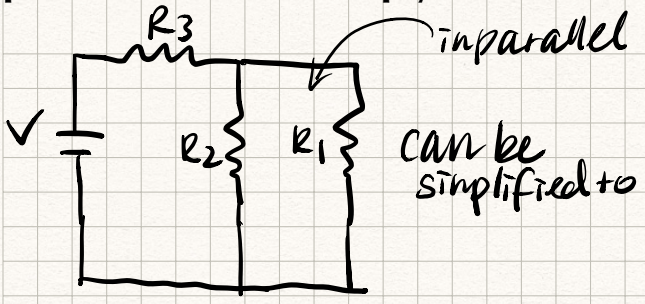
$I = I_1 = I_2$

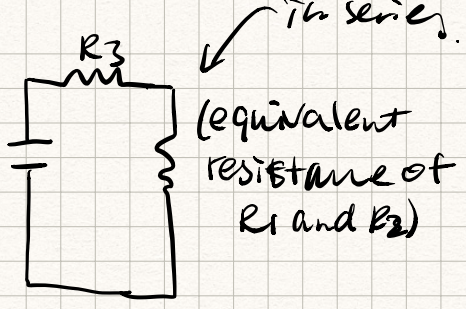
$R_{total} = R_1 + R_2$

$V_1 = \frac{R_1}{R_1+R_2} V_{total}$

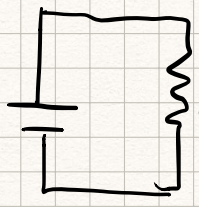
$V_2 = \frac{R_2}{R_1+R_2} V_{total}$.

Equivalence resistance: using what we have learned from series and parallel circuit to simply difficult circuit!





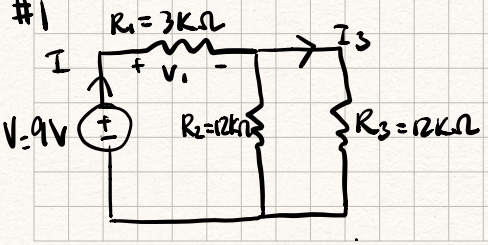
⇒ further simplified to



$R_3 + R_{equiv\,of\,R_1R_2} = R_{equiv\,of\,R_1R_2R_3}$.

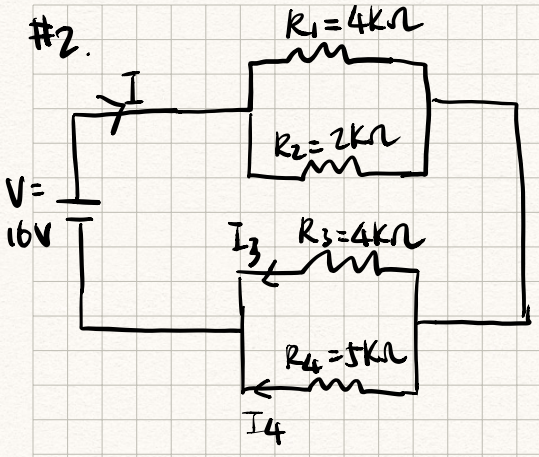
Practice Problems

#1



We know $V = 9V$,
$R_1 = 3K\Omega$, $R_2 = R_3 = 12K\Omega$
Find equivalent resistance of the circuit.
What is the value of V_1? the value of I_3?

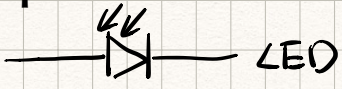
#2.



We know V = 16V,
$R_1 = R_3 = 4K\Omega$, $R_2 = 2K\Omega$, $R_4 = 5\Omega$
Find equivalent resistance of the circuit.

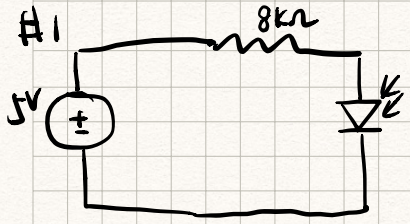
What is I ? What is the voltage across R_1 ? What is I_3 ? What is I_4 ?

LEDs- LED acts as a one-way valve - it only allows to flow from the positive end to the negative end, and it blocks the current flow from the other way. In order to activate LED, energy is required. So when the current passes through an LED, energy is used and thus the voltage is dropped. When LED lets current flow, however, the resistance of the LED is very low. In addition, LED has a fixed voltage and a current limit : if the current is higher than the current limit, LED will be burned; if a current(under the current limit of course) passes the LED, it will stay at the fixed voltage, usually it is around 3.3V for a normal LED. With those physical restrictions on a LED, if directly plugged into power, LED will be damaged since the current will be extremely large. In order to solve this problem, usually a resistor will be put into the circuit in parallel with the LED to protect the LED.

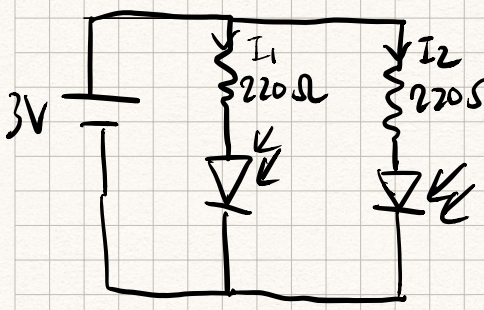


Practice Problems

#1



The circuit on the left turns a LED on. We know the fixed voltage LED has is 1.78 V. Find voltage across the resistor and current of the circuit



The circuit consists two identical LEDs with fixed voltage at 1.7 8.

Find I_1 and I_2