Kirchhoff's Rules

- Kirchhoff's Junction Rule:
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- Kirchhoff's Loop Rule:
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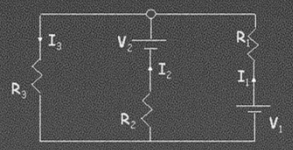
The Junction Rule

- Conceptual Basis: conservation of charge
- At any junction in a circuit, the current that enters the junction equals the current that leaves the junction.
- Example:

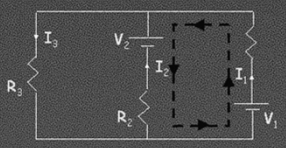
$I_1 + I_2 = I_3$



The Loop Rule

- Conceptual Basis: conservation of energy
- Going around any complete loop in a circuit, the sum total of all the potential differences is zero.
- Example:

$V_1 - I_1R_1 - V_2 + I_2R_2 = 0$



Using Kirchhoff's Rules

(1) Label all currents

(2) Write down junction equation

$I_{in} = I_{out}$

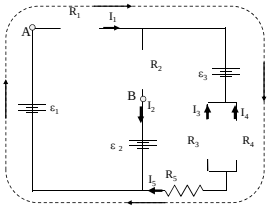
(3)Choose loop and direction

- Choose any direction
- You will need one less loop than unknown currents

(4) Write down voltage changes

Be careful about signs

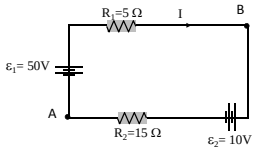
- For batteries – voltage change is positive when summing from negative to positive
- For resistors – voltage change is negative when summing in the direction of the current



Example

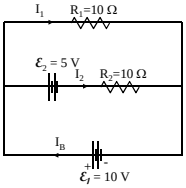
Loop Rule Practice

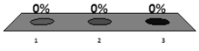
Find I:



Resistors R_1 and R_2 are

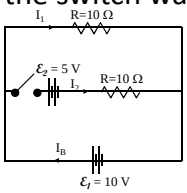
1. In parallel
2. In series
3. neither

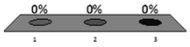




How would I_1 change if the switch was opened?

1. Increase
2. No change
3. Decrease

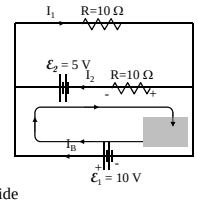




Checkpoint

How do I know the direction of I_2?

It doesn't matter. Choose whatever direction you like. Then solve the equations to find I_2. If the result is positive, then your initial guess was correct. If result is negative, then actual direction is opposite to your initial guess.



Work through checkpoint with opposite sign for I_2?

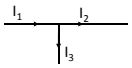
$+\mathcal{E}_1 - \mathcal{E}_2 + I_2R = 0$ Note the sign change from last slide

$\Rightarrow I_2 = -0.5A$ Answer has same magnitude as before but opposite sign. That means current goes to the left, as we found before.

Kirchhoff's Junction Rule

Current Entering = Current Leaving

$I_1 = I_2 + I_3$

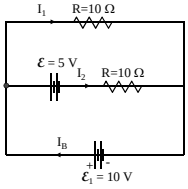


Checkpoint

1) $I_B = 0.5$ A 2) $I_B = 1.0$ A 3) $I_B = 1.5$ A

$I_B = I_1 + I_2 = 1.5$ A

"The first two can be calculated using V=IR because the voltage and resistance is given, and the current through E1 can be calculated with the help of Kirchhoff's Junction rule, that states whatever current flows into the junction must flow out. So I1 and I2 are added together."



Kirchhoff's Laws

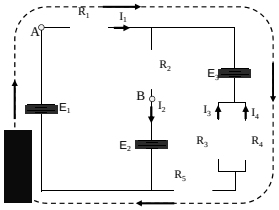
(1) Label all currents
Choose any direction

(2) Write down the junction equation
$I_{in} = I_{out}$

(3) Choose loop and direction
Your choice!

(4) Write down voltage changes
Follow any loops

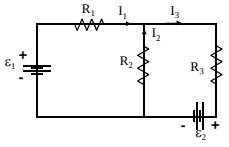
(5) Solve the equations by substitution or combination .



Example

You try it!

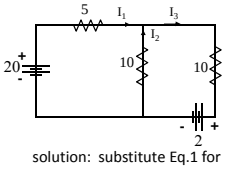
In the circuit below you are given $\mathcal{E}_1$, $\mathcal{E}_2$, R_1, R_2 and R_3. Find I_1, I_2 and I_3.



Example

Let's put in actual numbers

In the circuit below you are given $\mathcal{E}_1$, $\mathcal{E}_2$, R_1, R_2 and R_3. Find I_1, I_2 and I_3.



1. junction: $I_3 = I_1 + I_2$
2. left loop: $20 - 5I_1 + 10I_2 = 0$
3. right loop: $-2 - 10I_2 - 10I_3 = 0$

solution: substitute Eq.1 for I_3 in Eq. 3:
rearrange: $-10I_1 - 20I_2 = 2$
rearrange Eq. 2: $5I_1 - 10I_2 = 20$

Now we have 2 eq., 2 unknowns.