Kirchhoff's Rules

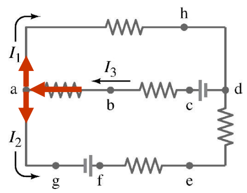
Some circuits cannot be broken down into series and parallel connections.

For these circuits we use Kirchhoff's rules.

Junction rule: The sum of currents entering a junction equals the sum of the currents leaving it.

At junction - a

$$I_3 = I_1 + I_2$$



Kirchhoff's Rules

Problem Solving: Kirchhoff's Rules

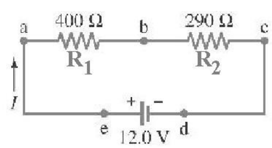
Label each current.

Identify unknowns.

Apply junction and loop rules; you will need as many independent equations as there are unknowns.

Solve the equations, being careful with signs.

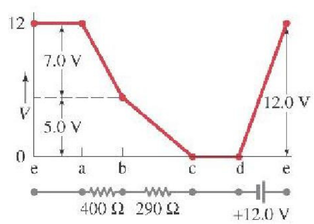
Kirchhoff's Rules



Loop rule: The sum of the changes in potential around a closed loop is zero.

$$\sum \Delta V = 0$$

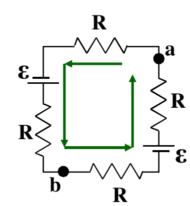
$$-IR_1 - IR_2 + \varepsilon = 0$$



Kirchhoff's Rules

Problem 19-26

For the circuit shown in diagram, find the potential difference between points a and b. Each resistor has R = 75 Ω and each battery is 1.5 V.



Kirchhoff's loop rule:

$$-IR + \varepsilon - IR - IR + \varepsilon - IR = 0$$

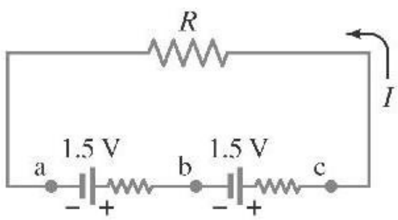
$$I = \frac{\varepsilon}{2R} = \frac{1.5\text{ V}}{2(75\ \Omega)} = 0.01\text{ A}$$

$$V_{ab} = -IR + \varepsilon - IR$$

$$V_{ab} = \varepsilon - 2IR = 1.5\text{ V} - 2(0.01\text{ A})75\ \Omega = \boxed{0}$$

EMFs in Series and in Parallel

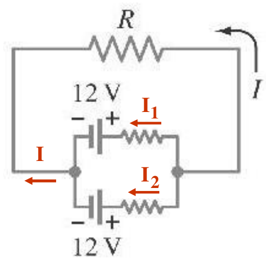
EMFs in series in the same direction: total voltage is the sum of the separate voltages



$$V_{ac} = V_{ab} + V_{bc} = 1.5\text{ V} + 1.5\text{ V} = \boxed{3.0\text{ V}}$$

EMFs in Series and in Parallel

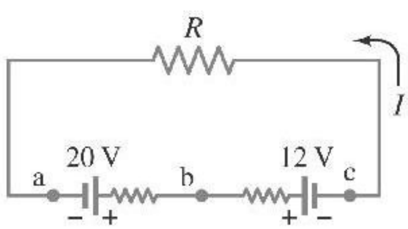
EMFs in parallel only make sense if the voltages are the same; this arrangement can produce more current than a single emf.



$$I = I_1 + I_2$$

EMFs in Series and in Parallel

EMFs in series, opposite direction: total voltage is the difference, but the lower-voltage battery is charged.



$$V_{ac} = V_{ab} + V_{bc} = 20\text{ V} + (-12\text{ V}) = \boxed{8.0\text{ V}}$$