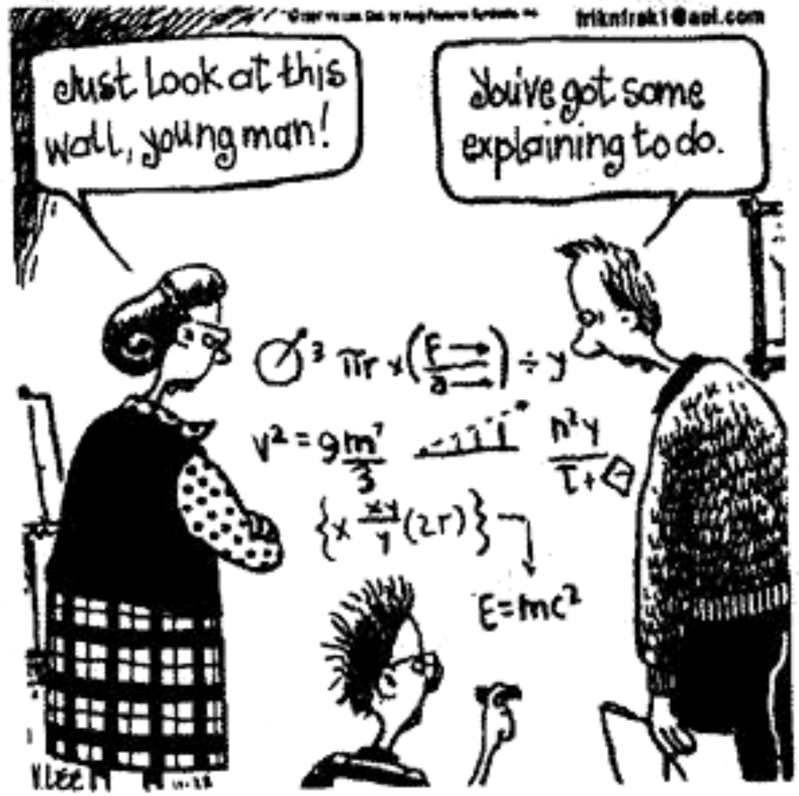
Kirchhoff's Rules

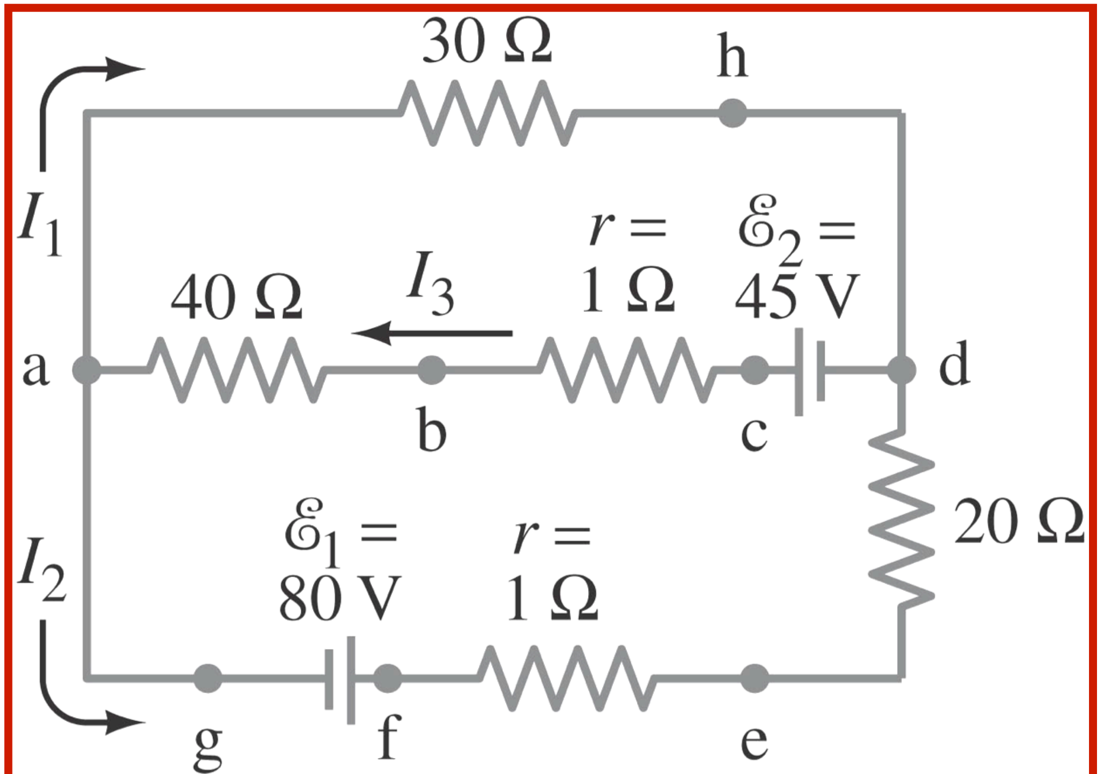
I NEED HELP By Vic Lee



Einstein as a boy.

Kirchhoff's Rules

- Some circuits cannot be broken down into series & parallel connections. For these circuits we use ***Kirchhoff's Rules***.



Kirchhoff's Rules:

Their Underlying Physics

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At a junction point, the sum of all currents entering the junction equals the sum of all currents leaving it.

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Physics: Conservation of Electric Charge.

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- **2. Kirchhoff's Loop Rule** (***Second Rule***):

The sum of the changes in Electric Potential **: V** around any closed loop in a circuit is zero.

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2. Kirchhoff's Loop Rule (*Second Rule*):

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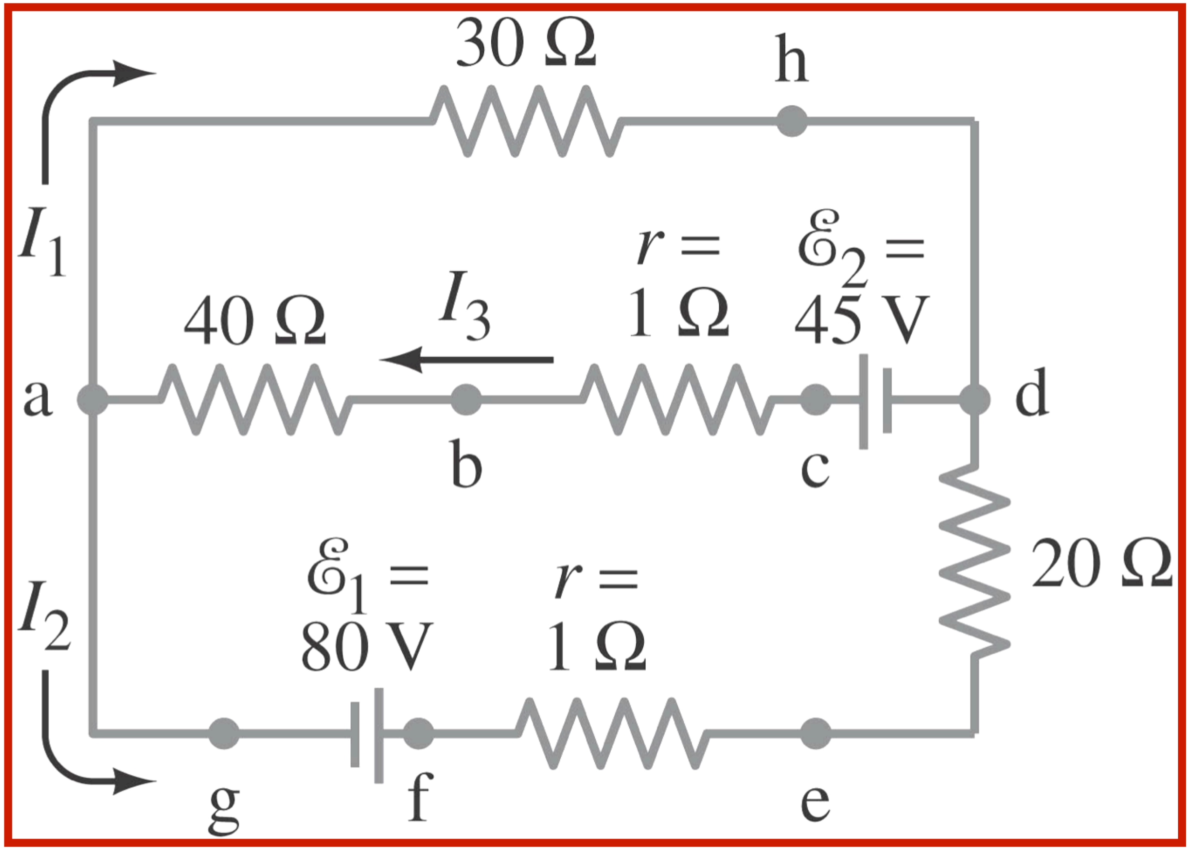
Physics: Conservation of Energy in the Circuit.

Kirchhoff's Junction Rule

- The sum of the currents entering a junction equals the sum of the currents leaving it.

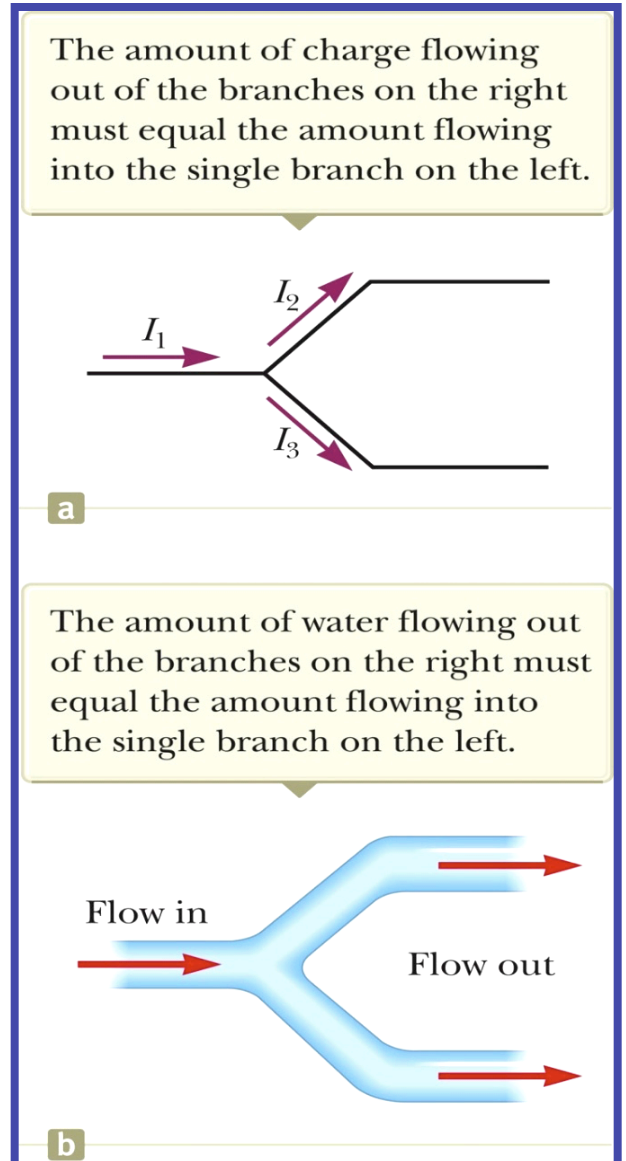


Kirchhoff's Junction Rule

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

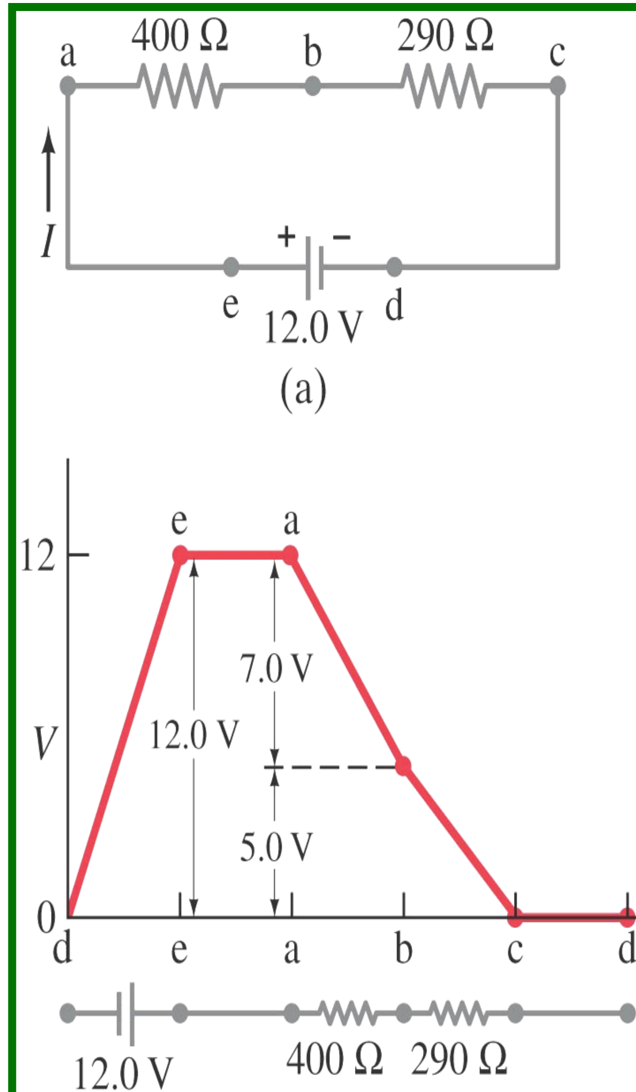
- Currents directed into the junction are entered into the equation as **+I** and those leaving as **-I.**
- This is analogous to water flowing in pipes at a junction.

See figure.



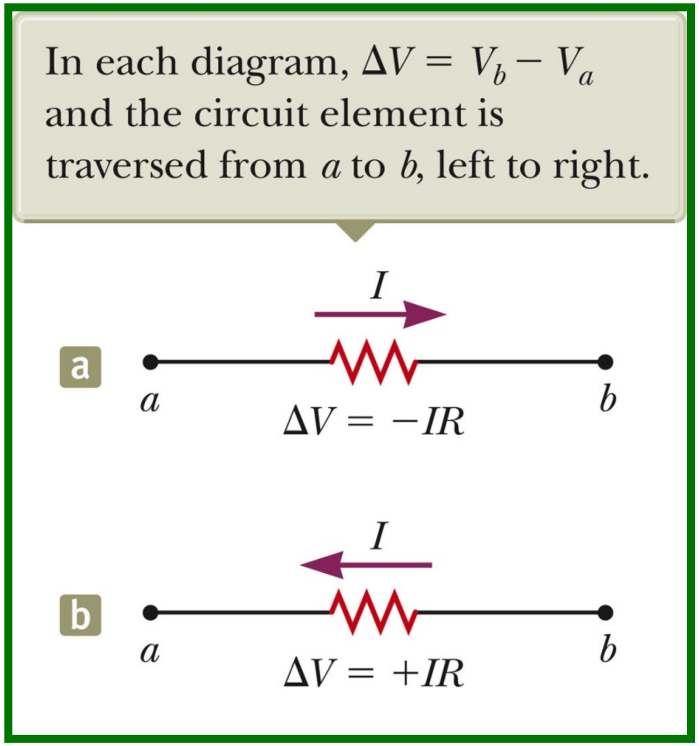
Kirchhoff' s Loop Rule

The sum of the changes in Electric Potential **ΔV** ***around any closed loop in a circuit is zero.***



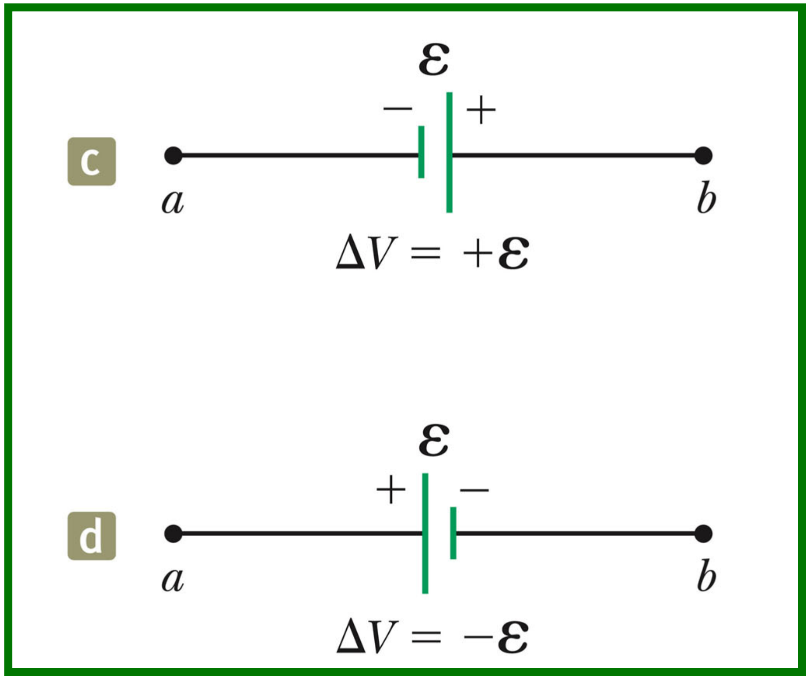
Kirchhoff's Loop Rule

- **Traveling around the loop from a to b:**
- In **(a)**, the resistor is traversed in the direction of the current, the potential across the resistor is **– IR.**
- In **(b)**, the resistor is traversed in the direction opposite of the current, the potential across the resistor is **+ IR.**



Kirchhoff's Loop Rule

- In **(c)**, the source of emf is traversed in the direction of the emf (from – to +), and the change in the potential difference is **+ε.**
- In **(d),** the source of emf is traversed in the direction opposite of the emf (from + to -), and the change in the potential difference is **-ε.**



Problem Solving: Kirchhoff's Rules

1. **Label each current**, including its direction.
2. **Identify unknowns**.
3. **Apply the Junction &Loop Rules:**

- The number of independent equations needed is equal to the number of unknowns in the problem.

4. **Solve the Equations**, with

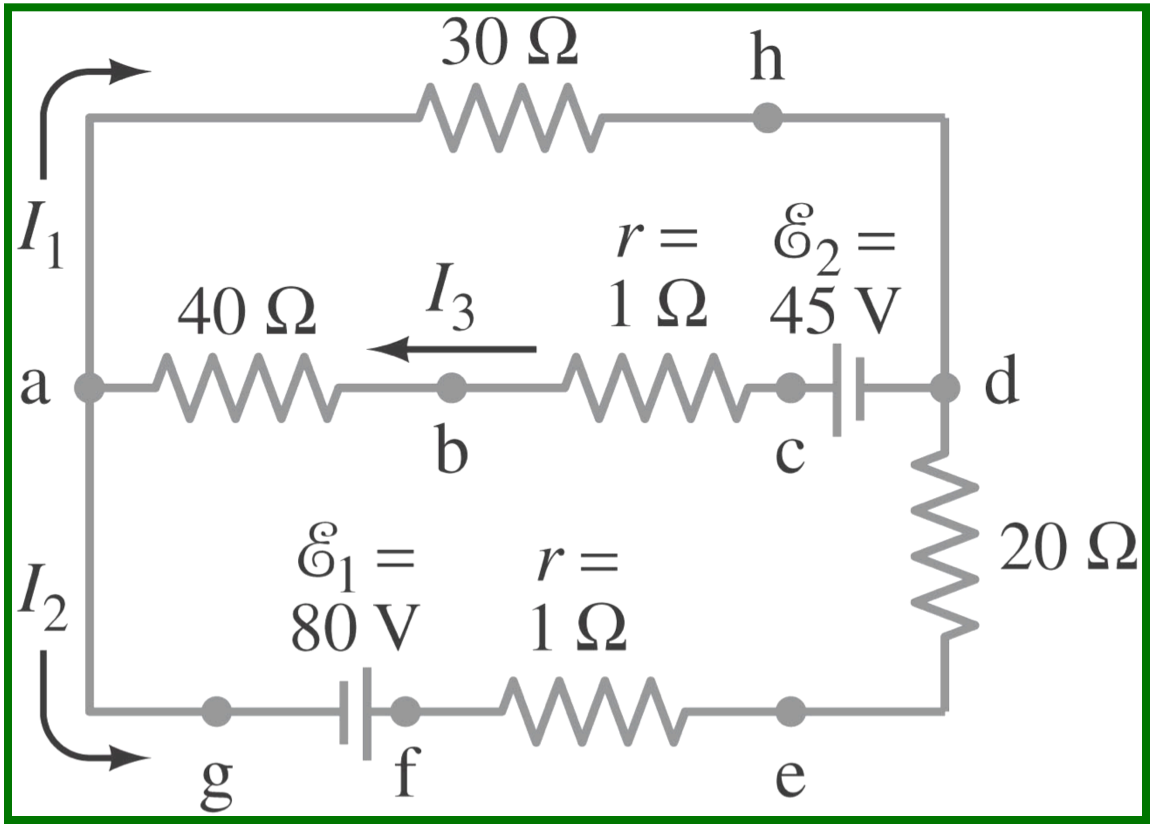
Careful Algebra!!!!

Be careful with signs!!!

- If the solution for a current is negative, that current is in the opposite direction from the one you have chosen.

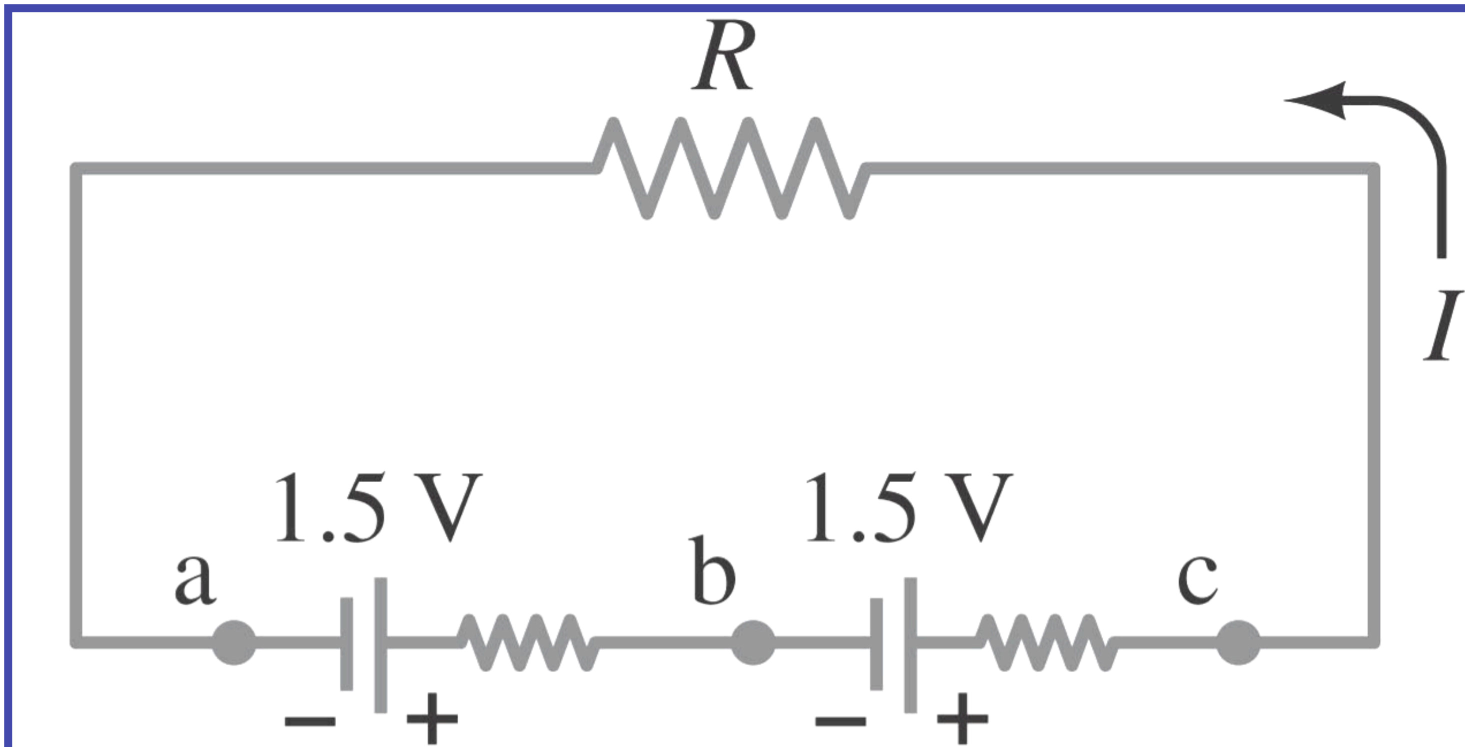
Example: Using Kirchhoff's rules.

Calculate the currents I_1, I_2, and I_3 in the three branches of the circuit in the figure.

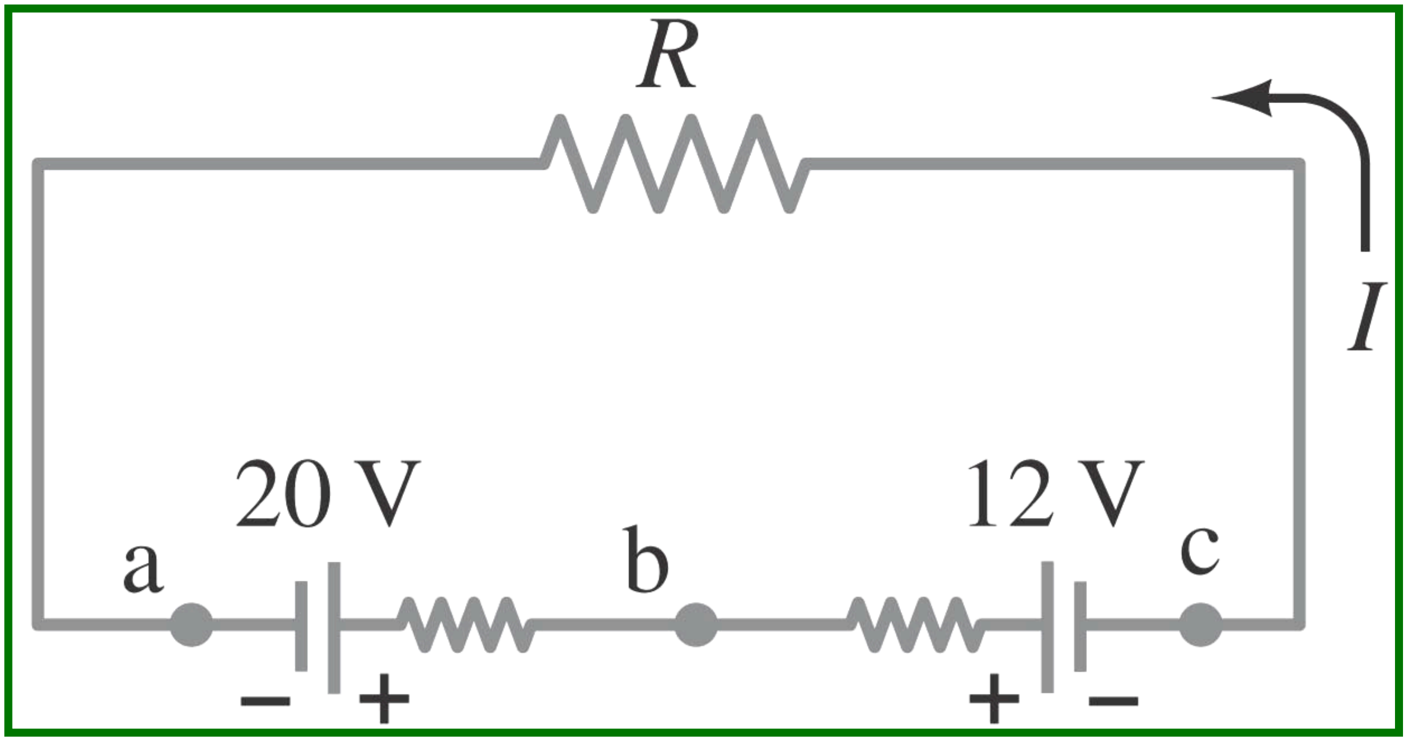


Series & Parallel EMFs; Battery Charging

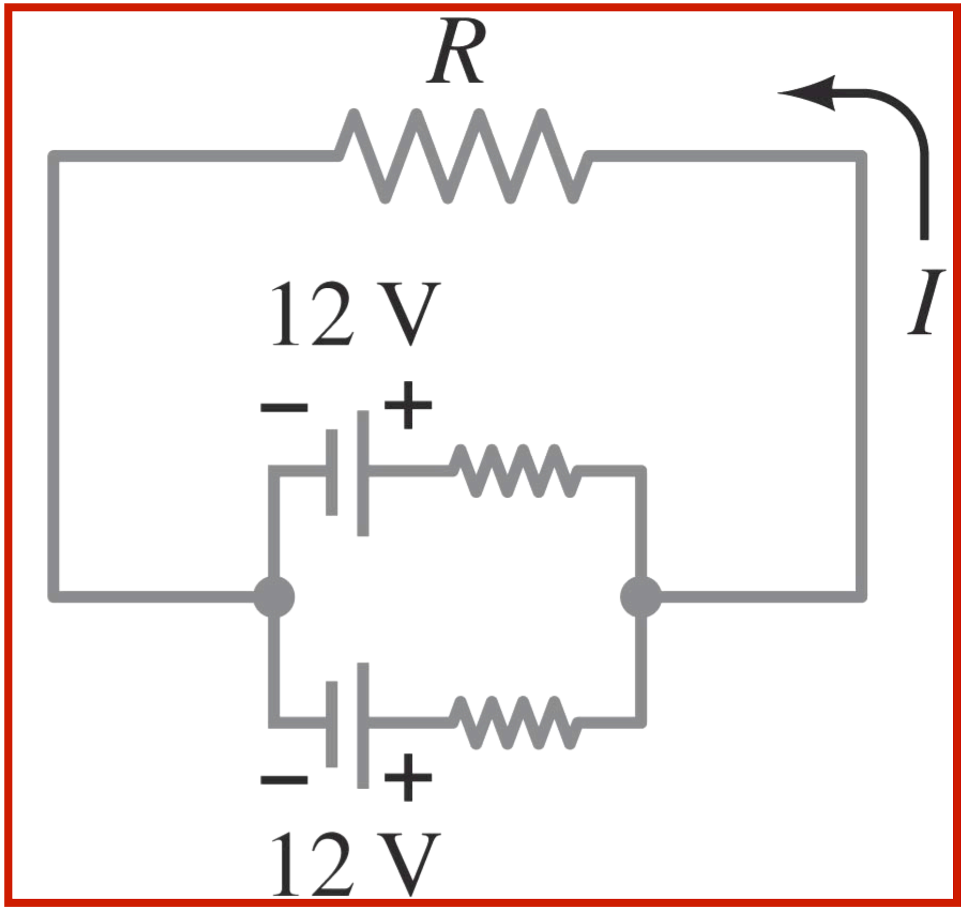
For **two or more EMFs *in series*** in the same direction, **the total voltage is the sum of the separate voltages.**



For **two EMFs** ***in series*** in the opposite direction, the total voltage is their difference. In addition, the lower-voltage battery will be charged by the higher voltage battery.



Two EMFs in *Parallel* only make sense if the voltages are the same. This arrangement can produce more current than a single emf.



Example: Jump starting a car.

A good car battery is being used to jump start a car with a weak battery. The good battery has an emf of **E_1 = 12.5 V** & internal resistance **r_1 = 0.020 Ω**. Suppose that the weak battery has an emf of **E_2 = 10.1 V** and internal resistance **r_2 = 0.10 Ω**. Each copper jumper cable is **3.0 m** long and **0.50 cm** in diameter, and can be attached as shown. Assume that the starter motor can be represented as a resistor **R_s = 0.15 Ω**. Calculate the current through the starter motor:

(a) if only the weak battery is connected to it,

(b) if the good battery is also connected.