12 DC Circuits – Resistors and Batteries

- *"Zeroth Law:"* Two points connected by an (ideal) wire are at the same potential.
- **Kirchoff's First Law (junction rule / conservation of charge):** At any junction in an electric circuit, the total current entering the junction must be equal to the total current leaving the junction,

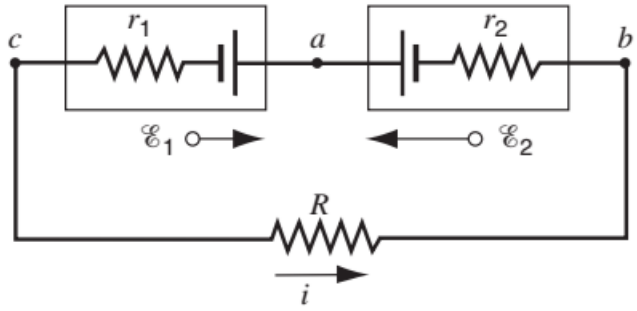
$$\sum_{junction} I_{in} = \sum_{junction} I_{out}$$

- **Kirchoff's Second Law (loop rule / conservation of energy):** The algebraic (signed) sum of all differences in potential around a complete circuit loop must be zero.

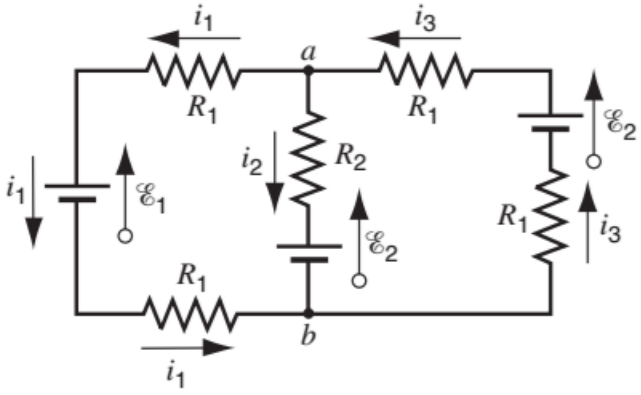
$$\sum_{loop} \Delta V = 0$$

- Resistors in series add directly: $R_{eq} = \sum_i R_i$
- Resistors in parallel add as reciprocals (conductances $G = R^{-1}$ add directly): $R_{eq}^{-1} = \sum_i R_i^{-1}$
- Ohm's law: $V = IR$, Power dissipated by a resistor: $P = IV = I^2R = V^2/R$

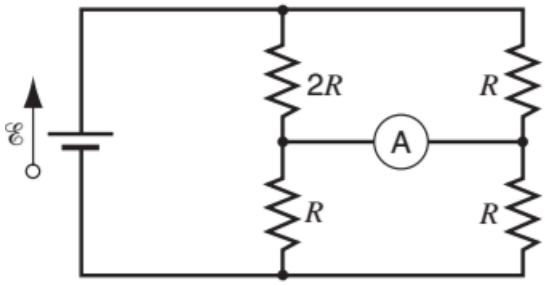
1. *(RHK Sample 31-1+2) (a)* What is the current i in the circuit shown below? (Given $\mathscr{E}_1, \mathscr{E}_2, r_1, r_2, R$) *(b)* What is the potential difference between points a and b? *(c)* What is the potential difference between points a and c? *(d)* Plot the electric potential as a function of position along the loop $a \to b \to c \to a$.



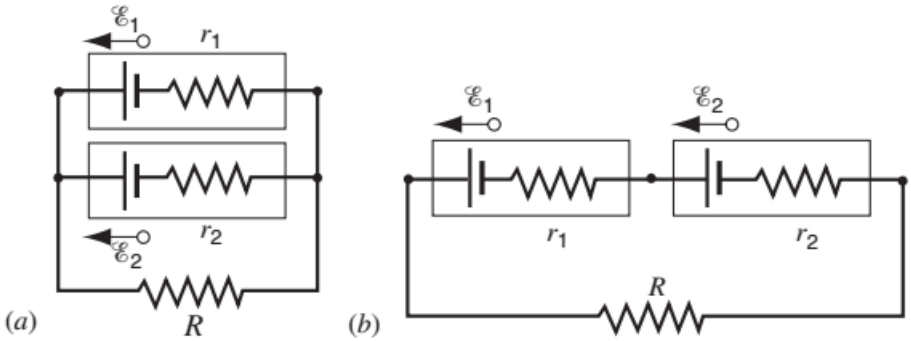
2. *(RHK Sample 31-3+4) (a)* Find the currents in the circuit below, if $\mathscr{E}_1 = 2$, $\mathscr{E}_2 = 6$, $R_1 = 2$, $R_2 = 4$. *(b)* What is the potential difference between points a and b?



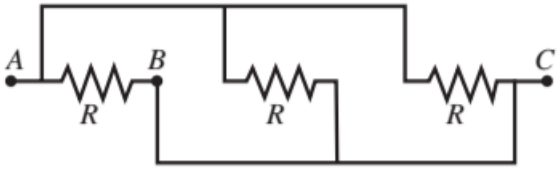
3. *(RHK Exercise 31-11)* What current, in terms of $\mathscr{E}$ and R, does the ammeter A measure in the circuit below? (Assume that A has zero resistance)



4. *(RHK Exercise 31-12)* You are given two batteries of emf values $\mathscr{E}_1$ and $\mathscr{E}_2$ and internal resistances r_1 and r_2. They may be connected either in *(a)* parallel or *(b)* series and are used to establish a current in a resistor R as shown in the diagrams below. Derive expressions for the current in R for both configurations. *(c)* If $r_1 = r_2 = r$, for what r is the power dissipated by R maximized in each configuration? *(d)* What is the maximum power dissipation in either case?

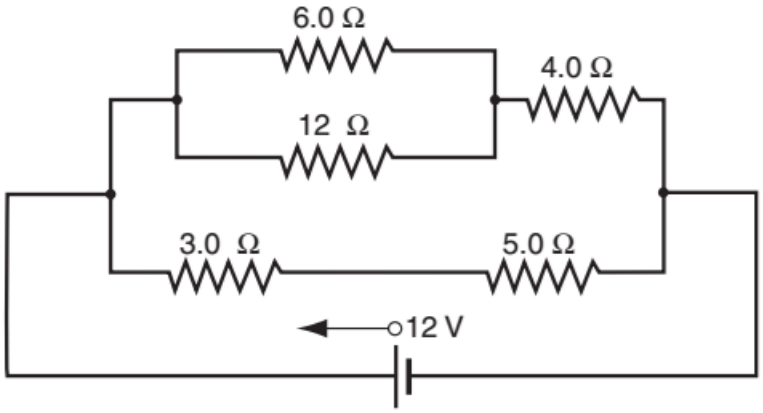


5. *(RHK Exercise 31-18)* Find the equivalent resistance between points *(a)* A and B , *(b)* B and C, *(c)* B and C.



6. *(RHK Exercise 31-20)* A 120 V power line is protected by a 15 A fuse. What is the maximum number of 500 W lamps that can be simultaneously operated in parallel on this line?

7. *(RHK Exercise 31-19)* A circuit containing five resistors connected to a 12 V battery is shown below. Find the potential difference across the 5.0 Ω resistor.



8. *(RHK Exercise 31-24)* In the circuit below, $\mathscr{E}$, R_1, and R_2 have constant values, but R can be varied. Find an expression for R that results in the maximum power dissipation in the whole circuit.