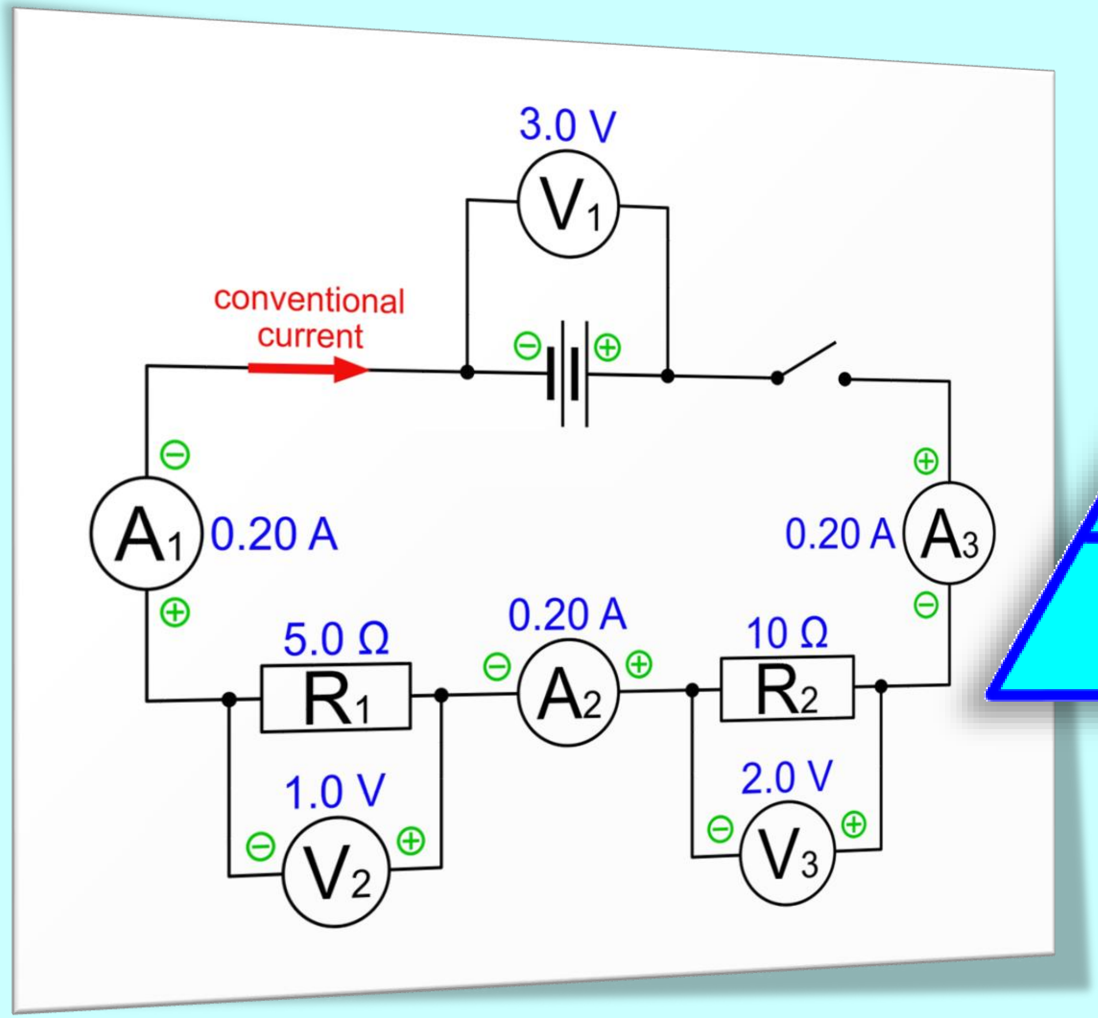
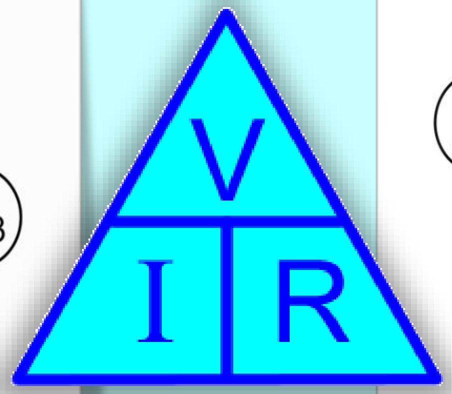
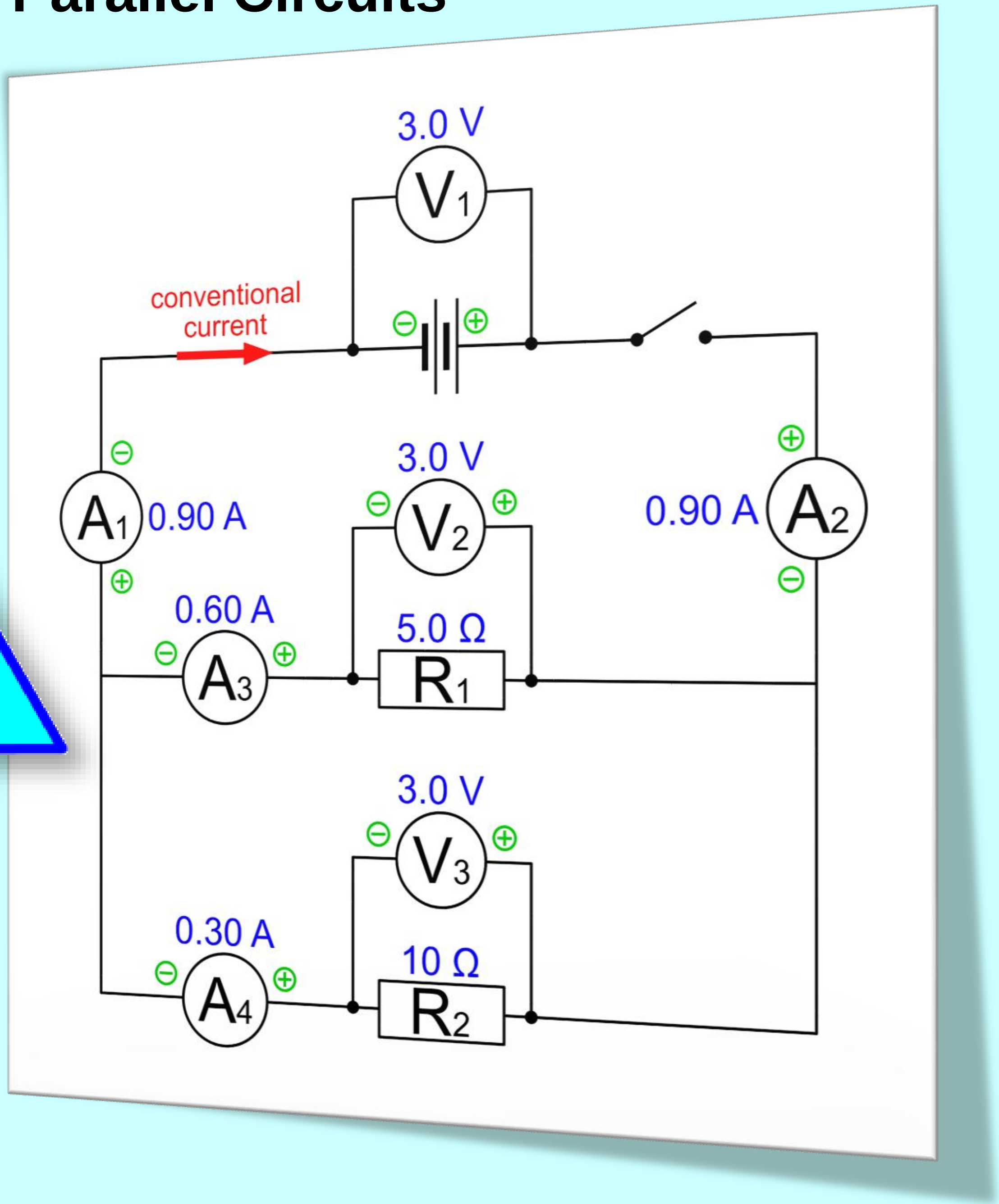
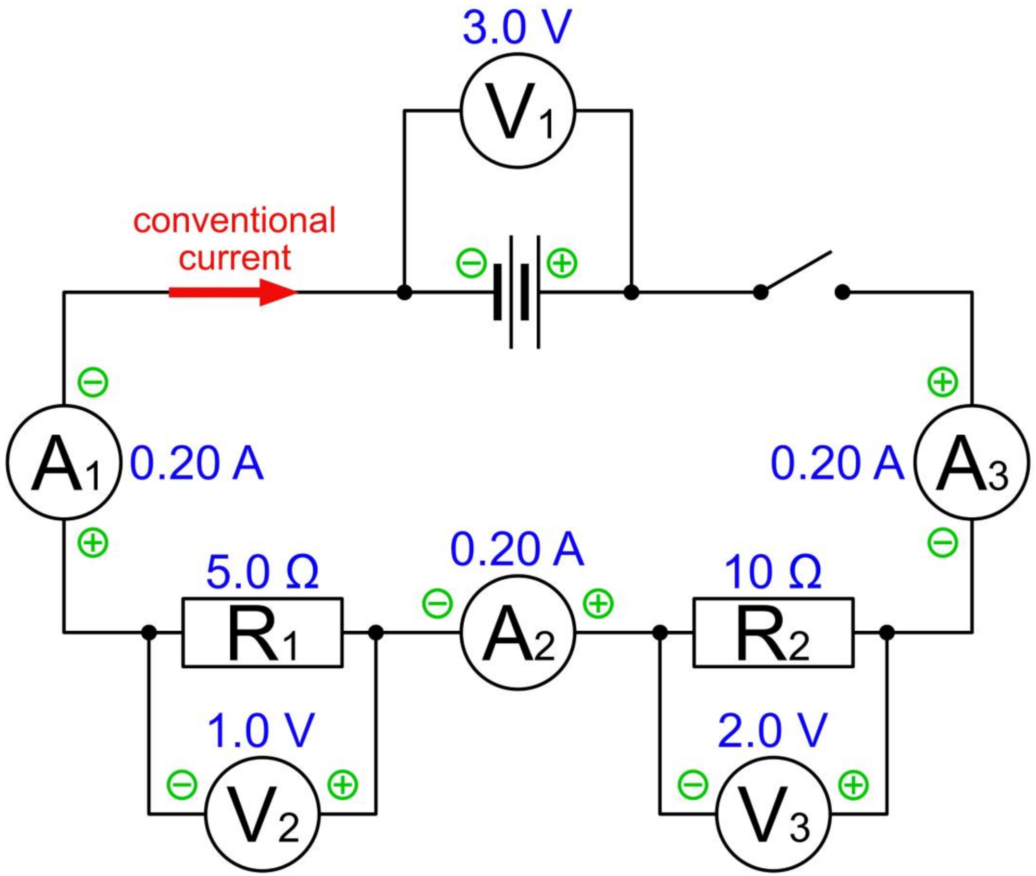
A Summary of Series and Parallel Circuits







A Summary of Series and Parallel Circuits



General Rules for a Series Circuit:

- The current is the same at all points in the circuit. *i.e.* $A_1 = A_2 = A_3$
- The sum of the potential differences (p.d.) across the resistors equals the electromotive force (e.m.f.) of the battery. *i.e.* $V_1 = V_2 + V_3$
- The effective resistance (R_e) through the circuit equals the sum of the resistors. *i.e.* $R_e = R_1 + R_2$
- If an additional resistor, R_3, is introduced in series, then the effective resistance (R_e) will *increase* ($R_e = R_1 + R_2 + R_3$) while the current through the circuit will *decrease* ($I = {}^{V}/_{R_e}$).

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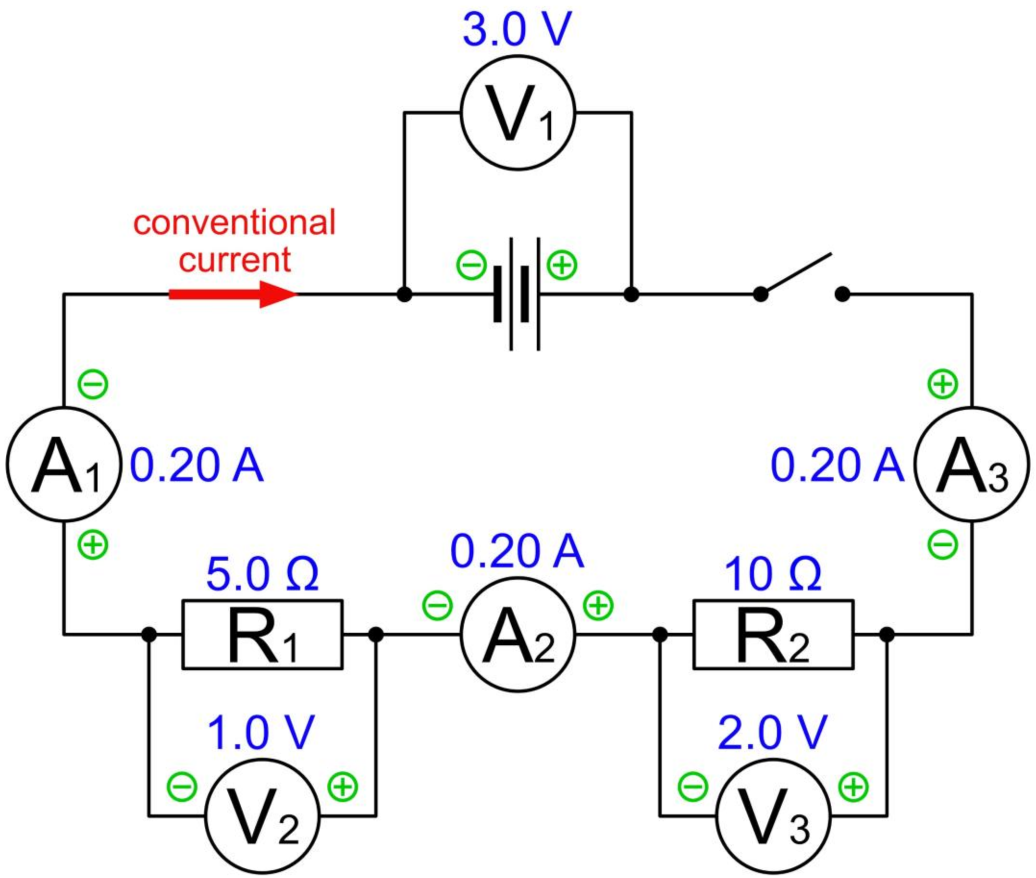

Calculations for this Circuit:

- effective resistance = $R_e = R_1 + R_2$

  $R_e = 5.0\ \Omega + 10\ \Omega = 15\ \Omega$

- current through circuit (readings on A_1, A_2 and A_3)

  $I = {}^{V}/_{R} = {}^{3.0\ V}/_{15\ \Omega} = 0.20\ A$

- potential difference across R_1 (reading on V_2)

  $V_2 = I \times R_1 = 0.20\ A \times 5.0\ \Omega = 1.0\ V$

- potential difference across R_2 (reading on V_3)

  $V_3 = I \times R_2 = 0.20\ A \times 10\ \Omega = 2.0\ V$

- Note: The sum of the potential differences across the two resistors, R_1 and R_2, equals the electromotive force of the battery.

  i.e. $1.0\ V + 2.0\ V = 3.0\ V$

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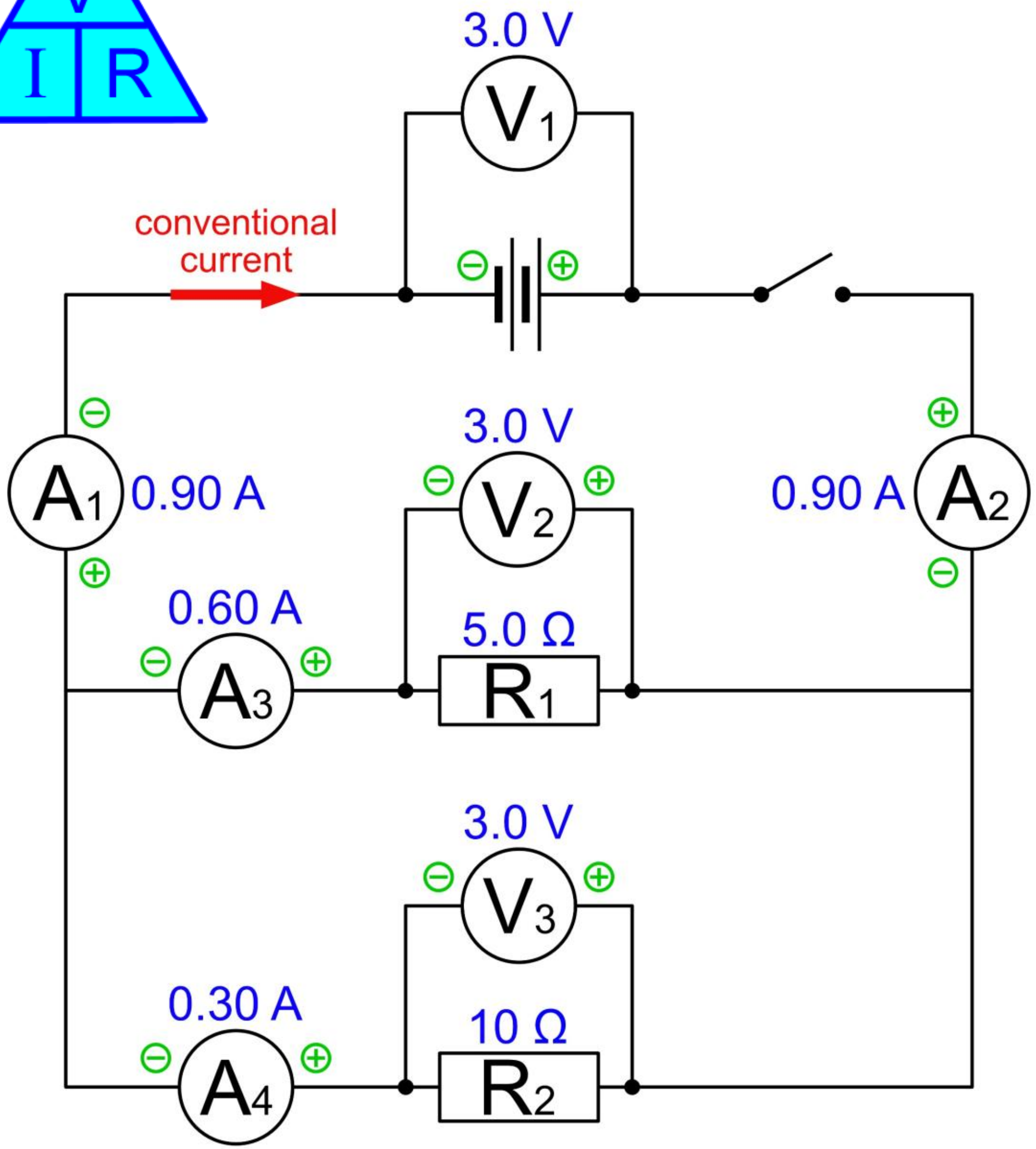

General Rules for a Parallel Circuit:

- The current divides to flow through both resistors. The current through the main circuit equals the sum of the currents through the branches of the circuit.
  i.e. $A_1 = A_2 = A_3 + A_4$

- The potential difference (p.d.) through the individual resistors is the same as the electromotive force (e.m.f.) of the battery.
  i.e. $V_1 = V_2 = V_3$

- The effective resistance (R_e) through the circuit is given by the equation: $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2}$

- If an additional resistor, R_3, is introduced in parallel, then the effective resistance (R_e) will *decrease* ($\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$) while the current through the main circuit (A_1 and A_2) will *increase* ($I = \frac{V}{R_e}$).

- Note: The effective resistance (R_e) is *smaller* than value of the *smallest resistor* in the parallel circuit.
  i.e. if $R_1 < R_2$, then $R_e < R_1$

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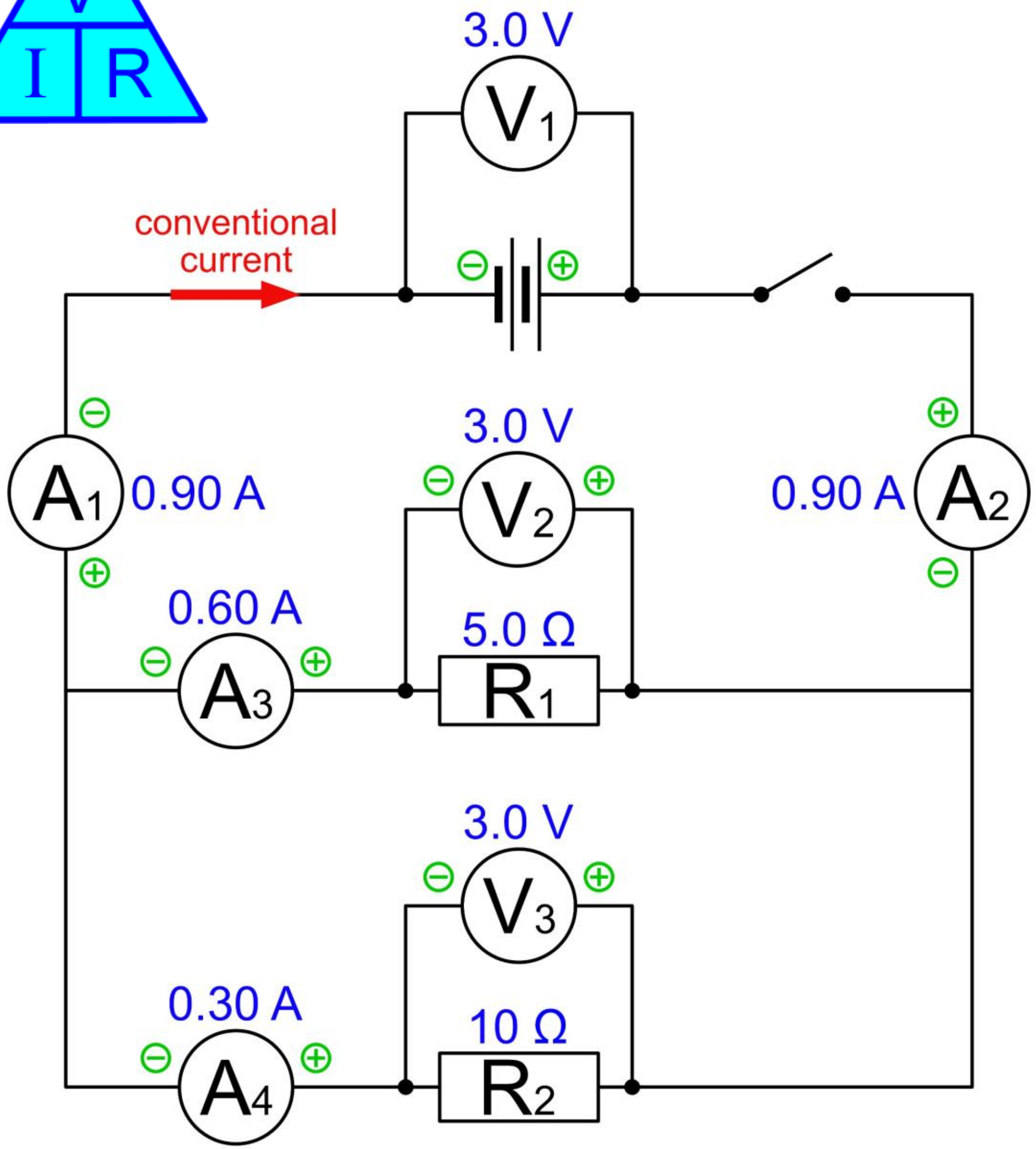

Calculations for this Circuit:

- effective resistance = $^1/_{Re} = {^1/_{R1}} + {^1/_{R2}}$

$$^1/_{Re} = {^1/_{5.0\ \Omega}} + {^1/_{10\ \Omega}}$$
$$^1/_{Re} = 0.20 + 0.10$$
$$^1/_{Re} = 0.30$$
$$R_e = {^1/_{0.30}}$$
$$R_e = 3.33\ \Omega \text{ or } 3.3\ \Omega \text{ to 2 s.f.}$$

- potential difference across R_1 (reading on V_2) and R_2 (reading on V_3)

$$V_1 = V_2 = V_3 \text{ so } V_2 = 3.0\text{ V and } V_2 = 3.0\text{ V}$$

- current through main circuit (readings on A_1 and A_2)

$$I = {^V/_R} = {^{3.0\text{ V}}/_{3.33\ \Omega}} = 0.90\text{ A}$$

- current through $A_3 = I = {^{V_2}/_{R_1}} = {^{3.0\text{ V}}/_{5.0\ \Omega}} = 0.60\text{ A}$
- current through $A_4 = I = {^{V_3}/_{R_2}} = {^{3.0\text{ V}}/_{10\ \Omega}} = 0.30\text{ A}$
- Note: $A_3 + A_4 = 0.6\text{ A} + 0.3\text{ A} = 0.90\text{ A}$

which is the current through the main circuit, A_1 & A_2

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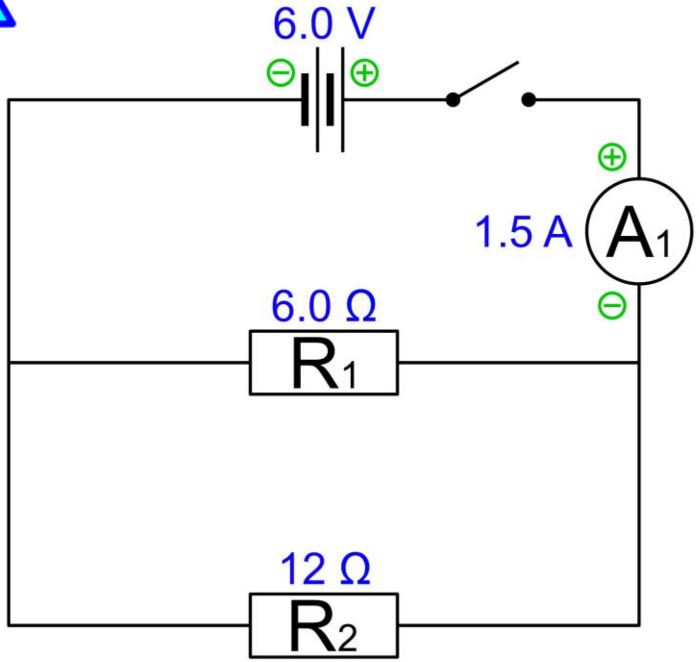
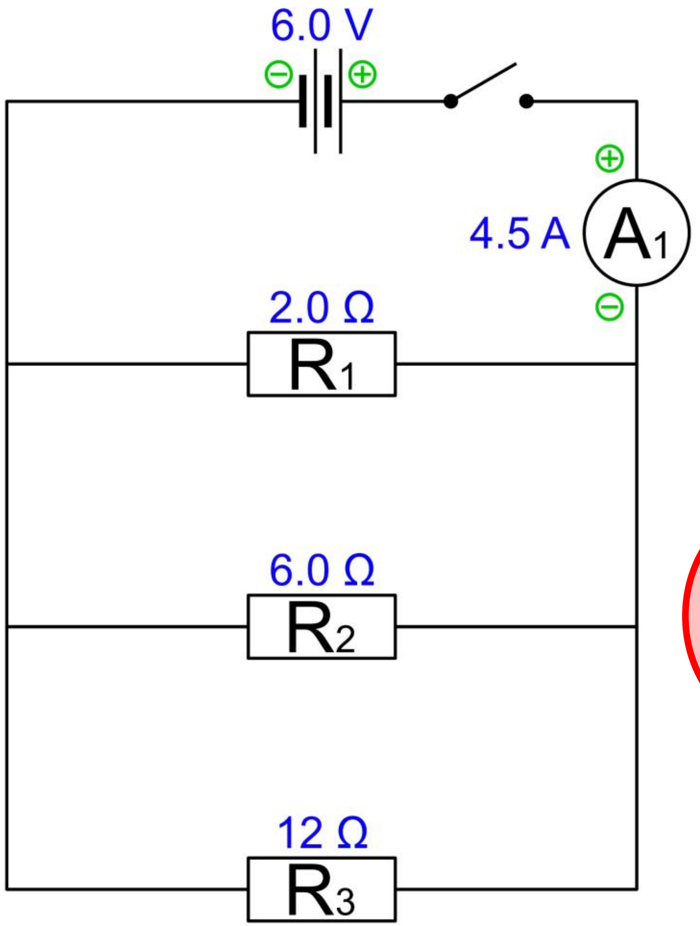
Circuit **A**



Important to Note #1:

- For a parallel circuit, the value of the effective resistance, R_e, is *always smaller* than the value of the smallest resistor.

For circuit **A**:
4.0 Ω < 6.0 Ω
For circuit **B**:
1.3 Ω < 2.0 Ω



Circuit **B**

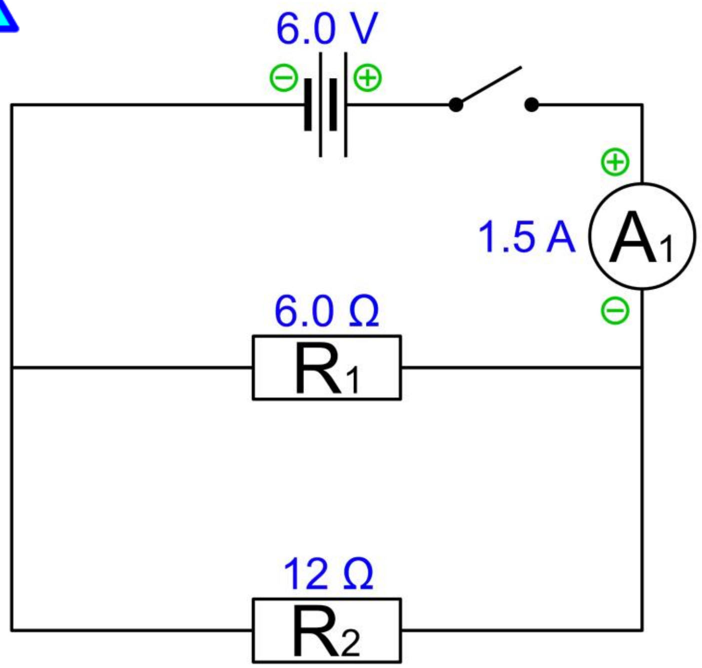
- effective resistance = $^1/_{R_e} = {}^1/_{R_1} + {}^1/_{R_2}$

$$^1/_{R_e} = {}^1/_{6.0\ \Omega} + {}^1/_{12\ \Omega}$$
$$^1/_{R_e} = 0.167 + 0.083$$
$$^1/_{R_e} = 0.25$$
$$R_e = {}^1/_{0.25}$$
$$R_e = 4.0\ \Omega \text{ to 2 s.f.}$$

- effective resistance = $^1/_{R_e} = {}^1/_{R_1} + {}^1/_{R_2} + {}^1/_{R_3}$

$$^1/_{R_e} = {}^1/_{2.0\ \Omega} + {}^1/_{6.0\ \Omega} + {}^1/_{12\ \Omega}$$
$$^1/_{R_e} = 0.50 + 0.167 + 0.083$$
$$^1/_{R_e} = 0.75$$
$$R_e = {}^1/_{0.75}$$
$$R_e = 1.33\ \Omega \text{ or } 1.3\ \Omega \text{ to 2 s.f.}$$

A Summary of Series and Parallel Circuits



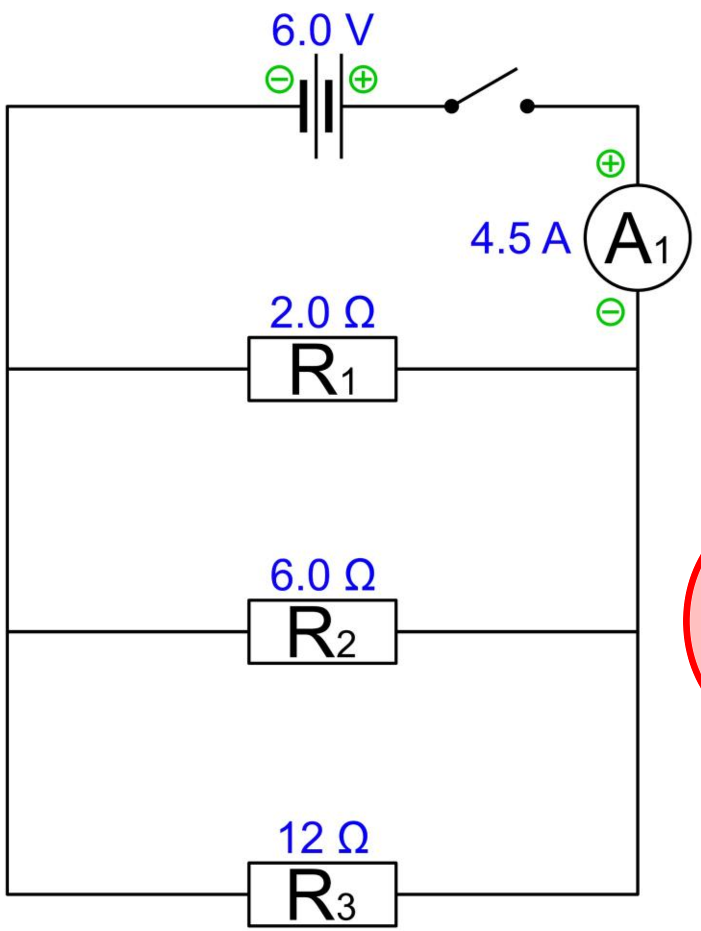
Circuit **A**

Important to Note #2:

- Introducing a new resistor in parallel will *reduce* the value of the effective resistance, R_e, of the circuit, and hence *increase* the current through the main circuit.

For circuit **A**:
$R_e = 4.0\ \Omega$
For circuit **B**:
$R_e = 1.3\ \Omega$

For circuit **A**:
Current = 1.5 A
For circuit **B**:
Current = 4.5 A



Circuit **B**

- effective resistance = $^1/_{R_e} = {}^1/_{R_1} + {}^1/_{R_2}$

$^1/_{R_e} = {}^1/_{6.0\ \Omega} + {}^1/_{12\ \Omega}$

$^1/_{R_e} = 0.167 + 0.083$

$^1/_{R_e} = 0.25$

$R_e = {}^1/_{0.25}$

$R_e = 4.0\ \Omega$ to 2 s.f.

- effective resistance = $^1/_{R_e} = {}^1/_{R_1} + {}^1/_{R_2} + {}^1/_{R_3}$

$^1/_{R_e} = {}^1/_{2.0\ \Omega} + {}^1/_{6.0\ \Omega} + {}^1/_{12\ \Omega}$

$^1/_{R_e} = 0.50 + 0.167 + 0.083$

$^1/_{R_e} = 0.75$

$R_e = {}^1/_{0.75}$

$R_e = 1.33\ \Omega$ or $1.3\ \Omega$ to 2 s.f.