

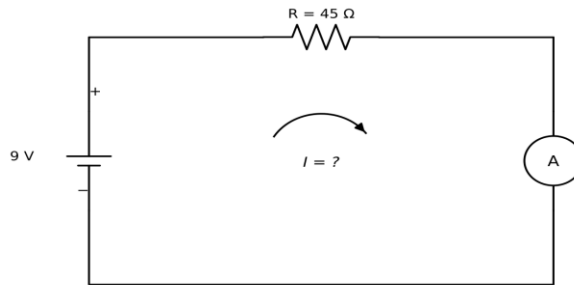
Solved Numericals – Ohm's Law, KCL & KVL

Part A: Ohm's Law (10 solved Numericals)

Ten original problems that use $V = I \times R$, from direct substitution to series and parallel networks. Every answer is worked step by step with units.

Problem A1

A 9 V battery is connected across a 45 Ω resistor as shown. Find the current drawn from the battery.



Given: $V = 9 \text{ V}$, $R = 45 \Omega$

To find: current I

Formula: $I = V / R$

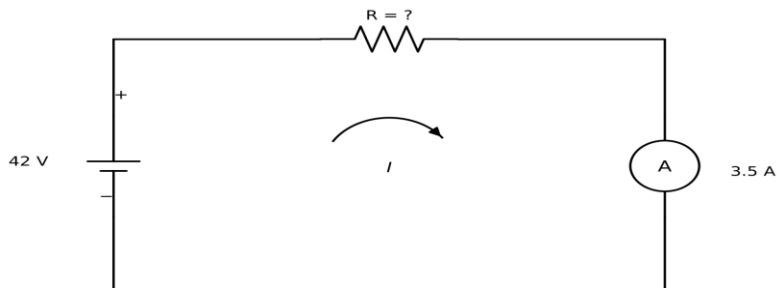
Solution:

1. Substitute the values: $I = 9 \text{ V} / 45 \Omega$
2. $I = 0.2 \text{ A}$
3. Convert to milliamperes: $0.2 \text{ A} \times 1000 = 200 \text{ mA}$

Answer: $I = 0.2 \text{ A}$ (200 mA)

Problem A2

A DC heating element is connected to a 42 V supply. The ammeter in the circuit reads 3.5 A. Find the resistance of the element.



Given: $V = 42 \text{ V}$, $I = 3.5 \text{ A}$

To find: resistance R

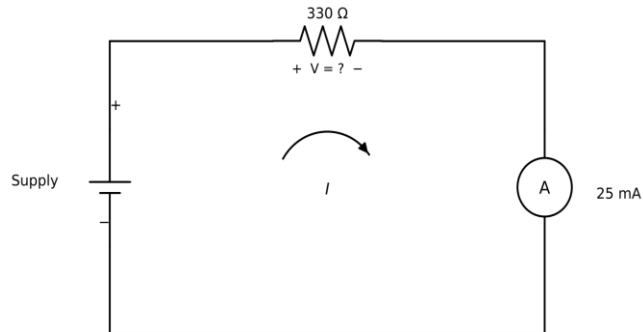
Formula: $R = V / I$

Solution:

1. Substitute the values: $R = 42 \text{ V} / 3.5 \text{ A}$
2. $R = 12 \Omega$
3. Check: $V = I \times R = 3.5 \times 12 = 42 \text{ V} \checkmark$

Answer: $R = 12 \Omega$ **Problem A3**

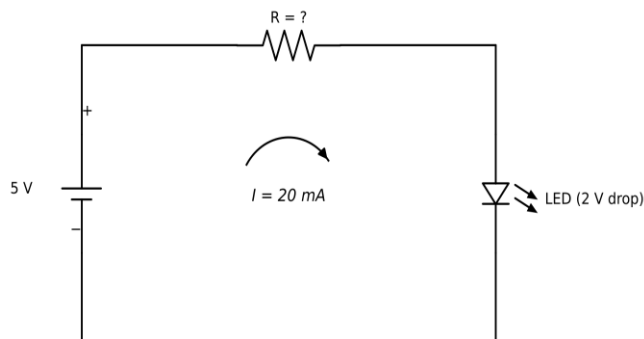
A current of 25 mA flows through a 330Ω resistor as shown. Find the voltage across the resistor.

**Given:** $I = 25 \text{ mA}$, $R = 330 \Omega$ **To find:** voltage V across the resistor**Formula:** $V = I \times R$ **Solution:**

1. Convert the current to amperes: $25 \text{ mA} = 25 \times 10^{-3} \text{ A} = 0.025 \text{ A}$
2. Substitute the values: $V = 0.025 \text{ A} \times 330 \Omega$
3. $V = 8.25 \text{ V}$

Answer: $V = 8.25 \text{ V}$ **Problem A4**

An LED needs 20 mA to glow normally and has a 2 V drop across it. It is powered from a 5 V supply through a series resistor R . Find the value of R .



Given: supply voltage = 5 V, LED voltage drop = 2 V, $I = 20 \text{ mA}$

To find: series resistance R

Formula: $R = V_R / I$, where V_R is the voltage across the resistor

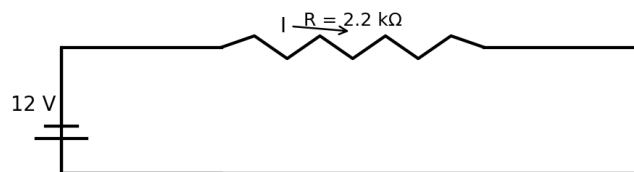
Solution:

1. The same current flows through the LED and the resistor, and the supply voltage is shared between them.
2. Voltage across the resistor: $V_R = 5 - 2 = 3 \text{ V}$
3. Convert the current: $20 \text{ mA} = 0.02 \text{ A}$
4. $R = 3 \text{ V} / 0.02 \text{ A} = 150 \Omega$

Answer: $R = 150 \Omega$

Problem A5

A $2.2 \text{ k}\Omega$ resistor is connected across a 12 V supply. Find the current through it in milliamperes.



Given: $V = 12 \text{ V}$, $R = 2.2 \text{ k}\Omega$

To find: current I in mA

Formula: $I = V / R$

Solution:

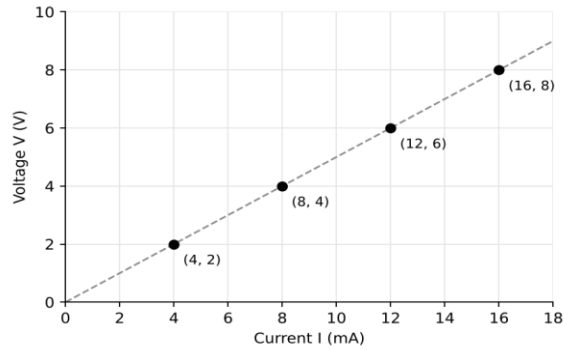
1. Convert the resistance to ohms: $2.2 \text{ k}\Omega = 2.2 \times 1000 = 2200 \Omega$
2. Substitute the values: $I = 12 \text{ V} / 2200 \Omega = 0.005454 \text{ A}$
3. Convert to milliamperes: $0.005454 \times 1000 = 5.45 \text{ mA}$

Answer: $I \approx 5.45 \text{ mA}$

Problem A6

The following voltage and current values are given for a resistor. (a) Check whether the resistor obeys Ohm's law. (b) Find its resistance. (c) Find the current when 10 V is applied.

Voltage V (V)	2	4	6	8
Current I (mA)	4	8	12	16



Given: the four (V, I) pairs above

To find: whether V/I is constant, the value of R , and I at 10 V

Formula: $R = V / I$

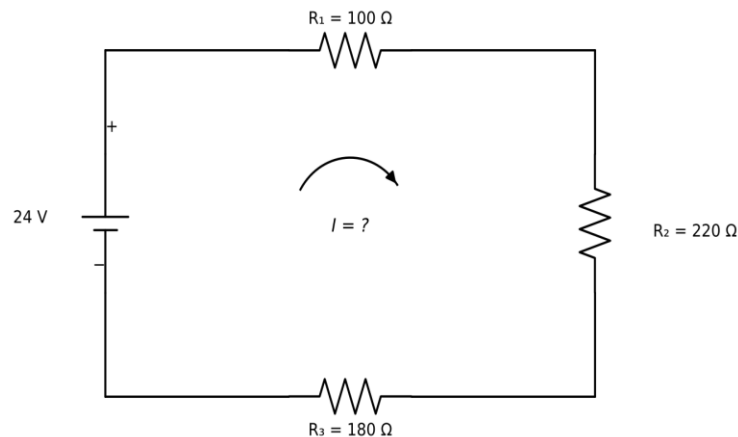
Solution:

1. Calculate V / I for each pair (current converted to amperes):
 - o $2 \text{ V} / 0.004 \text{ A} = 500 \Omega$
 - o $4 \text{ V} / 0.008 \text{ A} = 500 \Omega$
 - o $6 \text{ V} / 0.012 \text{ A} = 500 \Omega$
 - o $8 \text{ V} / 0.016 \text{ A} = 500 \Omega$
2. The ratio V / I is the same for every pair, and the graph is a straight line through the origin. So the resistor obeys Ohm's law (it is ohmic).
3. Resistance = slope of the V – I graph = $\Delta V / \Delta I = (8 - 2) \text{ V} / (16 - 4) \text{ mA} = 6 \text{ V} / 0.012 \text{ A} = 500 \Omega$
4. At 10 V: $I = V / R = 10 \text{ V} / 500 \Omega = 0.02 \text{ A} = 20 \text{ mA}$

Answer: (a) Yes, it obeys Ohm's law. (b) $R = 500 \Omega$. (c) $I = 20 \text{ mA}$

Problem A7

Three resistors $R_1 = 100 \Omega$, $R_2 = 220 \Omega$ and $R_3 = 180 \Omega$ are connected in series across a 24 V supply as shown. Find the total resistance, the circuit current and the voltage across each resistor.



Given: $V = 24 \text{ V}$, $R_1 = 100 \Omega$, $R_2 = 220 \Omega$, $R_3 = 180 \Omega$

To find: R_{total} , I , V_1 , V_2 , V_3

Formula: $R_{\text{total}} = R_1 + R_2 + R_3$, $I = V / R_{\text{total}}$, $V_n = I \times R_n$

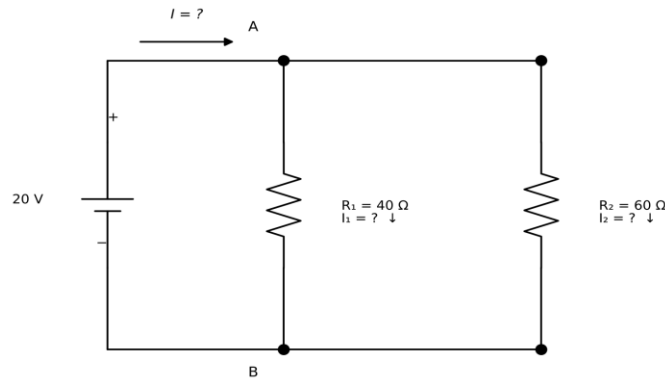
Solution:

1. $R_{\text{total}} = 100 + 220 + 180 = 500 \Omega$
2. $I = 24 \text{ V} / 500 \Omega = 0.048 \text{ A} = 48 \text{ mA}$ (the same current flows through every series resistor)
3. $V_1 = 0.048 \times 100 = 4.8 \text{ V}$
4. $V_2 = 0.048 \times 220 = 10.56 \text{ V}$
5. $V_3 = 0.048 \times 180 = 8.64 \text{ V}$
6. Check: $4.8 + 10.56 + 8.64 = 24 \text{ V} \checkmark$

Answer: $R_{\text{total}} = 500 \Omega$, $I = 48 \text{ mA}$, $V_1 = 4.8 \text{ V}$, $V_2 = 10.56 \text{ V}$, $V_3 = 8.64 \text{ V}$

Problem A8

Two resistors $R_1 = 40 \Omega$ and $R_2 = 60 \Omega$ are connected in parallel across a 20 V supply as shown. Find the current in each resistor, the total current and the equivalent resistance.



Given: $V = 20 \text{ V}$, $R_1 = 40 \Omega$, $R_2 = 60 \Omega$

To find: I_1 , I_2 , total current I , equivalent resistance R_{eq}

Formula: $I = V / R$ for each branch (the voltage across each parallel branch equals the supply voltage)

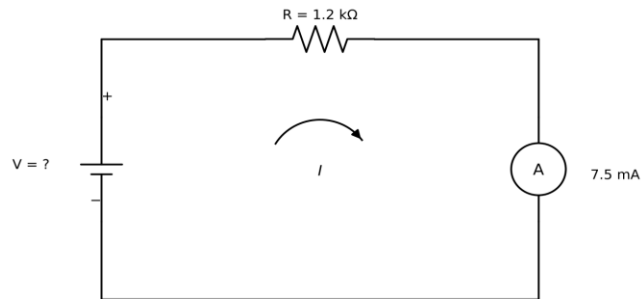
Solution:

1. $I_1 = 20 \text{ V} / 40 \Omega = 0.5 \text{ A}$
2. $I_2 = 20 \text{ V} / 60 \Omega = 0.333 \text{ A}$
3. Total current $I = I_1 + I_2 = 0.5 + 0.333 = 0.833 \text{ A}$
4. $R_{\text{eq}} = V / I = 20 \text{ V} / 0.833 \text{ A} = 24 \Omega$
5. Check: $(40 \times 60) / (40 + 60) = 2400 / 100 = 24 \Omega \checkmark$

Answer: $I_1 = 0.5 \text{ A}$, $I_2 = 0.333 \text{ A}$, $I = 0.833 \text{ A}$, $R_{\text{eq}} = 24 \Omega$

Problem A9

The ammeter in the circuit shown reads 7.5 mA when the battery is connected to a 1.2 k Ω resistor. Find the battery voltage.



Given: $I = 7.5 \text{ mA}$, $R = 1.2 \text{ k}\Omega$

To find: battery voltage V

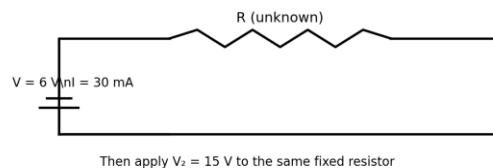
Formula: $V = I \times R$

Solution:

1. Convert the current: $7.5 \text{ mA} = 7.5 \times 10^{-3} \text{ A} = 0.0075 \text{ A}$
2. Convert the resistance: $1.2 \text{ k}\Omega = 1200 \Omega$
3. $V = 0.0075 \text{ A} \times 1200 \Omega = 9 \text{ V}$

Answer: $V = 9 \text{ V}$

Problem A10



When 6 V is applied across a fixed resistor, the current through it is 30 mA. Find (a) the resistance and (b) the current when the voltage is raised to 15 V.

Given: $V_1 = 6 \text{ V}$, $I_1 = 30 \text{ mA}$, $V_2 = 15 \text{ V}$

To find: R and I_2

Formula: $R = V / I$, then $I = V / R$

Solution:

1. Convert the current: $30 \text{ mA} = 0.03 \text{ A}$
2. $R = 6 \text{ V} / 0.03 \text{ A} = 200 \Omega$ (R stays constant because the resistor is fixed)
3. $I_2 = V_2 / R = 15 \text{ V} / 200 \Omega = 0.075 \text{ A} = 75 \text{ mA}$

4. Check using proportionality: $15 / 6 = 2.5$ times the voltage, so the current is $2.5 \times 30 \text{ mA} = 75 \text{ mA}$
✓

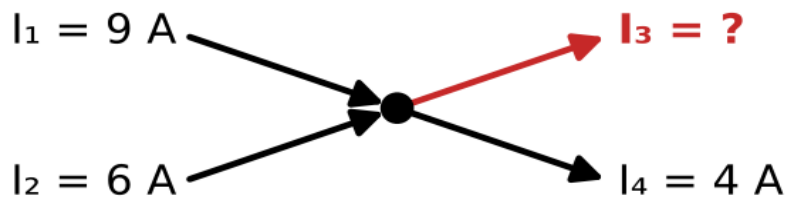
Answer: (a) $R = 200 \, \Omega$. (b) $I = 75 \text{ mA}$

Part B: Kirchhoff's Current Law (10 solved numericals)

Ten original problems that apply KCL ($\sum I = 0$ at a junction), each drawn as a junction or circuit. In every problem, currents entering the junction are taken as positive and currents leaving as negative. Unknown currents are shown in red.

Problem B1

Four wires meet at a junction as shown. Currents of 9 A and 6 A enter the junction, and 4 A leaves through one wire. Find the current I_3 in the fourth wire.



Given: $I_1 = 9 \text{ A}$ (in), $I_2 = 6 \text{ A}$ (in), $I_4 = 4 \text{ A}$ (out)

To find: I_3 (leaving)

Formula: $\sum I = 0$, so total current entering = total current leaving

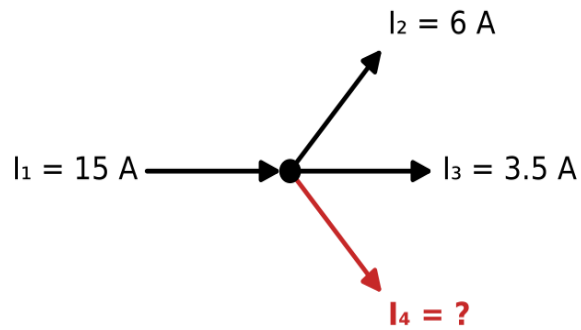
Solution:

1. Apply KCL: $I_1 + I_2 = I_3 + I_4$
2. Substitute: $9 + 6 = I_3 + 4$
3. $15 = I_3 + 4$
4. $I_3 = 15 - 4 = 11 \text{ A}$

Answer: $I_3 = 11 \text{ A}$, leaving the junction

Problem B2

A current of 15 A enters a junction and divides into three wires as shown. Two of the wires carry 6 A and 3.5 A. Find the current I_4 in the third wire.



Given: $I_1 = 15 \text{ A}$ (in), $I_2 = 6 \text{ A}$ (out), $I_3 = 3.5 \text{ A}$ (out)

To find: I_4 (leaving)

Formula: $\Sigma I = 0$

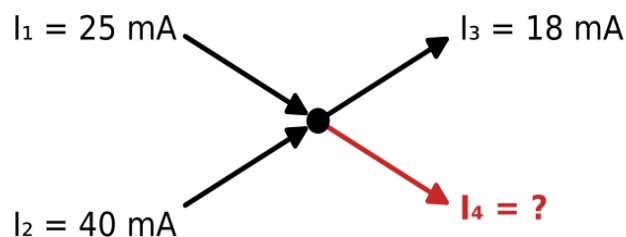
Solution:

1. Entering is positive, leaving is negative: $15 - 6 - 3.5 - I_4 = 0$
2. $5.5 - I_4 = 0$
3. $I_4 = 5.5 \text{ A}$

Answer: $I_4 = 5.5 \text{ A}$, leaving the junction

Problem B3

In an electronic circuit, currents of 25 mA and 40 mA enter a junction. One wire carries 18 mA away from the junction. Find the current I_4 in the other outgoing wire.



Given: $I_1 = 25 \text{ mA}$ (in), $I_2 = 40 \text{ mA}$ (in), $I_3 = 18 \text{ mA}$ (out)

To find: I_4 (leaving)

Formula: total current entering = total current leaving

Solution:

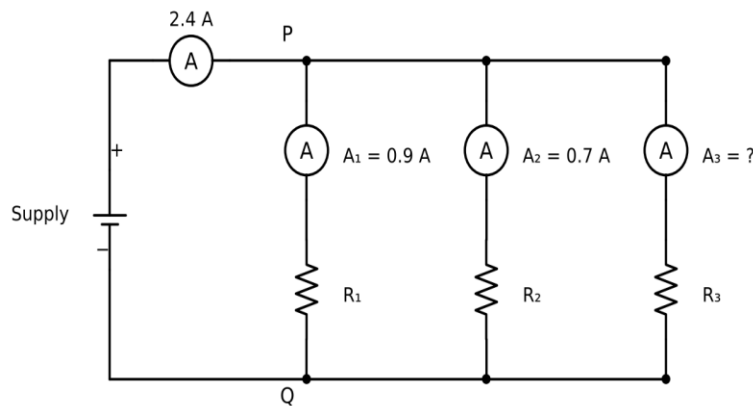
1. All currents are in the same unit (mA), so no conversion is needed.

2. Total entering: $25 + 40 = 65 \text{ mA}$
3. Total leaving: $18 + I_4$
4. Equate: $65 = 18 + I_4$, so $I_4 = 65 - 18 = 47 \text{ mA}$

Answer: $I_4 = 47 \text{ mA}$, leaving the junction

Problem B4

Three branches are connected in parallel across a supply as shown. The ammeter in the main line reads 2.4 A . The ammeters in the first two branches read 0.9 A and 0.7 A . Find the reading of ammeter A_3 in the third branch.



Given: main current = 2.4 A , $I_1 = 0.9 \text{ A}$, $I_2 = 0.7 \text{ A}$

To find: I_3

Formula: at junction P, the main current divides into the branch currents: $I = I_1 + I_2 + I_3$

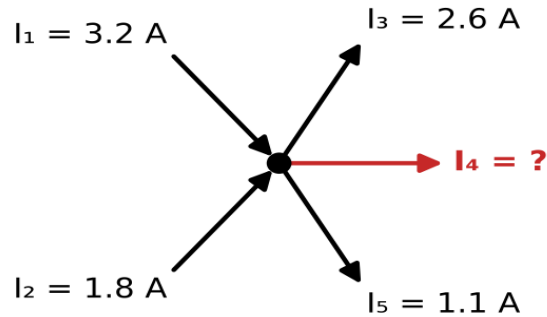
Solution:

1. Apply KCL at junction P: $2.4 = 0.9 + 0.7 + I_3$
2. $2.4 = 1.6 + I_3$
3. $I_3 = 2.4 - 1.6 = 0.8 \text{ A}$

Answer: A_3 reads 0.8 A

Problem B5

Five wires meet at a junction as shown. Currents of 3.2 A and 1.8 A flow towards the junction. Of the other three wires, two carry 2.6 A and 1.1 A away from it. Find the current I_4 and state its direction.



Given: $I_1 = 3.2 \text{ A}$ (in), $I_2 = 1.8 \text{ A}$ (in), $I_3 = 2.6 \text{ A}$ (out), $I_5 = 1.1 \text{ A}$ (out)

To find: I_4

Formula: $\sum I = 0$

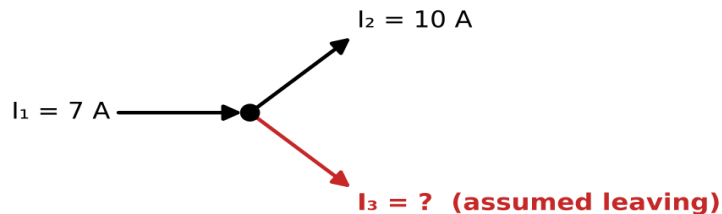
Solution:

1. Assume I_4 leaves the junction. Then: $3.2 + 1.8 - 2.6 - I_4 - 1.1 = 0$
2. $5.0 - 3.7 - I_4 = 0$
3. $I_4 = 1.3 \text{ A}$
4. The answer is positive, so the assumed direction (leaving) is correct.

Answer: $I_4 = 1.3 \text{ A}$, leaving the junction

Problem B6

At the junction shown, 7 A enters through one wire and 10 A leaves through a second wire. The direction of the current I_3 in the third wire is not known. It is assumed to leave the junction. Find I_3 and its actual direction.



Given: $I_1 = 7 \text{ A}$ (in), $I_2 = 10 \text{ A}$ (out), I_3 assumed leaving

To find: magnitude and actual direction of I_3

Formula: $\sum I = 0$ (entering +, leaving -)

Solution:

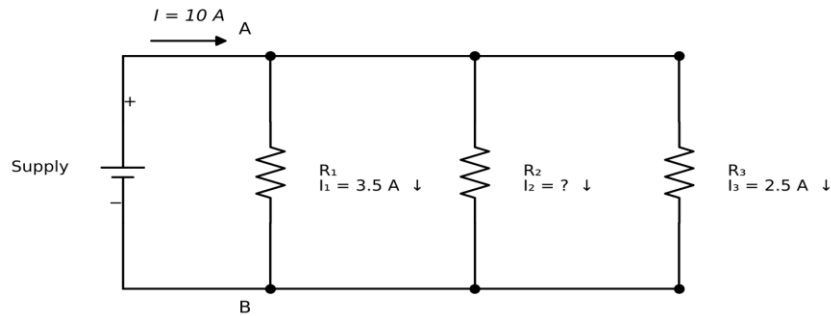
1. Write KCL with I_3 assumed to leave: $7 - 10 - I_3 = 0$
2. $-3 - I_3 = 0$, so $I_3 = -3 \text{ A}$

3. A negative sign means the current actually flows opposite to the assumed direction. So 3 A enters the junction through the third wire.
4. Check: entering = $7 + 3 = 10$ A, leaving = 10 A ✓

Answer: $I_3 = 3$ A, entering the junction (the assumed direction was wrong)

Problem B7

A 10 A supply current enters junction A of the parallel circuit shown and divides into three branches. Branches R_1 and R_3 carry 3.5 A and 2.5 A. Find the current I_2 in branch R_2 , then apply KCL at junction B to check the current returning to the supply.



Given: $I = 10$ A, $I_1 = 3.5$ A, $I_3 = 2.5$ A

To find: I_2 , and the current returning to the supply at B

Formula: KCL at each junction

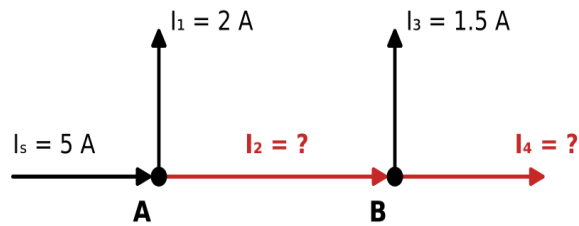
Solution:

1. At junction A (current entering = currents leaving): $I = I_1 + I_2 + I_3$
2. $10 = 3.5 + I_2 + 2.5$, so $10 = 6 + I_2$
3. $I_2 = 10 - 6 = 4$ A
4. At junction B the three branch currents enter and the supply current leaves: $I = I_1 + I_2 + I_3 = 3.5 + 4 + 2.5 = 10$ A
5. The current returning to the supply equals the current supplied, as expected.

Answer: $I_2 = 4$ A, and 10 A returns to the supply at B

Problem B8

A 5 A current enters junction A as shown. A current of 2 A leaves A through an upward wire, and the remaining current I_2 flows to junction B. At B, 1.5 A leaves through an upward wire and the rest, I_4 , continues to the right. Find I_2 and I_4 .



Given: $I_s = 5 \text{ A}$, $I_1 = 2 \text{ A}$, $I_3 = 1.5 \text{ A}$

To find: I_2 and I_4

Formula: KCL at junction A, then at junction B

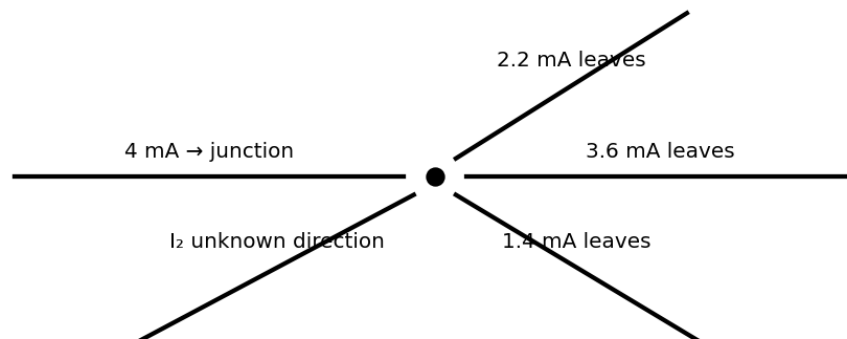
Solution:

1. At junction A: $I_s = I_1 + I_2$, so $5 = 2 + I_2$
2. $I_2 = 5 - 2 = 3 \text{ A}$
3. This I_2 is the current entering junction B. At B: $I_2 = I_3 + I_4$, so $3 = 1.5 + I_4$
4. $I_4 = 3 - 1.5 = 1.5 \text{ A}$

Answer: $I_2 = 3 \text{ A}$ and $I_4 = 1.5 \text{ A}$

Problem B9

In a signal-processing circuit, a 4 mA current enters a junction through one wire. Three other wires carry 2.2 mA, 3.6 mA and 1.4 mA away from the junction. A fifth wire carries a current I_2 that is not labelled with a direction. Find I_2 and state whether it enters or leaves.



Given: $I_1 = 4 \text{ mA}$ (in), 2.2 mA, 3.6 mA and 1.4 mA (out)

To find: I_2 and its direction

Formula: $\sum I = 0$

Solution:

1. Total current leaving: $2.2 + 3.6 + 1.4 = 7.2 \text{ mA}$

2. Current entering through I_1 : 4 mA
3. Entering is less than leaving, so the missing $7.2 - 4 = 3.2$ mA must enter through the fifth wire.
4. Check with signs, I_2 assumed entering: $4 + I_2 - 2.2 - 3.6 - 1.4 = 0$, so $I_2 = 3.2$ mA (positive, so the assumption is correct)

Answer: $I_2 = 3.2$ mA, entering the junction

Problem B10

Three resistors $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$ and $R_3 = 30\ \Omega$ are connected in parallel across a 30 V supply as shown. Find the current in each resistor and the total current drawn from the supply.

Given: $V = 30\text{ V}$, $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$, $R_3 = 30\ \Omega$

To find: I_1 , I_2 , I_3 and the supply current I

Formula: Ohm's law $I = V / R$ for each branch, then KCL: $I = I_1 + I_2 + I_3$

Solution:

1. The voltage across each parallel branch is 30 V.
2. $I_1 = 30 / 10 = 3\text{ A}$
3. $I_2 = 30 / 15 = 2\text{ A}$
4. $I_3 = 30 / 30 = 1\text{ A}$
5. Apply KCL at the top junction: $I = 3 + 2 + 1 = 6\text{ A}$
6. Check: $1 / R_{eq} = 1/10 + 1/15 + 1/30 = 6/30$, so $R_{eq} = 5\ \Omega$ and $I = 30 / 5 = 6\text{ A}$ ✓

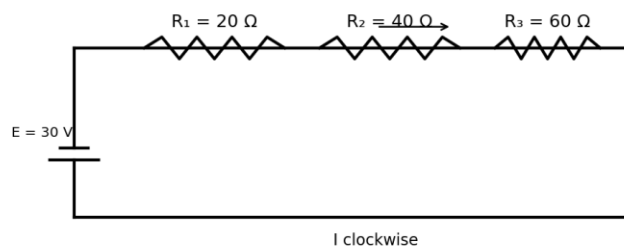
Answer: $I_1 = 3\text{ A}$, $I_2 = 2\text{ A}$, $I_3 = 1\text{ A}$, $I = 6\text{ A}$

Part C: Kirchhoff's Voltage Law (10 solved numericals)

Ten original problems that apply KVL ($\sum V = 0$ around a closed loop), each with its loop circuit. In every problem the loop is traversed clockwise, and the current I is assumed to flow clockwise. A voltage rise (moving through a source from its $-$ terminal to its $+$ terminal) is written as positive. A voltage drop (moving through a resistor in the direction of the current) is written as negative.

Problem C1

A 30 V battery is connected to three resistors in series as shown. Find the loop current and the voltage drop across each resistor, then verify KVL.



Given: $E = 30 \text{ V}$, $R_1 = 20 \Omega$, $R_2 = 40 \Omega$, $R_3 = 60 \Omega$

To find: I , V_1 , V_2 , V_3

Formula: KVL: $E - IR_1 - IR_2 - IR_3 = 0$

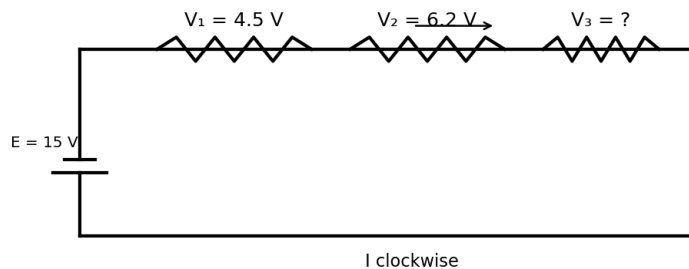
Solution:

1. Write KVL for the loop: $30 - 20I - 40I - 60I = 0$
2. $30 - 120I = 0$
3. $I = 30 / 120 = 0.25 \text{ A}$
4. $V_1 = 0.25 \times 20 = 5 \text{ V}$
5. $V_2 = 0.25 \times 40 = 10 \text{ V}$
6. $V_3 = 0.25 \times 60 = 15 \text{ V}$
7. Verify: $30 - 5 - 10 - 15 = 0 \checkmark$

Answer: $I = 0.25 \text{ A}$, $V_1 = 5 \text{ V}$, $V_2 = 10 \text{ V}$, $V_3 = 15 \text{ V}$

Problem C2

Three loads are connected in series across a 15 V source as shown. The voltage drops across the first two loads are 4.5 V and 6.2 V. Find the voltage V_3 across the third load.



Given: $E = 15 \text{ V}$, $V_1 = 4.5 \text{ V}$, $V_2 = 6.2 \text{ V}$

To find: V_3

Formula: $E = V_1 + V_2 + V_3$, i.e. $E - V_1 - V_2 - V_3 = 0$

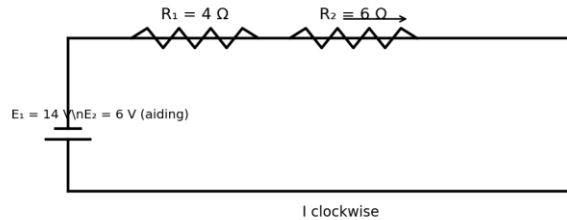
Solution:

1. Write KVL: $15 - 4.5 - 6.2 - V_3 = 0$
2. $15 - 10.7 - V_3 = 0$
3. $V_3 = 4.3 \text{ V}$
4. Verify: $4.5 + 6.2 + 4.3 = 15 \text{ V} \checkmark$

Answer: $V_3 = 4.3 \text{ V}$

Problem C3

Two batteries $E_1 = 14\text{ V}$ and $E_2 = 6\text{ V}$ are connected so that they both drive current in the same direction (aiding), with $R_1 = 4\ \Omega$ and $R_2 = 6\ \Omega$ in the loop as shown. Find the current and the voltage across each resistor.



Given: $E_1 = 14\text{ V}$, $E_2 = 6\text{ V}$ (aiding), $R_1 = 4\ \Omega$, $R_2 = 6\ \Omega$

To find: I , V_1 , V_2

Formula: $\Sigma E - I(R_1 + R_2) = 0$

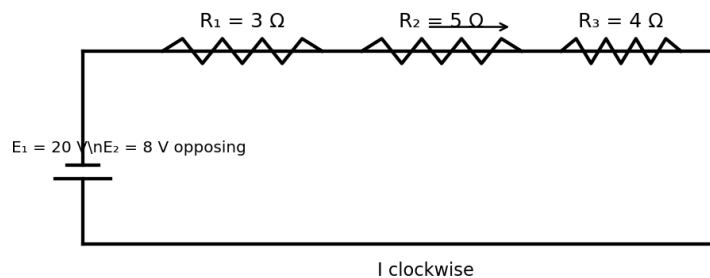
Solution:

1. Both sources are voltage rises in the clockwise direction: $14 + 6 - 4I - 6I = 0$
2. $20 - 10I = 0$
3. $I = 20 / 10 = 2\text{ A}$
4. $V_1 = 2 \times 4 = 8\text{ V}$ and $V_2 = 2 \times 6 = 12\text{ V}$
5. Verify: $8 + 12 = 20\text{ V} = 14 + 6\ \checkmark$

Answer: $I = 2\text{ A}$ (clockwise), $V_1 = 8\text{ V}$, $V_2 = 12\text{ V}$

Problem C4

In the circuit shown, battery $E_2 = 8\text{ V}$ opposes battery $E_1 = 20\text{ V}$. The resistors are $R_1 = 3\ \Omega$, $R_2 = 5\ \Omega$ and $R_3 = 4\ \Omega$. Find the current and its direction, and the voltage across each resistor.



Given: $E_1 = 20\text{ V}$, $E_2 = 8\text{ V}$ (opposing), $R_1 = 3\ \Omega$, $R_2 = 5\ \Omega$, $R_3 = 4\ \Omega$

To find: I , its direction, V_1 , V_2 , V_3

Formula: $(E_1 - E_2) - I(R_1 + R_2 + R_3) = 0$

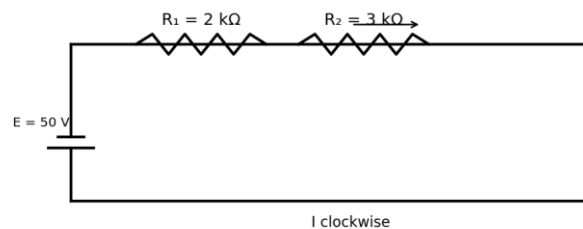
Solution:

1. E_1 is a rise in the clockwise direction. E_2 is oriented against the clockwise direction, so it is a drop of 8 V.
2. Write KVL: $20 - 8 - 3I - 5I - 4I = 0$
3. $12 - 12I = 0$, so $I = 1$ A
4. The answer is positive, so the current flows clockwise (the larger source, E_1 , decides the direction).
5. $V_1 = 1 \times 3 = 3$ V, $V_2 = 1 \times 5 = 5$ V, $V_3 = 1 \times 4 = 4$ V
6. Verify: $3 + 5 + 4 = 12$ V = $20 - 8$ ✓

Answer: $I = 1$ A (clockwise), $V_1 = 3$ V, $V_2 = 5$ V, $V_3 = 4$ V

Problem C5

A 50 V supply drives a series circuit of $R_1 = 2$ k Ω and $R_2 = 3$ k Ω as shown. Find the current in mA and the voltage across each resistor.



Given: $E = 50$ V, $R_1 = 2$ k Ω , $R_2 = 3$ k Ω

To find: I (in mA), V_1 , V_2

Formula: $E - IR_1 - IR_2 = 0$

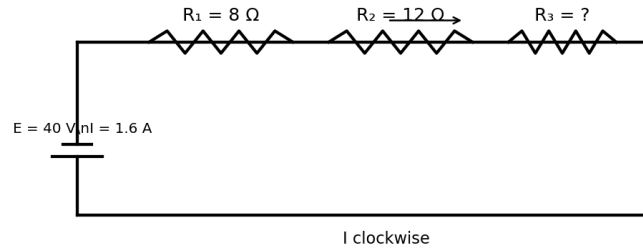
Solution:

1. Convert to ohms: $R_1 = 2000$ Ω , $R_2 = 3000$ Ω
2. Write KVL: $50 - 2000I - 3000I = 0$, so $50 = 5000I$
3. $I = 50 / 5000 = 0.01$ A = 10 mA
4. $V_1 = 0.01 \times 2000 = 20$ V
5. $V_2 = 0.01 \times 3000 = 30$ V
6. Verify: $50 - 20 - 30 = 0$ ✓

Answer: $I = 10$ mA, $V_1 = 20$ V, $V_2 = 30$ V

Problem C6

A 40 V battery drives a current of 1.6 A through the series circuit shown. $R_1 = 8$ Ω and $R_2 = 12$ Ω are known. Find the unknown resistor R_3 .



Given: $E = 40 \text{ V}$, $I = 1.6 \text{ A}$, $R_1 = 8 \Omega$, $R_2 = 12 \Omega$

To find: R_3

Formula: $E - IR_1 - IR_2 - IR_3 = 0$

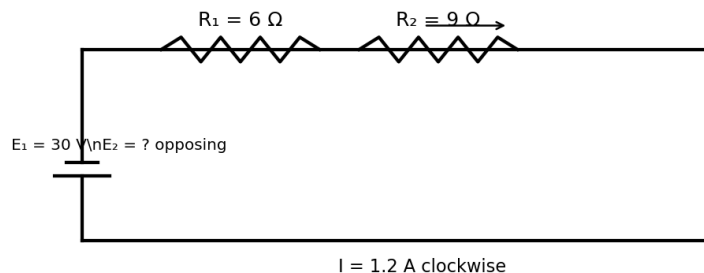
Solution:

1. Write KVL: $40 - 1.6(8) - 1.6(12) - 1.6R_3 = 0$
2. Drop across R_1 : $1.6 \times 8 = 12.8 \text{ V}$. Drop across R_2 : $1.6 \times 12 = 19.2 \text{ V}$
3. $40 - 12.8 - 19.2 - 1.6R_3 = 0$, so $8 = 1.6R_3$
4. $R_3 = 8 / 1.6 = 5 \Omega$
5. Check: $R_{\text{total}} = 8 + 12 + 5 = 25 \Omega$ and $I = 40 / 25 = 1.6 \text{ A} \checkmark$

Answer: $R_3 = 5 \Omega$

Problem C7

In the circuit shown, battery $E_1 = 30 \text{ V}$ drives a clockwise current of 1.2 A against an opposing battery E_2 of unknown voltage. $R_1 = 6 \Omega$ and $R_2 = 9 \Omega$. Find E_2 .



Given: $E_1 = 30 \text{ V}$, $I = 1.2 \text{ A}$, $R_1 = 6 \Omega$, $R_2 = 9 \Omega$, E_2 opposes E_1

To find: E_2

Formula: $E_1 - IR_1 - IR_2 - E_2 = 0$

Solution:

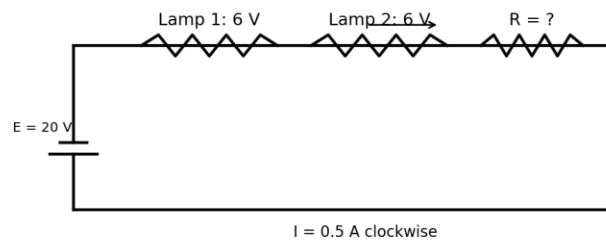
1. Write KVL clockwise: $30 - 1.2(6) - 1.2(9) - E_2 = 0$
2. Drops: $1.2 \times 6 = 7.2 \text{ V}$ and $1.2 \times 9 = 10.8 \text{ V}$
3. $30 - 7.2 - 10.8 - E_2 = 0$
4. $12 - E_2 = 0$, so $E_2 = 12 \text{ V}$

5. Check: net EMF = $30 - 12 = 18 \text{ V}$ and $I = 18 / (6 + 9) = 1.2 \text{ A}$ ✓

Answer: $E_2 = 12 \text{ V}$

Problem C8

Two identical lamps, each rated 6 V and 0.5 A , are connected in series with a resistor R across a 20 V supply as shown. Find R so that each lamp works at its rated values.



Given: $E = 20 \text{ V}$, each lamp: 6 V drop at 0.5 A

To find: R

Formula: $E - V_{\text{lamp1}} - V_{\text{lamp2}} - IR = 0$

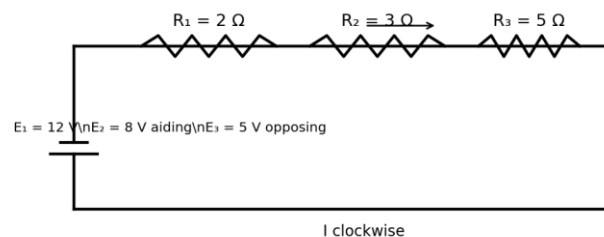
Solution:

1. The lamps are in series, so the circuit current is the rated lamp current: $I = 0.5 \text{ A}$
2. Write KVL: $20 - 6 - 6 - 0.5R = 0$
3. $8 - 0.5R = 0$, so $R = 8 / 0.5 = 16 \Omega$
4. Check: each lamp has resistance $6 / 0.5 = 12 \Omega$, so $R_{\text{total}} = 12 + 12 + 16 = 40 \Omega$ and $I = 20 / 40 = 0.5 \text{ A}$ ✓

Answer: $R = 16 \Omega$

Problem C9

The loop shown contains three batteries, $E_1 = 12 \text{ V}$ and $E_2 = 8 \text{ V}$ driving current clockwise and $E_3 = 5 \text{ V}$ opposing them, and three resistors $R_1 = 2 \Omega$, $R_2 = 3 \Omega$ and $R_3 = 5 \Omega$. Find the current and the voltage across each resistor.



Given: $E_1 = 12 \text{ V}$, $E_2 = 8 \text{ V}$ (aiding), $E_3 = 5 \text{ V}$ (opposing), $R_1 = 2 \Omega$, $R_2 = 3 \Omega$, $R_3 = 5 \Omega$

To find: I , V_1 , V_2 , V_3

Formula: $(E_1 + E_2 - E_3) - I(R_1 + R_2 + R_3) = 0$

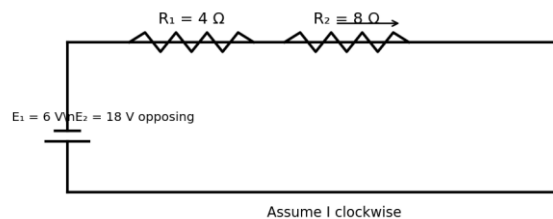
Solution:

1. Rises: 12 V and 8 V. Drop from the opposing source: 5 V.
2. Write KVL: $12 + 8 - 5 - 2I - 3I - 5I = 0$
3. $15 - 10I = 0$, so $I = 1.5$ A
4. $V_1 = 1.5 \times 2 = 3$ V, $V_2 = 1.5 \times 3 = 4.5$ V, $V_3 = 1.5 \times 5 = 7.5$ V
5. Verify: $3 + 4.5 + 7.5 = 15$ V = $12 + 8 - 5$ ✓

Answer: $I = 1.5$ A (clockwise), $V_1 = 3$ V, $V_2 = 4.5$ V, $V_3 = 7.5$ V

Problem C10

In the loop shown, $E_1 = 6$ V and $E_2 = 18$ V act in opposite directions, with $R_1 = 4$ Ω and $R_2 = 8$ Ω . Assume the current I flows clockwise. Find I and state its actual direction.



Given: $E_1 = 6$ V (clockwise rise), $E_2 = 18$ V (opposing, anticlockwise), $R_1 = 4$ Ω , $R_2 = 8$ Ω

To find: I and its actual direction

Formula: $E_1 - E_2 - I(R_1 + R_2) = 0$

Solution:

1. Write KVL for the assumed clockwise current: $6 - 18 - 4I - 8I = 0$
2. $-12 - 12I = 0$, so $I = -1$ A
3. The negative sign shows the actual current is opposite to the assumed direction, so it flows anticlockwise. E_2 is the larger source and decides the direction.
4. Check by writing KVL anticlockwise: $18 - 6 - 4(1) - 8(1) = 0$ ✓

Answer: $I = 1$ A, flowing anticlockwise