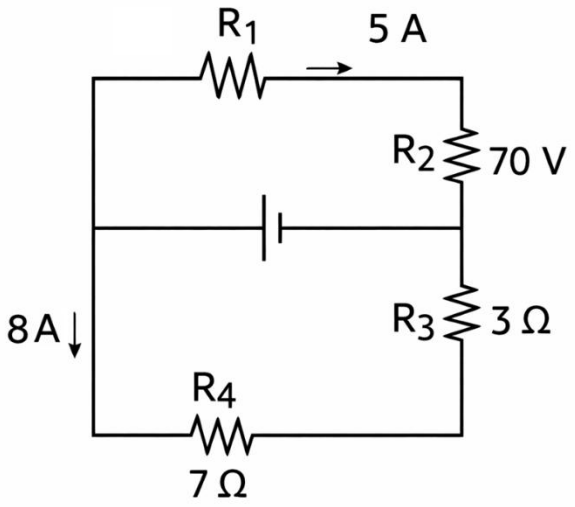
More Circuits

1. A DC power source is connected to a circuit consisting of **four resistors**, arranged as shown in the diagram.
   - **Resistors R_1 and R_2 are connected in series**, forming one branch of the circuit.
   - **Resistors R_3 and R_4 are connected in series**, forming a second branch of the circuit.
   - The two series branches are connected **in parallel** with each other.

The following information is known:

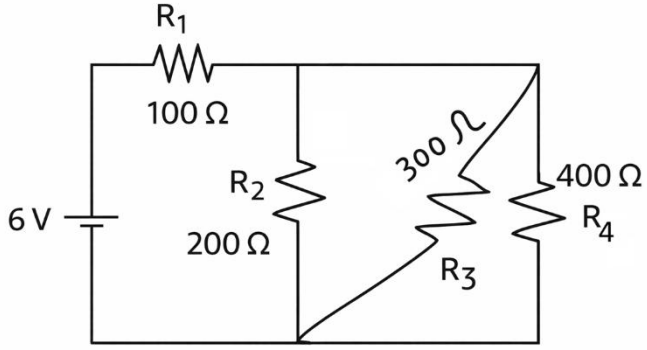
- The current through resistor R_1 is $I_{R_1} = 5.0$ A
- The current in the left vertical wire below the junction is $I = 8.0$ A
- The voltage drop across resistor R_2 is $V_{R_2} = 70$ V
- $R_3 = 3.0\ \Omega$



(a) Determine the **current in each branch** of the circuit.
(b) Determine the **current through** R_2.
(c) Determine the **resistance of** R_2.
(d) Determine the **current through** R_3 and R_4.
(e) Determine the **voltage across each series branch**.
(f) Determine the **resistance of** R_1.
(g) Determine the **voltage of the power source**.

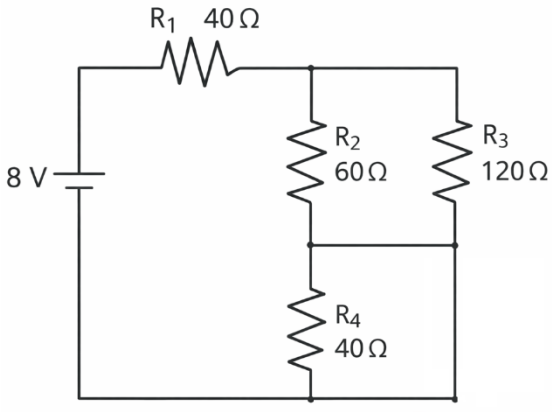
2. A **6.0 V DC battery** is connected to a circuit consisting of **four resistors**, arranged as shown in the diagram.
   - $R_1 = 100\ \Omega$ is connected **in series** with the rest of the circuit.
   - After R_1, the circuit splits into **three parallel branches**:
     - $R_2 = 200\ \Omega$
     - $R_3 = 300\ \Omega$
     - $R_4 = 400\ \Omega$

All three of these resistors are connected between the **same two junctions**, and therefore form a **parallel combination**.



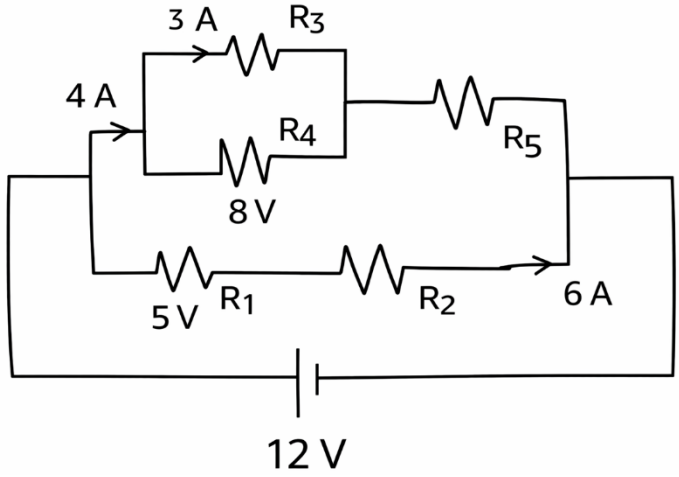
(a) Determine the **equivalent resistance** of the parallel combination of R_2, R_3, and R_4.
(b) Determine the **total resistance** of the circuit.
(c) Determine the **total current** supplied by the battery.
(d) Determine the **current through each resistor**: R_1, R_2, R_3, and R_4.
(e) Determine the **voltage drop across each resistor**.
(f) Verify that your results are consistent with **Ohm's Law** and the rules for **series and parallel circuits**.

3. An **8.0 V DC battery** is connected to a circuit consisting of **four resistors**, arranged as shown in the diagram.
   - $R_1 = 40\ \Omega$is connected **in series** with the rest of the circuit.
   - $R_2 = 60\ \Omega$and $R_3 = 120\ \Omega$are connected **in parallel** with each other.
   - Resistor $R_4 = 40\ \Omega$is **bypassed by a conducting wire**, creating a short circuit across it.



(a) Explain why R_4has **no effect** on the behaviour of the circuit.
(b) Determine the **equivalent resistance** of the parallel combination of $R_2$and R_3.
(c) Determine the **total resistance** of the circuit.
(d) Determine the **total current** supplied by the battery.
(e) Determine the **current through** $R_2$and R_3.
(f) Determine the **voltage drop across** R_1, R_2, and R_3.

4. A **12.0 V DC power source** is connected to a circuit consisting of **five resistors**, arranged as shown in the diagram.
   - **Lower branch**:
     - $R_1$is connected in series with R_2.
     - The voltage drop across $R_1$is **5.0 V**.
     - The current through $R_2$is **6.0 A**.
   - **Upper branch**:
     - A total current of **4.0 A** enters a parallel combination of:
       - R_3, which carries **3.0 A**
       - R_4, which has a voltage drop of **8.0 V**
     - The parallel combination then reconnects and passes through R_5in series.
   - The **upper and lower branches are connected in parallel** between the same two junctions.

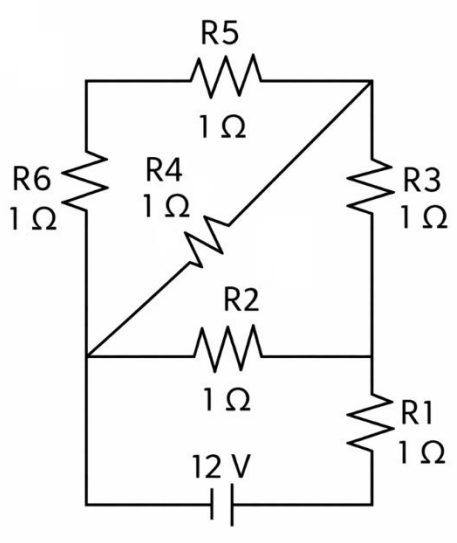


(a) Determine the **current through** R_4.
(b) Determine the **current through** R_5.
(c) Determine the **resistance of** R_4.
(d) Determine the **resistance of** R_3.
(e) Determine the **resistance of** R_1.
(f) Determine the **resistance of** R_2.
(g) Determine the **voltage across the upper branch**.

5. A **12.0 V DC battery** is connected to a circuit consisting of **six resistors**, arranged as shown in the diagram. All resistors have the **same resistance**:

$$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 1.0\ \Omega$$

- The circuit contains **multiple junctions** and **cannot be reduced** using simple series–parallel rules alone.
- Some resistors connect the **same pairs of nodes**, and symmetry may be used to simplify the analysis.
- Kirchhoff's Laws are required.



(a) Identify all **unique nodes** in the circuit and label them clearly.
(b) Determine which resistors (if any) carry **equal currents**, and explain why.
(c) Determine the **current through each resistor**.
(d) Determine the **voltage drop across each resistor**.
(e) Determine the **total current** supplied by the battery.
(f) Determine the **equivalent resistance** of the circuit.

6. A **100 V DC power source** is connected to a circuit consisting of **nine resistors**, arranged as shown in the diagram. The circuit contains **multiple junctions and loops** and **cannot be simplified** using basic series–parallel reductions alone.

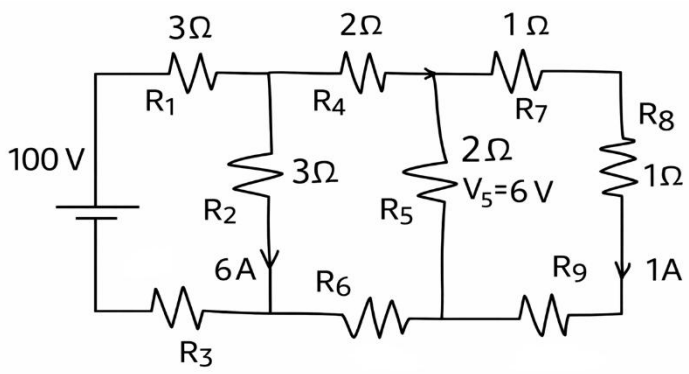
Given information

- $R_1 = 3\ \Omega$
- $R_2 = 3\ \Omega$
- $R_4 = 2\ \Omega$
- $R_5 = 2\ \Omega$
- $R_7 = 1\ \Omega$
- $R_8 = 1\ \Omega$

Additional measurements:

- The **current through** R_2 is $I_{R_2} = 6.0$ A
- The **voltage drop across** R_5 is $V_{R_5} = 6.0$ V
- The **current through** R_9 is $I_{R_9} = 1.0$ A

The resistances of R_3, R_6, and R_9 are **unknown**.



(a) Identify and clearly label all **junctions (nodes)** in the circuit.
(b) Determine:

- the current through R_1
- the current through R_4
- the current through R_7

(c) Determine the **voltage drop across** R_2.
(d) Determine the **resistance of** R_3.
(e) Determine the **resistance of** R_6.
(f) Determine the **resistance of** R_9.
(g) Determine the **total current supplied by the battery**.

Solutions

1.

$V_T = 80V$ $I_T = 13A$ $R_T = 6.15\Omega$	$V_1 = 10V$ $I_1 = 5A$ $R_1 = 2\Omega$	$V_2 = 70V$ $I_2 = 5A$ $R_2 = 14\Omega$
$V_3 = 24V$ $I_3 = 8A$ $R_3 = 3\Omega$	$V_4 = 56V$ $I_4 = 8A$ $R_4 = 7\Omega$	

2.

$V_T = 6V$ $I_T = 31.2mA$ $R_T = 192\Omega$	$V_1 = 3.12V$ $I_1 = 31.2mA$ $R_1 = 100\Omega$	$V_2 = 2.88V$ $I_2 = 14.4mA$ $R_2 = 200\Omega$
$V_3 = 2.88V$ $I_3 = 9.6mA$ $R_3 = 300\Omega$	$V_4 = 2.88V$ $I_4 = 7.2mA$ $R_4 = 400\Omega$	

3.

$V_T = 12V$ $I_T = 10A$ $R_T = 1.2\Omega$	$V_1 = 5V$ $I_1 = 6A$ $R_1 = 0.833\Omega$	$V_2 = 7V$ $I_2 = 6A$ $R_2 = 1.167\Omega$
$V_3 = 8V$ $I_3 = 3A$ $R_3 = 2.67\Omega$	$V_4 = 8V$ $I_4 = 1A$ $R_4 = 8\Omega$	$V_5 = 4V$ $I_5 = 4A$ $R_5 = 1\Omega$

4.

$V_T = 8V$ $I_T = 0.1A$ $R_T = 80\Omega$	$V_1 = 4V$ $I_1 = 0.1A$ $R_1 = 40\Omega$	$V_2 = 4V$ $I_2 = 0.067A$ $R_2 = 60\Omega$
$V_3 = 4V$ $I_3 = 0.033A$ $R_3 = 120\Omega$	$V_4 = 0A$ $I_4 = 0A$ $R_4 = 40\Omega$	

5.

$V_T = 12V$ $I_T = 7.38A$ $R_T = 1.625\Omega$	$V_1 = 7.38V$ $I_1 = 7.38A$ $R_1 = 1\Omega$	$V_2 = 4.62V$ $I_2 = 4.62A$ $R_2 = 1\Omega$
$V_3 = 2.77V$ $I_3 = 2.77A$ $R_3 = 1\Omega$	$V_4 = 1.85V$ $I_4 = 1.85A$ $R_4 = 1\Omega$	
$V_5 = 0.923V$ $I_5 = 0.923A$ $R_5 = 1\Omega$	$V_6 = 0.923V$ $I_6 = 0.923A$ $R_6 = 1\Omega$	

6.

$V_T = 100V$ $I_1 = 10A$ $R_1 = 10\Omega$	$V_1 = 30V$ $I_1 = 10A$ $R_1 = 3\Omega$	$V_2 = 18V$ $I_2 = 6A$ $R_2 = 3\Omega$	$V_3 = 52V$ $I_3 = 10A$ $R_3 = 5.2\Omega$	$V_4 = 8V$ $I_4 = 4A$ $R_4 = 2\Omega$
$V_5 = 6V$ $I_5 = 3A$ $R_5 = 2\Omega$	$V_6 = 4V$ $I_6 = 4A$ $R_6 = 1\Omega$	$V_7 = 1V$ $I_7 = 1A$ $R_7 = 1\Omega$	$V_8 = 1V$ $I_8 = 1A$ $R_8 = 1V$	$V_9 = 4V$ $I_9 = 1A$ $R_9 = 4\Omega$