Example of use of Kirchoff's laws

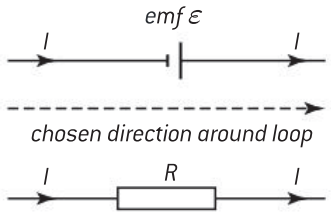
KIRCHOFF CIRCUIT LAWS EXAMPLE

Great care needs to be taken when applying Kirchoff's laws to ensure that every term in the equation is correctly identified as positive or negative. The concept of emf (see page 60) as sources of electrical energy can be used along with $V = IR$ to provide an alternative statement of the second law which may help avoid confusion: 'Round any closed circuit, the sum of the emfs is equal to the sum of the products of current and resistance'.

$$\sum(\text{emf}) = \sum(IR)$$

Process to follow

- Draw a full circuit diagram.
- It helps to set up the equations in symbols before substituting numbers and units.
- It helps to be as precise as possible. Potential difference V is a difference between two points in the circuit so specify which two points are being considered (use labels).
- Give the unknown currents symbols and mark their directions on the diagram. If you make a mistake and choose the wrong direction for a current, the solution to the equations will be negative.
- Use Kirchoff's first law to identify appropriate relationships between currents.
- Identify a loop to apply Kirchoff's second law. Go all around the loop in one direction (clockwise or anticlockwise) adding the emfs and $I \times R$ in senses shown below:



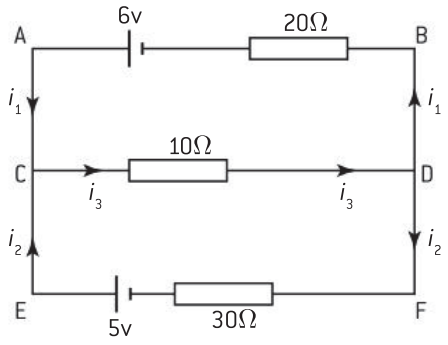
*With chosen direction around loop in the direction shown, ε and IR are both **positive** in the Kirchoff equation:*

$$\sum(\text{emf}) = \sum(IR)$$

(If chosen direction opposite to that shown, values are negative)

- The total number of different equations generated by Kirchoff's laws needs to be the same as the number of unknowns for the problem to be able to be solved.
- Use simultaneous equations to substitute and solve for the unknown values.
- A new loop can be identified to check that calculated values are correct.

Example



Kirchoff 1st law junction C(or D)

$$i_1 + i_2 = i_3 \qquad (1)$$

Kirchoff 2nd law and ACDB

$$10i_3 + 20i_1 = 6 \qquad (2)$$

Sub (1) into (2)

$$10\,(i_1 + i_2) + 20i_1 = 6$$

$$\therefore \quad 30i_1 + 10i_2 = 6 \qquad (3)$$

Kirchoff 2nd law and CEFD

$$-30i_2 - 10i_3 = -5 \qquad (4)$$

Sub (1) into (4)

$$30i_2 + 10(i_1 + i_2) = 5$$

$$10i_1 + 40i_2 = 5 \qquad (5)$$

$$(3) \times 4 \quad 120i_1 + 40i_2 = 24 \qquad (6)$$

$$(6) - (5) \quad 110i_1 = 19$$

$$\therefore \quad i_1 = 0.1727 \text{ A}$$

$$= \mathbf{172.7\ mA}$$

$$(3) \Rightarrow 10i_2 = 6 - 30i_1$$

$$= 0.8182$$

$$\therefore \quad i_2 = 0.08182 \text{ A}$$

$$= \mathbf{81.8\ mA}$$

$$i_3 = 172.7 + 81.8 \text{ mA}$$

$$= \mathbf{254.5\ mA}$$