1.2 Ohm's law, Kirchhoff's laws and reference directions

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS passive sign convention • Kirchhoff's current law • Kirchhoff's voltage law • node • loop

Objective

Use Ohm's law, series and parallel combination, and Kirchhoff's two laws with a consistent sign convention. Label reference directions before computing, and check every answer by a second route (an unused loop, a different node, or a power balance).

1 Key knowledge and worked examples

■ Reference directions come first

Ohm's law links a resistor's voltage and current: `v = Ri`. The **passive sign convention** makes the signs decidable: draw the current arrow entering the `+` terminal, and then `p = vi` is the power the element absorbs. A negative result means the element supplies power.

Kirchhoff's current law (**KCL**) says the signed currents leaving any node sum to zero. Kirchhoff's voltage law (**KVL**) says the signed voltages around any closed loop sum to zero. Both are bookkeeping for conservation of charge and energy – nothing is consumed at a node.

■ Worked example: divider, then check by KVL

A 9 V source feeds $R_1 = 6k\Omega$ in series with $R_2 = 3k\Omega$.

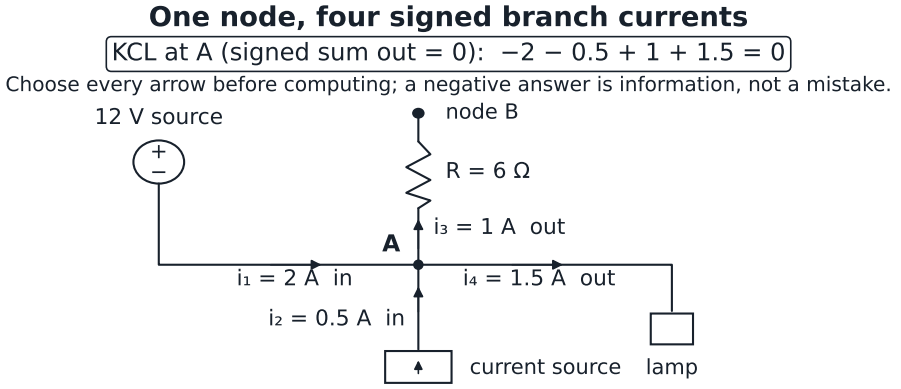
$$i = \frac{9\ \text{V}}{9\ \text{k}\Omega} = 1\ \text{mA} \qquad v_2 = 1\ \text{mA} \times 3\ \text{k}\Omega = 3\ \text{V}$$

The divider formula $9 \times 3/(6+3)$ gives the same 3 V. Check by KVL around the loop: `-9 + 6 + 3 = 0`. The two-resistor parallel rule is the **product over the sum**: $R_1R_2/(R_1+R_2)$, always smaller than either resistor.

■ Worked example: KCL with signs, not guesses

At node A, 2 A and 0.5 A flow in through two branches, and 1 A leaves through a third. Writing currents out as positive: $-2 - 0.5 + 1 + i_4 = 0$, so $i_4 = 1.5A$ leaves.

The minus signs belong to the arrows' directions, not to the values. If a later measurement shows a current flowing opposite to your arrow, the arithmetic returns a negative number – that is the method working, not failing.



2 Practice

2.1 A 12 V source drives a 48 Ω resistor. Calculate the current, and the power the resistor absorbs. State the power in more than one form and confirm they agree. [3]

2.2 Combine 4 Ω and 12 Ω: (a) in series, (b) in parallel. Then find the current the combination draws from a 6 V source in each case, and where the full source voltage appears across the series pair. [4]

2.3 At node B, currents of 3 A (in), 1.2 A (out) and 0.7 A (in) are labelled. Find the fourth branch current, stating clearly whether it enters or leaves B. [3]

3 Exam-style questions

3.1 A 9 V source with internal resistance 1 Ω feeds two loads in parallel: 6 Ω and 3 Ω.

Calculate the source current, the terminal voltage, and the current in each load. Then compute the power delivered by the source and show, numerically, that it equals the sum of the load powers plus the internal loss. [7]

3.2 Traversing a loop clockwise, the voltages encountered are: a rise of 9 V, a drop v_x across an unknown element, a drop of 3 V, and a rise of 2 V.

Write the KVL equation and find v_x. The loop current in the traversal direction is 0.5 A; state the power of the unknown element and whether it supplies or absorbs. [5]