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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A AS Kirchhoff Laws and Resistor Networks worksheet

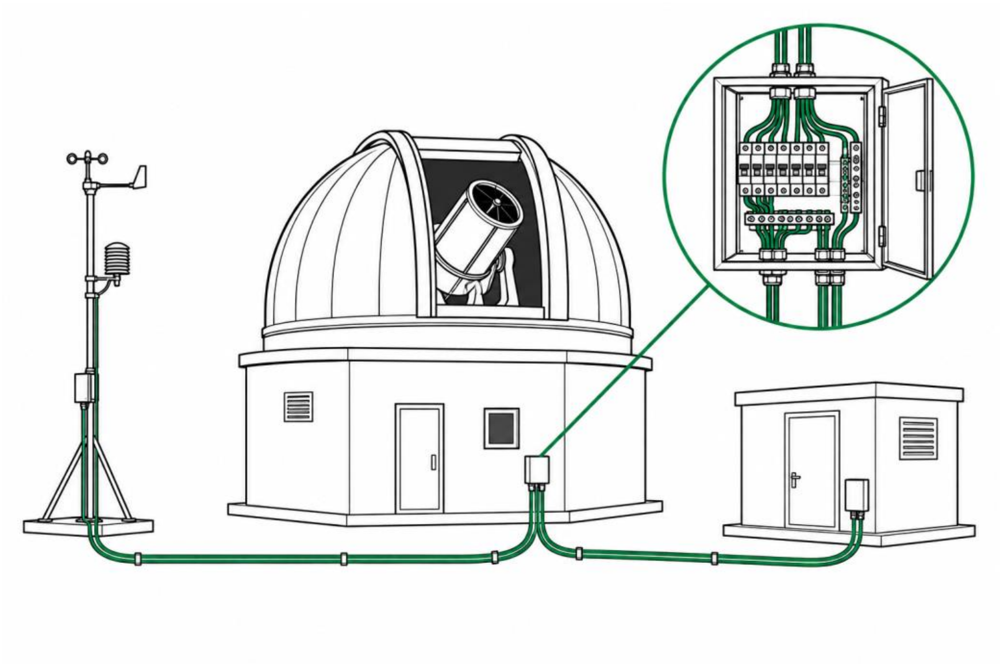
35–40 minutes independent practice + 15–20 minutes review | 39 marks

Specification points covered

- 4.3.1(a) Apply Kirchhoff's second law as conservation of energy in electrical circuits.
- 4.3.1(b) Apply Kirchhoff's first and second laws to analyse electrical circuits.
- 4.3.1(c) Calculate total resistance of resistors in series using $R = R_1 + R_2 + \ldots$
- 4.3.1(d) Calculate total resistance of resistors in parallel using $1/R = 1/R_1 + 1/R_2 + \ldots$
- 4.3.1(e) Analyse circuits with components including both series and parallel arrangements.

Solis remote mountain observatory

The Solis observatory uses a low-voltage distribution system for its telescope dome, lens heaters, weather station, communications equipment and roof de-icing strips.
Analyse currents and potential differences throughout the system, then diagnose faults and compare two practical resistor networks.



Context diagram: the Solis observatory and its low-voltage distribution system.

1. Kirchhoff laws at the observatory

1. State Kirchhoff's first law and identify the physical quantity conserved. [2 marks]

2. At one junction, a current of 4.80 A enters. Currents of 1.35 A and 2.10 A leave through the camera and heater branches. Calculate the current leaving through the communications branch. [1 mark]

3. State Kirchhoff's second law and identify the physical quantity conserved. [2 marks]

2. Series circuit for the lens heater

4. A 5.60 Ω lens heater and a cable with resistance 0.400 Ω are connected in series across a 12.0 V supply. Calculate the total resistance and the current in the circuit. [2 marks]

5. Calculate the p.d. across the lens heater and across the cable. Show that the values satisfy Kirchhoff's second law. [2 marks]

6. The cable connector resistance increases from 0.400 Ω to 1.40 Ω while the heater resistance and supply p.d. remain unchanged. Calculate the new current and the new p.d. across the heater. Use your results to describe the change in heating performance. [3 marks]

3. Parallel instrument loads

7. The observatory's 24.0 V distribution rail supplies three parallel loads. The camera controller has resistance 12.0 Ω, the weather station 16.0 Ω and the communications unit 24.0 Ω. Calculate the current in each branch. [3 marks]

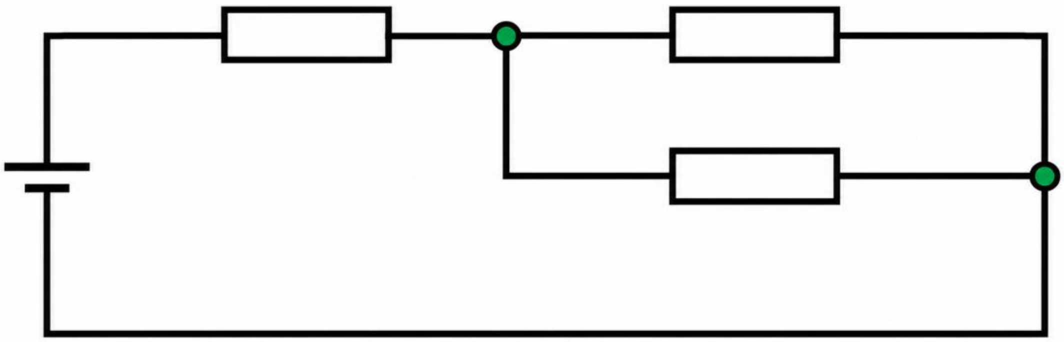
8. Use Kirchhoff's first law to determine the current supplied by the distribution rail. [1 mark]

9. Determine the equivalent resistance of the three parallel loads. [1 mark]

10. Explain why the equivalent resistance in Question 9 is less than the smallest branch resistance. Predict what happens to the equivalent resistance if another load is connected in parallel. [2 marks]

4. Mixed dome-control network

11. The circuit shown represents one branch of the dome control system. The ideal supply has e.m.f. 18.0 V. The resistor before the junction has resistance 2.00 Ω. The upper branch resistor is 6.00 Ω and the lower branch resistor is 3.00 Ω. Calculate the equivalent resistance of the parallel section. [1 mark]



Mixed network: one series resistor followed by two parallel resistor branches.

12. Calculate the total resistance of the circuit in Question 11 and the current supplied by the source. [2 marks]

13. Calculate the p.d. across the 2.00 Ω series resistor and the p.d. across the parallel section. [2 marks]

5. Current division and an open branch

14. Calculate the current in each parallel branch. Verify that the currents satisfy Kirchhoff's first law at the junction. **[3 marks]**

15. The lower branch develops an open-circuit fault. Calculate the new source current and the new p.d. across the remaining 6.00 Ω resistor. Explain why the p.d. across the 2.00 Ω series resistor changes. **[3 marks]**

6. De-icing network design

16. The observatory roof has four identical de-icing strips, each of resistance 24.0 Ω, supplied by 48.0 V. The table shows two proposed connections. Calculate the total resistance and supply current for each design. [4 marks]

Design	Connection of four identical 24 Ω strips
A	all four strips connected in series
B	two series pairs connected in parallel

17. Each de-icing strip is rated at 24.0 V and the supply current must not exceed 2.50 A. Select the suitable design and justify your choice using the p.d. across each strip and the supply current. [2 marks]

18. One strip in one branch of the selected design fails open circuit. Calculate the new total current. Explain whether the two strips in the unaffected branch continue to operate at their rated p.d. [3 marks]

Review and improve

□ I distinguish current through a component from p.d. across it.
□ I use junction and loop equations before substituting numerical values.
□ I replace a parallel section with its equivalent resistance before analysing a mixed network.