VCE Physics: Unit 1 AOS 3 Cheat Sheet

How Can Electricity be Used to Transfer Energy? — 2023–2026 Study Design — Heinemann 5th Ed.

1. Core Electrical Quantities and Formulae

- **Voltage (V):** Energy transferred per unit charge, measured in volts (V).
- **Current (I):** Rate of charge flow, measured in amperes (A).

$$I = \frac{Q}{t}$$

- **Resistance (R):** Opposition to current flow, measured in ohms (Ω).
- **Ohm's Law:**

$$V = IR \qquad I = \frac{V}{R} \qquad R = \frac{V}{I}$$

- **Power (P):** Rate of energy transfer, measured in watts (W).

$$P = VI \qquad P = I^2R \qquad P = \frac{V^2}{R}$$

- **Energy (E):** Energy transferred by an electrical device over time.

$$E = Pt \qquad E = VIt$$

2. Series, Parallel and Combination Circuits

- **Series Circuits:** Components are connected in one continuous path.
  - Current is the same everywhere.
  - Voltage is shared between components.
  - Total resistance increases as more components are added.

$$R_T = R_1 + R_2 + R_3 + \cdots$$

$$V_T = V_1 + V_2 + V_3 + \cdots$$

  - If one component fails, the entire circuit stops.
  - Adding more globes increases R_T, decreases I, and makes globes dimmer.
- **Parallel Circuits:** Components are connected in separate branches.
  - Voltage is the same across each branch.
  - Current splits between branches.
  - Total resistance decreases as more branches are added.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$I_T = I_1 + I_2 + I_3 + \cdots$$

  - If one branch fails, the other branches continue operating.
  - Adding more globes in parallel usually leaves brightness unchanged, but increases total current.
- **Combination Circuits:** Simplify parallel sections first, replace them with equivalent resistance, then combine series sections. Work backwards to determine branch voltages and currents.

3. Measuring Circuits and Experimental Data

- **Ammeter:** Measures current. It is connected in series and has very low resistance.
- **Voltmeter:** Measures voltage. It is connected in parallel and has very high resistance.
- **Data Analysis:** Given voltage, current, or resistance values, use Ohm's Law to calculate missing values and identify trends.

Voltage Drop: Measured voltage may be lower than the set supply voltage.

$$V_{\text{measured}} < V_{\text{supply}}$$

This may occur due to internal resistance, increased load, weak supply, or connection resistance.

4. Ohmic and Non-Ohmic Devices

- **Ohmic Device:** A device with constant resistance that obeys Ohm's Law.
  - Its voltage-current graph is linear.
  - Examples include fixed resistors and metal wires at constant temperature.
- **Non-Ohmic Device:** A device whose resistance changes with voltage, current, temperature, or light level.
  - Its voltage-current graph is non-linear.
  - Examples include filament lamps, diodes, thermistors, and LDRs.
- **Graph Interpretation:**
  - Independent variable (V) is placed on the x-axis.
  - Dependent variable (R) is placed on the y-axis.
  - Linear graph: straight line and constant gradient.
  - Non-linear graph: curved line and changing gradient.
  - For a voltage-current graph:

$$R = \frac{\Delta V}{\Delta I}$$

A steeper V-I graph indicates greater resistance.

5. Voltage Dividers, Sensors and Switching Circuits

- **Voltage Divider:** A series resistor pair that divides supply voltage between two resistors.

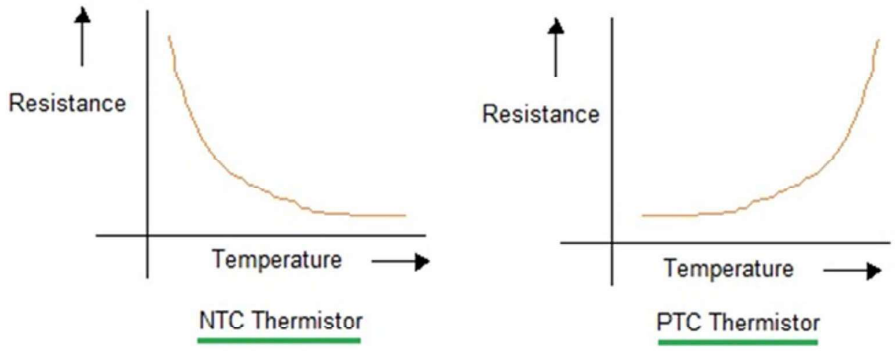
$$V_{Out} = V_{In}\left(\frac{R_2}{R_1 + R_2}\right)$$

Refer to diagram for Designator Definitions

- **Key Idea:** The larger resistance receives the larger voltage drop.
- **Light Dependent Resistor (LDR):** Resistance decreases as light intensity increases.

$$\text{light} \uparrow \Rightarrow R_{\text{LDR}} \downarrow$$

- **Thermistors:** Resistance Changes as temperature changes.



- **Applications:** Voltage dividers are used in automatic lighting, thermostats, sensor circuits, LED switching circuits, heaters, and air-conditioning systems.
- **Using Sensor Graphs:** Read the resistance from the graph at the given light level or temperature, then use voltage divider or Ohm's Law calculations to analyse the circuit.

6. Energy Transformations and Household Electricity

- **Battery:** Chemical energy → electrical energy.
- **Light Globe:** Electrical energy → light energy + thermal energy.
- **Speaker:** Electrical energy → sound energy.
- **Motor:** Electrical energy → kinetic energy.
- **Heater:** Electrical energy → thermal energy.
- **Australian Mains Supply:** Approximately 230 V AC $50Hz$.
- **Household Wiring:** Appliances are connected in parallel so that each receives the full supply voltage, can operate independently, and is not switched off by failure of another appliance.

7. Electrical Safety Devices

- **Fuse:** A thin wire that melts when current is too high, breaking the circuit. It protects against overcurrent but must be replaced after operating.
- **Circuit Breaker:** A reusable automatic switch that opens the circuit when current becomes too high.
- **Residual Current Device (RCD):** Detects an imbalance between active and neutral currents. It rapidly disconnects the circuit when leakage current occurs, helping protect people from electric shock.
- **Isolator:** A manual switch used to completely disconnect a circuit or appliance from power for safer maintenance.
- **RCD vs Fuse:** An RCD is usually better for personal safety because it responds quickly to leakage current, whereas a fuse mainly protects wiring and appliances from excessive current.

8. Circuit Laws, Trends and Common SAC Skills

- **Junction Rule:** Current entering a junction equals current leaving the junction.

$$I_{\text{in}} = I_{\text{out}}$$

- **Loop Rule:** The supply voltage equals the total voltage drops around a closed loop.

$$V_{\text{supply}} = \sum V_{\text{drops}}$$

- **Useful Trends:**
  - Increasing voltage increases current if resistance is constant.

$$V \uparrow \Rightarrow I \uparrow$$

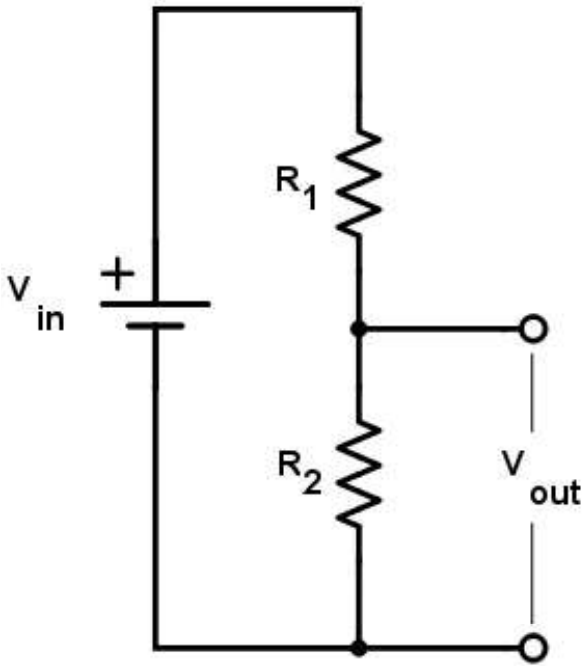
  - Increasing resistance decreases current if voltage is constant.

$$R \uparrow \Rightarrow I \downarrow$$

  - Increasing power increases energy transferred for the same time.

$$P \uparrow \Rightarrow E \uparrow$$

VOLTAGE DIVIDER



Graph Checklist

- Title
- Label axes + units
- Independent variable on x-axis
- Dependent variable on y-axis
- Even scale
- Use most of graph space
- Accurate plotting
- Line of best fit

Feature	Series	Parallel
Current	Same everywhere	Splits between branches
Voltage	Shared	Same across branches
Resistance	Increases	Decreases
Globe brightness when adding more	Dimmer	Usually unchanged
If one globe fails	Entire circuit stops	Others continue