

2.3 Resistors and I-V characteristics

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS Ohmic conductor

• Filament lamp

• Diode

• Thermistor

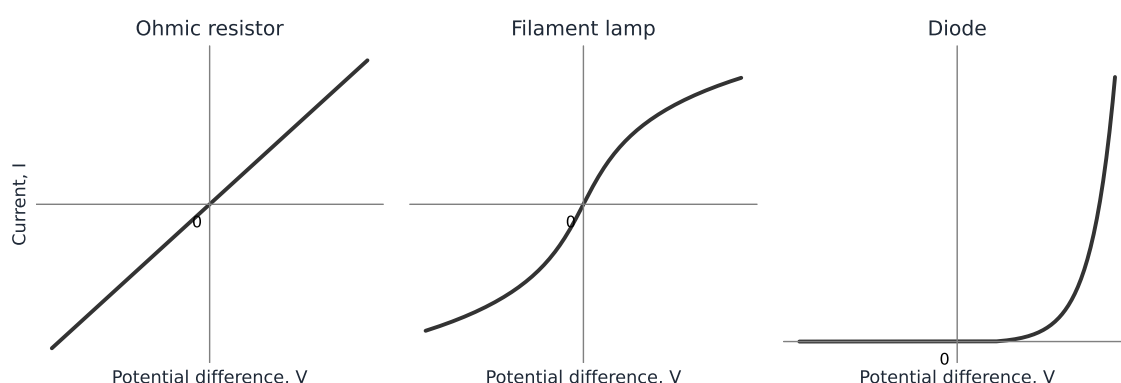
• LDR

Objective

Describe the I–V characteristic of a resistor, filament lamp and diode, explain the lamp's curve, state the thermistor and LDR rules with their applications, and describe RP4. Original questions for spec statement 4.2.1.4 and required practical 4.

1 Key knowledge and worked examples

An **I–V characteristic** is a graph of current against potential difference. **RP4** measures it: vary the potential difference with a variable resistor, record I and V , repeat with the supply reversed for negative values.

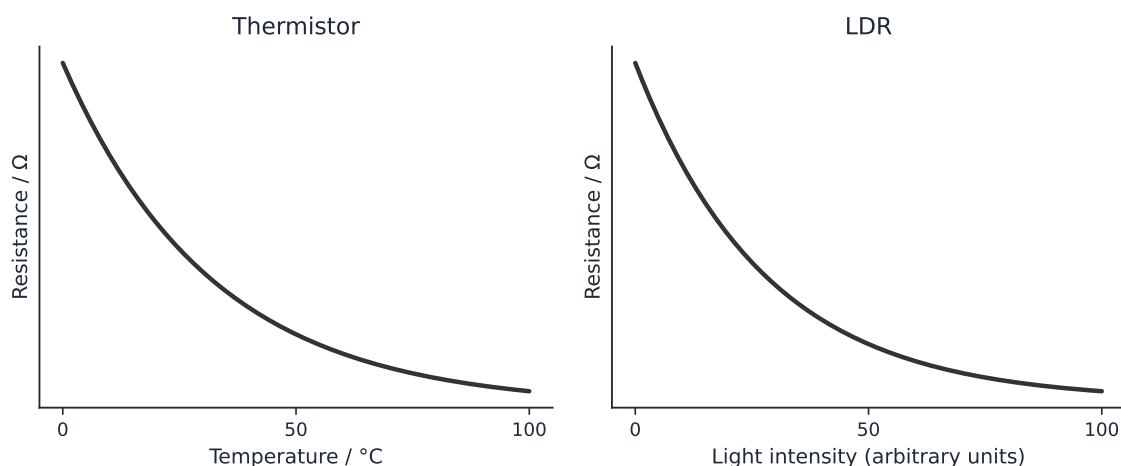


The shape names the component.

Component	Graph shape	Why
resistor (constant temperature)	straight line through origin	resistance constant: $I \propto V$
filament lamp	S-curve, flattening at large V	current heats the filament; resistance rises with temperature
diode	conducts forward only; no current in reverse	very high resistance in reverse

The lamp explanation in three linked steps:

1. A larger current makes the filament **hotter**.
2. The hotter filament has **higher resistance** (the moving electrons collide more with the vibrating lattice).
3. So current grows **less than proportionally** with potential difference – the curve bends over.



Sensors: resistance falls when their trigger rises.

- **Thermistor** : resistance **decreases** as temperature **increases**. Application: temperature sensor in a thermostat.
- **LDR** : resistance **decreases** as **light intensity increases**. Application: switching lights on when it gets dark.

RP4 method: ammeter in series, voltmeter in parallel; variable resistor changes the current; reverse the supply connections for negative potential differences; use a protective series resistor to limit diode current and a milliammeter to measure it; connect the voltmeter across the diode alone; keep the resistor's temperature constant (short bursts / low current); repeat and take means.

Worked example (reading an I–V graph). A lamp's graph shows 0.16 A at 2.0 V and 0.26 A at 6.0 V.

- Known: two points on the curve. Resistance changes, so compute each separately.

$$R_{2.0\text{V}} = \frac{2.0 \text{ V}}{0.16 \text{ A}} = 12.5 \, \Omega \quad R_{6.0\text{V}} = \frac{6.0 \text{ V}}{0.26 \text{ A}} = 23 \, \Omega$$

- The resistance rose with potential difference because the current heated the filament.

2 Practice

2.1 Sketch and label the I–V graph for (a) a fixed resistor at constant temperature and (b) a filament lamp. [4]

2.2 Explain why the filament lamp's graph is not a straight line. [3]

2.3 State what happens to the resistance of (a) a thermistor as temperature rises, (b) an LDR as it gets darker, and name one application of each. [4]

3 Exam-style questions

3.1 A student investigates the I–V characteristic of a diode.

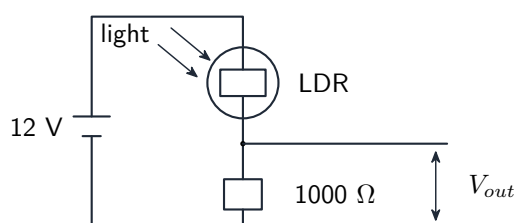
- (a) Describe how the student obtains negative values of potential difference. [1]
- (b) The ammeter displays 0.0 A for all reverse values. Explain why. [2]
- (c) Give one reason a protective resistor is placed in series with the diode. [1]

3.2 A student plots the I–V graph of a resistor and of a filament lamp on the same axes. The lamp's curve lies **below** the resistor's line for all positive values.

Explain what this shows about the lamp's resistance compared with the resistor's at the same potential difference. [2]

3.3 A car's automatic headlight circuit uses an LDR in series with a $1000\ \Omega$ fixed resistor across a 12 V supply. The output is taken **across the LDR**; the lights switch on when it reaches 6.0 V. In daylight the LDR's resistance is $500\ \Omega$; after dark it rises to $5000\ \Omega$.

- (a) Calculate the output potential difference in daylight. [3]
- (b) Calculate the output potential difference after dark. [3]
- (c) Explain why the lights come on as it gets dark. [3]



Solutions

2.1 (a) Straight line through the origin, axes labelled current against potential difference.
(b) S-shaped curve through the origin, steepest near the origin and flattening at both ends.

2.2 The (larger) current heats the filament; the filament's temperature rises and its resistance increases; so the current is smaller than proportional to the potential difference and the graph curves.

2.3 (a) Thermistor resistance decreases as temperature rises; application: temperature sensor / thermostat. (b) LDR resistance increases as it gets darker (light intensity falls); application: automatic lighting / street lamps.

3.1 (a) Reverse the connections to the power supply (swap the supply's + and -). (b) A diode conducts in the forward direction only; in reverse its resistance is very high, so the current is too small for the ammeter to register. (c) To limit the (forward) current so the diode is not damaged.

3.2 For the same potential difference the lamp's current is smaller, and since $R = V/I$, a smaller current at the same V means a larger resistance.

3.3 (a) Daylight: total resistance = $500 + 1000 = 1500 \, \Omega$ (C1).

$$I = \frac{12}{1500} = 0.0080 \, \text{A} \quad V_{out} = IR_{LDR} = 0.0080 \times 500 = \mathbf{4.0 \, V}$$

(substitution C1, answer with unit A1.) (b) Dark: total resistance = $5000 + 1000 = 6000 \, \Omega$.

$$I = \frac{12}{6000} = 0.0020 \, \text{A} \quad V_{out} = 0.0020 \times 5000 = \mathbf{10 \, V}$$

(C1, A1.) (c) As light intensity falls the LDR's resistance increases; in the series chain the component with the larger resistance takes the larger share of the supply's potential difference, so the output across the LDR rises; it passes the 6.0 V switching threshold only in the dark, so the lights come on.