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OCR GCSE Physics B

Twenty First Century Science J259

CHAPTER P3

Electric Circuits

Foundation Tier

Systematic lesson notebook

Teaching and worked examples, lesson practice, a chapter assessment, complete indicative answers and a knowledge organiser.

Read the explanation, try the practice independently, then use the answers to improve your reasoning and calculations.

Name _____ Class _____

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How to use this notebook

Follow the lesson sequence. Each assessed lesson includes an explanation, a worked example and practice. Keep your working and units visible. Check the numbered lesson answers after attempting the questions; equivalent correct scientific wording can receive credit.

Specification reference: Cambridge OCR J259, Version 5.0, July 2026. References identify the intended outcomes; this independent notebook does not replace the official specification.

Foundation and Higher

Foundation contains shared assessable outcomes. Higher-only lessons are identified as awareness pages, without marked Foundation practice. In mixed lessons the shared material remains assessed and the Higher-only boundary is stated explicitly.

Separate Physics content belongs to J259 at both tiers unless the specification explicitly marks an outcome as Higher-only.

Working and marking

Use the maximum mark shown for each question. The answer sections are indicative classroom guidance, not official OCR mark schemes. Credit valid alternatives and avoid awarding the same idea twice. This assessment is diagnostic; no GCSE grade boundary is implied.

Numerical tariffs, example data and model situations are classroom examples, not current prices or real safety estimates.

Lesson map

Lesson	Focus	References
1	Static electricity: charging, attraction and repulsion	P3.1.1
2	Electron transfer model	P3.1.2
3	Electric fields	P3.1.3
4	Current as rate of flow of charge; Q = It	P3.2.1-2
5	Resistance, potential difference and V = IR	P3.2.3-4a
6	PAG7: investigating resistance of a wire	P3.2.4b
7	Linear and non-linear components	P3.2.5-6a
8	PAG6: I-V characteristics and circuit symbols	P3.2.6b-7
9	Potential difference as work done per charge	P3.3.1
10	Series and parallel circuits + bulb-brightness practical	P3.3.2

Use lesson numbers to locate the matching practice and answers. Pagination differs between editions because the assessed scope differs.

Lesson map continued

Lesson	Focus	References
11	Equivalent resistance in series and parallel	P3.3.3-4
12	Sensing and testing circuits: LDRs, thermistors and diodes	P3.3.5
13	Electrical energy transfer, power and E = QV	P3.4.1-3
14	Electrical power: P = VI and P = I^2R	P3.4.4
15	Transformer power and efficient transmission	P3.4.5-6
16	Permanent magnets, fields, Earth and induced magnetism	P3.5.1-4
17	Magnetic fields from currents and solenoids	P3.5.5-8
18	Loudspeakers and headphones	P3.5.9 • Awareness only
19	Motor effect and electric motors	P3.6.1-4 • Awareness only
20	Electromagnetic induction, generators and transformers	P3.7.1-8 • Awareness only

Use lesson numbers to locate the matching practice and answers. Pagination differs between editions because the assessed scope differs.

Lesson 1 Static electricity charging, attraction and repulsion

P3.1.1 | Foundation

describe charging by rubbing, sparking, and non-contact attraction/repulsion.

Rubbing certain insulating materials can transfer electrons between their surfaces. One object becomes negatively charged because it gains electrons; the other becomes positively charged because it loses electrons.

Like charges repel and unlike charges attract. A charged object can also attract an uncharged object because charges inside the uncharged object can redistribute.

A spark is a sudden discharge when the electric field becomes strong enough for charge to move through the air.

Worked example

A plastic rod gains 100 electrons from a cloth. The rod becomes negative and the cloth positive. No charge is created: the gain by one equals the loss from the other.

Lesson 1 practice

Static electricity: charging, attraction and repulsion

Answer independently. Show a clear method, substitutions and units for calculations.

1. Explain how rubbing can charge two objects. [3]

2. State what happens when two negatively charged objects are brought close. [1]

3. Explain why a charged rod can attract small neutral paper pieces. [3]

4. What is a spark in electrostatic terms? [2]

5. Give one piece of evidence that electrostatic forces act without contact. [2]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 2 Electron transfer model

P3.1.2 | Foundation

explain static electricity using transfer of electrons.

Only electrons are transferred in ordinary static charging; protons remain bound in nuclei.

Gaining electrons makes an object negatively charged; losing electrons makes it positively charged.

Charge is conserved overall: electrons move from one object to another rather than being created or destroyed.

Worked example

An initially neutral object loses electrons. Its proton number is unchanged but it now has fewer electrons than protons, so its net charge is positive. Positive charging does not require adding protons.

Lesson 2 practice

Electron transfer model

Answer independently. Show a clear method, substitutions and units for calculations.

1. Which subatomic particle is transferred during static charging? [1]

2. An object gains electrons. State its final charge. [1]

3. Explain why protons do not move between rubbed solids. [2]

4. Explain how charge is conserved when two objects are rubbed. [3]

5. Correct: 'positive charge moves from the cloth to the rod'. [2]

Practice total 9 marks

Self check Write one correction you made and why it matters.

Lesson 3 Electric fields

P3.1.3 | Foundation

explain electric fields and use them to account for non-contact forces.

An electric field is a region where a charge experiences a force. Field diagrams help represent strength and direction.

A positive test charge would be pushed away from a positive source charge and pulled toward a negative one.

The field becomes weaker with increasing distance from an isolated charge; this explains why electrostatic forces diminish with distance.

Worked example

Place a small positive test charge near a negative source charge. It is attracted towards the source, so the electric-field arrow at that point also points towards the negative source.

Lesson 3 practice

Electric fields

Answer independently. Show a clear method, substitutions and units for calculations.

1. Define an electric field. [2]

2. Describe the field direction around a positive charge. [2]

3. Explain why electrostatic force weakens with distance. [2]

4. How does a field model explain non-contact force? [3]

5. Sketch field directions around a negative charge. [2]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 4 Current as rate of flow of charge; Q = It

P3.2.1-2 | Foundation

recall current conditions and calculate charge, current or time.

Current is the rate of flow of charge. A source of potential difference and a closed conducting path are needed for a steady current.

In a single closed loop, current has the same value at every point because charge is not used up.

Use Q = It, with charge in coulombs, current in amperes and time in seconds.

Worked example

A current of 0.25 A flows for 2 minutes. Time = 120 s; Q = It = 0.25 × 120 = 30 C. The same 30 C passes each point in an unbranched steady-current circuit.

Lesson 4 practice

Current as rate of flow of charge; Q = It

Answer independently. Show a clear method, substitutions and units for calculations.

1. State two conditions needed for steady current. [2]

2. Calculate charge passing in 20 s at 0.30 A. [2]

3. A charge of 48 C flows in 2 min. Calculate current. [3]

4. Explain why current is the same at all points in a single loop. [2]

5. Correct: 'current gets used up by a lamp'. [2]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 5 Resistance, potential difference and V = IR

P3.2.3-4a | Foundation

relate current to resistance and p.d. and calculate using V = IR.

Potential difference drives charge through resistance. For a given resistance, increasing p.d. increases current; for a given p.d., increasing resistance reduces current.

Use V = IR. Resistance is measured in ohms.

Convert prefixes before calculation: mA to A, kΩ to Ω where needed.

Worked example

A resistor carries 0.20 A with 6.0 V across it. R = V/I = 6.0/0.20 = 30 Ω. If it stays at the same temperature and p.d. doubles, current doubles.

Lesson 5 practice

Resistance, potential difference and V = IR

Answer independently. Show a clear method, substitutions and units for calculations.

1. Calculate current for 12 V across 6 Ω. [2]

2. Calculate resistance for 9 V and 0.30 A. [2]

3. Explain how increasing resistance affects current at fixed p.d. [2]

4. Convert 250 mA to A. [1]

5. A resistor carries 0.4 A at 8 V. Calculate R. [2]

Practice total 9 marks

Self check Write one correction you made and why it matters.

Lesson 6 PAG7 investigating resistance of a wire

P3.2.4b | Foundation

describe and evaluate an experiment to investigate wire resistance.

Measure current through the test wire with an ammeter in series and p.d. across it with a voltmeter in parallel.

Change wire length or another chosen variable while controlling material, diameter and temperature where appropriate.

Calculate R = V/I for each reading. Keep current low or switch off between readings to reduce heating, because temperature changes resistance.

Worked example

A wire has 1.8 V across it and carries 0.30 A. R = 1.8/0.30 = 6.0 Ω. To compare lengths, keep material, diameter and temperature constant; otherwise a change in resistance cannot be attributed to length alone.

Lesson 6 practice

PAG7: investigating resistance of a wire

Answer independently. Show a clear method, substitutions and units for calculations.

1. Draw/describe where the ammeter and voltmeter go. [3]

2. State three control variables when changing wire length. [3]

3. Explain why the wire should not heat significantly. [2]

4. Describe how R is calculated from readings. [2]

5. Give one limitation and one matching improvement. [2]

Practice total 12 marks

Self check Write one correction you made and why it matters.

Lesson 7 Linear and non-linear components

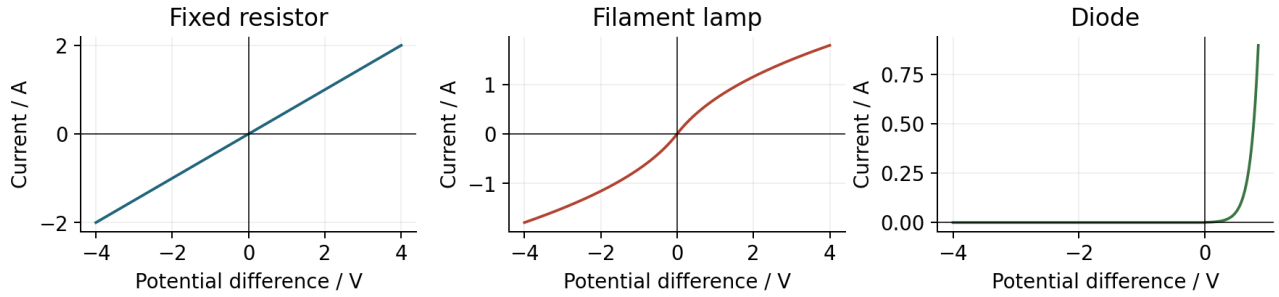
P3.2.5-6a | Foundation

use I-V graphs to identify fixed-resistor, filament-lamp and diode behaviour.

A fixed resistor at constant temperature has an approximately straight-line I-V graph through the origin.

A filament lamp heats as current rises, so resistance increases and the graph curves.

A diode allows significant current mainly in one direction after a threshold p.d.; reverse current is very small.



Worked example

At 2 V a lamp carries 0.40 A: R = 5 Ω. At 6 V it carries 0.60 A: R = 10 Ω. The larger V has heated the filament and increased its resistance, so current has not tripled with voltage.

Lesson 7 practice

Linear and non-linear components

Answer independently. Show a clear method, substitutions and units for calculations.

1. Describe the I-V graph of a fixed resistor. [2]

2. Explain why a filament lamp graph curves. [3]

3. Describe diode behaviour. [2]

4. Using the labelled I–V curves in Lesson 7, identify the component with a linear characteristic. [1]

5. Explain how heating changes filament resistance. [3]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 8 PAG6 I-V characteristics and circuit symbols

P3.2.6b-7 | Foundation

describe I-V practicals and represent common circuit elements correctly.

Use an ammeter in series and voltmeter in parallel with the component. Vary the p.d. using a variable resistor or variable supply and collect positive/negative readings where appropriate.

Know standard symbols for cells, batteries, switches, lamps, resistors, variable resistors, diodes, LDRs and thermistors.

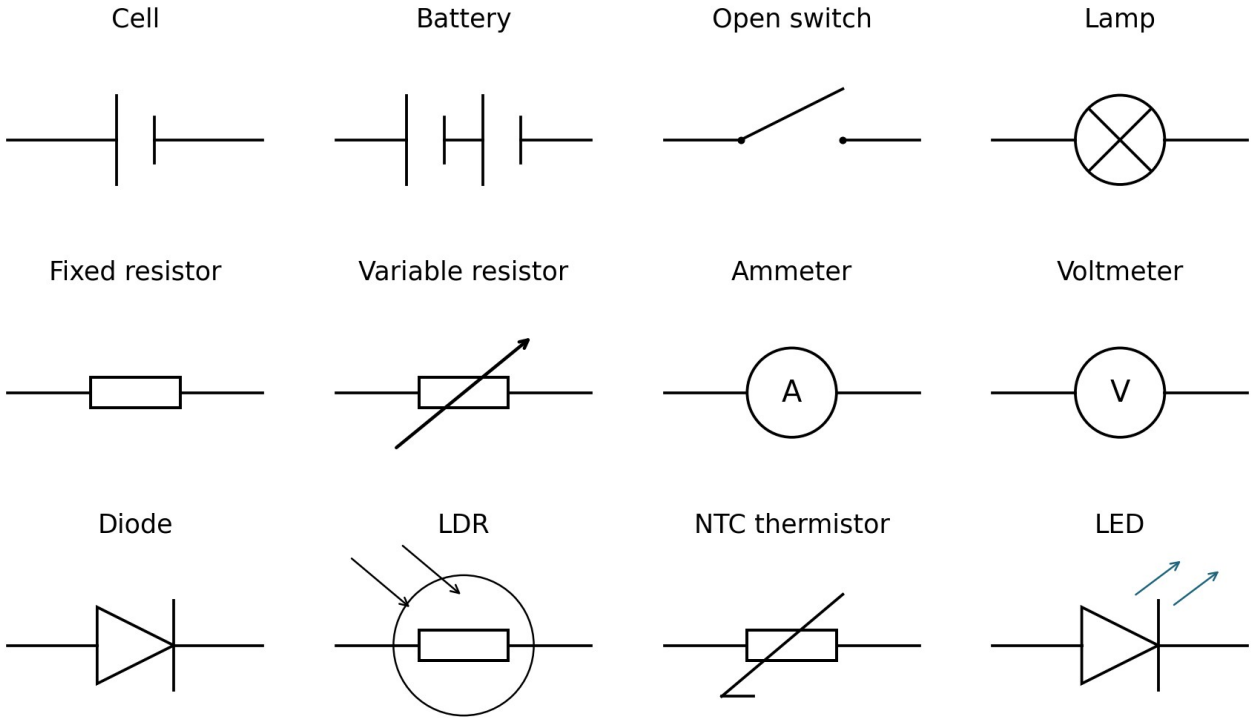
For LDRs and thermistors, resistance changes with environmental conditions, so control light/temperature during a basic I-V investigation.

Worked example

Connect an ammeter in series so all component current passes through it. Connect a voltmeter across the two component terminals so it measures that component's energy transfer per charge, rather than the p.d. of the whole circuit.

Circuit symbol reference

Use these standard schematic symbols in circuit diagrams. Lines show conducting connections, not pictorial wires.



Ammeter in series; voltmeter in parallel across the component. Diode current is appreciable in the forward direction towards the bar. Light arrows point into an LDR and out from an LED.

Lesson 8 practice

PAG6: I-V characteristics and circuit symbols

Answer independently. Show a clear method, substitutions and units for calculations.

1. Describe a method to obtain an I-V graph for a lamp. [5]

2. Why is a variable resistor useful? [2]

3. Where is the voltmeter connected? [1]

4. State the purpose of repeating readings. [2]

5. Name four circuit components whose symbols must be recognised. [4]

Practice total 14 marks

Self check Write one correction you made and why it matters.

Lesson 9 Potential difference as work done per charge

P3.3.1 | Foundation

relate p.d. to work done per unit charge and calculate using V = W/Q.

Potential difference measures energy transferred per unit charge between two points.

Use V = W/Q, so 1 volt means 1 joule transferred per coulomb.

A larger p.d. means each coulomb transfers more energy.

Worked example

4 C of charge transfers 24 J in a component. V = E/Q = 24/4 = 6 V. Each coulomb transfers 6 J; the charge is not used up.

Lesson 9 practice

Potential difference as work done per charge

Answer independently. Show a clear method, substitutions and units for calculations.

1. Define potential difference. [2]

2. Calculate V when 18 J is transferred by 3 C. [2]

3. Calculate energy for 5 C through 12 V. [2]

4. Explain what 1 V means. [2]

5. A charge transfers 40 J through 8 V. Calculate Q. [3]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 10 Series and parallel circuits + bulb-brightness practical

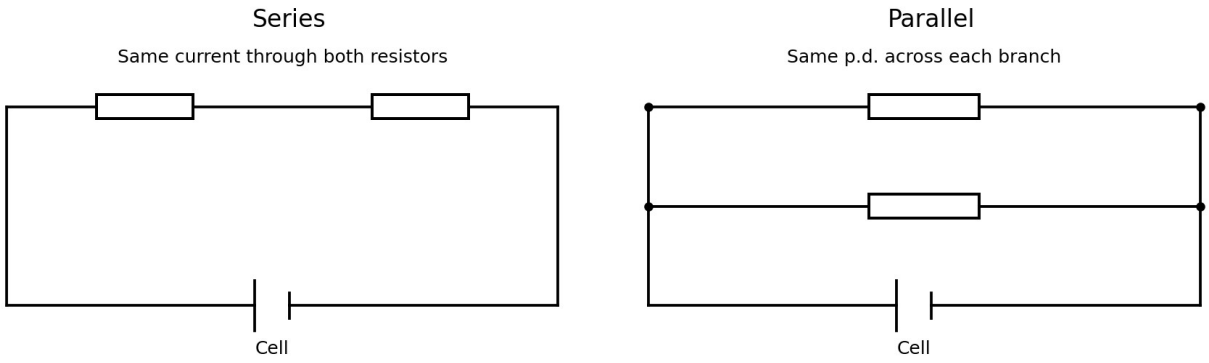
P3.3.2 | Foundation

describe current/p.d. in series and parallel circuits and investigate bulb brightness.

In series, current is the same through each component and the supply p.d. is shared between components.

In parallel, p.d. is the same across each branch while current splits between branches and recombines.

For a fair bulb-brightness comparison, use identical lamps and the same supply, and change only the series/parallel arrangement.



Worked example

A 6 V supply feeds two identical series resistors. Equal resistances share the voltage, giving 3 V each. Put them in parallel instead and each has the full 6 V across it. This does not mean the supply voltage is doubled.

Lesson 10 practice

Series and parallel circuits + bulb-brightness practical

Answer independently. Show a clear method, substitutions and units for calculations.

1. State current rule for series circuits. [1]

2. State p.d. rule for parallel branches. [1]

3. Explain why adding a second identical lamp in series can reduce brightness. [3]

4. Describe a fair brightness comparison. [4]

5. Explain how branch currents recombine. [2]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 11 Equivalent resistance in series and parallel

P3.3.3-4 | Foundation

explain resistance changes qualitatively and solve series-resistor problems.

Resistors in series add: the effective resistance is the sum of their resistances.

Adding parallel branches gives more paths for charge, so effective resistance decreases; the specification requires this qualitatively.

Use series resistance to predict how current changes for a fixed supply p.d.

Worked example

Two series resistors of 4 Ω and 8 Ω have Rtotal = 12 Ω. With a 6 V supply, I = 6/12 = 0.50 A. The p.d.s are 2 V and 4 V respectively; they add to 6 V.

Lesson 11 practice

Equivalent resistance in series and parallel

Answer independently. Show a clear method, substitutions and units for calculations.

1. Calculate total resistance of 3 Ω, 5 Ω and 7 Ω in series. [2]

2. Explain qualitatively why parallel resistance decreases. [3]

3. A 12 V supply is connected to 6 Ω total resistance. Calculate current. [2]

4. Explain why adding a series resistor reduces current. [2]

5. State whether parallel effective resistance is greater or less than either branch alone. [1]

Practice total 10 marks

Self check Write one correction you made and why it matters.

Lesson 12 Sensing and testing circuits LDRs, thermistors and diodes

P3.3.5 | Foundation

explain how d.c. series circuits can be used for measurement and sensing.

An LDR has lower resistance in brighter light. An NTC thermistor has lower resistance at higher temperature.

A diode is useful when current should pass mainly in one direction.

Changes in resistance can change current or the p.d. across parts of a sensing circuit, allowing environmental monitoring.

Worked example

An NTC thermistor drops from 1000 Ω to 500 Ω on heating. If held at a constant 2 V, its current rises from 2 mA to 4 mA. In a control circuit the changing resistance provides a signal about temperature.

Lesson 12 practice

Sensing and testing circuits: LDRs, thermistors and diodes

Answer independently. Show a clear method, substitutions and units for calculations.

1. How does LDR resistance change in brighter light? [1]

2. How does NTC thermistor resistance change when heated? [1]

3. Explain one use of an LDR sensing circuit. [3]

4. Why is a diode useful in a one-direction circuit? [2]

5. Explain how changing sensor resistance can alter current. [3]

Practice total 10 marks

Self check Write one correction you made and why it matters.

Lesson 13 Electrical energy transfer, power and E = QV

P3.4.1-3 | Foundation

describe electrical work and calculate energy transferred using charge and p.d.

When current flows through a component, the supply does work and transfers energy to the component and surroundings.

Power is energy transferred per unit time: P = E/t.

Use E = QV for energy transferred when charge Q moves through potential difference V.

Worked example

A heater transfers 3600 J in 120 s. P = E/t = 3600/120 = 30 W, meaning 30 J transferred each second on average.

Lesson 13 practice

Electrical energy transfer, power and E = QV

Answer independently. Show a clear method, substitutions and units for calculations.

1. State the meaning of electrical power. [2]

2. Calculate power if 120 J is transferred in 30 s. [2]

3. Calculate energy transferred by 20 C through 6 V. [2]

4. Explain where energy goes in a heater. [2]

5. Calculate charge if 240 J is transferred through 12 V. [3]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 14 Electrical power P = VI and P = I^2R

P3.4.4 | Foundation

calculate electrical power from p.d., current and resistance.

Use P = VI when p.d. and current are known.

Use P = I^2R when current and resistance are known.

Check units carefully and distinguish power in watts from energy in joules.

Worked example

A 5 Ω resistor carries 2 A. P = I^2R = 2^2 × 5 = 20 W. Over 30 s it transfers E = Pt = 20 × 30 = 600 J. Square the current before multiplying by resistance.

Lesson 14 practice

Electrical power: P = VI and P = I²R

Answer independently. Show a clear method, substitutions and units for calculations.

1. Calculate power at 12 V and 2 A. [2]

2. Calculate power for 3 A through 4 Ω. [2]

3. A 60 W device operates at 12 V. Calculate current. [3]

4. Explain difference between power and energy. [2]

5. State the SI unit of power. [1]

Practice total 10 marks

Self check Write one correction you made and why it matters.

Lesson 15 Transformer power and efficient transmission

P3.4.5-6 | Foundation

use conservation of energy in transformers and explain high-voltage transmission.

For an ideal transformer, input power equals output power: VpIp = VsIs.

If voltage is stepped up, current must decrease for the same power transfer.

Lower current reduces heating losses in transmission cables, so high-voltage transmission is more efficient.

Worked example

An ideal transformer receives 230 V at 0.20 A. Pin = 46 W. If output p.d. is 11.5 V, Is = 46/11.5 = 4.0 A. The larger current does not create extra power because voltage is lower.

Lesson 15 practice

Transformer power and efficient transmission

Answer independently. Show a clear method, substitutions and units for calculations.

1. A transformer output is 12 V at 5 A. Calculate output power. [2]

2. An ideal transformer has 240 V, 0.5 A input and 12 V output. Calculate output current. [3]

3. Explain why stepping up voltage reduces current for same power. [3]

4. Explain why low current reduces cable losses. [3]

5. State the ideal power relationship. [2]

Practice total 13 marks

Self check Write one correction you made and why it matters.

Lesson 16 Permanent magnets, fields, Earth and induced magnetism

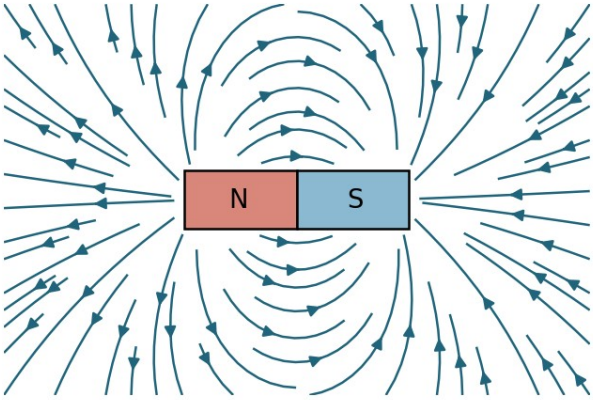
P3.5.1-4 | Foundation

describe permanent-magnet interactions, field patterns, Earth's field and induced magnets.

Like magnetic poles repel and unlike poles attract.

Magnetic field lines show direction and relative strength; outside a bar magnet they run from north to south and are closer where the field is stronger.

A compass aligns with Earth's magnetic field. Magnetic materials may be induced to become magnets; permanent magnets retain magnetisation more strongly.



Worked example

Place a compass at several points around a bar magnet and mark the direction of its north-seeking end. The directions trace a field from the magnet’s north pole towards its south pole outside the magnet. Move the compass, not the magnet, while mapping.

Lesson 16 practice

Permanent magnets, fields, Earth and induced magnetism

Answer independently. Show a clear method, substitutions and units for calculations.

1. State attraction/repulsion rules for poles. [2]

2. Describe the field outside a bar magnet. [3]

3. Explain how a compass gives evidence for Earth's magnetic field. [3]

4. Distinguish permanent and induced magnets. [2]

5. Where is a bar magnet's field strongest? [1]

Practice total 11 marks

Self check Write one correction you made and why it matters.

Lesson 17 Magnetic fields from currents and solenoids

P3.5.5-8 | Foundation

describe fields around wires and explain how solenoids/electromagnets can be strengthened.

A current-carrying wire produces concentric magnetic-field lines around it.

Increasing current strengthens the field; increasing distance from the wire weakens it.

A solenoid combines the fields from many turns. More turns, larger current and an iron core can strengthen the electromagnet.

Worked example

A solenoid carrying current produces a field like a bar magnet, with a strong field inside. Reverse the current and the poles swap. Add a soft-iron core and the induced magnetisation increases the field strength.

Lesson 17 practice

Magnetic fields from currents and solenoids

Answer independently. Show a clear method, substitutions and units for calculations.

1. Describe the field around a straight current-carrying wire. [2]

2. State two ways to strengthen an electromagnet. [2]

3. Explain why a solenoid has a stronger field than one loop. [3]

4. How does field strength change with distance from a wire? [1]

5. Explain the role of an iron core. [2]

Practice total 10 marks

Self check Write one correction you made and why it matters.

Lesson 18 Loudspeakers and headphones

P3.5.9 | Higher only awareness

Recognise the tier boundary and identify the shared ideas that prepare for it.

This lesson concerns Higher-only outcomes. It is not part of the assessed Foundation practice or end-of-chapter assessment in this notebook.

Before moving to Higher, make sure you can explain the shared ideas in the preceding lessons. The Higher edition develops this extension with teaching, worked examples and questions.

Foundation retrieval

Foundation retrieval task: choose a shared lesson earlier in this chapter, explain its key idea without notes, then check your explanation against the lesson answer section.

Lesson 19 Motor effect and electric motors

P3.6.1-4 | Higher only awareness

Recognise the tier boundary and identify the shared ideas that prepare for it.

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Before moving to Higher, make sure you can explain the shared ideas in the preceding lessons. The Higher edition develops this extension with teaching, worked examples and questions.

Foundation retrieval

Foundation retrieval task: choose a shared lesson earlier in this chapter, explain its key idea without notes, then check your explanation against the lesson answer section.

Lesson 20 Electromagnetic induction, generators and transformers

P3.7.1-8 | Higher only awareness

Recognise the tier boundary and identify the shared ideas that prepare for it.

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Before moving to Higher, make sure you can explain the shared ideas in the preceding lessons. The Higher edition develops this extension with teaching, worked examples and questions.

Foundation retrieval

Foundation retrieval task: choose a shared lesson earlier in this chapter, explain its key idea without notes, then check your explanation against the lesson answer section.

End of chapter assessment

Foundation | Total 57 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

1. Explain static charging using electron transfer. [4]

2. A current of 0.35 A flows for 4.0 min. Calculate charge. [3]

3. A resistor has 9.0 V across it and carries 0.30 A. Calculate resistance. [2]

4. Describe a method to investigate resistance of a wire. [5]

5. Describe the I-V behaviour of a fixed resistor, lamp and diode. [5]

End of chapter assessment continued

Foundation | Total 57 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

6. A charge of 5.0 C transfers 30 J. Calculate the p.d. [2]

7. Compare series and parallel circuits in terms of current and p.d. [5]

8. Three series resistors are 4 Ω, 7 Ω and 9 Ω across 10 V. Calculate current. [3]

9. Explain how LDRs and thermistors can be used as sensors. [4]

10. A device transfers 1800 J in 60 s. Calculate power. [2]

End of chapter assessment continued

Foundation | Total 57 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

11. A heater carries 3.0 A through 8 Ω. Calculate power. [2]

12. An ideal transformer has 240 V, 0.50 A input and 12 V output. Calculate output current. [3]

13. Explain why high-voltage transmission reduces cable losses. [4]

14. Describe magnetic field patterns for a bar magnet and a current-carrying wire. [4]

15. Explain how to increase a solenoid's magnetic field. [3]

End of chapter assessment continued

Foundation | Total 57 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

16. Distinguish permanent and induced magnets. [2]

17. Explain what a compass shows about Earth's magnetic field. [3]

18. State how reversing the current in a solenoid affects its north and south poles. [1]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 1 Static electricity charging, attraction and repulsion

1. Electrons transfer between the materials during rubbing. The object gaining electrons becomes negative and the one losing them becomes positive. The charges are equal and opposite if the pair is isolated. [maximum 3]

2. They repel. [maximum 1]

3. The rod causes a redistribution/polarisation of charge in the neutral paper. Opposite charge is effectively closer to the rod than like charge. The attraction on the nearer charge exceeds the repulsion, so there is a net attraction. [maximum 3]

4. A rapid discharge through air. A sufficiently strong electric field ionises the air, allowing charge to flow. [maximum 2]

5. Two charged objects attract or repel while separated by a gap. Motion without touching demonstrates a non-contact force. [maximum 2]

Lesson 2 Electron transfer model

1. Electrons. [maximum 1]

2. Negative. [maximum 1]

3. Protons are bound inside nuclei. Rubbing transfers some outer electrons, not nuclei/protons between the solid materials. [maximum 2]

4. Electrons lost by one object are gained by the other. The pair gains equal and opposite net charges. Total charge of the isolated pair is unchanged. [maximum 3]

5. Describe electrons moving instead. If the rod ends positive, it has lost electrons to the cloth; positive protons did not migrate into it. [maximum 2]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 3 Electric fields

1. A region in which an electric charge experiences an electric force. [maximum 2]

2. Radially outwards from the positive charge, in the direction a small positive test charge would be pushed. [maximum 2]

3. The field strength of an isolated charge decreases with distance. The same test charge therefore experiences a smaller force farther away. [maximum 2]

4. A source charge produces a field in the surrounding region. A second charge experiences a force due to that field at its position, without the objects touching. [maximum 3]

5. Draw radial lines with arrowheads pointing towards the negative charge. Lines do not cross and are more closely spaced near the charge. [maximum 2]

Lesson 4 Current as rate of flow of charge; Q = It

1. A complete conducting path and a source of potential difference. [maximum 2]

2. $Q = It = 0.30 \times 20 = 6.0$ C. [maximum 2]

3. $t = 2 \times 60 = 120$ s. $I = Q/t = 48/120 = 0.40$ A. [maximum 3]

4. Charge is conserved and does not steadily accumulate at one point in a series loop. The same amount per second passes every point. [maximum 2]

5. The lamp transfers energy, not consumes charge. Current into and out of a series lamp is equal. [maximum 2]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 5 Resistance, potential difference and V = IR

1. I = V/R = 12/6 = 2.0 A. [maximum 2]

2. R = V/I = 9/0.30 = 30 Ω. [maximum 2]

3. I = V/R, so current decreases as resistance increases at fixed p.d. [maximum 2]

4. 250 mA = 0.250 A. [maximum 1]

5. R = 8/0.4 = 20 Ω. [maximum 2]

Lesson 6 PAG7 investigating resistance of a wire

1. Connect the ammeter in series with the wire and supply. Connect the voltmeter in parallel across the tested length. Include current limiting and a switch as appropriate. [maximum 3]

2. Wire material, cross-sectional area and temperature. [maximum 3]

3. Resistance changes with temperature. Heating would introduce another variable when investigating length. [maximum 2]

4. Measure V across the length and I through it. Calculate R = V/I in ohms for each tested length. [maximum 2]

5. Example: heating biases resistance, so use a small current and switch off between readings. Accept another specific limitation with a suitable improvement. [maximum 2]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 7 Linear and non-linear components

1. At constant temperature, a straight line through the origin: current is proportional to potential difference. [maximum 2]

2. As current increases, the filament gets hotter and its resistance rises. On an I-against-V graph the gradient decreases as the magnitude of V increases, so the trace curves. [maximum 3]

3. It carries appreciable current mainly in one direction. Reverse current is very small in normal operation; forward current rises rapidly beyond its turn-on region. [maximum 2]

4. The fixed-resistor trace is linear (the straight line through the origin). [maximum 1]

5. Heating increases lattice vibrations in the metal. These impede the movement of conduction electrons, so resistance rises. [maximum 3]

Lesson 8 PAG6 I-V characteristics and circuit symbols

1. Use a low-voltage supply, lamp and ammeter in series, with a voltmeter across the lamp. Adjust p.d. using a variable resistor/suitable supply. Record several paired V and I readings, within safe ratings. Reverse polarity for negative values. Plot I against V and repeat/check readings. [maximum 5]

2. It changes circuit current and the component p.d., allowing a range of paired readings. [maximum 2]

3. In parallel across the component. [maximum 1]

4. Repeats help reveal anomalies and estimate scatter. Averaging suitable repeated readings reduces the effect of random variation. [maximum 2]

5. Any four appropriate components, for example cell, switch, lamp, resistor, ammeter, voltmeter, diode, thermistor or LDR. [maximum 4]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 9 Potential difference as work done per charge

1. Energy transferred (work done) per unit charge between two points. [maximum 2]

2. V = E/Q = 18/3 = 6.0 V. [maximum 2]

3. E = QV = 5 × 12 = 60 J. [maximum 2]

4. 1 V means 1 joule of energy transferred per coulomb of charge (1 J/C). [maximum 2]

5. Q = E/V = 40/8 = 5.0 C. [maximum 3]

Lesson 10 Series and parallel circuits + bulb-brightness practical

1. The current is the same at every point in a series circuit. [maximum 1]

2. Each parallel branch has the same p.d. across it. [maximum 1]

3. Adding a lamp increases total resistance, reducing current. The supply p.d. is shared, and each lamp receives less power than one alone at the same supply. [maximum 3]

4. Use identical lamps and a fixed supply p.d. Compare a single lamp with series/parallel arrangements using a light sensor at the same distance and background conditions. Allow stable readings and repeat; stay within ratings. [maximum 4]

5. Total current entering a junction equals total current leaving. Returning branch currents add to give the main-circuit current. [maximum 2]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 11 Equivalent resistance in series and parallel

1. Rtotal = 3 + 5 + 7 = 15 Ω. [maximum 2]

2. Parallel branches provide additional paths for charge. At fixed supply p.d., the total current increases, so effective resistance V/Itotal decreases. [maximum 3]

3. I = 12/6 = 2.0 A. [maximum 2]

4. It raises total resistance. At the same supply voltage, I = V/R is smaller. [maximum 2]

5. Less than either branch resistance (for positive finite resistances). [maximum 1]

Lesson 12 Sensing and testing circuits LDRs, thermistors and diodes

1. It decreases. [maximum 1]

2. It decreases for an NTC thermistor. [maximum 1]

3. An LDR can sense falling light level in an automatic lamp. Its resistance rises as it becomes darker; the sensing/control circuit responds by switching the lamp on. The switching circuit determines the output behaviour. [maximum 3]

4. A diode conducts appreciably in its forward direction and blocks normal reverse current, so it can enforce one-direction flow. [maximum 2]

5. At fixed p.d. across the sensor, I = V/R. Lower sensor resistance gives larger current. In a multi-component circuit, analyse how p.d. is shared as well. [maximum 3]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 13 Electrical energy transfer, power and E = QV

1. Rate of energy transfer by electrical working. [maximum 2]

2. P = E/t = 120/30 = 4.0 W. [maximum 2]

3. E = QV = 20 × 6 = 120 J. [maximum 2]

4. Electrical working increases the internal energy of the heater. Heating then transfers energy to the target and surrounding material. [maximum 2]

5. Q = E/V = 240/12 = 20 C. [maximum 3]

Lesson 14 Electrical power P = VI and P = I^2R

1. P = VI = 12 × 2 = 24 W. [maximum 2]

2. P = I^2R = 3^2 × 4 = 36 W. [maximum 2]

3. I = P/V = 60/12 = 5.0 A. [maximum 3]

4. Energy is an amount transferred, in joules; power is its transfer rate, in watts (joules per second). [maximum 2]

5. The watt, W. [maximum 1]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 15 Transformer power and efficient transmission

1. Pout = VsIs = 12 × 5 = 60 W. [maximum 2]

2. Pin = 240 × 0.5 = 120 W. Ideal Pout = 120 W, so Is = 120/12 = 10 A. [maximum 3]

3. For a fixed power, I = P/V. Increasing voltage reduces the current needed for the same power transfer. [maximum 3]

4. Cable heating power is I^2R. Reducing current therefore reduces unwanted heating strongly when resistance is unchanged. [maximum 3]

5. VpIp = VsIs for an ideal transformer; input power equals output power. [maximum 2]

Lesson 16 Permanent magnets, fields, Earth and induced magnetism

1. Like poles repel; unlike poles attract. [maximum 2]

2. Outside a bar magnet field lines run from N to S, curve around the magnet and do not cross. They are closest near the poles, where the field is strongest. [maximum 3]

3. A compass is a small magnet that turns to align with the local field. Its consistent approximate north–south alignment shows that Earth has a magnetic field. [maximum 3]

4. A permanent magnet retains a magnetic field. An induced magnet becomes magnetised in an external field and may lose most magnetisation when that field is removed. [maximum 2]

5. Near its poles. [maximum 1]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 17 Magnetic fields from currents and solenoids

1. Concentric circles centred on the wire; direction follows the right-hand grip rule. [maximum 2]

2. Any two: increase current, add more turns per unit length, insert a suitable soft-iron core. [maximum 2]

3. Fields from neighbouring turns combine and reinforce inside the coil. The resulting field is stronger and approximately uniform inside a long solenoid. [maximum 3]

4. It decreases with distance. [maximum 1]

5. The iron becomes magnetised and strengthens/concentrates the field produced by the coil. [maximum 2]

Assessment answers

Indicative marking guidance. Award distinct valid points and correct method, up to the stated maximum.

1. Electrons transfer between the materials during rubbing. The object gaining electrons becomes negative and the one losing them becomes positive. The charges are equal and opposite if the pair is isolated. The resulting electric interaction acts without contact. [maximum 4]

2. 4.0 min = 240 s; $Q = It = 0.35 \times 240 = 84$ C. [maximum 3]

3. $R = V/I = 9.0/0.30 = 30\ \Omega$. [maximum 2]

4. Connect a supply, current limiter, ammeter and wire in series, with voltmeter across the selected length. Measure length, V and I; calculate $R = V/I$. Repeat for several lengths. Control material, diameter and temperature, using low current and switching off between readings. Credit five distinct method points. [maximum 5]

5. Fixed resistor at constant temperature: straight line through origin (1). Lamp: curved with decreasing I–V gradient at larger |V| as resistance rises on heating (2). Diode: appreciable forward current but very small reverse current in normal operation (2). [maximum 5]

6. $V = E/Q = 30/5.0 = 6.0$ V. [maximum 2]

7. Series: same current everywhere (1); supply p.d. shared and component p.d.s add (1). Parallel: same p.d. across branches (1); total current splits into branches (1) and equals their sum at a junction (1). [maximum 5]

Assessment answers continued

Indicative marking guidance. Award distinct valid points and correct method, up to the stated maximum.

8. Rtotal = 4 + 7 + 9 = 20 Ω. I = 10/20 = 0.50 A. [maximum 3]

9. LDR resistance decreases with light intensity (1); a control circuit uses that change to detect light/dark (1). NTC resistance decreases with temperature (1); its change provides a temperature-dependent signal (1). [maximum 4]

10. P = E/t = 1800/60 = 30 W. [maximum 2]

11. $P = I^2R = 3.0^2 \times 8 = 72$ W. [maximum 2]

12. Input power = 240 × 0.50 = 120 W. Ideal output power equals this, so Is = 120/12 = 10 A. [maximum 3]

13. At fixed power P = VI (1), higher voltage gives lower current (1). Cable dissipation is I^2R (1), so it decreases at lower current for fixed cable resistance (1). [maximum 4]

14. Bar magnet: curved field lines outside from N to S, closest near poles (2). Straight wire: concentric circular field lines, direction determined by current/right-hand grip rule (2). [maximum 4]

Assessment answers continued

Indicative marking guidance. Award distinct valid points and correct method, up to the stated maximum.

15. Increase current, increase turns per length, insert a soft-iron core (one each). [maximum 3]

16. A permanent magnet retains a magnetic field. An induced magnet becomes magnetised in an external field and may lose most magnetisation when that field is removed. [maximum 2]

17. A compass is a small magnet that turns to align with the local field. Its consistent approximate north–south alignment shows that Earth has a magnetic field. [maximum 3]

18. The north and south poles swap. [maximum 1]

Knowledge organiser

Lesson 1 Static electricity charging, attraction and repulsion

Rubbing certain insulating materials can transfer electrons between their surfaces. One object becomes negatively charged because it gains electrons; the other becomes positively charged because it loses electrons.

Lesson 2 Electron transfer model

Only electrons are transferred in ordinary static charging; protons remain bound in nuclei.

Lesson 3 Electric fields

An electric field is a region where a charge experiences a force. Field diagrams help represent strength and direction.

Lesson 4 Current as rate of flow of charge; Q = It

Current is the rate of flow of charge. A source of potential difference and a closed conducting path are needed for a steady current.

Lesson 5 Resistance, potential difference and V = IR

Potential difference drives charge through resistance. For a given resistance, increasing p.d. increases current; for a given p.d., increasing resistance reduces current.

Lesson 6 PAG7 investigating resistance of a wire

Measure current through the test wire with an ammeter in series and p.d. across it with a voltmeter in parallel.

Lesson 7 Linear and non-linear components

A fixed resistor at constant temperature has an approximately straight-line I-V graph through the origin.

Lesson 8 PAG6 I-V characteristics and circuit symbols

Use an ammeter in series and voltmeter in parallel with the component. Vary the p.d. using a variable resistor or variable supply and collect positive/negative readings where appropriate.

Retrieval task Explain each idea without notes, then check it. For calculations, state the equation and SI units.

Knowledge organiser continued

Lesson 9 Potential difference as work done per charge

Potential difference measures energy transferred per unit charge between two points.

Lesson 10 Series and parallel circuits + bulb-brightness practical

In series, current is the same through each component and the supply p.d. is shared between components.

Lesson 11 Equivalent resistance in series and parallel

Resistors in series add: the effective resistance is the sum of their resistances.

Lesson 12 Sensing and testing circuits LDRs, thermistors and diodes

An LDR has lower resistance in brighter light. An NTC thermistor has lower resistance at higher temperature.

Lesson 13 Electrical energy transfer, power and E = QV

When current flows through a component, the supply does work and transfers energy to the component and surroundings.

Lesson 14 Electrical power P = VI and P = I^2R

Use P = VI when p.d. and current are known.

Lesson 15 Transformer power and efficient transmission

For an ideal transformer, input power equals output power: VpIp = VsIs.

Lesson 16 Permanent magnets, fields, Earth and induced magnetism

Like magnetic poles repel and unlike poles attract.

Retrieval task Explain each idea without notes, then check it. For calculations, state the equation and SI units.

Knowledge organiser continued

Lesson 17 Magnetic fields from currents and solenoids

A current-carrying wire produces concentric magnetic-field lines around it.

Retrieval task Explain each idea without notes, then check it. For calculations, state the equation and SI units.

Publication notes and references

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