GCSE ONLINE TUTORING

x RS REMOTE TUTORING

OCR GCSE Physics B

Twenty First Century Science J259

COMPLETE CHAPTER P8

Practical Skills

Higher Tier

Systematic lesson notebook

Plan and carry out practical work, record measurements, analyse data and explain how to improve the evidence.

PAG	Core investigations
1	Density of solids and liquids
2	Forces and springs
3	Speed and acceleration
4	Measuring waves
5	Energy transfers
6	Circuit component characteristics
7	Series and parallel circuits
8	Reflection refraction and wave interactions

Eight lessons with methods, original data practice, practical record pages, a 30-mark assessment, worked answers and a knowledge organiser.

Name _____ Class _____

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How to use this notebook

P8 brings together the practical skills used across P1 to P6 and the evidence skills in P7. For each PAG, study the method, complete the practice and use the record page during a teacher-approved activity. Record what you actually did and measured, including changes to the method.

Practical requirements

OCR requires at least eight practical activities covering the specified apparatus and techniques. PAGs group techniques; they are not eight uniquely prescribed experiments. Centres may choose suitable alternatives. The example investigations here support preparation but completing written pages alone does not replace practical experience.

Foundation and Higher

All eight PAGs are included. Higher adds one analysis or evaluation extension per lesson. These extensions increase demand; they do not represent a different OCR apparatus checklist.

Use each three page lesson

1. Method and analysis: identify the quantities, apparatus, sequence, controls, hazard and expected relationship.
2. Practice: work from the original classroom dataset, showing units and calculations.
3. Practical record: enter your own plan, diagram, measurements, conclusion and evaluation during supervised work.

Keep evidence honest

The printed practice datasets are invented for learning. Do not copy them into a record of work you performed. Retain unusual readings and note any justified exclusions. Repeats help estimate variation but do not remove fixed zero offsets or other systematic errors.

Before switching on or loading apparatus

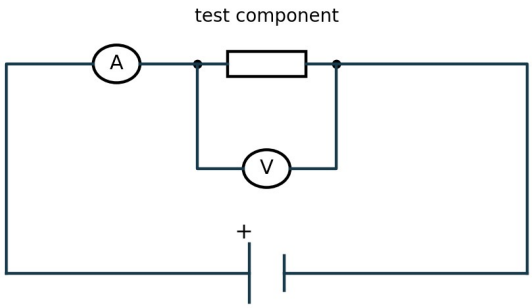
Use the centre’s approved procedure and risk assessment. Ask the teacher to check circuits, heaters, stands and moving equipment where required. Record a hazard, the possible harm and a matching precaution. Never improvise a mains circuit.

Specification basis: Cambridge OCR J259 Version 5.0, July 2026, Chapter P8, printed pages 59-61. Lesson numbering follows PAG1 to PAG8, not P1 to P8 content chapters.

Reading apparatus diagrams

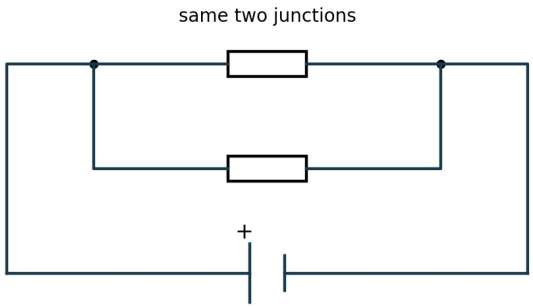
Use diagrams to identify connections and reference points before collecting readings. These simplified examples show the measurement arrangement; add the specific switch, current limit and controls required by your approved method.

Component measurement



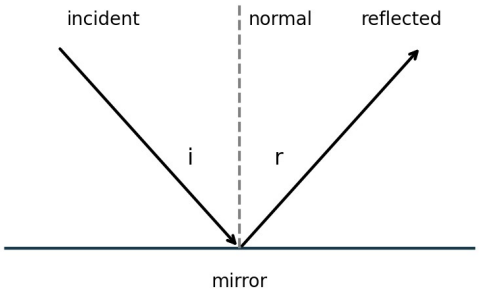
A in series; V across the component

Two parallel branches



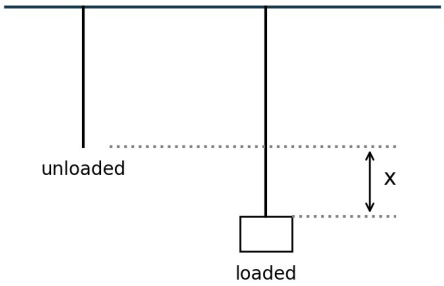
Each branch is across the supply

Reflection from a plane mirror



Measure both angles from the normal

Extension from two length readings



x = loaded length - original length

Check the setup

The rectangular circuit symbol represents a resistor. The ammeter lies in the current path and the voltmeter connects to the two ends of the component. Parallel branches share the same pair of junctions. A connection at a junction is marked by a dot.

In the spring sketch, the straight vertical lines only mark the endpoint positions. Measure both lengths from the same fixed reference. For a ray diagram, draw the normal before using the protractor.

Draw a standard circuit diagram for the PAG6 investigation, including the chosen test component, supply, switch, current control and meters.

PAG1 Materials

Determine density for regular solids, irregular solids and liquids.

Apparatus and quantities

Balance, ruler or callipers, measuring cylinder, water, regular block, insoluble irregular object and a suitable liquid.

Method to understand and adapt

1. Check the balance zero. Measure the mass of the dry solid. For a rectangular block, measure length, width and height at several positions; calculate volume = length × width × height.

2. For an irregular object, record the initial cylinder volume. Lower the object fully into water, remove trapped air and read the new volume. Its volume is the increase. For an overflow can, fill to the spout and let excess water drain before positioning an empty collecting cylinder. Lower the object fully into the can and measure the displaced water.

3. For a liquid, measure the mass of an empty dry container, then the container with a known liquid volume. Subtract to find liquid mass. Read the bottom of a water meniscus at eye level. Repeat with suitable volumes and record units.

Processing and expected pattern

Calculate density = mass/volume. Convert units before calculating in SI units: 1 g = 0.001 kg and 1 $cm^3 = 10^{-6}$ m^3. Compare repeated results and investigate differences between objects. Measure projected area as length × width if needed; area is not volume.

Errors and useful improvements

An irregular or tapered block limits a simple length × width × height model. Trapped air makes displacement too large and calculated density too small. A small volume change has a large percentage reading uncertainty. Choose a suitable cylinder, check submersion and repeat.

Safety

Glass may break and water can spill. Use stable equipment, handle objects gently and clear spills. Select non-reactive objects that will not dissolve. Do not immerse electrical equipment.

PAG1 practice

Materials

Original practice data

Object	Mass / g	Dimensions or volume readings
Block	54	2.0 cm × 3.0 cm × 4.0 cm
Irregular solid	81	Water: 40 cm³ to 70 cm³
Liquid	Empty container 40; filled 104	Liquid volume 80 cm³

1. Calculate the block volume and density in g/cm³. [3]

2. Calculate the irregular solid density in kg/m³. [3]

3. Find the liquid mass and density in g/cm³. [2]

4. Explain how trapped air affects an irregular solid density result and give an improvement. [3]

5. A displacement is 6.0 cm³. Each cylinder reading has uncertainty ±0.5 cm³. Use a conservative sum to estimate percentage uncertainty in the displacement, and explain a better choice of object. [3]

Practice total 14 marks

PAG1 practical record

Materials | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Object or trial	Mass / g	Volume / cm^3	Density / g cm^{-3}

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG2 Forces

Measure spring extension, test proportional behaviour and estimate work done.

Apparatus and quantities

Clamp stand with a secure base, spring, ruler, pointer, mass hanger and slotted masses or a force meter. Use g = 10 N/kg for this notebook unless told otherwise.

Method to understand and adapt

1. Secure the stand and measure the unloaded length. Add small known loads, including the hanger mass when calculating total force F = mg with mass in kg. Wait for movement to stop and read the pointer at eye level.

2. Record the loaded length and subtract the original length to find extension. Increase force in suitable steps within the safe range identified by a pilot. Repeat readings or loading sequences.

3. Unload and check the original length. Return to the starting length indicates elastic behaviour; it does not on its own establish a straight force-extension relationship. Stop if the spring becomes permanently stretched.

Processing and expected pattern

Plot force vertically against extension horizontally. In the straight region through zero, gradient k = F/x in N/m. The area under a force-extension graph is work done in J. For a straight line through zero, use triangle area = ½Fx. Convert cm to m.

Errors and useful improvements

Parallax changes a ruler reading; use a pointer and eye-level reading. Record extension rather than total length. A constant length offset can cancel when taking a difference, but poor alignment still matters. Use a large gradient triangle on the best-fit line.

Safety

Falling masses can injure feet; a released spring can move suddenly. Secure the stand, use a low catch tray and keep faces clear. Follow the teacher's load limit.

PAG2 practice

Forces

Original practice data

Force / N	Original length / cm	Loaded length / cm
0.0	10.0	10.0
0.5	10.0	12.0
1.0	10.0	14.0
1.5	10.0	16.0

1. Find extension at 1.0 N, in metres. [2]

2. Calculate the spring constant from the data. [2]

3. Find the work done from zero to 1.5 N using graph area. [3]

4. Explain why unloading is useful, and give one precaution for the experiment. [2]

5. A new material returns to its original length but has a curved force-extension graph. Evaluate the claim that it obeys Hooke’s law and explain how the work done in stretching it could be estimated. [3]

Practice total 12 marks

PAG2 practical record

Forces | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Force / N	Length / cm	Extension / m	Repeat or check

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG3 Motion

Use distance and time measurements to determine speed and acceleration.

Apparatus and quantities

Trolley, ramp, stop block, card of measured length, two light gates with a timer or data logger, ruler and stable supports.

Method to understand and adapt

1. Set up a shallow ramp with a secure stop at the end. Measure the card length in the direction of travel. Align two light gates so the card interrupts each beam cleanly.

2. Release the trolley from rest at a marked position without pushing. Record each beam-interruption time and the elapsed time between the centres of the two speed measurements, using the data logger's suitable timing mode.

3. Calculate speed at each gate as card length divided by interruption time. Estimate acceleration from change in speed divided by the time between those measurements. Repeat from the same position. Vary one factor, such as ramp slope, and keep the trolley, release point and gate positions fixed when appropriate.

Processing and expected pattern

Speed = distance/time; mean acceleration = (final speed - initial speed)/elapsed time. A light-gate speed is an average over the short card passage and approximates instantaneous speed if the card is short enough. Distance between gates divided by travel time gives an average over that section, not both endpoint speeds.

Errors and useful improvements

Human timing is a large fraction of a short journey; light gates reduce reaction error. Card length, alignment and gate timing definitions still matter. A push at release changes initial speed. A long card averages over more acceleration, whereas a very short card increases relative length uncertainty.

Safety

Secure ramp supports, keep the trolley on the bench and use a stop block or catch arrangement. Keep feet clear of falling apparatus. Do not place hands in the moving trolley's path.

PAG3 practice

Motion

Original practice data

Quantity	Value
Card length	0.050 m
Gate 1 interruption	0.100 s
Gate 2 interruption	0.050 s
Time between speed measurements	0.40 s

1. Calculate speed at each gate. [3]

2. Calculate the mean acceleration between the measurements. [2]

3. Explain why the trolley must be released without a push and from the same position for repeats. [2]

4. Give a measurement limitation of a light-gate method and a targeted improvement. [2]

5. The logger times between the leading edges arriving at the gates. Explain why that interval may not exactly match the interval between the two speed estimates, and propose a remedy. [3]

Practice total 12 marks

PAG3 practical record

Motion | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Trial	Card length / m	Gate 1 interruption / s	Gate 2 interruption / s	Midpoint interval / s

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG4 Measuring waves

Choose methods for measuring wavelength, frequency and speed in water and solid media.

Apparatus and quantities

Ripple tank with straight wave source, lamp and scale; alternatively a vibrating string with a suitable low-voltage driver. Stopwatch, camera or strobe used under supervision.

Method to understand and adapt

1. Set a shallow, even water depth. Produce steady straight ripples at a known frequency. Use illumination and a scale to locate crests. If a projected image is used, calibrate its scale rather than assuming the image is life size.

2. Measure across several complete wavelengths, from one crest to another, then divide by the number of gaps. Count gaps, not simply crests. Determine frequency from a calibrated driver or count cycles in a recording with a known time scale and sufficient frame rate. Do not try to count rapid ripples by eye.

3. Calculate wave speed = frequency × wavelength. Repeat for another suitable frequency while maintaining water depth. For a solid medium, use a string: measure a known number of loops in a standing pattern; each loop is half a wavelength. Keep string tension and length controlled for a comparison.

Processing and expected pattern

Use $v = f\lambda$, with λ in m and f in Hz. Count N cycles in time t using $f = N/t$. A direct travel method uses distance divided by wave-travel time where observation or video resolution makes this feasible. Compare the apparatus response with the speed and size of the waves.

Errors and useful improvements

Blur makes single-crest readings uncertain; measuring several gaps reduces relative uncertainty. Reflections at the tank edge can disturb the pattern. Use steady waves, suitable damping and a consistent water depth. A stationary-looking strobe image does not mean the water is motionless; aliasing is possible.

Safety

Keep electrical equipment and connections away from spilled water. Use the approved tank supply. Avoid staring at flashing lights; follow school guidance for photosensitivity. Do not touch a moving driver.

PAG4 practice

Measuring waves

Original practice data

Measurement	Value
Distance across 5 crest-to-crest gaps	15.0 cm
Cycles counted in a suitable recording	40
Elapsed real time in recording	2.0 s

1. Calculate wavelength in metres. [2]

2. Calculate frequency and wave speed. [3]

3. Explain why measuring five gaps is usually better than measuring one gap. [2]

4. A string shows three loops over 0.60 m. Find wavelength. [2]

5. A projected ripple pattern is 1.5 times life size. A wavelength measured on the screen is 4.5 cm at 20 Hz. Calculate the real wave speed and explain the error if screen scale is ignored. [3]

Practice total 12 marks

PAG4 practical record

Measuring waves | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Trial	Gaps counted	Distance / m	Frequency / Hz	Speed / m s^{-1}

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG5 Energy

Determine specific heat capacity and measure energy transfers and work.

Apparatus and quantities

Metal block with heater and thermometer holes, balance, low-voltage heater suitable for the block, thermometer, insulation, timer and joulemeter or suitable voltage/current meters.

Method to understand and adapt

1. Measure the block mass. Fit the heater and thermometer with good thermal contact, following the teacher's instructions. Insulate the block and use a safe initial temperature well below any limit.

2. Record initial temperature. Supply electrical energy and measure it with a joulemeter, or calculate input energy from measured VIt if voltage and current remain sufficiently steady. Record heating time and final temperature.

3. Calculate temperature rise. Use several readings of input energy and temperature where possible, and repeat or compare results after allowing suitable cooling. Check that the thermometer reading represents the block rather than only the hot region near the heater.

Processing and expected pattern

For energy transferred to the block, $\Delta E = mc\Delta\theta$, so $c = \Delta E/(m\Delta\theta)$. Electrical input is not necessarily all transferred to the block. A plot of input energy vertically against temperature rise horizontally has approximate gradient mc if losses are small. Work done by a constant force along its displacement is $W = Fd$; force-extension graph area handles varying spring force.

Errors and useful improvements

Energy lost to surroundings or stored in the heater makes using all electrical input overestimate c for the block. Insulation reduces loss; good thermal contact and time for the thermometer to respond reduce temperature mismatch. Repeat readings do not remove consistent heat-loss bias.

Safety

The block and heater become hot. Use a heat-resistant mat, switch off before adjusting equipment, allow cooling and avoid touching hot metal. Use approved low-voltage apparatus and do not leave the heater energised unattended.

PAG5 practice

Energy

Original practice data

Quantity	Value
Block mass	0.50 kg
Electrical input energy	4500 J
Initial temperature	20.0 °C
Final temperature	30.0 °C

1. Calculate temperature rise and the experimental value of specific heat capacity. [3]

2. Explain how energy loss affects this calculated value. [2]

3. A heater operates at 12 V and 2.0 A for 150 s. Calculate electrical energy transferred. [2]

4. A 4.0 N force moves an object 0.50 m in its direction. Calculate work done and give a suitable safety precaution for the block experiment. [2]

5. For a 0.50 kg block, input-energy against temperature-rise gradient is 480 J/°C. Calculate c assuming negligible losses, then explain why insulation is still needed. [3]

Practice total 12 marks

PAG5 practical record

Energy | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Time / s	Input energy / J	Temperature / °C	Rise / °C

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG6 Circuit components

Measure current and potential difference and investigate resistor, lamp and diode characteristics.

Apparatus and quantities

Low-voltage DC supply, switch, ammeter, voltmeter, variable resistor or adjustable supply, fixed resistor, filament lamp, diode and protective current-limiting resistor.

Method to understand and adapt

1. With the supply off, put the ammeter in series with the test component and connect the voltmeter across it. Check meter polarity, range and connections. Use a current-limiting resistor for a diode and observe component ratings.

2. Change the potential difference in small steps. Record current and component voltage at each setting. For negative values, reverse the supply connections with the power off and record signs consistently. Do not exceed safe reverse voltage or forward current for a diode.

3. Repeat for the components. Keep a fixed resistor’s temperature approximately constant with low currents and brief readings. A lamp is deliberately investigated over a range where its filament temperature changes, so its resistance may change.

Processing and expected pattern

Plot I vertically against V horizontally. A fixed resistor at constant temperature has a straight line through zero. A filament lamp curve becomes less steep as |V| increases because its resistance rises as it heats. A diode carries appreciable current mainly in one direction once the forward voltage is sufficient. Calculate resistance at a point using R = V/I; the I-V gradient is not generally resistance.

Errors and useful improvements

An ammeter connected across the supply can cause a very large current. A voltmeter in series does not measure component voltage correctly. Check the diagram before switching on. Reading a rapidly changing current or allowing unintended heating can make comparisons inconsistent.

Safety

Use only approved low-voltage supplies. Switch off before changing connections, avoid short circuits and protect the diode from excessive current. Lamps and resistors may become hot.

PAG6 practice

Circuit components

Original practice data

V / V	Fixed resistor I / A	Lamp I / A
1.0	0.10	0.18
2.0	0.20	0.28
3.0	0.30	0.34

1. State how to connect an ammeter and a voltmeter for a component measurement. [2]

2. Calculate the fixed resistor resistance at 2.0 V. [2]

3. Calculate lamp resistance at 1.0 V and 3.0 V, to two significant figures. [2]

4. Explain the difference between the two I-V characteristics and state a diode precaution. [3]

5. Explain why using the reciprocal of a tangent gradient on a curved lamp I-V graph does not generally give the lamp's V/I resistance at that point. [3]

Practice total 12 marks

PAG6 practical record

Circuit components | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Component	V / V	I / A	R = V/I / ohm

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG7 Series and parallel circuits

Construct and check circuits using diagrams and test current and voltage rules.

Apparatus and quantities

Low-voltage supply, switches, connecting leads, two suitable lamps or resistors, ammeter and voltmeter. Use identical lamps when comparing brightness.

Method to understand and adapt

1. Draw the planned circuit using standard symbols. With power off, build a series circuit and check the path against the diagram. Measure current at different positions and voltage across each component and the supply.

2. Build a parallel circuit with two branches. Measure total current before the junction, then each branch current. Measure voltage across each branch. Switch off before moving meters and check each connection.

3. Compare series and parallel lamps at the same supply voltage, within their ratings. Keep lamps and supply conditions controlled. Judge brightness cautiously: voltage and current measurements provide stronger quantitative evidence about electrical power than visual appearance alone.

Processing and expected pattern

Series: current is the same throughout; component voltages add to the supply voltage. Parallel: branch voltages equal the supply; branch currents add to total current. Use P = VI to compare power where relevant. Identical lamps generally receive less power in series than separately across the same supply; lamp resistance changes with temperature, so simple fixed-resistance brightness calculations need care.

Errors and useful improvements

Measure actual supply voltage under load; an unregulated supply may change when the circuit changes. Loose contacts add resistance. Inserting an ammeter can slightly change a circuit, so suitable low-resistance meters and consistent procedures matter. A parallel voltmeter measures two points, not a current through a wire.

Safety

Prevent short circuits and avoid bypassing a lamp with a wire. Check current ratings before making a parallel circuit, which can draw more total current. Lamps can be hot.

PAG7 practice

Series and parallel circuits

Original practice data

Arrangement	Measurements
Series at 6.0 V	$I = 0.20$ A; $V_1 = 2.4$ V; $V_2 = 3.6$ V
Parallel at 6.0 V	$I_1 = 0.20$ A; $I_2 = 0.30$ A

1. State the current through each series component and check the voltage rule. [2]

2. Find total current and each branch voltage in the parallel circuit. [2]

3. Calculate power transferred to the second series component. [2]

4. Explain why lamp comparisons need a measured supply voltage and identify a short-circuit hazard. [2]

5. Parallel branch currents are 0.24 A and 0.31 A; the total-current meter reads 0.57 A. Evaluate whether this alone disproves the junction rule and propose checks. [3]

Practice total 11 marks

PAG7 practical record

Series and parallel circuits | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Circuit or position	Supply V / V	Component V / V	Current / A

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

PAG8 Interactions of waves

Measure reflection and refraction and observe how waves interact with matter.

Apparatus and quantities

Ray box with a narrow visible beam, plane mirror, transparent rectangular block or prism, paper, pencil, ruler and protractor; ripple tank for water-wave interactions where available.

Method to understand and adapt

1. For reflection, draw a mirror line and a normal at right angles. Place the mirror on the line. Mark two separated points on incident and reflected rays, then draw their paths with a ruler after removing the apparatus.

2. Measure incidence and reflection angles from the normal, not the mirror surface. Repeat at several incidence angles. Use a narrow beam and check the mirror is aligned; mirror backing may create a small positional offset.

3. For refraction, trace the block outline before shining the ray. Mark incoming and outgoing paths, remove the block and join entry and exit points to reconstruct the internal ray. Draw the normal at each surface and measure angles. In a ripple tank, observe reflection at a barrier, refraction at a depth change and diffraction through a gap; choose gap size comparable with wavelength to see strong spreading.

Processing and expected pattern

Reflection predicts i = r. A ray entering glass from air bends towards the normal when incident obliquely; it bends away when leaving. A rectangular block with parallel faces gives a parallel emerging ray displaced sideways in the usual air-glass-air setup. A prism generally changes the emerging direction. Visible light itself is an electromagnetic wave, so these observations investigate electromagnetic-wave interaction with matter.

Errors and useful improvements

Thick lines or a wide beam make angles uncertain. Mark widely separated points, use a sharp pencil and read the protractor carefully. Keep the normal exactly perpendicular. Do not infer that no direction change at normal incidence means no speed change. In water, changing depth changes wave behaviour; avoid confusing this with a frequency change at the boundary.

Safety

Do not look directly into the ray box or shine its beam into anyone’s eyes. Handle glass carefully and avoid hot lamp housings. Keep ripple-tank water away from electrical connections. Lasers are unnecessary for these activities.

PAG8 practice

Interactions of waves

Original practice data

Trial	Incidence / degrees	Reflection / degrees
1	20	21
2	40	39
3	60	60

1. State the predicted relationship and evaluate whether the data support it. [2]

2. A ray makes 30 degrees with the mirror surface. Find its angle of incidence. [2]

3. Describe how to locate the internal ray in a transparent block after removing it. [2]

4. Explain one way to improve angle measurements and predict bending from air into glass at an oblique angle. [2]

5. A ray enters a rectangular glass block obliquely and emerges parallel to its original direction. Explain why this does not mean no refraction occurred and give an observable check. [3]

Practice total 11 marks

PAG8 practical record

Interactions of waves | Complete during a supervised practical

Date _____ Partners _____ Activity or method reference _____

Aim and prediction with a scientific reason

Apparatus sketch or circuit diagram with labels and measuring positions

Independent quantity if varied _____ Measured outcome _____

Controls and how they are maintained

Hazard and matching precaution

Your measurements Add units and repeat columns or attach further records as needed

Trial	Incidence / degrees	Reflection or refraction / degrees	Observation

Calculation or graph reference and evidence based conclusion

Main limitation and a targeted improvement Note any method changes or excluded readings

Additional wave measurement methods

PAG4 also includes measuring sound in air. Choose an arrangement that resolves the travel time; a handheld stopwatch is usually unsuitable for a short one-way distance.

Two microphones and a time trace

Place two microphones a measured distance apart along the direction of sound travel. Connect them to a two-channel oscilloscope or suitable data logger. Make a brief sharp sound near one end, away from ears. Compare the same feature on the two recorded pulses to find its delay. Calculate speed = microphone separation/delay. Repeat at several separations to check consistency.

A 1.20 m separation with a 0.0035 s delay gives 1.20/0.0035 ≈ 343 m/s. At 0.001 s resolution, the uncertainty would be a large fraction of this delay, so choose a suitable time base and sampling rate. Check equal channel delays or use several distances and a distance-time graph to investigate a fixed timing offset.

Echo method

An alternative uses a large reflector at measured distance d. Record a pulse and its echo with suitable audio timing software, then use speed = 2d/delay. The factor of two accounts for the outward and return paths. Keep other reflecting surfaces in mind and identify the correct echo. Repeat and use a large enough distance for a resolved delay.

Prism method

For a triangular prism, trace its outline, mark two points on the incident and emerging rays, and reconstruct the internal ray by joining the entry and exit points. Draw a separate normal at each face. Measure incidence and refraction at a chosen face; the normals at the two faces are not parallel. Repeat at several incident directions. Do not assume the emerging ray will be parallel to the incoming ray.

Choosing a method

Use ripple-tank images for wavelengths large enough to locate, string patterns for waves in solids, and microphones for sound travel. Justify the instrument using its spatial or time resolution. A drawing of light refraction alone cannot directly time light across a classroom block.

Additional circuit investigations

The J259 practical descriptions also include LDRs, thermistors and resistance of a wire. Use the PAG6 meter arrangement, substituting the component as appropriate, and keep current within ratings.

Light dependent resistor

Use a low-current circuit with an ammeter in series and voltmeter across the LDR, or a suitable resistance meter on an isolated component. Change illumination using a lamp at measured positions or suitable light filters. Keep temperature and background lighting controlled. Allow readings to settle, measure V and I and calculate R = V/I. At a fixed light level, vary voltage to investigate an I-V characteristic without changing the illumination. Repeat for other light levels.

An LDR generally has lower resistance in brighter light. Lamp distance is a way to change illumination; it is not itself a measurement of light intensity. Avoid warming the LDR with the lamp because temperature could confound the comparison.

Thermistor

Use a school-approved negative-temperature-coefficient thermistor in a controlled warm-water bath if suitable for immersion, or in an approved protected arrangement. Measure bath temperature close to the sensor, allow thermal equilibration and use a small sensing current to limit self-heating. Record V and I and calculate resistance. At each fixed temperature, a range of voltage-current pairs can give an I-V characteristic if heating is kept negligible.

For an NTC thermistor, resistance decreases as temperature rises. Keep connections dry and use warm rather than dangerously hot water. Changing temperature and current at the same time prevents a clean interpretation; identify the controlled condition for each curve.

Resistance of a wire

Fix a uniform resistance wire along a ruler. Use a low-voltage supply and current limit. Measure voltage across a chosen length and current through it, then calculate R = V/I. Change the contact position to vary length while keeping material, diameter and temperature constant. Record several lengths and repeats; plot resistance against length. Switch off between readings to reduce heating, and check contact positions carefully. Wire can become hot; do not use an unrestricted short length.

For a uniform wire at fixed temperature, resistance is proportional to length. A non-zero graph intercept may suggest contact or connection resistance, so inspect the setup before claiming the material violates the model.

Additional methods practice

1. Two microphones 1.50 m apart record a sound delay of 0.0045 s. Calculate speed, to two significant figures. [2]

2. A reflector is 17 m away. The echo delay is 0.10 s. Calculate sound speed and explain the distance used. [3]

3. An LDR carries 0.0020 A at 4.0 V in dim light and 0.0080 A at 4.0 V in bright light. Calculate both resistances. [2]

4. Explain why thermistor temperature must be allowed to settle and why sensing current should be small. [2]

5. A wire experiment changes length from 0.20 to 0.40 m but also allows heating. Explain why its result does not isolate the effect of length and suggest an improvement. [2]

Practice total 11 marks

Practical skills toolkit

Measure a useful interval

Choose apparatus whose range and resolution suit the quantity. Read a ruler and water meniscus at eye level. Check instrument zero. Measure several repeated distances or periods and divide to reduce relative reading uncertainty.

Build a reproducible method

State the independent and dependent quantities, controls, apparatus, range, intervals and repeats. Explain how a measured quantity is calculated. Include a labelled setup diagram, units, a safe sequence and a check that equipment remains suitable.

Record complete evidence

Use headings containing quantity and unit. Record raw values before calculating. Keep observations, unusual readings and changes to procedure. More objects sample material variation; more readings of one object assess repeatability.

Draw and interpret graphs

Plot paired numerical values with suitable axes and scales. Show means and range bars where useful; state what bars mean. Draw a suitable best-fit line or curve. Use a large triangle for gradient and give its units. Extrapolation beyond the data needs caution.

Make a justified conclusion

Quote numerical evidence and the tested range. Explain whether observations support a prediction. Consider uncertainty, alternative explanations and whether the proposed pattern is physically reasonable. Matching data support a model without proving it universally.

Improve the right problem

Random error creates scatter; repeats can improve a mean. A systematic error consistently biases results; fix the offset, calibration or method. Link an improvement to the effect it reduces. More repeats do not remove heat loss or incorrect meter placement.

Planning challenge across the PAGs

Choose one investigation from this book. Write a plan that another student could follow, then exchange plans and identify a missing detail. This planning challenge is not part of the 30-mark assessment.

Aim hypothesis and predicted graph

Apparatus and labelled setup

Range controls and method sequence

Hazards and precautions

Planned analysis and a check on data quality

End of chapter assessment 1

Measurements and energy | 12 marks

1. An irregular solid has mass 96 g. Cylinder readings are 30 cm^3 before immersion and 62 cm^3 afterwards. Calculate density in kg/m^3. [3]

2. Explain one measurement problem that could make this density too small and a matching improvement. [2]

3. A 0.40 kg block receives 3600 J electrical input and warms by 10 °C. Calculate the experimental specific heat capacity. [2]

4. Explain why heat loss can bias this result and how to reduce it. [3]

5. A card 0.040 m long interrupts a light gate for 0.080 s. Calculate the trolley speed and state one limitation. [2]

End of chapter assessment 2

Waves and circuits | 10 marks

1. Six wavelength gaps span 18 cm. Frequency is 25 Hz. Calculate wavelength in metres and speed. [3]

2. A ray is at 25 degrees to a plane mirror surface. Calculate the incidence and predicted reflection angles. [2]

3. State correct meter connections to measure component current and voltage, and calculate resistance at 3.0 V and 0.15 A. [3]

4. Parallel branch currents are 0.12 A and 0.18 A across a 4.0 V supply. Give total current and voltage across each branch. [2]

End of chapter assessment 3

Planning a spring investigation | 8 marks

Plan an investigation that determines a spring constant and tests whether a spring obeys Hooke's law over a chosen range. Justify controls, data collection, analysis, checks and safety. Explain how you would recognise a limit to the model. [8]

Score _____ / 30 Practical skill to revisit _____

Practice answers PAG1 and PAG2

Indicative marking points. Accept equivalent correct explanations. Award each point once, up to the stated maximum.

PAG1 Materials

1. Volume = 2.0 × 3.0 × 4.0 = 24 cm^3 (1); density = 54/24 (1) = 2.25 g/cm^3, or 2.3 to two significant figures (1).

2. Displaced volume = 30 cm^3 (1); 0.081 kg/(30 × 10^{-6} m^3) (1) = 2700 kg/m^3 (1).

3. Mass = 104 - 40 = 64 g (1); density = 64/80 = 0.80 g/cm^3 (1).

4. Measured displacement too large (1); density too small (1); remove bubbles/check complete wetting before reading (1).

5. Difference uncertainty estimated as ±1.0 cm^3 (1); 1.0/6.0 × 100 ≈ 17% (1); use a larger fully submerged object of the same material to increase displacement relative to reading uncertainty (1). This sum is an explicitly requested conservative estimate.

PAG2 Forces

1. 14.0 - 10.0 = 4.0 cm (1) = 0.040 m (1).

2. k = 1.0/0.040 (1) = 25 N/m (1).

3. Final extension 0.060 m (1); ½ × 1.5 × 0.060 (1) = 0.045 J (1).

4. Checks whether original length is recovered/elastic behaviour (1); suitable falling-mass/stand precaution (1).

5. Returning length supports elastic behaviour (1); curved graph means F is not proportional to x, so Hooke's law does not apply throughout (1); estimate area under the loading graph using small strips/squares (1).

Practice answers PAG3 and PAG4

Indicative marking points. Accept equivalent correct explanations. Award each point once, up to the stated maximum.

PAG3 Motion

1. v = card length/interruption time (1); first speed = 0.50 m/s (1); second = 1.0 m/s (1).

2. (1.0 - 0.50)/0.40 (1) = 1.25 m/s² (1).

3. Avoids changing its initial speed/energy (1); gives consistent starting conditions (1).

4. Any linked pair, e.g. inaccurate card length (1), measure it carefully with suitable apparatus and repeat/check (1).

5. Each speed averages a finite card passage (1); its representative time is nearer the middle of that passage, so leading-edge timing differs (1); use midpoint timestamps/a suitable logger mode, or assess a shorter card with sufficient length precision (1).

PAG4 Measuring waves

1. 15.0/5 = 3.0 cm (1) = 0.030 m (1).

2. f = 40/2.0 = 20 Hz (1); v = 20 × 0.030 (1) = 0.60 m/s (1).

3. Longer measured distance (1); reading uncertainty is a smaller fraction of it (1).

4. Each loop is half a wavelength, so 0.60 = 3λ/2 (1); λ = 0.40 m (1).

5. Real wavelength = 4.5/1.5 = 3.0 cm (1); speed = 20 × 0.030 = 0.60 m/s (1); ignoring scale gives speed 1.5 times too high (1).

Practice answers PAG5 and PAG6

Indicative marking points. Accept equivalent correct explanations. Award each point once, up to the stated maximum.

PAG5 Energy

1. Rise = 10.0 °C (1); c = 4500/(0.50 × 10.0) (1) = 900 J/(kg °C) (1).

2. Less than 4500 J heats the block (1); using all input energy therefore overestimates c (1).

3. E = VIt = 12 × 2.0 × 150 (1) = 3600 J (1).

4. W = Fd = 2.0 J (1); valid hot-equipment/electrical precaution (1).

5. c = gradient/m = 480/0.50 (1) = 960 J/(kg °C) (1); heat loss would make input energy exceed energy stored by the block and bias the estimate (1).

PAG6 Circuit components

1. Ammeter in series (1); voltmeter in parallel across the component (1).

2. R = 2.0/0.20 (1) = 10 ohms (1).

3. 1.0/0.18 = 5.6 ohms (1); 3.0/0.34 = 8.8 ohms (1).

4. Fixed resistor approximately constant resistance (1); lamp heats and resistance increases (1); use a current-limiting resistor/observe ratings (1).

5. Tangent gradient is a local change ΔI/ΔV (1); V/I uses the coordinates relative to the origin (1); on a curved graph the tangent and origin-to-point gradients generally differ (1).

Practice answers PAG7 and PAG8

Indicative marking points. Accept equivalent correct explanations. Award each point once, up to the stated maximum.

PAG7 Series and parallel circuits

1. Each current 0.20 A (1); 2.4 + 3.6 = 6.0 V (1).

2. Total = 0.20 + 0.30 = 0.50 A (1); each branch 6.0 V (1).

3. P = VI = 3.6 × 0.20 (1) = 0.72 W (1).

4. Supply voltage can change under load and affect brightness (1); a low-resistance bypass can cause excessive current/heating (1).

5. Expected sum is 0.55 A (1); 0.02 A discrepancy may reflect uncertainty or changing conditions (1); check meter calibration/resolution, contacts and stable supply, ideally measure consistently under unchanged conditions (1).

PAG8 Interactions of waves

1. i = r (1); differences of at most 1 degree are consistent with small measurement uncertainty, so data support it (1).

2. Angle measured from the normal (1); i = 90 - 30 = 60 degrees (1).

3. Mark block outline and entry/exit points (1); join entry and exit points with a straight line (1).

4. Narrow beam/sharp pencil/widely separated points with suitable explanation (1); towards the normal (1).

5. It bends at entry (1) and in the opposite sense at exit through parallel faces (1); inspect the internal ray or lateral displacement (1).

Additional methods answers

1. v = 1.50/0.0045 (1) ≈ 330 m/s to two significant figures (1).

2. Sound travels out and back, so distance = 34 m (1); v = 34/0.10 (1) = 340 m/s (1).

3. Dim: 4.0/0.0020 = 2000 ohms (1); bright: 4.0/0.0080 = 500 ohms (1).

4. Ensures sensor is at the measured bath temperature (1); small current limits self-heating (1).

5. Temperature also changes resistance (1); low current/switch off between readings/control temperature (1).

What to check in a practical record

Your record should contain the actual date and activity, the question investigated, a clear diagram, raw measurements with units, calculations or a referenced graph, a conclusion tied to evidence, and an improvement linked to a limitation. Attach extra measurements, repeats and graph paper where needed.

For a sound experiment, identify the time feature used and whether the path is one-way or a return trip. For a sensor, record the temperature or light condition associated with each set of readings. For resistance of a wire, record the measured length and any measures taken to limit heating.

Further investigation

Choose a practical result that disagreed with a prediction. Identify an instrument or method check before changing the model. Then suggest a new comparison that could distinguish two possible explanations. Your answer will depend on the observations actually made.

Assessment answers

Assessment page 1

1. Volume = 32 cm^3 (1); $0.096/(32 \times 10^{-6})$ (1) = 3000 kg/m^3 (1).

2. Trapped air/too large displacement (1); remove bubbles and check submersion before reading (1).

3. $c = 3600/(0.40 \times 10)$ (1) = 900 J/(kg °C) (1).

4. Not all input heats the block (1); calculated c too high (1); insulate the block appropriately (1).

5. Speed = 0.50 m/s (1); valid limitation, e.g. speed is an average during card passage or card length uncertainty (1).

Assessment page 2

1. Wavelength = 18/6 = 3.0 cm = 0.030 m (1); $v = 25 \times 0.030$ (1) = 0.75 m/s (1).

2. Incidence = 65 degrees (1); reflection = 65 degrees (1).

3. Ammeter series (1); voltmeter across component (1); R = 20 ohms (1).

4. Total 0.30 A (1); each branch 4.0 V (1).

Assessment page 3

Award one mark for each: suitable apparatus measuring load and length; extension from loaded minus original length; controlled setup with suitable range and steps; repeated measurements and assessment of spread; best-fit force-extension plot in SI units; gradient gives k in linear region; detect departure from straight proportional behaviour and unload to distinguish non-linearity from permanent deformation; specific safety precaution linked to hazard.

No grade boundaries are implied. Use the assessment to identify particular measurement, calculation or evaluation skills to revisit. Practical record pages and the open planning challenge have no single fixed answer.

Final knowledge organiser

PAG	Measurement	Processing	Main check
1	Mass and volume	$\rho = m/V$	Dry mass; remove bubbles; subtract container mass
2	Force and extension	$k = F/x$; work = graph area	Extension is a difference; check unloading
3	Card length and time	$v = d/t$; $a = \Delta v/\Delta t$	No push; align gates; correct time interval
4	Several gaps and cycle timing	$v = f\lambda$; $f = N/t$	Count gaps; calibrate projected scale
5	Mass energy temperature rise	$c = E/(m\Delta\theta)$; $E = VIt$	Heat loss biases c high
6	Component voltage and current	$R = V/I$ at a point	Ammeter series; voltmeter parallel
7	Branch and total readings	Series V add; parallel I add	Check actual supply under load
8	Angles and ray paths	i = r for reflection	Angles from the normal

Key conversions

1 cm = 0.01 m; 1 $cm^2 = 10^{-4}$ m^2; 1 $cm^3 = 10^{-6}$ m^3; 1 g = 0.001 kg; 1 mA = 0.001 A.
Use SI units before substitution. Keep working digits and round the final answer sensibly.

Evaluation vocabulary

Accuracy: closeness to a true or accepted value. Precision: small spread. Repeatability: same procedure, operator and equipment. Reproducibility: changed operator, equipment or method. Resolution: smallest distinguishable change. Random error: unpredictable variation. Systematic error: consistent bias.

One complete practical answer

Describe what is measured and how. Name controls and precautions. Explain the calculation or graph. Quote evidence, identify a limitation and link an improvement to it.

Practical experience tracker

Use this personal tracker alongside the centre's own records. Entries reflect actual experience; they do not certify centre compliance. A teacher may use alternative activities that collectively cover the apparatus and techniques.

PAG	Activity and date	Record location	Skill to improve
1			
2			
3			
4			
5			
6			
7			
8			

Apparatus and technique reflection

Identify where you measured length, area, mass, time, volume and temperature, used circuit diagrams, measured motion and energy, and observed waves interacting with matter. Add an activity or record reference for each technique that needs further evidence. The techniques may be spread across multiple activities.

Publication notes and references

Independent publication

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Specification and scope

Cambridge OCR GCSE Physics B J259 specification, Version 5.0, July 2026. Chapter P8, printed pages 59-61, supplies the practical framework. P1-P6 supply the physics relationships and P7 the investigation and evaluation skills. Direct specification PDF checked 14 November 2026.

https://www.ocr.org.uk/Images/234601-specification-accredited-gcse-twenty-first-century-science-suite-physics-b-j259.pdf

OCR, Example set of physics practicals. Used to cross-check the eight PAG areas and example activities.

https://www.ocr.org.uk/news/example-set-of-physics-practicals/

OCR, GCSE sciences practical activities. Consult the current qualification guidance for centre requirements.

https://www.ocr.org.uk/administration/general-qualifications/assessment/gcse-science-practical-activities/

Using the book

The example activities support, but do not replace, supervised practical experience, approved procedures and centre records. Printed practice data are not observations made by the learner. Additional recording or graph paper may be attached. Higher extensions are teaching choices within practical reasoning and are not a separate mandatory list.

Revised edition 2.0, 15 November 2026. Incorporates all changes from the reviewed P8 edition 1.1.