REAL-LIFE SCIENCE

Applications of Science

Teacher guide

For the National 3 and National 4 Science workbooks



C. Blewis

Blewis LEARNING

Using the workbooks

The National 3 and National 4 workbooks for **Applications of Science** are parallel: the same nine topics in the same order, the same contexts, and the same practical in every topic. Topic numbers match, so a mixed class can work together and each learner records the work at their own level.

HOW THE LEVELS DIFFER

N3	follows a given method, uses ready-made tables and graph frames, circles or ticks conclusions and improvements
N4	plans the investigation (variables, prediction, kit, risk, method), repeats readings, works out averages, draws graphs with their own scales, writes conclusions and evaluations

PRACTICAL SAFETY

Every practical has a Stay safe table and a teacher note with hazards, adapted versions and common problems. The Stay safe tables and these notes are a starting point, not a complete risk assessment: the teacher or school must risk assess every practical for their own learners, room and kit before use, following their employer's policies and national guidance (in Scotland, SSERC). Always check learners' care plans and medical information. Activities with flames or microbes are teacher demonstrations, with example results provided.

NO LAB, NO KIT, OR A LEARNER ABSENT

Each practical includes example results so learners can still complete the results, graph, conclusion and evaluation.

EVIDENCE

The practicals give evidence for the experiment and investigation outcome; the learn pages and check-ups give evidence for knowledge and problem solving. The skills tracker at the back of each workbook can be signed off as you go. Always check the latest course documents and your centre's arrangements.

Contents

Topic 1	Sending signals	**4**
Topic 2	Microphones, speakers and radio	**7**
Topic 3	Satellites and fibre optics	**10**
Topic 4	Plastics	**13**
Topic 5	Smart materials	**16**
Topic 6	Fibres and fabrics	**19**
Topic 7	Materials and the environment	**22**
Topic 8	Hazards and risk	**25**
Topic 9	Staying safe on the move	**28**

TEACHER NOTES

Practical 1: String telephone

Time	One 50-minute lesson in pairs. Making the telephones takes about 10 minutes. A corridor or hall gives room for the longer lengths.
Kit per pair	Two paper or plastic cups, 10 to 12 m of thin string (not fishing line: it is hard to see at head height and can cut skin under tension), two paper clips, a tape measure, five cards of 10 simple words each, a sharp pencil to make the holes.
Prep	Make the word cards in advance (simple words of similar difficulty, e.g. animals or colours). Pre-punch the cups for groups who would find this hard.
Expected results	Close to 10 words at 2 m, falling to about 4 to 6 words at 10 m. A slack string, or one touching a wall or table, gives very poor results.
Levels	N3 follows the given method, records one result per length and draws a bar chart on a ready-made frame. N4 plans the test (variables, prediction, kit, risk, method), repeats each length, averages and draws a line graph with their own scales.

Safety and inclusion

- Run the string away from doors and walkways, and do not leave it lying on the floor between tests.
- Each learner speaks into their own cup; cups are not put to the mouth.
- A learner with a hearing impairment can be the speaker or the recorder, or the test can use a phone sound-meter app at the listener's cup instead of words.
- Follow your school and local authority guidance on practical work.

Common problems

- **Slack string:** the vibrations die away. The string must be tight and touch nothing.
- **Hearing through the air:** at short distances the listener hears the speaker directly. Ask the speaker to talk quietly, or turn away.
- **Reusing word cards:** the listener learns the words. Use a new card each time.

No lab, no time, or a learner absent?

The sample results let learners complete the results, graph, conclusion and evaluation without doing the practical.

Assessment link

Gives evidence for the experiment and investigation outcome: following procedures safely, recording and presenting results, drawing a conclusion and evaluating (N3), plus planning the investigation (N4).

Answers: Topic 1

Topic 1: Sending signals (N3)

1 From beacon fires to the internet

1 Beacon fires.

2 only a little; in seconds.

3 Any two, e.g. text message, phone call, video call, email, social media, letter or card.

2 Sound or radio?

1 sound; radio waves; cannot.

2 Light.

3 Codes, and life online

1 SOS

2 Good, bad, good, bad.

3 e.g. do not share personal details or passwords; only talk to people you know; tell a trusted adult if something upsets you; block and report bullying.

Practical 1: How far can a string telephone reach?

Risk controls, e.g. use the string away from doors and walkways and tell people it is there; hold the cup firmly and do not over-tighten the string.

Expected results: fewer words heard as the string gets longer. Sample data: 10, 9, 7, 6 and 4 words.

Bar chart: five bars, falling from 10 at 2 m to 4 at 10 m.

Conclusion: fewer. Why: vibrations; quieter.

Improvement: repeats and an average are more reliable; recording the words keeps the voice the same; a quiet room means background noise does not spoil the test.

Check-up

1 Beacon fire, telephone, mobile phone. 2 faster; something to travel through. 3 Dots and dashes (short and long).

4 Fewer words were heard correctly (the sound was quieter). 5 e.g. you can call for help in an emergency, keep in touch with family.

Topic 1: Sending signals (N4)

1 From beacon fires to the internet

1 Advantage, e.g. very fast over long distances, needs no technology. Disadvantage, e.g. carries very little information (only yes or no), cannot be seen in fog or daylight, can be misread.

2 The telephone sent the actual sound of the voice; the telegraph could only send coded pulses.

3 time = distance ÷ speed = 800 ÷ 15 = 53.3 hours (over 2 days, and more with rests).

2 Sound waves and electromagnetic waves

1 Space is a vacuum: there are no particles to pass on the vibrations of sound. Radio waves are electromagnetic and need no medium.

2 time = distance ÷ speed = 680 ÷ 340 = 2 s

3 e.g. much faster; can travel through space to satellites; travel much further; can carry far more information; are not blocked by needing a material.

3 Analogue, digital and life online

1 HELP

2 e.g. digital signals can be copied and sent without getting worse; noise has little effect because the receiver only needs to tell on from off; digital data can be compressed and stored easily.

3 Improvement, e.g. calling for help in emergencies, keeping in touch, working from home, online learning, faster news. Problem, e.g. online bullying, scams, fake news, screen time and sleep, loss of privacy.

Practical 1: String telephone

Variables: change the length of the string (m); measure the number of words heard correctly (out of 10); keep the same: the speaker's voice and loudness, the words list length, the cups and string, how tight the string is, background noise.

Prediction, e.g. the longer the string, the fewer words heard, because more energy is lost from the vibrations along a longer string.

Equipment: paper cups, string, paper clips, tape measure, word cards. Not needed: thermometer, stopwatch.

Hazards, e.g. pulling the string too tight (cup pulls out of a hand: hold firmly, do not over-tighten); sharing cups (use your own, keep it away from your mouth).

Method key points: make the telephone with paper clips to anchor the string; measure the length with a tape; keep the string tight and not touching anything; read 10 new words in the same voice each time; count correct words; test 2, 4, 6, 8 and 10 m; repeat each length three times.

Headings: Length (m), Trial 1, 2, 3 (words), Average (words).

Sample averages: 2 m 9.7; 4 m 8.7; 6 m 7.3; 8 m 5.7; 10 m 4.3 words.

Graph: length (m) on the x axis, average words heard on the y axis, even scales, a downward line of best fit.

Conclusion: as the length of the string increased, the number of words heard correctly decreased.

Explain: the sound travels as vibrations along the string; some energy is lost along the way (to the air and as heat), so over a longer string the sound reaching the listener is quieter and harder to make out.

Evaluate: (a) e.g. play the words from a recording at the same volume, or measure the speaker's loudness with a sound-meter app. (b) e.g. more repeats; a quiet room; the same listener each time; new word lists of equal difficulty; keep the string tension the same.

Check-up

1 Sound is a vibration passed on by particles; space has no particles. Radio waves are electromagnetic waves, which need no medium.

2 distance = speed × time = 340 × 6 = 2040 m (about 2 km)

3 An analogue signal changes smoothly and can have any value; a digital signal has only two values, on (1) and off (0).

4 Any two of radio waves, microwaves, light (or infrared).

5 e.g. people can call for help anywhere; families keep in touch; but also online bullying, less face-to-face time, poor sleep.

TEACHER NOTES

Practical 2: Speaker cones

Time	One 50-minute lesson in pairs or threes. The readings themselves take about 15 minutes.
Kit per group	Two phones or tablets: one to play a steady tone (a free tone-generator app set to about 1000 Hz works well), one with a free sound-meter app. A paper cup, a cardboard tube, a thick plastic tumbler, a plastic bowl, a metre stick.
Prep	Check the apps work on school devices, or provide two tablets. A quiet room makes a big difference: avoid running this next to a noisy class.
Expected results	Readings of about 60 to 80 dB. Any cone raises the level by several decibels; hard, smooth, deep shapes are usually best. Apps differ, so compare within one group, not between groups.
Levels	N3 follows the given method, records one reading per cone and completes a ready-made bar chart. N4 plans the test (variables, prediction, kit, risk, method), takes repeat readings, averages and draws a bar chart with their own scale.

Safety and inclusion

- Keep volumes at half or below. Learners never hold a playing phone against their ear.
- Use a thick plastic tumbler, not glass, to avoid breakages.
- Learners with hearing loss or sound sensitivity can read the meter and record; ear defenders are fine as the meter does the measuring.
- Follow your school and local authority guidance on practical work.

Common problems

- **Readings jump about:** sound-meter apps fluctuate. Wait 5 seconds and take the steady value, or use the app's average.
- **Moving the meter:** keep it fixed, propped up in the same place.
- **Music instead of a tone:** music gets louder and quieter. Use a steady tone.

No lab, no time, or a learner absent?

The sample results let learners complete the results, graph, conclusion and evaluation without doing the practical.

Assessment link

Gives evidence for the experiment and investigation outcome: following procedures safely, recording and presenting results, drawing a conclusion and evaluating (N3), plus planning the investigation (N4).

Answers: Topic 2

Topic 2: Microphones, speakers and radio (N3)

1 From sound to electricity and back

1 microphone; bigger; sound.

2 Mobile phone; laptop.

3 The amplifier.

2 How radio works

1 Voice → microphone → transmitter → radio waves → (aerial and receiver) → loudspeaker.

2 do not need.

3 There is often no phone signal in the hills; radios work without a phone network.

3 Good and bad sides of technology

1 They were kept in a drawer (14 phones).

2 6

3 Take it to be recycled, or give it to someone who needs one.

Practical 2: Which cone makes a phone loudest?

Risk controls, e.g. keep the volume at half and do not hold the phone to your ear; use a thick tumbler (or a plastic one), hold it carefully and keep it away from the edge.

Expected results: any cone is louder than no cone; hard, smooth cones (tumbler, bowl) are usually loudest. Sample data: 62, 68, 70, 74, 72 dB.

Bar chart: five bars starting from the 50 dB line, the plastic tumbler tallest.

Conclusion: plastic tumbler; louder. Why: towards the meter; everywhere.

Improvement: an average of three readings is more reliable; a quiet room stops background noise changing the readings; the same volume keeps the test fair.

Check-up

1 Microphone: changes sound into a signal. Amplifier: makes the signal bigger. Loudspeaker: changes the signal back into sound.

2 Radio waves. 3 The aerial. 4 The plastic tumbler (in the sample results). 5 e.g. recycle it, give it away, sell it, keep using it for longer.

Topic 2: Microphones, speakers and radio (N4)

1 Microphones, amplifiers and loudspeakers

1 Microphone: sound energy to electrical energy. Loudspeaker: electrical energy to sound energy (and some heat).

2 It increases the amplitude (size) of the signal. The extra energy comes from its power supply (mains or battery).

3 The changing signal in the coil makes it a changing magnet, so it is pushed in and out by the permanent magnet; the coil moves the cone, which pushes the air back and forth, making sound waves.

2 Radio: transmitter to receiver

1 Microphone, (amplifier), transmitter, aerial on the mast, radio waves, receiving aerial, receiver, amplifier, loudspeaker.

2 So that the receiver can pick out one station; if two stations used the same frequency their signals would mix (interfere).

3 Radio waves can be blocked by hills and buildings; a high mast lets the waves reach further, over the hills, to more listeners.

3 Technology, society and the environment

1 6 ÷ 28 × 100 = 21.4, so about 21%.

2 The metals and plastics inside could be recycled and used again; keeping them unused means more metals must be mined for new devices.

3 For, e.g. better phone signal, safety in emergencies, helps local businesses and home working. Against, e.g. spoils the view, some people worry about health (no evidence of harm at normal levels), cost, building work on the hill.

Practical 2: Speaker cones

Variables: change the type of speaker cone; measure the sound level (dB); keep the same: the sound played, the phone volume, the distance to the meter (50 cm), the position of the phone, the meter app.

Prediction, e.g. the plastic tumbler will give the highest sound level because its hard sides reflect the sound towards the meter.

Equipment: phone, phone with a sound meter app, cup, tube, tumbler, metre stick. Not needed: thermometer.

Hazards, e.g. loud sounds (keep the volume low, never hold the phone against your ear); phone falling (keep it in the middle of the bench); cables (keep them tidy so no one trips).

Method key points: play the same tone at the same volume; meter 50 cm away, measured; place the phone the same way in each cone; take three readings per cone; average.

Headings: Speaker cone, Reading 1, 2, 3 (dB), Average (dB).

Sample averages: no cone 62 dB; paper cup 68 dB; cardboard tube 70 dB; plastic tumbler 74 dB; plastic bowl 72 dB.

Bar chart: a bar for each cone, sound level (dB) on the y axis (may start at 50 dB if marked clearly), bars with gaps.

Conclusion: the plastic tumbler gave the highest sound level (74 dB), 12 dB more than no cone.

Explain: a cone directs the sound waves towards the meter instead of letting them spread in all directions; hard, smooth materials reflect sound well and absorb little of its energy.

Evaluate: (a) louder background noise would make some readings too high, so the results would not be a fair comparison. (b) e.g. a quiet room, more repeats, a tone from an app at a fixed volume, fixing the meter in a stand so the distance is the same.

Check-up

1 Microphone: sound → electrical. Loudspeaker: electrical → sound.

2 The signal flows through the coil, making it a magnet that changes; the permanent magnet pushes and pulls it, so the coil and cone vibrate in and out with the signal.

3 time = distance ÷ speed = 30 000 ÷ 300 000 000 = 0.0001 s

4 Problem, e.g. e-waste, mining for metals, energy used by networks and chargers. Reduce, e.g. recycle or reuse devices, repair them, keep them longer, switch chargers off, use renewable electricity.

5 Any two of: the sound played, the volume, the distance to the meter, the meter used, the position of the phone.

TEACHER NOTES

Practical 3: Light round the bends

Time	One 50-minute lesson in pairs. N3 and N4 can run together; N4 pairs repeat each reading three times.
Kit	1 m lengths of plastic (PMMA) optical fibre, 1 to 2 mm diameter (sold cheaply for craft and science; side-glow fibre shows the light escaping at bends very well). A small LED torch, a thick pen or 15 mm dowel, sticky tape, a phone or tablet with a free light meter app (or a data logger light sensor).
Prep	Cut fibre ends square with a sharp blade (adult only) so light gets in and out well. Check the app reads in lux. Dim the room if possible. Fresh torch batteries.
Expected results	The reading falls with each loop, often by 10 to 20% per loop round a pen. Exact values depend on the torch, the fibre and the phone. Side-glow fibre visibly glows at the tight bends where light escapes.
Levels	N3 follows the method, records one reading per test and draws a bar chart on a ready-made frame. N4 plans the test, repeats three times, averages, draws a line graph with their own scales and calculates percentage loss.

Safety and inclusion

- LED torches only; no lasers. Learners never look straight into a lit fibre end or torch.
- Do not kink the fibre; if it snaps, the ends can be sharp. Collect broken pieces.
- The whole practical can be done seated at a desk. A learner with limited fine motor control can read the meter while a partner wraps the loops.
- Follow your school and local authority guidance on practical work.

Common problems

- **Readings jump about:** the fibre end has moved on the sensor or room light is changing. Tape both ends firmly and shade the phone.
- **Loops of different sizes:** always wrap round the same pen, keeping the loops snug.
- **Demonstration:** shine an LED torch through the side of a clear bottle so the light follows a stream of water from a hole; the stream glows where light escapes.

No lab, no time, or a learner absent?

The sample results let learners complete the graph, conclusion and evaluation without the kit.

Assessment link

Evidence for the experiment and investigation outcome: following a procedure safely, recording and presenting results, concluding and evaluating (N3), plus planning and repeat measurements (N4).

Answers: Topic 3

Topic 3: Satellites and fibre optics (N3)

1 Satellites

1 Earth; radio waves.

2 Any two: TV, phone calls, satnav, weather forecasts, watching (mapping) the Earth, internet.

3 It shows them where they are and the way to go.

2 Dishes and signals

1 So it can catch the signal over its whole surface and bounce it to one spot, where the receiver is.

2 bigger.

3 Good: storm warnings, internet on ships. Problems: space junk, cost of launching.

4 They can get TV, phone and internet even though they are far from a town and cables.

3 Optical fibres

1 Light (flashes or pulses of light carrying messages).

2 bouncing.

3 To look inside the body (an endoscope) without big cuts.

4 Any one: it carries lots of information very fast; the signal stays strong; it is not affected by the weather.

Practical 3

Safety controls: never point the torch at anyone's eyes; bend the fibre gently and do not kink it.

Sample results: bars 420, 350, 300, 250 and 210 lux.

Conclusion: less. Why: escapes.

Improvement: repeating and averaging makes the results more reliable; a dark room stops other light changing the readings. A different torch each time is not a good idea (it would not be a fair test).

Check-up

1 Any two: TV, phone calls, satnav, weather, watching the Earth.

2 collect.

3 A zigzag line from the torch to the end, bouncing off the top and bottom walls of the fibre.

4 Any one: space junk; they cost a lot; rockets use lots of fuel.

Topic 3: Satellites and fibre optics (N4)

1 Satellites

1 It takes 24 hours to orbit, the same time as the Earth takes to spin, so it stays above the same point on the Earth.

2a 36 000 + 36 000 = 72 000 km.

2b 72 000 ÷ 300 000 = 0.24 s.

2 Dishes and signals

1 The curved dish reflects all the signal it collects to the focus, so the receiver gets the strongest signal there.

2 The signal at sea may be weaker (farther from the satellite's beam); a bigger dish collects more of the signal energy.

3 Problem: it can hit and damage working satellites (or the space station). Reduce it: e.g. bring old satellites down to burn up, move them to a "graveyard" orbit, design rockets that leave less debris.

4 Any one: weather satellites warn of storms; satnav helps rescue teams find people; satellite phones work in remote places.

3 Optical fibres

1 Light hits the inside wall at a shallow angle and is totally internally reflected, bouncing along the core to the other end.

2 Any two: carries much more information; signal stays strong over long distances; no electrical interference; thinner and lighter.

3 Any one: cost; disruption and traffic delays; it takes a long time to reach remote homes.

Practical 3

Variables: change the number of loops; measure the light reaching the meter (lux); keep the same: the torch (and batteries), the fibre, the pen (loop size), positions of torch and phone, room light.

Prediction example: more loops will let less light through, because some light escapes at each tight bend.

Kit: optical fibre, LED torch, pen, light meter app, tape. Not needed: thermometer, stopwatch.

Hazards: e.g. torch in eyes (point it only at the fibre); fibre snapping and leaving sharp ends (bend gently); tripping on a trailing fibre or bag.

Table headings: Number of loops, Trial 1 (lux), Trial 2 (lux), Trial 3 (lux), Average (lux).

Sample averages: 0 loops 423, 1 loop 349, 2 loops 301, 3 loops 252, 4 loops 213 lux.

Graph: number of loops on the x axis, average light (lux) on the y axis; a falling line.

Conclusion: as the number of loops increased, less light got through the fibre.

Explain: at tight bends, some light hits the wall at too steep an angle, so it is not totally internally reflected and escapes out of the side.

Evaluate a: (423 − 213) ÷ 423 × 100 = 49.6%, about 50% lost.

Evaluate b: e.g. more repeats; work in a darkened room or cover the phone; fix the torch and phone in clamps; check the reading is steady before recording.

Check-up

1 A satellite that orbits in 24 hours above the equator, so it stays over the same place. Use: TV broadcasting or communications.

2 The curve reflects all the signals to one point (the focus) where the receiver is; a bigger dish collects more signal energy.

3 Total internal reflection.

4 Advantage: e.g. carries lots of data quickly / signal stays strong / no interference. Issue: e.g. space junk / cost of launches / fuel / signal delay / e-waste.

5 72 000 ÷ 300 000 = 0.24 s.

TEACHER NOTES

Practical 4: Which bag is strongest?

Time	One 50-minute lesson in pairs or threes. Cutting the strips takes about 10 minutes; pre-cut them for groups who need more time.
Kit	Five plastic films (cling film, bin bag, thin carrier bag, freezer bag, thick reusable bag), scissors, ruler, clamp stand with boss and clamp (G-clamped to the bench or weighted), 100 g mass hanger and about 25 slotted 100 g masses, a tray of sand or a folded towel underneath, eye protection. Optional: 50 g masses.
Prep	Cut test strips 2 cm wide and 15 cm long, all in the same direction across the bag (films are stronger one way than the other). A hole punch makes a neat hole for the hanger; reinforce it with a square of tape.
Expected results	Thin films such as cling film fail at a few hundred grams; thick reusable bags hold over 2 kg. Thicker films hold more. Strips often stretch a long way before they break, so wait a few seconds after each mass.
Levels	N3 follows the method, tests one strip of each plastic and draws a bar chart on a ready-made frame. N4 plans a fair test, tests three strips of each plastic, averages and draws a bar chart with their own scale.

Safety and inclusion

- Falling masses are the main hazard: tray of sand or towel underneath, feet clear, add masses gently. Keep the mass hanger no more than about 10 cm above the sand tray. Do not go above about 3 kg. Strips can snap back: everyone wears eye protection and stands to the side.
- Clamp stands must be clamped to the bench or have a heavy base. Stand to the side of the masses.
- Scissors used carefully; pre-cut strips for learners with limited fine motor control. All roles can be done seated.
- Follow your school and local authority guidance on practical work.

Common problems

- **Strip tears at the hole:** reinforce the hole with tape, or fold the end over a paperclip hook.
- **Strip slips out of the clamp:** fold the top end over twice before clamping.
- **Counting the hanger:** remind learners the hanger itself is 100 g.

No lab, no time, or a learner absent?

The sample results let learners complete the averages, bar chart, conclusion and evaluation without doing the test.

Assessment link

Evidence for the experiment and investigation outcome: following a procedure safely, recording and presenting results, concluding and evaluating (N3), plus planning and repeat measurements (N4).

Answers: Topic 4

Topic 4: Plastics (N3)

1 What are plastics?

1 Crude oil.

2 long; insulator.

3 It is waterproof (also light and flexible).

2 Choosing the right plastic

1 Plug case: an insulator. Shower curtain: waterproof. Packaging for a phone: cushions and protects. Water bottle: clear and strong.

2 Plastic is light and does not smash if it is dropped; glass is heavy and breaks.

3 The handle needs to stay cool to hold (plastic does not let heat through easily), but the pan must be heated and plastic would melt.

4 Any sensible example, e.g. a ruler: strong, light, cheap; a chair seat: strong, waterproof, easy to wipe.

3 Plastic problems and solutions

1 They get tangled in it or eat it by mistake, which can hurt or kill them.

2 Take a reusable bottle to school; recycle clean plastic tubs.

3 Tiny bits of plastic (smaller than a grain of rice) that come from bigger plastic breaking up.

Practical 4

Safety controls: tray of sand underneath and keep feet clear; clamp the stand to the bench or use a heavy base.

Sample results: bars cling film 300, bin bag 900, thin carrier 1300, freezer bag 1600, thick reusable bag 2400 g.

Conclusion: the thick reusable bag was the strongest; thicker.

Which bag: thick reusable bag; strongest.

Improvement: testing three strips and averaging makes results more reliable; smaller masses near the end make the result more accurate. Strips of different widths would not be a fair test.

Check-up

1 Crude oil.

2 Any two: light, strong, flexible, waterproof, insulator, cheap, easy to shape.

3 rot.

4 Any one: reuse bags and bottles; recycle; say no to straws or single-use plastic; pick up litter.

5 Plastic is an insulator, so electricity cannot pass through it to your hand.

Topic 4: Plastics (N4)

1 What are plastics?

1 A monomer is a small molecule; a polymer is a very long molecule made by joining many monomers together.

2 Crude oil is finite (non-renewable), so the raw material for most plastics will become scarce and more expensive.

3 Any two: light, strong, waterproof, easy to clean, easy to shape, cheap.

2 Choosing the right plastic

1 A thermosetting plastic does not soften when heated, so the handle will not melt or bend near a hot pan.

2 Nylon (or polythene): strong fibres, waterproof, does not rot, flexible.

3 Thermoplastics soften when heated, so they can be melted down and remoulded; thermosetting plastics do not soften, so they cannot be remoulded.

3 Plastic problems and solutions

1 288 ÷ 400 × 100 = 72%.

2 Microplastics in the sea or soil are eaten by small animals such as plankton and shellfish, which are eaten by fish and people (they pass up the food chain).

3 Advantage: made from a renewable resource; some are biodegradable or compostable. Disadvantage: e.g. land used to grow crops for plastic instead of food; some only break down in special composting conditions; can contaminate recycling; can cost more.

Practical 4

Variables: change the type of plastic; measure the mass held before breaking (g); keep the same: width and length of strip, direction the strip is cut, size of masses added, time between masses.

Prediction example: the thick reusable bag will hold the most mass because it is the thickest plastic.

Kit: plastic strips, clamp stand, masses, tray of sand, ruler, eye protection (scissors). Not needed: thermometer.

Hazards: e.g. clamp stand tipping (clamp to bench, heavy base); scissors (cut away from hand); plastic snapping back (stand to the side).

Table headings: Plastic, Strip 1 (g), Strip 2 (g), Strip 3 (g), Average (g).

Sample averages: cling film 300 g, bin bag 900 g, thin carrier bag 1300 g, freezer bag 1600 g, thick reusable bag 2400 g.

Bar chart: type of plastic on the x axis, average mass held (g) on the y axis, bars of equal width with gaps.

Conclusion: the thick reusable bag was strongest, holding an average of 2400 g; cling film was weakest at 300 g.

Explain: it is thicker (more material, more polymer chains across the strip) so it needs a bigger force to break.

Evaluate a: the true breaking mass could be anywhere up to 100 g above the recorded value, so results are only accurate to the nearest 100 g.

Evaluate b: e.g. use 50 g or 10 g masses near the breaking point; test more strips; cut all strips in the same direction; add masses gently so they do not jerk the strip.

Check-up

1 Crude oil is separated at a refinery; small molecules (monomers) are joined into long chains (polymers), which make the plastic.

2 Thermoplastics soften when heated and can be reshaped; thermosetting plastics stay hard and do not soften.

3 It is an electrical insulator, flexible, tough and waterproof.

4 Animals get tangled in it or swallow it; it does not break down, and it forms microplastics.

5 150 × 60 ÷ 100 = 90 items.

TEACHER NOTES

Practical 5: How much water can a hydrogel soak up?

Time	One 50-minute lesson in pairs: about 10 minutes to set up and 30 minutes of soaking, with a weighing every 5 minutes. N3 and N4 run together.
Kit per group	Water-absorbing polymer crystals (garden "water crystals" sold for plant pots; avoid fine nappy powder, which forms an irritant dust), 250 cm^3 beaker, tea strainer or small sieve, top-pan balance reading to 0.1 g, stopwatch, paper towels, disposable gloves, eye protection.
Prep	Try the crystals first: coarse garden crystals can take an hour or more to swell, so choose a fine grade or soak a sample first to check. Use the same tap water for every group.
Expected results	The mass rises quickly at first, then levels off as the gel fills up: about 60 g from 0.5 g in tap water. In pure (distilled) water the gel swells much more; in salty water much less.
Levels	N3 follows the method, fills in a ready-made table and plots a line graph on a labelled frame. N4 plans the test, repeats it three times, averages and draws a line graph with their own scales.

Safety and inclusion

- The crystals are low hazard but must not be eaten or put near eyes; dry powder can be slippery if spilled. Gloves are sensible for learners with sensitive skin.
- Never pour gel down the sink: it can block drains. Put it in the general waste or use it in plant pots.
- Wipe up water at once. Use plastic beakers if glass is a concern. All roles can be done seated. Demos: thermochromic sheets, UV beads (never shine a UV torch into eyes), shape memory wire in warm water (the teacher pours the hot water).
- Follow your school and local authority guidance on practical work.

Common problems

- **Different drip times:** wet gel weighs more. Use a fixed 30 s drip each time.
- **Gel lost in the sieve:** tip it all back each time, or results drop.
- **Taring:** weigh the gel on a small dish and zero the balance with the empty dish first.

No lab, no time, or a learner absent?

Sample results let learners complete the graph, conclusion and evaluation without doing the practical.

Assessment link

Evidence for the experiment and investigation outcome: following a procedure safely, recording and presenting results, concluding and evaluating (N3), plus planning and repeat measurements (N4).

Answers: Topic 5

Topic 5: Smart materials (N3)

1 What is a smart material?

1 Colour-change mug: a hot drink. Glasses that darken: sunlight. Nappy gel: water.

2 changes.

3 Heat (warmth) from the person's body.

2 Colour-changing materials

1 thermochromic; photochromic.

2 It changes colour if the food is too hot, so the adult knows not to give it to the baby (it stops the baby burning their mouth).

3 They slowly go clear (light) again.

3 Materials that remember and soak

1 warmed.

2 It soaks up lots of liquid and holds it, so the baby stays dry.

3 Any one: glasses frames; a wire (stent) that holds open a blood vessel; brace wires.

Practical 5

Safety controls: crystals: wear gloves, keep away from mouth and eyes, wash hands after; water: wipe up spills straight away.

Graph: a curve rising steeply at first, then levelling off at about 60 g.

Conclusion: went up; stopped changing much. Why: soaks up; full.

Improvement: same drip time each weighing (fairer, less extra water) or repeat three times and average (more reliable). Using more crystals each time would not be fair.

5 60 − 0.5 = 59.5 g of water.

Check-up

1 A material that changes (colour, shape or size) when something around it changes, and changes back.

2 Thermochromic: changes colour when hot. Photochromic: changes colour in sunlight. Hydrogel: soaks up water.

3 e.g. glasses frames that spring back; a stent that opens a blood vessel.

4 Thermochromic.

Topic 5: Smart materials (N4)

1 What is a smart material?

1 Photochromic: stimulus light (ultraviolet). Shape memory alloy: change is shape (returns to its original shape). Hydrogel: use e.g. nappies, plant gel, wound dressings.

2 The change can be undone: when the stimulus is removed, the material returns to how it was.

3 A melting candle does not change back by itself when it cools to its old shape and has not been designed to respond; the change is not a reversible, useful response to a stimulus.

2 Colour-changing materials

1 The spoon changes colour if the food is above a safe temperature, so the adult can see it is too hot before feeding the baby.

2 Photochromic lenses darken in response to UV light; the windscreen blocks most UV, so there is no stimulus.

3 e.g. thermochromic paint on a wall panel or cushion that changes colour where hands touch it: body heat is the stimulus, so learners see their handprint, which is calming and fun to explore.

3 Materials that remember and soak

1 Folded up it is small enough to pass through the blood vessel; body heat then makes it return to its open shape and hold the vessel open.

2 It soaks up water and releases it slowly, so the soil stays moist for longer and the plant needs watering less often.

3 A piezoelectric material: stepping on it squeezes it, which makes a voltage that can switch on the lights.

Practical 5

Variables: change the time soaking; measure the mass of the gel (g); keep the same: mass of crystals, volume and type of water, drip time before weighing, the balance, water temperature.

Prediction example: the mass will go up quickly then level off, because the gel can only hold so much water.

Kit: crystals, beaker, sieve, balance, stopwatch, eye protection. Not needed: thermometer.

Hazards: crystals swallowed or in eyes (gloves, wash hands, no eating); spilled water or powder (wipe up at once, slip risk); gel blocking drains (bin it).

Headings: Time (min), Mass 1 (g), Mass 2 (g), Mass 3 (g), Average mass (g).

Sample averages: 0.5, 24.1, 39.1, 50.1, 56.1, 59.2, 60.4 g.

Graph: time on the x axis, average mass on the y axis, a smooth curve rising steeply then levelling off.

Conclusion: as time increased the mass of the gel increased, quickly at first and then more slowly, levelling off at about 60 g after 25 to 30 minutes.

9a Water soaked up = 60.4 − 0.5 = 59.9 g by 0.5 g, so about 59.9 ÷ 0.5 = 119.8 g (about 120 g) per gram of crystals.

10a Extra water clinging to the gel is weighed as if it had been soaked up, so the masses are too big (and vary from reading to reading).

10b e.g. a fixed drip time and blotting with paper towel the same way; repeat more times; weigh on a dish and tare the balance; use more frequent readings at the start.

Check-up

1 A material whose properties change in response to a stimulus (a change in its surroundings, such as heat, light, water or force), and change back when the stimulus is removed.

2 a UV light b water c force (being squeezed).

3 They return to their original shape when warmed.

4 Advantage e.g. quick, cheap, no batteries, nothing put in the mouth. Disadvantage e.g. less accurate than a digital thermometer; only shows whole degrees; can be affected by a warm room.

5 1.2 × 50 = 60 g of liquid.

TEACHER NOTES

Practical 6: Which fabric keeps the rain out?

Time	One 50-minute lesson in pairs. Each test takes about 4 minutes, so five fabrics take about 20 minutes, or one hour for N4 repeats unless groups share the fabrics.
Kit per group	15 cm squares of cotton (old T-shirt or tea towel), wool (old jumper), polyester fleece, nylon (lining or bag fabric) and waterproof jacket fabric (an old jacket or offcut); 250 cm^3 beakers; strong elastic bands; 100 cm^3 measuring cylinder; stopwatch; paper towels.
Prep	Cut the squares in advance so they are all the same size. Older waterproof fabric may leak at seams or worn spots, so test a clean piece first.
Expected results	Cotton lets most water through, wool and fleece less, nylon very little and waterproof fabric none. Some water stays soaked in the fabric, especially cotton and wool.
Levels	N3 follows the method, fills in a ready-made table and draws a bar chart on a labelled frame. N4 plans a fair test, repeats each fabric three times, averages and draws a bar chart with their own scale.

Safety and inclusion

- Pre-cut fabric so learners do not need scissors, or supervise their use. Plastic beakers avoid breakages.
- Do the test in a tray to catch spills, and wipe up water at once. All roles can be done seated.
- Some learners dislike certain textures, such as wool; let them handle the beaker and cylinder instead.
- Follow your school and local authority guidance on practical work.

Common problems

- **Fabric too tight:** water runs off the edge. Let it sag a little to make a dip.
- **Pouring too fast:** pour slowly onto the centre in every test.
- **Reading the cylinder:** read the bottom of the curved surface at eye level.

No lab, no time, or a learner absent?

Sample results let learners complete the bar chart, conclusion and evaluation without doing the practical.

Assessment link

Evidence for the experiment and investigation outcome: following a procedure safely, recording and presenting results, concluding and evaluating (N3), plus planning and repeat measurements (N4).

Answers: Topic 6

Topic 6: Fibres and fabrics (N3)

1 Natural and synthetic fibres

1 Wool: sheep. Cotton: a plant. Nylon: chemicals from oil.

2 synthetic.

3 fibre, yarn, fabric.

2 Properties of fabrics

1 Cotton: it soaks up lots of water, dries slowly and makes you cold.

2 big.

3 Sweat cannot get out, so it collects on the inside and you get wet from the inside.

3 Layers and composites

1 The outer layer.

2 Layers trap warm air between them, and you can take one off or put one on as you get hot or cold.

3 It is strong and light.

Practical 6

Safety controls: scissors: cut carefully, away from fingers, or use pre-cut squares; water: wipe up spills straight away.

Sample results: cotton 41, wool 24, fleece 31, nylon 8, jacket fabric 0 cm^3.

Conclusion: jacket fabric best; cotton worst. Why: soaks up and lets through; small.

Improvement: same size square (fairer) or test three times and average (more reliable). Pouring faster for some fabrics would not be fair.

5 A waterproof jacket (made of the jacket fabric) over a fleece or polyester top, not cotton, because the jacket fabric let no water through and cotton let the most through.

Check-up

1 Natural: wool, cotton or silk. Synthetic: nylon or polyester.

2 soaks up; keeps out.

3 Polyester top, fleece and a waterproof jacket.

4 A material made by joining two or more materials, so it has the best properties of both (e.g. glass fibre, carbon fibre).

Topic 6: Fibres and fabrics (N4)

1 Natural and synthetic fibres

1 Cotton: natural. Silk: source silkworm cocoons. Nylon: source chemicals from crude oil. Polyester: synthetic.

2 Advantage e.g. cheap, strong, can be designed to be waterproof or quick-drying, made in large amounts. Disadvantage e.g. uses up crude oil (non-renewable); manufacture releases carbon dioxide; fibres do not biodegrade and shed microplastics when washed.

2 Properties of fabrics

1 Cotton is very absorbent: it soaks up rain and sweat, holds it, dries slowly and the wet fabric takes heat from the body, so the walker gets cold.

2 Its tiny holes are far smaller than raindrops, so rain cannot get in (dry outside); water vapour from sweat is small enough to pass out through the holes, so sweat does not build up inside (dry inside).

3 Polyester (fleece) or nylon: absorbs very little and dries fast, so sweat is not held against the skin.

3 Layers and composites

1 Air is a poor conductor of heat (a good insulator); trapping it stops heat escaping from the body.

2 Carbon fibre is lighter (and stiff and strong), so the poles are easier to carry over a long walk.

3 It combines the useful properties of each material, e.g. strong fibres with a stiff resin, giving a material that is strong, stiff and light, which neither material is alone.

Practical 6

Variables: change the type of fabric; measure the volume of water that gets through (cm^3); keep the same: volume of water, size of square, time waited, how fast it is poured, the beaker.

Prediction example: the jacket fabric will let least through because it is designed to be waterproof; cotton most because it is absorbent.

Kit: fabrics, beaker, elastic band, measuring cylinder, timer. Not needed: ruler, balance.

Hazards: scissors (pre-cut or cut away from fingers); spilled water (tray, wipe up at once); glass (plastic beakers).

Headings: Fabric, Test 1 (cm^3), Test 2 (cm^3), Test 3 (cm^3), Average (cm^3).

Sample averages: cotton 41.0, wool 23.7, polyester fleece 31.3, nylon 8.0, waterproof jacket fabric 0.3 cm^3.

Conclusion: the waterproof jacket fabric was most waterproof (0.3 cm^3 through); then nylon; cotton let most through (41.0 cm^3).

9a Wool fibres are a little oily and absorb some water, so the water soaks in rather than running straight through, but there are still gaps between the fibres.

9b 41.0 ÷ 50 × 100 = 82%.

10a The volume collected is less than the water that passed into the fabric, so absorbent fabrics look more waterproof than they are (results are too low).

10b e.g. weigh each fabric before and after to measure the water it held; more repeats; pour through a funnel at the same rate; same size squares; read the cylinder at eye level.

Check-up

1 Fibres are spun (twisted) into yarn; the yarn is woven or knitted into fabric.

2 e.g. wool: warm even when damp; nylon: strong, light, absorbs little water and dries quickly.

3 It lets water vapour from sweat escape; this stops sweat building up inside, so the walker stays dry and warm.

4 e.g. lighter (and stiff and strong), so it is faster and easier to carry.

5 12 ÷ 50 × 100 = 24%.

TEACHER NOTES

Practical 7: Starch peanuts and temperature

Time	One 50-minute lesson in pairs. N3 and N4 can run together.
Kit per group	Starch packing peanuts (check they dissolve before the lesson), 250 ml beaker, thermometer, measuring jug, stirring rod, stopwatch, paper towels. One polystyrene peanut to compare.
Prep	An adult mixes kettle and cold water in jugs to give about 20, 30, 40, 50 and 60 °C (never above 60 °C).
Expected results	Dissolving time falls as temperature rises, roughly from 1.5 minutes at 20 °C to about half a minute at 60 °C with gentle stirring. The polystyrene peanut does not dissolve.
Levels	N3 follows the given method, records one time per temperature and draws a bar chart on a ready-made frame. N4 plans the test (variables, prediction, kit, risk, method), repeats, averages and draws a line graph with their own scales.

Safety and inclusion

- Only adults handle the kettle. Water at 60 °C can still scald: learners do not put fingers in the water. Learners never lift, carry or empty a beaker of water above 50 °C; stand beakers on a tray.
- Starch peanuts may contain maize or wheat starch: do not eat them, wash hands after, check allergies.
- Plastic beakers can replace glass. All roles can be done seated.
- Follow your school and local authority guidance on practical work.

Common problems

- **End point unclear:** agree that "dissolved" means no solid pieces can be seen.
- **Different stirring:** ask the same person to stir, counting a steady rhythm.

No lab, no time, or a learner absent?

The sample results let learners complete the results, graph, conclusion and evaluation without doing the practical.

Assessment link

Gives evidence of following procedures safely, recording and presenting results, drawing a conclusion and evaluating (N3), plus planning the investigation (N4).

Answers: Topic 7

Topic 7: Materials and the environment (N3)

1 Where do materials come from?

1 Plastic bottle: crude oil. Paper: trees. Drinks can: mines (metal ore). Woolly jumper: animals (sheep).

2 crude oil; will.

2 Rot away or stay for ever?

1 Banana skin, paper bag, wooden lolly stick.

2 The glass bottle (thousands of years). The plastic bottle lasts about 450 years.

3 It does not rot, so it stays in the ground for hundreds of years and landfill sites fill up.

3 Reduce, reuse, recycle

1 Reuse; recycle; reduce.

2 e.g. it saves raw materials; it saves energy; less rubbish goes to landfill.

Practical 7: Starch peanuts and warm water

Risk controls, e.g.: carry beakers carefully and tell an adult about any breakage; wipe up spills straight away.

Expected results: the peanut dissolves faster in warmer water (sample: 95 s at 20 °C down to 32 s at 60 °C).

Conclusion: faster; shortest. Why it matters: biodegradable; better.

Improvement: repeats and an average give more reliable results; same-sized peanuts and the same stirring keep the test fair.

Check-up

1 Plastic: crude oil. Paper: trees. Glass: sand. Wool: sheep.

2 It can be broken down by microbes and rot away.

3 plastic straw 4 e.g. a water bottle, a carrier bag, a jar, clothes.

5 The warmer the water, the faster it dissolved (the shorter the time).

Topic 7: Materials and the environment (N4)

1 Raw materials and finite resources

1 Finite: crude oil, iron ore, sand. Renewable: cotton, trees, wool. (Sand is accepted as finite on a human timescale.)

2 e.g. plastic bottles, bags, nylon, polyester clothing, packaging.

3 e.g. mining or drilling destroys habitats; cutting down forests; oil spills; pollution from extraction and transport.

2 Biodegradable or not?

1 Microbes can break down the fibres in paper; plastic is made from long, tough molecules that microbes cannot break down.

2 e.g. plants are renewable, so it saves crude oil (a finite resource); some plant-based materials biodegrade.

3 No. Some plant-based plastics only break down in hot industrial compost, so they should go where the label says, not in general waste or the countryside.

3 Life cycles and recycling

1 Sand (and other raw materials) is quarried; melted in a furnace to make glass and shaped into a bottle; filled, transported and used; collected for recycling, crushed and melted to make new glass.

2 95% of 200 = 190, so it uses 200 − 190 = 10 units of energy.

3 Reusing needs no extra energy or raw materials to melt and reshape it, and causes less pollution.

Practical 7: Starch peanuts and temperature

Variables: change the water temperature (°C); measure the time to dissolve (s); keep the same: volume of water, size and type of peanut, stirring speed, beaker.

Prediction, e.g. the higher the temperature, the shorter the time, because the water particles move faster and break up the starch more quickly.

Equipment: starch peanuts, beaker, thermometer, measuring jug, stirring rod, stopwatch. Not needed: ruler, masses.

Hazards, e.g. glass beaker breaking (handle with care, report breakages); spilled water (wipe up at once).

Method key points: an adult provides water at each temperature; measure 100 ml; check the temperature; drop in one peanut and start timing; stir at the same rate; stop when no solid can be seen; repeat three times per temperature.

Headings: Temperature (°C), Time 1, 2, 3 (s), Average time (s).

Sample averages: 20 °C 95 s; 30 °C 72 s; 40 °C 54 s; 50 °C 41 s; 60 °C 32 s.

Graph: temperature (°C) on the x axis, average time (s) on the y axis, a smooth curve falling.

Conclusion: as the temperature increased, the time to dissolve decreased (it dissolved faster).

Explain: (a) about 47 s (accept 45 to 49 s). (b) It never breaks down, so it stays in landfill or the sea for hundreds of years and can harm wildlife.

Evaluate: (a) different people may stop the clock at different moments, so times vary; this makes results less reliable. (b) e.g. more repeats; agree a clear end point; use peanuts of the same mass; use a magnetic stirrer at a fixed speed; use a water bath to keep the temperature steady.

Check-up

1 A resource that will run out because it cannot be replaced (or takes millions of years to form), e.g. crude oil, coal, metal ores.

2 It is made of long, tough molecules that microbes cannot break down.

3 Crude oil extracted; refined and made into plastic; bottle made; transported and used; thrown away (landfill or burned) or recycled.

4 e.g. saves raw materials; less waste in landfill; less litter; less pollution from mining or drilling.

5 e.g. Will it actually biodegrade, and where (home compost, industrial compost)? Which bin should it go in?

TEACHER NOTES

Practical 8: Which material protects best?

Time	One 50-minute lesson in pairs. N3 and N4 can run together.
Kit per group	250 ml beaker, measuring jug, thermometer (or temperature probe), stopwatch, 10 cm squares of foil, cotton tea towel, silicone baking mat, wool felt and a quilted oven glove (cut up or laid flat).
Prep	An adult provides water at about 50 °C in jugs (never hotter). Cut materials to the same size.
Expected results	Thin foil gives the biggest rise (around 10 °C or more); thick, quilted or felted materials the smallest (1 to 3 °C). Exact values depend on room temperature and thermometer.
Levels	N3 follows the given method, records one rise per material and draws a bar chart on a ready-made frame. N4 plans the test (variables, prediction, kit, risk, method), repeats, averages and draws a bar chart with their own scale.

Safety and inclusion

- Only adults handle the kettle; keep water at 50 °C or below. Learners do not put fingers in the water.
- Keep water away from sockets and trailing cables. Plastic beakers can replace glass.
- All roles can be done seated. A learner who finds reading a thermometer hard can use a digital probe.
- Follow your school and local authority guidance on practical work.

Common problems

- **Thermometer not cooled:** wait until it is back at room temperature before each test.
- **Bulb not touching the material:** rest it flat on top, or hold it with a small piece of tape.

Linking to the learn pages

Use the practical to talk about controls: the oven glove is a control that reduces the risk from a hazard (a hot dish).

No lab, no time, or a learner absent?

The sample results let learners complete the results, graph, conclusion and evaluation without doing the practical.

Assessment link

Gives evidence of following procedures safely, recording and presenting results, drawing a conclusion and evaluating (N3), plus planning the investigation (N4).

Answers: Topic 8

Topic 8: Hazards and risk (N3)

1 Warning symbols

1 A corrosive (burns skin and eyes); B flammable (catches fire easily); C harmful (can irritate or make you ill).

2 fire; wash it off with water.

3 They could drink them or get them on their skin or in their eyes and be badly hurt; small children cannot read the warnings.

2 Spot the hazards

1 A pan handle sticking out over the edge: it could be knocked and spill hot food; turn the handle in. B kettle cable hanging down: someone could pull the kettle of hot water over; push the cable back or use a short cable. C too many plugs in one adaptor: it could overheat and cause a fire; use fewer plugs or a separate socket. D knife on the edge of the worktop: it could fall and cut someone; put it away in a drawer or block. E water on the floor: someone could slip; wipe it up.

2 Any sensible answer with a reason, e.g. the wet floor, because older people can fall and be badly hurt.

3 Safe with electricity

1 Drying your hands before switching on the hair dryer; switching off at the wall before unplugging.

2 It melts if too much current flows, which switches off the appliance and stops a fire.

3 Water conducts electricity, so you could get a deadly electric shock.

Practical 8: Which material keeps the heat out?

Risk controls, e.g.: handle beakers carefully and report breakages; wipe up spills straight away and keep water away from sockets.

Expected results: foil lets most heat through (about 12 °C rise); the quilted oven glove the least (about 2 °C).

Conclusion: quilted oven glove; foil. Why: insulator; burned.

Improvement: averages of three tests are more reliable; same water and same-sized squares keep the test fair.

Check-up

1 Flammable: it catches fire easily. 2 Something that could cause harm.

3 e.g. a hot pan with the handle sticking out; turn the handle in. (Any hazard with a sensible control.)

4 wet 5 The quilted oven glove, because the thermometer went up the least.

Topic 8: Hazards and risk (N4)

1 Hazards, risks and warning symbols

1 Oven cleaner: corrosive. Spray polish: flammable. Weed killer: hazardous to the environment (it may also carry harmful or toxic).

2 A knife is a hazard because it can cut. The risk is how likely it is to cut someone and how badly: low if it is stored in a block and used carefully, higher if it is left on the edge of a worktop.

2 Measuring risk

1 A 3 × 3 = 9 (high), e.g. turn handles inwards, use the back rings. B 2 × 3 = 6 (high), e.g. coil the cable or use a cordless kettle. E 2 × 2 = 4 (medium), e.g. wipe up spills at once, use a mat.

2 1 × 3 = 3 (medium).

3 Electrical safety

1 Brown: live. Green and yellow: earth.

2 Current flows from the case through the earth wire to the ground instead of through a person. This large current melts (blows) the fuse, which cuts off the live supply.

3 It draws too much current, so the adaptor and cables overheat and could start a fire; the many trailing cables are a trip hazard.

Practical 8: Which material protects best?

Variables: change the material; measure the temperature rise after 3 minutes (°C); keep the same: water volume and starting temperature, time, size of material, thermometer position.

Prediction, e.g. the quilted oven glove will let the least heat through because it is thick and traps air.

Equipment: beaker, measuring jug, thermometer, materials, stopwatch. Not needed: ruler (optional for cutting squares), starch peanuts.

Hazards, e.g. glass beaker breaking (handle with care); spilled water near sockets (wipe up, keep water away from plugs).

Method key points: an adult fills the beaker with the same volume of 50 °C water each time; lay the material over the top; thermometer bulb on top; read the start temperature; read again after 3 minutes; let the thermometer cool; repeat three times per material.

Headings: Material, Rise 1, 2, 3 (°C), Average rise (°C).

Sample averages: foil 12.0 °C; cotton 8.0 °C; silicone 4.3 °C; wool felt 2.7 °C; quilted oven glove 1.7 °C.

Bar chart: materials on the x axis, average temperature rise (°C) on the y axis with an even scale, bars of equal width with gaps.

Conclusion: the quilted oven glove let the least heat through (1.7 °C rise); foil let the most (12.0 °C).

Explain: (a) metal is a good thermal conductor, so heat passes through quickly and would burn your hand. (b) Air is a poor conductor, so trapped air slows the flow of heat.

Evaluate: (a) if it is still warm, the start reading is higher and the rise is not a fair comparison. (b) e.g. more repeats; use a water bath so the water stays at 50 °C; use a temperature probe and data logger; cut every material to the same size and thickness.

Check-up

1 A hazard is anything that could cause harm; a risk is how likely it is that harm will happen and how serious it would be.

2 A corrosive, e.g. oven cleaner, drain cleaner, bleach. B oxidising, e.g. some pool chemicals or hair bleach products.

3 3 × 2 = 6, high.

4 If too much current flows, the fuse melts and breaks the circuit, so cables do not overheat and cause a fire.

5 It slows the flow of heat from the hot pan to your hand, so your hand does not get burned.

TEACHER NOTES

Practical 9: How much does cushioning help?

Time	One 50-minute lesson in pairs. N3 and N4 can run together.
Kit per group	About 200 g of modelling clay, five squares of craft foam or bubble wrap (about 5 mm thick), a 100 g slotted mass (a stack held with tape works), metre stick, 30 cm ruler, cocktail sticks, a tray.
Prep	Soften the clay. Cut foam squares a little larger than the base of the mass. A cardboard tube can guide the mass so it lands flat.
Expected results	The dent depth falls as layers are added, quickly at first and then more slowly. Values depend on the clay: soft clay gives deeper dents.
Levels	N3 follows the given method, records one dent per test and draws a bar chart on a ready-made frame. N4 plans the test (variables, prediction, kit, risk, method), repeats, averages and draws a line graph with their own scales.

Safety and inclusion

- Drop heights stay low (30 cm) and over a tray on the bench. Keep feet away from the bench edge.
- Cocktail sticks can be swapped for a blunt lolly stick with marks on it.
- All roles can be done seated. A learner with limited grip can measure or record.
- Follow your school and local authority guidance on practical work.

Common problems

- **Mass lands on its edge:** use a guide tube, or release from just above the tube.
- **Clay not reset:** dents add up. Re-smooth the clay before every drop.

Link to the learn pages

Draw out the idea that a longer stopping time means a smaller force. Learners do not need any equations at this level.

No lab, no time, or a learner absent?

The sample results let learners complete the results, graph, conclusion and evaluation without doing the practical.

Assessment link

Gives evidence of following procedures safely, recording and presenting results, drawing a conclusion and evaluating (N3), plus planning the investigation (N4).

Answers: Topic 9

Topic 9: Staying safe on the move (N3)

1 Be safe, be seen

1 A jacket with reflective strips; a light that clips on his bag.

2 white; red.

3 You are not looking or listening for traffic, so you might step out in front of a car.

2 Stopping a car

1 23 m (9 m + 14 m).

2 36 m − 12 m = 24 m further.

3 Driving on an icy road; texting while driving; driving when very tired.

3 Protection in a crash

1 Seatbelt: stops you flying forward. Airbag: a soft cushion for your head. Crumple zone: squashes to soak up the crash. Helmet: protects a cyclist's head.

2 An adult belt does not fit them: it would cross their neck or tummy and could hurt them in a crash. A child seat holds them in the right place.

3 gentler

Practical 9: Cushioning a fall

Risk controls, e.g.: push masses back from the edge of the bench and use a tray; point the cocktail stick away from you and take care.

Expected results: the dent gets smaller as layers are added (sample: 9, 6, 4, 3, 2 mm).

Conclusion: smaller; 0. Why: gentler.

Improvement: averages of three drops are more reliable; a guide tube and the same smoothing keep the test fair.

Check-up

1 Any two: use front and back lights; wear reflective strips or a reflective vest; wear bright or light colours.

2 9 + 14 = 23 m

3 e.g. going faster, a wet or icy road, a tired driver, using a phone, worn tyres.

4 It holds you in your seat so you do not hit the inside of the car or get thrown out.

5 The dent got smaller.

Topic 9: Staying safe on the move (N4)

1 Being seen

1 Fluorescent material glows brightly in daylight, so the wearer is seen during the day; reflective strips send headlight light back to drivers, so the wearer is seen at night.

2 Moving reflections catch a driver's eye and the movement shows the shape of a person.

3 The foam has been crushed, so it cannot absorb another impact as well; there may be hidden cracks.

2 Stopping distances

1 12 m + 24 m = 36 m.

2 73 ÷ 23 = 3.17..., so about 3.2 times longer.

3 At 20 mph the stopping distance is only 12 m, compared with 23 m at 30 mph, so a driver is much more likely to stop before hitting a child who steps out.

3 Protection in a crash

1 It keeps its shape so the space around the people is not crushed, while the crumple zones absorb the energy.

2 The mat squashes, so you take longer to stop; a longer stopping time means a smaller force on your body.

Practical 9: How much does cushioning help?

Variables: change the number of foam layers (thickness); measure the depth of the dent (mm); keep the same: mass, drop height, type of foam, clay and how it is smoothed.

Prediction, e.g. the more layers of foam, the smaller the dent, because the foam squashes and makes the mass stop more gradually.

Equipment: modelling clay, foam sheets, 100 g mass, metre stick, ruler (and a cocktail stick). Not needed: thermometer, stopwatch.

Hazards, e.g. mass rolling off the bench (use a tray, keep feet clear); cocktail stick (point away, handle carefully).

Method key points: smooth fresh clay each time; hold the mass at 30 cm using the metre stick and release, not throw; measure the dent depth with a cocktail stick and ruler (or a depth gauge); test 0 to 4 layers; repeat three times; average.

Headings: Layers of foam, Dent 1, 2, 3 (mm), Average dent (mm).

Sample averages: 0 layers 8.5 mm; 1 layer 6.0 mm; 2 layers 4.2 mm; 3 layers 3.2 mm; 4 layers 2.3 mm.

Graph: layers (or thickness in mm) on the x axis, average dent (mm) on the y axis, a smooth curve falling more slowly.

Conclusion: as the number of layers increased, the dent got smaller, but each extra layer made less difference.

Explain: (a) the foam squashes, so the mass takes longer to stop; the force on the clay is smaller, so the dent is smaller. (b) The thick foam crushes in a crash so the head stops more slowly and the force on it is smaller.

Evaluate: (a) e.g. use the depth gauge on vernier callipers, or press clay level and measure with a ruler against a straight edge. (b) e.g. more repeats; drop the mass down a guide tube so it lands flat; use a clamp to release from exactly the same height.

Check-up

1 It reflects the light from the car's headlights straight back towards the driver, so the walker shows up brightly.

2 15 + 38 = 53 m

3 A tired driver reacts more slowly, so the car travels further before the brakes go on. On a wet road there is less grip (friction) between the tyres and the road, so the car takes further to stop once braking.

4 The crumple zone squashes, so the car and people take longer to stop; this makes the force on them smaller.

About the author

C. Blewis has taught for 17 years, including 10 years in Additional Support Needs (ASN) provision, teaching sciences, maths, PE and more.

In many schools, especially smaller and specialist settings, teachers are often asked to teach outside their own subject. These books are written for them, and for the young people they teach: clear, practical and ready to use from the first lesson.