STUDYWALKS · HOMESCHOOL PACK · FREE TO PRINT

Physical Science Lab Guide

Twelve home labs in physics and chemistry basics at a 9th-grade level: density, changes of matter, motion, forces, energy, heat, circuits and sound. Keyed to the units of Physical Science.

Twelve hands-on labs in physics and chemistry basics at a 9th-grade physical science level, keyed to the units of Physical Science. Each unit's capstone names its lab, and the parent grades each report with the rubric.

Safety first

Read this page with your student before the first lab, and reread each lab's own safety notes before starting it.

- **An adult supervises every lab** and reads the whole lab, safety notes included, before it starts. An adult handles knives, the electric kettle, hot water and anything hot. No lab in this guide uses a stove, a burner, a candle or any other open flame.
- **Wear eye protection** (safety goggles marked ANSI Z87.1, sold inexpensively at hardware stores) in every lab with liquids, heat or anything that can splash or snap.
- **Wear gloves** (disposable nitrile, or rubber kitchen gloves) when a lab's safety box says so: iodine, hydrogen peroxide, cabbage juice, steel wool, cold salted ice, the sealed mold bags and outdoor work.
- **Never taste, eat or drink** anything used in a lab, even when it began as food. No food or drinks in the work area. Label every container, and wash borrowed kitchen tools well (or keep a set just for labs).
- **Never mix unknown chemicals** or household products, and use only the materials a lab lists. Never use bleach, ammonia, drain, oven or toilet-bowl cleaners in these labs: some combinations release toxic gases.
- **Ventilation:** work in a well-aired room, with a window open if you can.
- **Dress for it:** closed-toe shoes, long hair tied back, loose sleeves rolled up, old clothes or an apron.
- **Allergies:** before each lab, check for allergies to anything it uses, such as latex (balloons), iodine, foods, mold, plants, pollen or insect stings. Substitute or skip.
- **Cleanup and disposal:** the liquids in these labs can go down the sink with running water; food scraps go in the trash or compost; follow each lab's own disposal note. Wipe the surfaces and wash hands with soap after every lab.
- **If something goes wrong:** for a splash in the eye, rinse with running water for 15 minutes and get medical help; cool a burn under cool running water. In the U.S., Poison Help is 1-800-222-1222. Stop if anything unexpected happens.
- **Young children and pets** stay out of the work area. Balloons, marbles and small parts are choking hazards.
- **Electricity.** The circuit labs (Labs 10 and 11) use only small household batteries (AA, C or D). Never connect anything in this guide to a wall outlet or household wiring, and never use a car battery.
- **No flames, no stove.** No lab here uses a candle, a match, a lighter or the stove. Hot water comes from an electric kettle and is poured by an adult (Labs 3 and 9). Keep steel wool (Lab 2) away from batteries: a battery's terminals can set fine steel wool alight.

What this guide leaves out on purpose: open flames of every kind (no candles, matches, lighters or burners) and stove-top heating; mercury (no fluorescent tubes or CFL bulbs, and never a broken bulb of any kind); hydrogen

peroxide stronger than the 3% sold for first aid; strong acids and bases; flammable solvents (which is why there is no DNA-extraction lab: it needs rubbing alcohol); dissection; opening anything that has grown mold; and anything that makes a toxic gas.

How to use this guide

1. Do each lab after the student has finished the course unit it names. The unit is listed with each lab.
2. Read the whole lab together first: purpose, safety, materials and procedure. Gather everything before starting.
3. The student records everything in a lab notebook as the lab happens (see the notebook guide), then writes a lab report using the template.
4. Grade the report with the parent rubric and log the hours.

Each lab ends with **Go further**, a second investigation that changes one variable. For a lab every week of the school year, add these and investigations of your student's own design.

Lab hours

There is no single national rule for how much lab work makes a "lab science", and rules differ by state. Many homeschool families plan a lab most weeks, about 1 to 2 hours of hands-on work plus time to write it up. The twelve labs here come to roughly 25 to 40 hours with write-ups; the Go further investigations add about as much again. Use the lab-hours log at the end. Lab time can also be logged as offline study hours for the course in StudyWalks, which counts them separately from lesson time. You decide what counts and what credit to grant.

The labs

Lab	Physical Science unit	Time
1. Density: Identifying Materials	Unit 2: Measurement and Scientific Math; Unit 3: Matter and Its Properties	1 hour
2. Physical or Chemical Change?	Unit 3: Matter and Its Properties; Unit 8: Chemical Reactions and Equations	1 hour
3. Acids, Bases and a Cabbage Indicator	Unit 10: Solutions, Acids and Bases	1 hour
4. Motion on a Ramp	Unit 12: Describing Motion; Unit 13: Acceleration and Free Fall	1.5 hours
5. The Pendulum and the Strength of Gravity	Unit 16: Gravity and Circular Motion	1 hour
6. Friction on Different Surfaces	Unit 14: Forces and Newton's First and Second Laws	1 hour
7. Bouncing Balls and Energy	Unit 18: Energy and Its Conservation	1 hour
8. Buoyancy: Archimedes' Principle	Unit 19: Fluids and Pressure	1 hour
9. Keeping Heat In: Insulation and Cooling	Unit 20: Thermal Energy and Heat	1.5 hours
10. Series and Parallel Circuits	Unit 24: Electricity and Circuits	1.5 hours

Lab	Physical Science unit	Time
11. Building an Electromagnet	Unit 25: Magnetism and Electromagnetism	1 hour
12. Sound in an Air Column	Unit 22: Sound	1 hour

Keeping a lab notebook

- Use a bound notebook (a composition book works) and write in pen. Number the pages and keep a table of contents on the first page.
- Start each lab on a new page with the date, the lab title and anyone who helped.
- Record raw data the moment you take it, with units. Never copy it from scrap paper later.
- Do not erase or tear out pages. Cross out a mistake with a single line so it can still be read, and note why.
- Sketch what you see and label the sketch. Write down anything unexpected and any change you made to the procedure.
- End each entry with a one-line summary of the result. The parent initials and dates the entry.

Lab 1. Density: Identifying Materials

PHYSICAL SCIENCE Unit 2: Measurement and Scientific Math; Unit 3: Matter and Its Properties · About 1 hour

Purpose

Measure the mass and volume of regular and irregular objects, calculate their densities, and use density to identify materials and predict floating and sinking.

Materials

- Kitchen scale
- A ruler
- A measuring cup marked in mL (or a 100 mL graduated cylinder) and water
- String
- Objects: a wooden block, a piece of candle wax (unlit), a rock, a steel bolt or washers, an aluminum item, a plastic toy, a ball of modeling clay

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Wipe up spills; dry the objects.

- No sharp objects. Wipe up spills.

Procedure

1. Weigh each object and record its mass.
2. For a box-shaped object, measure length, width and height in cm; volume = L × W × H.
3. For an irregular object, use water displacement: fill the cup to a marked level, lower the object on a string until it is just under water, and read the new level. The rise in mL is the object's volume in cm^3 (1 mL = 1 cm^3). Push floating objects just under with a pencil tip.
4. Calculate density = mass ÷ volume.
5. Predict whether each object floats in water (density of water: 1.00 g/cm^3), then test.
6. Compare with these approximate densities (g/cm^3): pine wood 0.35 to 0.6, candle wax about 0.9, ice 0.92, rock 2.5 to 3.0, aluminum 2.70, steel about 7.8 to 7.9, copper 8.96.

Data

Object	Mass (g)	Volume method	Volume (cm^3)	Density (g/cm^3)	Floats? predicted / observed

Analysis questions

1. Which objects floated, and how does density explain it?
2. Identify the metal objects from their densities.
3. A small object raises the water level only a little. Why does that make its density less certain?
4. If you cut the clay ball in half, what happens to its mass, its volume and its density?
5. Shape the clay into a boat. Explain why it floats now, even though clay is denser than water.

What to expect. Larger objects usually come within about 10 percent of the reference values. Wood and wax float; rock and metal sink. Small objects give the least certain densities because the water level changes so little.

Typical sources of error. Reading the water level; air bubbles clinging to the object; water absorbed by wood; the scale's resolution.

Go further. Measure the density of a potato, then find how much salt per cup of water makes it float.

Lab 2. Physical or Chemical Change?

PHYSICAL SCIENCE Unit 3: Matter and Its Properties; Unit 8: Chemical Reactions and Equations · About 1 hour

Purpose

Observe a set of changes, record the evidence, and decide whether each is a physical or a chemical change.

Background

In a chemical change new substances form. Clues include a gas that is not from boiling, a color change, a temperature change without heating, a new solid, or light. Clues are not proof: melting ice also changes temperature, and boiling water also makes gas.

Materials

- Ice cubes, sugar, water and clear cups
- Baking soda and vinegar
- Soap-free steel wool (a small pad), vinegar, a jar and a thermometer
- Milk at room temperature and vinegar
- Paper to tear
- An apple, a knife (adult) and a little lemon juice

Safety

Adult present for the whole lab · **Wear:** safety goggles and gloves · **Disposal:** Liquids down the sink with running water; steel wool, apple and curds in the trash.

- Wear eye protection.
- Fine steel wool can catch fire from a spark: keep it away from batteries, outlets, the stove and any flame. Wear gloves to handle it (splinters).
- An adult cuts the apple.
- Nothing in this lab is eaten or drunk.

Procedure

1. Station 1: let an ice cube melt in a cup. Record what you see.
2. Station 2: stir a teaspoon of sugar into half a cup of water until it disappears.
3. Station 3: add a teaspoon of baking soda to a quarter cup of vinegar.
4. Station 4: soak a piece of steel wool in vinegar for 1 minute, squeeze it out, wrap it around the thermometer bulb, and put both in the jar. Record the temperature every minute for 5 minutes, and look at the steel wool again the next day.
5. Station 5: stir 1 tablespoon of vinegar into half a cup of milk that has stood at room temperature for an hour, and wait 10 minutes.
6. Station 6: tear a sheet of paper into pieces.
7. Station 7: an adult cuts an apple into slices. Leave one slice in the air and brush lemon juice over the cut face of another. Compare them after 30 minutes.

Data

Station	Observations	Evidence of a new substance?	Physical or chemical	Reason
1 Melting ice				
2 Dissolving sugar				
3 Baking soda and vinegar				
4 Steel wool				
5 Milk and vinegar				
6 Tearing paper				
7 Cut apple				

Analysis questions

1. Which station gave the strongest evidence of a chemical change? Explain.
2. The apple slice and the steel wool both react with oxygen in the air. What evidence did each give, and how did the lemon juice change the apple's result?
3. Melting ice absorbs heat. Why is it still a physical change?
4. Milk curdling is a hard case. What happens to the milk proteins, and how would you classify it?
5. Write a word equation for the baking soda and vinegar reaction.

What to expect. Melting, dissolving and tearing are physical changes. Baking soda and vinegar (gas), steel wool (temperature rises a few degrees as the iron reacts with oxygen; rust appears by the next day) and the browning apple (new brown compounds form where the cut surface meets oxygen) are chemical changes; lemon juice slows the browning. Curdling milk is usually classed as chemical, because the vinegar changes the structure of the milk proteins, though textbooks vary.

Typical sources of error. Small temperature changes are easy to miss; judging "new substance" by eye.

Go further. Classify five changes you see at home this week (an egg cooked for a meal, bread in the toaster, ice cubes freezing, a banana ripening, a nail rusting) and give the evidence for each. Watch while an adult cooks; this investigation is observation only.

Lab 3. Acids, Bases and a Cabbage Indicator

PHYSICAL SCIENCE Unit 10: Solutions, Acids and Bases · About 1 hour

Purpose

Make an indicator from red cabbage and use it to sort household liquids into acids, bases and neutral liquids, then watch a neutralization.

Materials

- About 1/4 of a red cabbage, a knife and hot water from an electric kettle (adult)
- A strainer, a jar and clear cups
- Samples: vinegar, lemon juice, clear soda pop, tap water, milk, baking soda solution (1 teaspoon in 1/2 cup water), dish soap in water

Safety

Adult present for the whole lab · **Wear:** safety goggles and gloves · **Disposal:** Samples down the sink with running water; cabbage in the compost or trash.

- An adult handles the knife and the hot water.
- Wear eye protection and disposable gloves (the juice stains).
- Test only the listed samples. Never use cleaning products such as bleach, ammonia or drain cleaner, and never mix household products.
- Pour samples down the sink with running water.

Procedure

1. Chop the cabbage, cover it with hot water, steep for 15 to 30 minutes, strain, and cool. The purple liquid is the indicator.
2. Put 2 tablespoons of indicator in each cup and add 1 teaspoon of one sample to each. Record the colors.
3. Use the scale: red to pink means acidic (pH below about 6), purple means about neutral (pH about 6 to 7), blue to green means basic (pH about 8 to 11).
4. Add baking soda solution a few drops at a time to the vinegar cup, swirling, until the color turns purple. Count the drops.

Data

Sample	Prediction	Color	Acid, neutral or base	About what pH?

Analysis questions

1. Which samples were acids and which were bases? Which were close to neutral?
2. What happened when you added baking soda to the vinegar? What is this kind of reaction called, and what gas formed?
3. What does the pH scale measure? Is pH 3 more or less acidic than pH 5, and by how much?
4. Why can an indicator only estimate pH?

What to expect. Vinegar, lemon juice and soda pop turn red or pink. Water and milk stay purple. Baking soda solution turns blue to blue-green. The vinegar cup turns back toward purple as baking soda neutralizes the acid, fizzing as carbon dioxide forms.

Typical sources of error. Judging color by eye; indicator strength.

Go further. Soak coffee-filter strips in indicator, dry them, and use them as homemade pH paper.

Lab 4. Motion on a Ramp

PHYSICAL SCIENCE Unit 12: Describing Motion; Unit 13: Acceleration and Free Fall · About 1.5 hours

Purpose

Measure position and time for a ball rolling down a ramp, graph the motion, and find its acceleration.

Materials

- A smooth board or shelf 1.5 to 2 m long (a grooved piece of trim or a curtain rod also works)
- Books to prop one end
- A ball (golf ball or marble)
- A tape measure and masking tape
- A phone stopwatch, or better, phone video (slow motion if available)

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Pick up every ball and marble.

- Keep the ramp low and stable.
- Pick up balls after the lab; marbles are a choking hazard for young children and a tripping hazard for everyone.

Procedure

1. Prop one end of the board on one book. Mark 0, 25, 50, 75, 100, 125 and 150 cm along it with tape.
2. Release the ball from rest at 0 (let go; do not push).
3. Time how long it takes to reach each mark. Do three trials per mark. With video, step through the frames and read the time.
4. Find the mean time for each distance and square it.
5. Graph distance against time, then distance against time squared.
6. Calculate the acceleration $a = 2 \times \text{distance} \div \text{time}^2$ for each mark, and the mean.
7. Add a second book and repeat.

Data

Distance (cm)	t1 (s)	t2 (s)	t3 (s)	Mean t (s)	t^2 (s^2)	a (cm/s^2)
25						
50						
75						
100						
125						
150						

Analysis questions

1. What is the shape of the distance-time graph? What does that shape tell you about the ball's speed?
2. Is the distance against time-squared graph close to a straight line? What does that tell you about the acceleration?
3. How did a steeper ramp change the acceleration?
4. Calculate the ball's average speed over the first 25 cm and the last 25 cm. Compare them.
5. Stopwatch timing adds an error of about 0.1 to 0.2 s. Which of your measurements did that affect most?

What to expect. The distance-time graph curves upward (the ball speeds up), and distance against time squared is close to a straight line, meaning nearly constant acceleration. A steeper ramp gives a larger acceleration. A rolling ball accelerates less than a sliding object would, because some energy goes into spinning it.

Typical sources of error. Reaction time with a stopwatch; an uneven or sagging board; a release that is not clean.

Go further. Use three or four ramp heights and graph acceleration against ramp height.

Lab 5. The Pendulum and the Strength of Gravity

PHYSICAL SCIENCE Unit 16: Gravity and Circular Motion · About 1 hour

Purpose

Find which variables change a pendulum's period, and use the period to estimate the acceleration due to gravity, g.

Background

For small swings, the period (one full swing out and back) is $T = 2 \times \text{pi} \times \text{square root of } (L \div g)$, where L is the length in meters. Rearranged, $g = 39.5 \times L \div T^2$ (39.5 is 4 times pi squared). A 1.00 m pendulum has a period of about 2.0 s.

Materials

- About 1.5 m of string
- 3 heavy washers or nuts
- Tape and a sturdy place to hang it from (a door frame or a table edge)
- A tape measure and a stopwatch

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Nothing to throw away.

- Hang the pendulum from something sturdy. Keep faces away from the swinging weight.

Procedure

1. Tie one washer to the string and hang it so the length from the pivot to the middle of the washer is 1.00 m.
2. Pull the washer aside a small amount (about 10°, a swing of about 15 cm to each side) and release. Time 10 full swings and divide by 10 to get T.
3. Mass test: repeat with 2 and then 3 washers at the same length. Amplitude test: repeat with a larger swing (about 30°). Record these in your notebook.
4. Length test: time 10 swings at lengths of 0.25, 0.50, 0.75, 1.00 and 1.25 m.
5. For each length, calculate T^2, and $g = 39.5 \times L \div T^2$. Graph T^2 against L.

Data

Length L (m)	Time for 10 swings (s)	Period T (s)	T^2 (s^2)	g (m/s^2)
0.25				
0.50				
0.75				
1.00				
1.25				

Analysis questions

1. Which variables changed the period: mass, amplitude or length?
2. Why time 10 swings instead of one?
3. What is your mean value of g? Calculate the percent difference from 9.8 m/s^2.
4. Your graph of T^2 against L should be a straight line. What does its slope equal?
5. A pendulum clock runs slow. Should you lengthen or shorten its pendulum? Explain.

What to expect. Mass makes no measurable difference, and amplitude makes little difference for small swings (large swings are slightly slower). Period grows with length: a 4 times longer pendulum has a 2 times longer period. Values of g within a few percent of 9.8 m/s^2 are common.

Typical sources of error. Measuring length to the wrong point on the washer; starting and stopping the watch; swings that are too large or that wobble in a circle.

Go further. Test whether the period changes on a pendulum with a very light weight (a paper clip), where air resistance matters more.

Lab 6. Friction on Different Surfaces

PHYSICAL SCIENCE Unit 14: Forces and Newton's First and Second Laws · About 1 hour

Purpose

Measure the force needed to start and to keep a shoe sliding on different surfaces, and test how friction depends on the weight pressing the surfaces together.

Materials

- A spring scale or an inexpensive digital luggage scale
- A sneaker and a string
- Surfaces: wood or tile floor, carpet, a large sheet of sandpaper, wax paper taped down
- 2 or 3 full food cans to add weight

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Nothing to throw away.

- Pull slowly and keep the path clear. Do not stand on wax paper or sandpaper.

Procedure

1. Weigh the shoe by hanging it from the scale. Convert to newtons: kilograms × 9.8, or pounds × 4.45.
2. Tie the string to the shoe and hook it to the scale. Pull horizontally. Record the largest reading just before the shoe starts to move (starting friction).
3. Keep pulling at a slow, steady speed and record the reading while it slides (sliding friction).
4. Do three trials on each surface.
5. On one surface, add one, two and then three cans inside the shoe, weighing the loaded shoe each time, and repeat.
6. For each run, calculate the coefficient of friction μ = sliding force ÷ weight. Graph sliding force against weight for the loaded shoe.

Data

Surface	Load	Weight (N)	Starting force (N)	Sliding force (N)	μ (sliding ÷ weight)

Analysis questions

1. When the shoe slides at a steady speed, how does the pulling force compare with friction? Use Newton's first law.
2. Was the starting force larger than the sliding force? Explain why.
3. How did adding weight change friction? Was μ about the same?
4. Why must the string pull horizontally?
5. Why do tires and shoes have treads?

What to expect. Carpet and sandpaper need the most force, wax paper the least. Starting friction is usually larger than sliding friction. On one surface, friction rises roughly in proportion to weight, so μ stays roughly the same.

Typical sources of error. Pulling at an angle or unevenly; reading a moving scale; surfaces that are not uniform.

Go further. Compare a shoe with worn soles and one with new soles on the same surface.

Lab 7. Bouncing Balls and Energy

PHYSICAL SCIENCE Unit 18: Energy and Its Conservation · About 1 hour

Purpose

Measure how high different balls bounce compared with the drop height, and track where the mechanical energy goes.

Background

Gravitational potential energy is *mgh*. At the top of the bounce the ball is momentarily still, so the share of energy kept is about bounce height ÷ drop height.

Materials

- 3 different balls (for example a tennis ball, a rubber bouncy ball and a basketball)
- A meter stick or tape measure taped upright to a wall
- Phone video
- A hard floor and a carpeted floor
- Kitchen scale

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Nothing to throw away.

- Clear the area. Drop, do not throw.

Procedure

1. Hold a ball with its bottom at 50 cm and drop it (do not push). Video the bounce beside the meter stick.
2. Step through the video to find the bounce height (bottom of the ball at the top of the bounce).
3. Do three trials each at 50, 100 and 150 cm.
4. Repeat for each ball, on the hard floor and on carpet.
5. Calculate percent of energy kept = bounce ÷ drop × 100. For one ball, weigh it and calculate its potential energy before the drop and at the top of the bounce (use m in kg, g = 9.8 m/s^2, h in m).

Data

Ball	Surface	Drop height (cm)	Bounce heights (cm)	Mean bounce (cm)	Energy kept (%)

Analysis questions

1. Which ball kept the largest share of its energy? On which surface?
2. Was the percent kept about the same at every drop height? Explain any change.
3. Energy is conserved. Where did the energy that was not returned to height go?
4. Why does carpet lower the bounce?
5. Sports leagues test balls by dropping them from a set height. Why?

What to expect. Every ball returns to less than its drop height. A rubber bouncy ball keeps the largest share; a tennis ball keeps roughly half on a hard floor. Carpet lowers every bounce. For each ball and surface the percent is roughly the same at each height, sometimes a little lower from higher drops as air resistance grows.

Typical sources of error. Reading the bounce height from video; parallax (camera not level with the top of the bounce); releasing with a push.

Go further. Compare a cold tennis ball (from the refrigerator) with a room-temperature one.

Lab 8. Buoyancy: Archimedes' Principle

PHYSICAL SCIENCE Unit 19: Fluids and Pressure · About 1 hour

Purpose

Measure the buoyant force on objects in water and compare it with the weight of the water they push aside.

Background

Archimedes' principle: an object in a fluid is pushed up with a force equal to the weight of the fluid it displaces. Water pushes up on the object, and the object pushes down on the water with an equal force (Newton's third law), so a scale under the water container reads more.

Materials

- Kitchen scale
- A container of water that fits on the scale
- String
- A measuring cup
- Objects that sink (a rock, a steel bolt, a clay ball) and objects that float (a wooden block, an apple)

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Wipe up spills; dry the scale.

- Keep the scale dry; set a towel nearby and wipe up spills.

Procedure

1. Weigh each object (mass in grams) and find its volume by water displacement in the measuring cup.
2. Put the container of water on the scale and zero it.
3. Hang a sinking object from the string and lower it until it is completely under water, not touching the sides or bottom. Record the scale reading: this is the mass of water displaced.
4. Let a floating object float freely in the container and record the reading.
5. Buoyant force (N) = scale reading in kg × 9.8.

Data

Object	Mass (g)	Volume (mL)	Scale reading in water (g)	Buoyant force (N)	Sinks or floats

Analysis questions

1. For the sinking objects, compare the scale reading with the object's volume. What pattern do you see, and why? (1 mL of water has a mass of 1 g.)
2. For the floating objects, compare the scale reading with the object's whole mass. Explain.
3. Why did the scale reading go up at all, if the object never touched the container?
4. A steel ship floats although steel is about 8 times as dense as water. Explain.
5. Predict how the results would change in salt water, and why.

What to expect. For a fully submerged object the scale reading in grams nearly equals its volume in mL. A floating object raises the reading by its whole mass, because it displaces its own weight of water. Readings usually agree within a few grams.

Typical sources of error. The object touching the container; water splashing out; air bubbles on the object; scale resolution.

Go further. Repeat with salt water and measure the difference for the same object.

Lab 9. Keeping Heat In: Insulation and Cooling

PHYSICAL SCIENCE Unit 20: Thermal Energy and Heat · About 1.5 hours

Purpose

Compare how quickly hot water cools in containers with different insulation, and identify conduction, convection and radiation.

Materials

- 4 identical jars or mugs with lids
- Hot water at about 60 °C (an adult mixes water from an electric kettle with cold water)
- 1 to 4 thermometers
- Insulation: a wool sock, aluminum foil, bubble wrap or a towel; one jar has none (control)
- A timer, a measuring cup and a tray

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Let the water cool, then pour it down the sink.

- Water at 60 °C can scald in seconds. An adult pours the water; carry jars on a tray and keep them away from the edge of the table.
- Keep young children away from the hot jars.

Procedure

1. Wrap three jars, one in each insulation. Leave the fourth bare.
2. An adult pours 200 mL of water at about 60 °C into each jar. Put the lids on, with a thermometer through a hole in each lid or lifted in quickly.
3. Record each temperature at the start and every 5 minutes for 40 minutes.
4. Graph temperature against time, one line per jar, and calculate each jar's total drop.

Data

Time (min)	No insulation (°C)	Sock (°C)	Foil (°C)	Bubble wrap (°C)
0				
5				
10				
15				
20				
25				
30				
35				
40				

Analysis questions

1. Which jar cooled fastest and which slowest? Explain using trapped air.
2. Name one way each jar lost heat by conduction, by convection and by radiation.
3. Why are the cooling curves steepest at the start?
4. Foil reflects radiation but conducts heat well. How did it compare with the others?
5. How does a vacuum flask (thermos) slow all three kinds of heat transfer?

What to expect. The bare jar cools fastest. Insulators that trap air (sock, bubble wrap) cool slowest. Foil alone usually helps only a little. All jars cool fastest at the start, when the water is much hotter than the room, and more slowly as they approach room temperature.

Typical sources of error. Lids that differ; opening lids to read the temperature (lets heat escape); jars at different starting temperatures.

Go further. Repeat with and without lids to measure how much heat escapes from the open top.

Lab 10. Series and Parallel Circuits

PHYSICAL SCIENCE Unit 24: Electricity and Circuits · About 1.5 hours

Purpose

Build simple circuits, sort materials into conductors and insulators, and compare bulbs connected in series and in parallel.

Materials

- 2 AA batteries in a battery holder (3 V)
- 3 small flashlight bulbs rated about 2.5 to 3 V, in bulb holders (or 3 LEDs with built-in resistors)
- Insulated wire with alligator clips
- Optional: an inexpensive digital multimeter
- Test materials: a coin, a paper clip, aluminum foil, a rubber band, a plastic spoon, wood, a pencil lead (graphite), paper

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Take the batteries out of the holder; recycle used batteries where your area collects them.

- Use only small batteries (AA, AAA, C or D). Never connect anything to a wall outlet or household wiring.
- Never connect a wire straight from one battery terminal to the other (a short circuit): the wire and battery get hot.
- Do not use leaking or damaged batteries. Keep button and coin batteries away from young children; they are dangerous if swallowed.
- Small bulbs get warm.

Procedure

1. Connect one bulb to the battery holder with two wires so it lights. Rate its brightness as 5.
2. Conductor test: open the circuit and bridge the gap with each test material. Record whether the bulb lights.
3. Series: connect two bulbs one after the other in a single loop. Rate the brightness. Unscrew one bulb and record what happens. Repeat with three bulbs.
4. Parallel: connect two bulbs so each has its own path to the battery. Rate the brightness. Unscrew one bulb and record what happens. Repeat with three.
5. With a multimeter, measure the voltage across the battery and across each bulb in the series and parallel circuits.

Data

Conductors and insulators

Material	Bulb lights?	Conductor or insulator

Series and parallel

Circuit	Brightness (1 to 5)	When one bulb is removed	Voltage across each bulb (V)
1 bulb			
2 in series			
3 in series			
2 in parallel			
3 in parallel			

Analysis questions

1. What did the conductors have in common?
2. Why do bulbs in series get dimmer as you add more? Use the voltages you measured.
3. Why do bulbs in parallel stay about as bright as one bulb alone? What is the cost to the battery?
4. Why are the lights and outlets in a house wired in parallel?
5. Draw a circuit diagram of your three-bulb series and three-bulb parallel circuits.

What to expect. Metals and graphite conduct (graphite only weakly); plastic, rubber, wood and paper do not. Bulbs in series are dimmer and all go out when one is removed; the voltages across them add up to about the battery voltage. Bulbs in parallel are each about as bright as one alone, and the others stay lit when one is removed; each has about the full battery voltage across it, and the battery runs down faster.

Typical sources of error. Loose clips; tired batteries; bulbs that are not identical; judging brightness by eye.

Go further. Add a switch to a parallel circuit so it controls only one bulb.

Lab 11. Building an Electromagnet

PHYSICAL SCIENCE Unit 25: Magnetism and Electromagnetism · About 1 hour

Purpose

Build an electromagnet and test how the number of turns of wire changes its strength.

Materials

- A large steel nail (about 8 to 10 cm)
- About 3 m of thin insulated copper wire (22 to 26 gauge), ends stripped
- A D-cell battery in a holder
- A box of small steel paper clips
- A compass
- Tape

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Disconnect the battery; recycle used batteries where your area collects them.

- The wire and battery get hot quickly because this circuit draws a lot of current. Connect for no more than 10 seconds at a time and let them cool between trials.
- Use an ordinary alkaline D cell only, not a lithium or rechargeable pack, a car battery or an outlet.
- The nail and wire ends are sharp.

Procedure

1. Leaving 20 cm of free wire at the start, wrap 10 neat turns around the nail. Tape the coil in place.
2. Connect the wire ends to the battery, touch the nail tip to the paper clips, and count how many it lifts. Disconnect.
3. Do three trials, then add turns to make 20, 30, 40 and 50, testing each.
4. Hold the compass near the nail tip with the battery connected and note which end of the needle points to it. Reverse the battery connections and look again.
5. Remove the nail and test the coil alone (an air core).
6. Graph mean clips lifted against number of turns.

Data

Turns	Clips trial 1	Trial 2	Trial 3	Mean
10				
20				
30				
40				
50				
50, no nail				

Analysis questions

1. How did the number of turns affect the strength? Was the relationship a straight line?
2. What happened to the compass when you reversed the battery? Explain.
3. Why is the electromagnet much stronger with the nail inside?
4. Name two other ways to make the electromagnet stronger.
5. Electromagnets can be switched on and off. Name two machines that depend on that.

What to expect. More turns lift more clips, though the increase usually slows at higher turn counts as the longer wire carries less current and the battery tires. Reversing the current reverses the poles. The coil alone is much weaker than with the nail. The nail may stay slightly magnetic afterward.

Typical sources of error. A battery that runs down during the lab; clips of different sizes; uneven wrapping.

Go further. Induction: connect a coil of 50 or more turns (no battery) to a multimeter on its lowest voltage setting, and push a strong magnet in and out. Record what the meter shows.

Lab 12. Sound in an Air Column

PHYSICAL SCIENCE Unit 22: Sound · About 1 hour

Purpose

Measure the pitch of the note from tubes of different lengths, closed at one end, and use it to estimate the speed of sound.

Background

A tube closed at one end resonates when its length is a quarter of a wavelength, so its lowest note has frequency $f = v \div (4 \times L)$. The air just outside the open end also takes part, so add about 0.3 times the tube's inside width to L. Sound travels about 343 m/s in air at 20 °C.

Materials

- Wide drinking straws (smoothie straws) or thin plastic tubing
- Scissors, tape and a ruler
- A free tuner or frequency app on a phone
- A thermometer for the room

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Straws in the trash; each person uses only their own.

- Each person uses their own straws.
- Keep any speaker or headphone volume low.

Procedure

1. Cut straws to 6, 8, 10, 12, 15 and 18 cm. Seal one end of each with tape.
2. Measure the inside width of a straw.
3. Hold the open end just below your lower lip and blow gently across it until it gives a clear note.
4. Hold the phone near the straw and read the frequency of the strongest note. Take three readings for each straw.
5. For each straw, calculate $v = 4 \times (L + 0.3 \times \text{width}) \times f$, with lengths in meters.
6. Record the room temperature.

Data

Length L (m)	L + end correction (m)	Frequency f (Hz)	Speed v = 4(L + correction)f (m/s)
0.06			
0.08			
0.10			
0.12			
0.15			
0.18			

Analysis questions

1. How did the pitch change as the straw got longer?
2. What is your mean speed of sound? Compare it with 331 + 0.6 × (room temperature in °C) m/s.
3. Sometimes the app jumps to a note about three times higher. Explain this using overtones of a tube closed at one end.
4. Why does the end correction matter more for short straws?
5. Pour water into a glass bottle and blow across the top as the water rises. How does the pitch change, and why?

What to expect. Shorter straws give higher notes. Speeds of sound between about 320 and 360 m/s are typical. Apps sometimes lock onto an overtone (at about 3 times the lowest frequency), which gives a speed about 3 times too high; discard those readings and note them.

Typical sources of error. The app picking up an overtone or room noise; a leaky seal at the closed end; measuring the length.

Go further. Make a pan flute: calculate the straw lengths for the notes of a scale, then test your predictions.

Lab report template

Print one copy per lab, or copy the headings into the notebook.

Student _____ Lab number and title _____ Date _____

Course unit _____

Question or purpose

Hypothesis (If … then … because …)

Variables: independent, dependent, and those kept the same

Materials and procedure (summarize; note any changes you made)

Safety steps followed

Data (attach tables and graphs) and calculations, with units

Results in words

Conclusion: claim, evidence from the data, reasoning

Sources of error, how each affected the result, and improvements

Hands-on minutes

Write-up minutes

Rubric score (of 20)

Parent initials

Parent grading rubric

Score each criterion from 4 to 1 and add them (20 points in all). How the score becomes a grade, and how lab grades combine with course work, is the parent's decision.

Criterion	4	3	2	1
Safety and procedure	Followed every safety rule without reminders; set up, carried out and cleaned up carefully; noted any change to the procedure.	Followed safety rules and the procedure with few reminders.	Needed several reminders; some steps rushed or skipped.	Unsafe or careless work, or procedure not followed.
Data	Complete, organized tables with units; repeated trials; raw data recorded as it was taken; clear observations.	Mostly complete, with units; minor gaps.	Incomplete or disorganized; units missing.	Little usable data.
Analysis	Calculations correct and shown with units; graphs titled, labeled and scaled well; all questions answered fully.	Minor calculation or graph errors; questions mostly answered.	Several errors; graph or questions incomplete.	Calculations, graph or questions largely missing.
Conclusion	Answers the purpose with a clear claim, evidence from the data and scientific reasoning; compares with the expected result.	Claim and evidence given; reasoning thin.	Claim stated with little evidence.	No real conclusion.
Error and improvement	Names specific sources of error, says how each would change the result, and proposes a better method.	Names specific sources of error.	Only general errors ("human error").	Not addressed.

Score sheet

Lab	Safety	Data	Analysis	Conclusion	Error	Total (20)
1. Density: Identifying Materials						
2. Physical or Chemical Change?						
3. Acids, Bases and a Cabbage Indicator						
4. Motion on a Ramp						
5. The Pendulum and the Strength of Gravity						
6. Friction on Different Surfaces						
7. Bouncing Balls and Energy						
8. Buoyancy: Archimedes' Principle						
9. Keeping Heat In: Insulation and Cooling						
10. Series and Parallel Circuits						
11. Building an Electromagnet						

Lab	Safety	Data	Analysis	Conclusion	Error	Total (20)
12. Sound in an Air Column						

Lab-hours log

Log every lab and investigation, including Go further and the student's own. Print as many copies as you need.

Date	Lab or investigation	Unit	Hands-on min	Write-up min	Running hours	Parent

Total lab hours _____ Parent signature _____ Date _____

Beyond the kitchen

Virtual labs. Free simulations from universities and science organizations cover gas laws, circuits, genetics, titrations and more, including experiments that are not safe at home. They are good practice and a good way to repeat a lab with many more trials. Use them alongside hands-on labs; whether a simulation counts toward a lab requirement is your call under your state's rules.

A formal lab course. If you want lab work with equipment a home cannot have, such as microscopes, analytical balances and fume hoods, look for lab classes through a homeschool co-op, your state or local homeschool association, a community college's dual-enrollment office, or a science center. StudyWalks does not endorse or partner with any provider; ask each one what is covered and how work is documented.

StudyWalks is a curriculum and study-tool provider, not a school. In a homeschool the parent decides the courses, the credit and the grades, and keeps the records. Check your own state's homeschool rules. This pack is free to print and copy for your family or homeschool group; please do not sell it or repost the file.

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