

ELECTROMAGNET - COIL TURNS VS MAGNETIC STRENGTH STEM INVESTIGATION

Print-and-go
STEM lab where
students learn
about
electromagnetis
m through a
hands-on activity.

Electromagnet: Coil Turns vs Magnetic Strength — STEM Investigation

Driving Question
How does the number of wire coils affect the strength of an electromagnet?

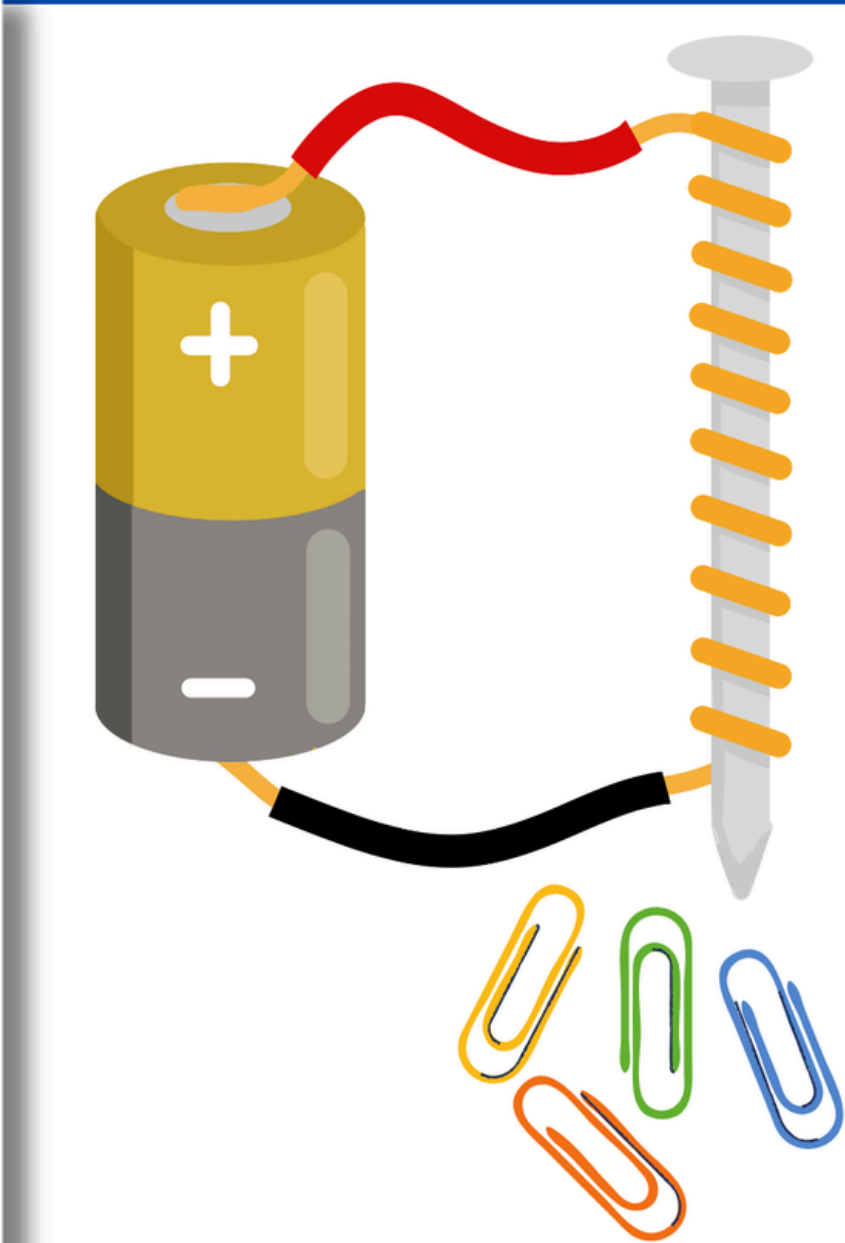
Hypothesis
Write a testable hypothesis predicting how increasing the number of coil turns will affect the number of paper clips lifted (number lifted represents the strength of the electromagnet).

Variables	
Type	Describe for This Experiment
Independent Variable	
Dependent Variable	
Controlled Variables	

Experimental Design
Test four coil settings: 10, 20, 30, and 40 wraps.
For each setting:

- Wrap wire tightly around the nail.
- Connect to the battery for 3 seconds.
- Count paper clips lifted.
- Repeat 3 trials per setting.
- Record data and calculate the average.

Coil Turns	Trial 1	Trial 2	Trial 3	Average
10				
20				



SCROLL
to take a look inside!



NO PREP

HOW THIS LAB WILL HELP YOU



- Print-and-go setup
- Clear Testing Procedure
- Teaches Scientific Method
- Low-cost & common materials

Electromagnet: Coil Turns vs Magnetic Strength — STEM Investigation

Purpose

Use a hands-on electromagnet challenge to teach experimental design, variables and controls, data collection and averaging, graphing, and evidence-based explanations for electricity and magnetism.

Learning Objectives

- Plan and carry out a controlled investigation with clear independent, dependent, and controlled variables.
- Collect sufficient data (replicates) and compute averages with correct units.
- Graph Average Paper Clips Lifted vs Number of Coil Turns to analyze trends and condition.
- Explain results using electric current, magnetic fields, and electromagnet strength.

Safety

- Do not leave batteries connected for long periods.
- Disconnect the battery between trials.
- Handle wires carefully.
- Keep magnets and batteries away from water.
- Do not place electromagnets near electronics.

Materials

- Iron nail (same size for all groups)
- Insulated copper wire (1–2 m)
- D-cell battery or AA battery pack
- Paper clips (identical size)
- Electrical tape
- Scissors or wire strippers
- Ruler (cm)
- Data table + pencil

Background Science for the Teacher

When electric current flows through a wire, it creates a magnetic field. Wrap around an iron core concentrates and strengthens that field, turning the nail into a magnet. Increasing the number of coil turns increases the magnetic field strength, allowing it to lift more paper clips.

Variables

Type	Describe for This Experiment
Independent Variable	Ramp height (cm) at the start
Dependent Variable	Time (s) used to compute Average Speed (m/s)
Controlled Variables	Marble type/size; ramp length and surface; starting position; release method (no push); timing method; environment

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10				
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40				

★ Teacher Guide: setup, safety, pacing, and background science.

★ Student Packet: clear, step-by-step setup and timing instructions with blank data tables.

★ Graphing pages templates and marking rubric.

★ Complete answer key with example data tables.

What you get inside

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Safety

- Do not leave hands on wires.

Rubric Category	Exceeds (4)	Meets (3)	Approaches (2)	Beginning (1)
Experimental Design	Variables clearly named; coil counts planned; standardized wrapping and connection method; sufficient trials completed.	Variables named; mostly consistent wrapping and connections; trials completed.	Some variables unclear; inconsistent wrapping or connections; fewer trials than planned.	Variables missing; no consistent setup; very few or no trials.
Data Quality	All trials recorded neatly; averages calculated correctly; any invalid trials repeated; summary complete.	Most trials recorded; minor errors corrected; summary mostly complete.	Several omissions or calculation errors; summary incomplete.	Many missing entries; averages incorrect or missing; summary not usable.
Graphing & Analysis	Correct graph with labels/units; data reflected accurately; clear takeaway identifying strongest coil setting with numbers.	Graph present with labels; basic takeaway stated.	Graph present but missing key labels/clarity; takeaway vague.	No graph or incorrect graph; no takeaway.
Claim-Evidence-Reasoning	Clear claim naming strongest electromagnet; evidence cites data values; reasoning correctly uses magnetic field/current ideas.	Claim supported with basic evidence; some correct reasoning.	Claim present but weakly supported; limited or unclear reasoning.	Claim absent or unrelated; no reasoning.
Collaboration & Safety	Roles used effectively; safe, organized work area throughout; battery disconnected between trials.	Mostly cooperative; safe behavior with minor reminders.	Uneven participation; repeated safety or behavior reminders needed.	Off-task or unsafe behavior; roles unclear or not followed.

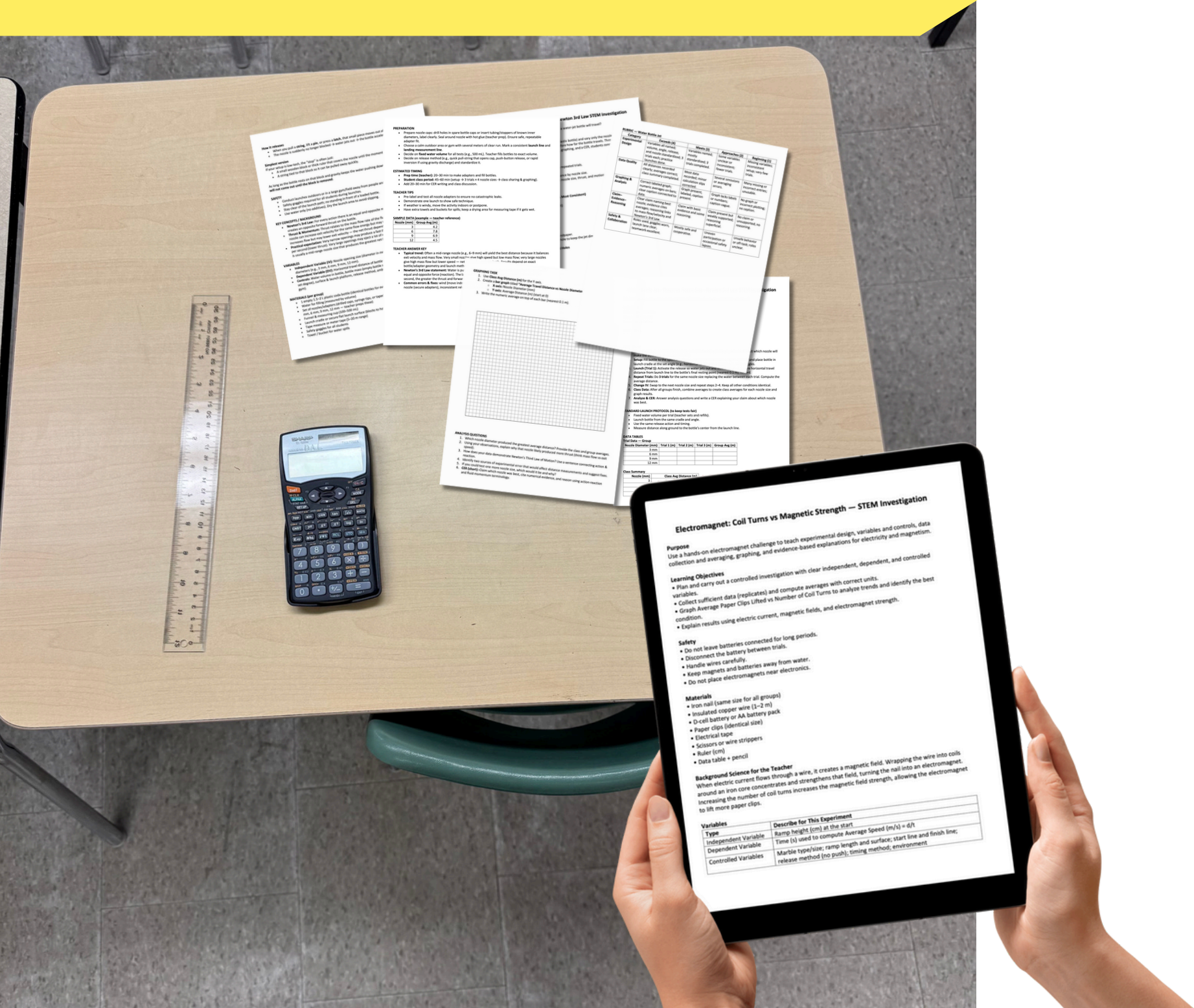
magnetic field. Wrapping the wire into coils, turning the nail into an electromagnet. Magnetic field strength, allowing the electromagnet

Speed (m/s) = d/t
Surface; start line and finish line; Method; environment

st electromagnet?
nd magnet strength.
ain why they matter.
s magnet strength.

Strength? Why or why not?
tter data?

Skills Your Students Will Learn/Improve



✓ Carrying out Controlled Experiments

✓ Precise Measurement

✓ Design and Redesign

✓ Graphing Data

✓ Claim—Evidence—Reasoning

✓ Analyzing Results

Your Lab

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Variables

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Dependent Variable	Time (s) used to compute Average Speed (m/s) = d/t
Controlled Variables	Marble type/size; ramp length and surface; start line and finish line; release method (no push); timing method; environment

All steps are clearly outlined and easy to follow

Students collect data in organized charts

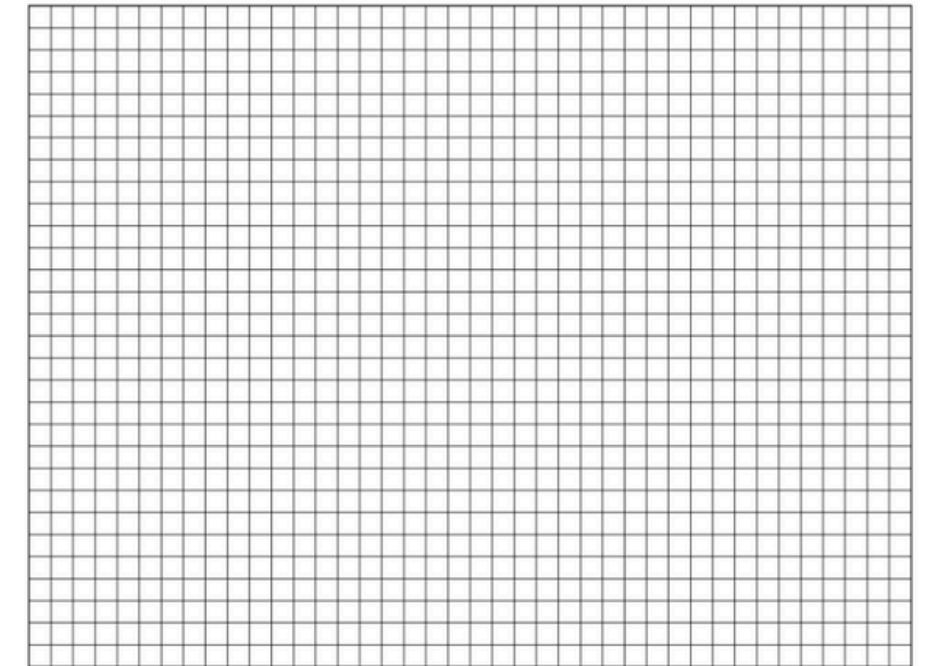
Graphing

Students analyze their data and draw conclusions

Graphing

Create a bar or line graph with:

- Y-axis: Average Number of Paper Clips Lifted
- X-axis: Number of Coil Turns



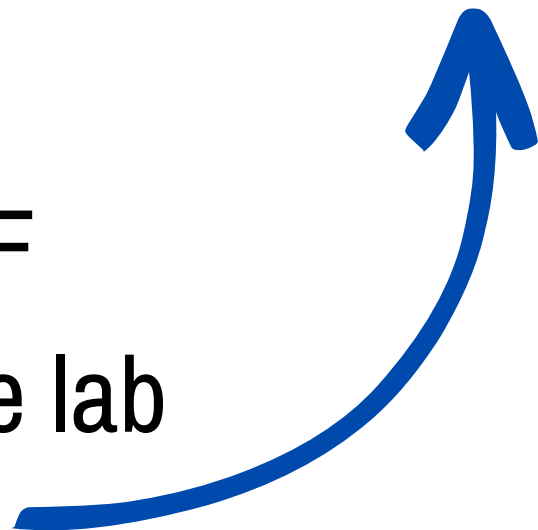
Analysis Questions

1. Which coil setting produced the strongest electromagnet?
2. Describe the trend between coil turns and magnet strength.
3. Identify two controlled variables and explain why they matter.
4. Explain why increasing coil turns increases magnet strength.
5. Identify two sources of error.
6. Would doubling the coils always double the strength? Why or why not?
7. What improvement would you make for better data?

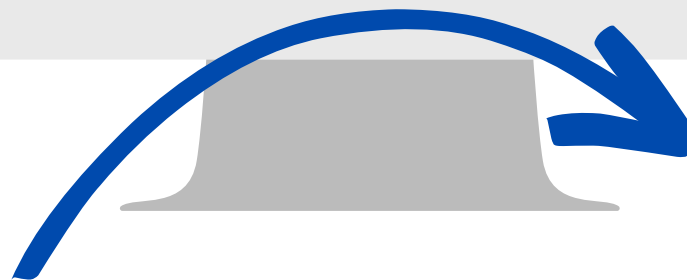
At School or at Home



Word and PDF
versions of the lab

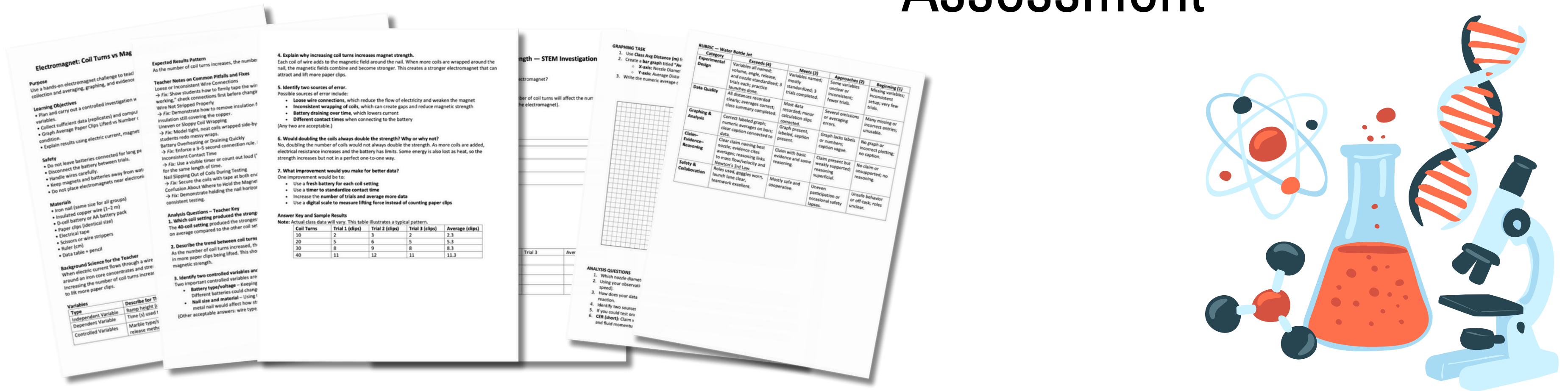


Fully digital and editable - can be
done in class or through distance
education/homeschool



Ways to Use this Resource

- ★ Introduce the Scientific Method
- ★ Teach data analysis and graphing
- ★ Reinforce key ideas
- ★ Formative or Summative Assessment



Download my Angle of Attack STEM Lab FREE
CLICK HERE

Paper Airplane Angle of Attack STEM Lab

Scientific Method • Variables • Data & Graphing

✓ Classroom-Ready

✓ Data tables + bar graph templates included



✓ Teacher guide with setup, safety, background science, pacing

✓ Step-by-step procedure for testing

✓ Analysis questions with model answers and Rubric



Paper Airplane: Angle of Attack STEM Investigation: Scientific Method Activity

Teachers Reference:

Angle of Attack Explained - <https://youtu.be/D1J1oUP-aKA?si=vsnb9a72PajoWnZs>



Purpose

Use a high-engagement paper-airplane challenge to teach experimental design, variables and controls, proportional reasoning, data analysis, and communication of results.

Learning Objectives

- Plan and carry out a controlled investigation with clear independent, dependent, and controlled variables.
- Collect sufficient data (replicates) and compare results across angle conditions.
- Graph distance data to analyze trends and construct evidence-based claims.
- Explain the physical principles (lift, drag, stall) that affect flight distance.

only airplanes; no paper clips or sharp nose cones.
a clear launch lane; stand behind the throw line; throw parallel to the floor.
ing area clear; retrieve planes only after all throws in a round are complete.

- Use a standard 8.5x11 in. — identical for all planes
- Use a standard template (optional, one standard design for all teams)
- Use a protractor (or angle guides) to set release angle relative to horizontal
- Tape for a throw line and distance marks; measuring tape or meter tape
- Data sheets (included), clipboards, pencils

Background Science for the Teacher

Lift vs Angle of Attack (AoA): Lift generally increases with AoA up to a point. Beyond a critical AoA, airflow separates (stall), causing lift to drop and drag to rise, shortening distance.

Drag and Energy: Higher AoA increases frontal area and induced drag; too much drag slows the plane quickly. Moderate AoA balances adequate lift with manageable drag for a longer glide.

Consistency: A single plane design, constant throw force/height, and a clear angle-setting method are key to fair comparisons.

Expected Results Pattern

- Distances typically peak at a moderate AoA (around 10°–15° for a simple dart design).
- Very low AoA (0°–5°) may dive or fail to generate a strong glide; very high AoA (20°+) often stalls or climbs then falls rapidly.
- As throw technique becomes consistent, variation decreases and the distance curve vs angle becomes clearer.

Implementation Notes

- Use one standard airplane design per class for consistency (provide a template or model).
- Assign roles: Thrower, Angle Setter/Checker, Measurer, Recorder. Rotate roles between angles.
- Mark the throw line and measure angle at release using a protractor or an angle card taped to the forearm or launcher guide.

Answer Key and Sample Results

Note: Actual class data will vary. The sample below models typical trends and acceptable analysis quality.

Sample Summary Data

Angle (°)	Average Distance (m)
0	7.8
5	10.6
10	12.9
15	12.1
20	8.9

Interpretation

- Greatest average distance at 10° (=12.9 m) with a close second at 15° (=12.1 m).
- Very low angle (0°) underperformed (dives/low lift). Very high angle (20°) lost distance (near-stall and higher drag).
- The trend supports a moderate-angle optimum due to balance of lift and drag.

Model Responses to Analysis Questions

- Best angle: 10° with an average of ~12.9 m (our class graph shows a peak around 10–15°).
- Consistency: Results were reasonably consistent after the practice round; using the same thrower and angle card reduced variation.
- Controls that mattered most: Plane design and paper type, release height and throw force, indoor/no-draft room, and measuring to first contact.
- Follow-up: Test nose mass with paper clips at the best angle. Hypothesis: Adding a small nose mass (1–2 clips) will increase distance by improving stability without greatly increasing drag.

STEM INVESTIGATION BUNDLE

Build a high-engagement, low-prep STEM program.

- This Bundle includes my best STEM investigations—each one built around true engineering design, fair testing, repeated trials, data tables, graphing, and CER writing.
- STEM develops crucial skills like critical thinking and creativity and prepares students for a changing world and future opportunities.



Tell me and I forget. Teach me and I remember. Involve me and I learn. - Benjamin Franklin



STEM Investigation Growing Bundle

Scientific Method • Variables • Data & Graphing

✓ Classroom-Ready

✓ A Variety of Science Topics Included



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