

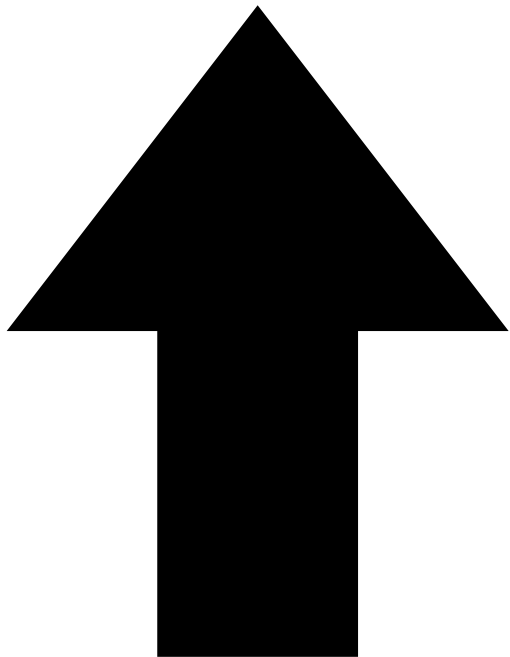
Balloon Lift Design

STEM Lab

Scientific Method • Variables • Data & Graphing

✓ **Classroom-Ready**

✓ **Data tables + bar graph templates included**



Balloon Life STEM Investigation

Teachers Reference:

Learning Objectives

- Plan and carry out a controlled engineering test with clear independent, dependent, and controlled variables.
- Collect sufficient data (replicates), compute averages and simple rates, and compare across conditions to optimize a design.
- Graph performance vs. design variable and construct evidence-based claims.
- Explain how reaction amounts, gas production, seals, and mass affect lift.

Safety

- Wear safety goggles at all times. Do not taste materials.
- Use 3% household hydrogen peroxide only, in small amounts, or substitute baking soda + vinegar.
- Do not tightly seal gases in rigid containers; the balloon is the pressure relief device.
- Keep faces away from bottle openings; clean spills immediately; wash hands after the lab.

Variables

- Independent Variable:** Amount of Baking soda
- Dependent Variables:** Max lift height (cm) and time to max height (s).
- Controlled Variables:** Same bottle, Balloon size/type, seal/harness method, vinegar, test area, measuring tools, trigger method.

Materials

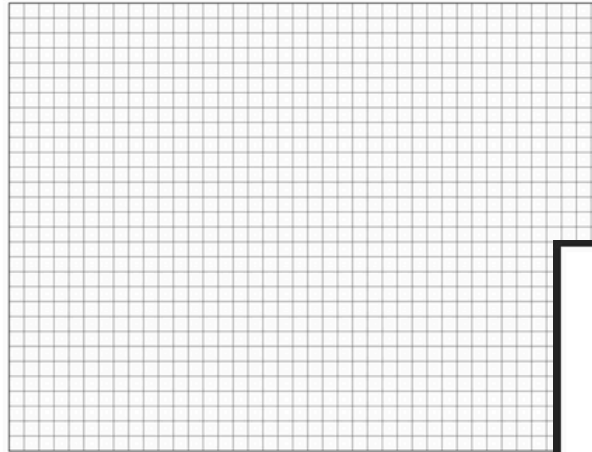
- 500 mL plastic bottle with cap (1 per group).
- White balloon (1 per group).
- Baking soda.
- Vinegar cups (60 mL portions).
- Funnels or paper funnels; measuring spoons; graduated cup for mL.
- Masking tape, permanent marker, ruler/tape measure, string, scissors, tape.
- Data sheets (included), clipboards, pencils.

Background Science for the Teacher

- Gas Generation and Lift:** CO₂ produced by a reaction inflates a balloon. The volume of gas depends on reactant amounts and reaction completion; sealing leaks increases usable gas for lift.
- Mass, Force, and Pressure:** The balloon exerts an upward force as it inflates and displaces air; a lighter

Graphing

Create a bar graph with Avg Max Height (cm) on the y-axis vs Reactant Amount on the x-axis.



Analysis Questions

- Which reactant amount had the best overall performance? Include height, time, and success in your answer.
- What controlled variables were most important to keep the test fair?

Implementation Notes

- Assign roles: Builder, Measurer, Recorder, Safety Lead. Rotate between trials.
- Mark a consistent test area and a target height on a wall or meter stick.

Teacher Notes on Common Pitfalls and Fixes

- Leaky seals reduce inflation: Stretch balloon neck before use and secure with rubber band + tape over the bottle threads.
- Excess liquid mass: Using too much vinegar adds weight; optimize amounts rather than 'more is better.'
- Inconsistent triggering: Pre-load baking soda in the balloon and flip to start reaction or use a tissue packet as a delayed-release pouch.

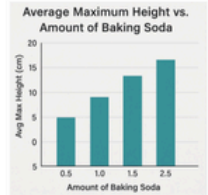
Analysis Questions KEY

- Best condition: Typically, a mid-level reactant amount (e.g., 1.0–1.5 tbsp baking soda with 60 mL vinegar) that maximizes gas while minimizing mass and leaks. Results vary by class.
- Controlled variables: Bottle/balloon type, cap/neck seal method, puck mass, target height, test surface, room conditions, measurement method (same ruler/observer).

Answer Key and Sample Results

Illustrative data—class results will vary

Reactant Amount (tbsp baking soda)	Avg Max Height (cm)	Avg Time to Target (s)
0.5	6	—
1.0	12	18
1.5	16	12
2.0	15	14
2.5	13	16



Balloon Lift Design STEM Investigation

Driving Question

How does the reactant amount affect balloon lift performance?

Mission Brief

- Goal:** Lift the balloon to the target line using a balloon powered by a safe, gas-producing reaction.
- Your Role:** Optimize the mixture, prevent leaks, and collect solid evidence to defend your design.
- Win Condition:** Reach or exceed the target line and justify your **best mixture strength** with a good CER.

Hypothesis

Write a testable hypothesis predicting which reactant amount will produce the greatest lift and fastest target, and why.

Variables

- Independent Variable:** Amount of Baking soda
- Dependent Variables:** Max lift height (cm) and time to max height (s).
- Controlled Variables:** Same bottle, Balloon size/type, seal/harness method, vinegar, test area, measuring tools, trigger method.

Experimental Design

- Test five reactant levels: 0.5, 1.0, 1.5, 2.0, and 2.5 tbsp baking soda with a constant 60 mL vinegar.
- For each level conduct 3 test trials using the same trigger method (drop-in packet or balloon pop).
- Measure maximum height, time to reach 10 cm.

Condition: 0.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 1.0 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 1.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 2.0 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 2.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Summary Table

Reactant Amount	Avg Max Height (cm)	Avg Time to 10 cm (s)
0.5 tbsp		
1.0 tbsp		
1.5 tbsp		
2.0 tbsp		
2.5 tbsp		

Rubric

Category	Exceeds (4)	Meets (3)	Approaches (2)	Beginning (1)
Experimental Design	Variables clearly named; standardized trigger; success defined; enough trials across 5 levels.	Variables named; mostly consistent; trials completed.	Variables partly named; inconsistent procedure; fewer trials.	Variables missing; no consistent procedure.
Data Quality	All trials recorded; clear units; averages computed; invalid trials noted & redone.	Most trials recorded; summary mostly complete.	Several omissions; summary incomplete.	Many missing; summary not usable.
Graphing & Analysis	Correct graph with labels; bars accurate; clear takeaway naming best level with numbers.	Graph present with titles and labels; takeaway stated.	Graph incomplete or unclear; vague takeaway.	No graph or incorrect.
Claim–Evidence–Reasoning	Claim cites best level; evidence uses this lab's data; reasoning connects gas generation, seal, and lift.	Claim supported with basic evidence; some correct reasoning.	Claim weakly supported; unclear reasoning.	Claim absent or unrelated.
Collaboration & Safety	Roles used; area organized; eye protection; on-task.	Mostly cooperative; safe with minor reminders.	Uneven participation; repeated reminders.	Off-task or unsafe behavior.

What You Get

- **Teacher Guide:** Setup checklist, materials, safety, timing/roles; background on center of mass, rotation, fluid damping; quick troubleshooting + extensions.
- **Student Packet:** Driving question, hypothesis template, variables table (IV/DV/controls), numbered step-by-step procedure.
- **Data Tables (0%, 25%, 33%, 50%, 75%):** Trial logs with spaces for averages, success counts, quick notes.
- **Analysis + Model Answers:** Focused questions on best fill level, errors, improvements; concise answer key.
- **Simple Rubric:** Single-point rubric with 4 performance levels.