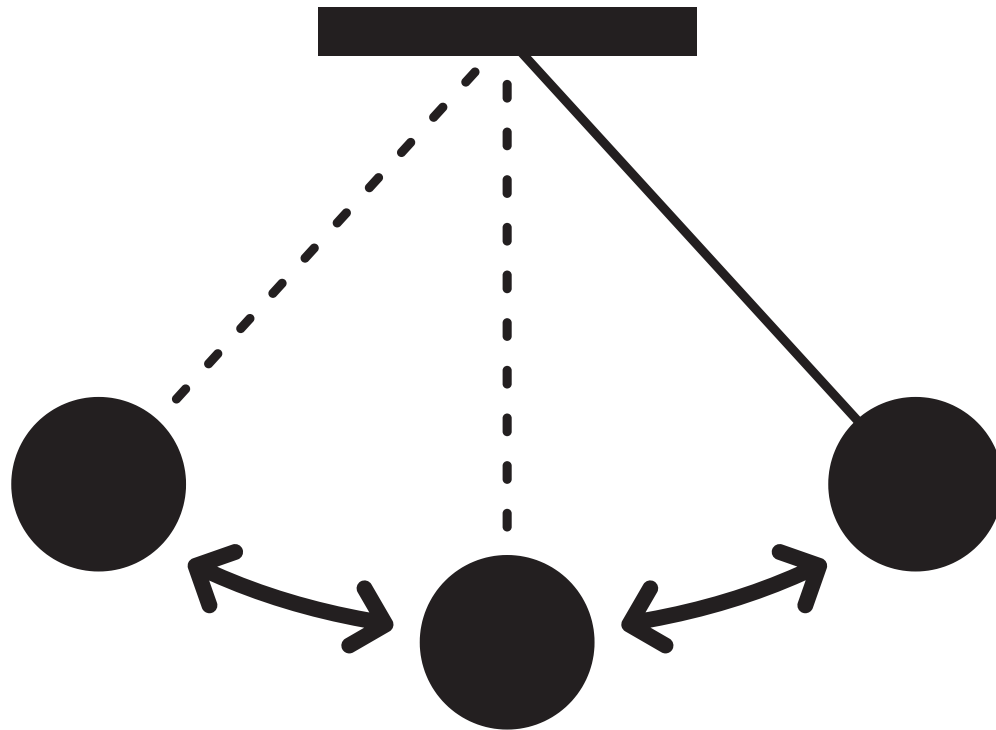


Pendulum Length vs Swing Period

Scientific Method • Variables • Data & Graphing

✓ Classroom-Ready

✓ Data tables + bar graph templates included



Pendulum STEM Investigation: Scientific Method Activity

Purpose

Use a simple pendulum 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 string lengths.
- Graph period data to analyze trends and construct evidence-based claims.
- Explain the physical principles of periodic motion.

Safety

- Keep swings below shoulder height and a clear area around the pendulum path.
- Use secure pivot points (ring stand or doorway hinge with tape) and check knots.
- Do not use heavy or sharp bobs; washers taped together are sufficient.

Materials

- String
- Washers (or other constant mass for all trials)
- Protractor (or angle card) to measure release angle ($< 15^\circ$)
- Stopwatch
- Meter stick or tape measure
- Ring stand/rod or doorway mount, tape
- Data sheets (included), pencils

Background Science for the Teacher

For small angles ($< 15^\circ$), the period T of a simple pendulum depends only on string length L and gravity.

Mass of the bob does not affect T (for small angles). Release angle has little effect if kept small and consistent.

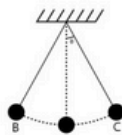
Timing several swings and dividing by the number (e.g., 10 swings) reduces reaction-time error.

Expected Results Pattern

- Period increases with the square root of length; graphs of T vs L show a gentle upward curve.
- Doubling length increases period by about $\sim 1.41\times$.
- Mass changes should not change period if other factors are controlled.

Implementation Notes

- Use a consistent pivot point and measure length from the pivot to the center of mass of the bob.
- Keep the release angle under 15° ; mark a small angle guide with the protractor.
- Time 10 swings per trial; divide by 10 to find the average period per trial.



Answer Key and Sample Results

Note: Actual class data will vary. The sample below models the expected trend for small angles.

Sample Summary Data

Length (cm)	Average Period (s)
20	0.90
30	1.10
40	1.27
50	1.42
60	1.55

Interpretation

- Average period increases with length.
- Doubling length from 30 cm to 60 cm increases period by about $\sim 1.41\times$.
- Mass of the bob should not change the period if the angle is small and the pivot is low friction.

Model Responses to Analysis Questions

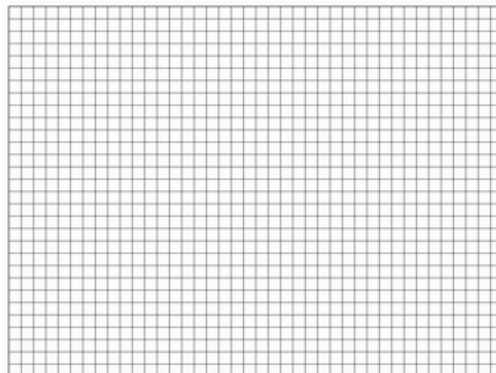
- Longest period at 60 cm (~ 1.55 s).
- Data follow a gentle upward curve; the increase from 50 to 60 cm is smaller than from 20 to 30 cm.
- Most important controls: small release angle, consistent pivot point and length measurement, identical bob mass, timing 10 swings and dividing by 10.
- Follow-up: Investigate release angle (5° , 10° , 15° , 20° , 25°) at a fixed length. Hypothesis: Period remains nearly constant up to $\sim 15^\circ$, then increases slightly for larger angles due to non-linear effects.

Graphing

- Create a graph of Average Period (s) on the y-axis vs String Length (cm) on the x-axis.
- Start y-axis at 0; include a clear title and axis labels. Optionally, add a smooth curve line.

Analysis Questions

- Which string length produced the longest average period? Include the mean period and the length value.
- How well do your data follow the square-root trend? Explain using your graph shape.
- Which controlled variables were most important to keep the test fair?
- If time allowed, what follow-up experiment would you run next (release angle, bob mass, different pivots)? State a testable hypothesis.



Pendulum STEM Investigation: Scientific Method Activity

Driving Question

How does string length affect the period of a pendulum?

Hypothesis

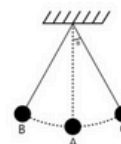
Write a testable hypothesis predicting which string length will produce the longest period and why.

Variables

Type	Describe for This Experiment
Independent Variable	String length (cm) measured from pivot to bob center
Dependent Variable	Average period for 10 swings (seconds)
Controlled Variables	Bob mass; release angle ($< 15^\circ$); pivot type; location; timing method; number of swings per timing; number of trials per length

Experimental Design

- Test five string lengths: 20 cm, 30 cm, 40 cm, 50 cm, and 60 cm.
- For each length, complete a practice set (2 timings, not recorded) to standardize technique. Then perform 5 timed trials for each and measure the time for 10 swings for each trial.
- Calculate the period (time for one complete cycle – i.e. B $\rightarrow$ B) for each trial by dividing the recorded time by 10.
- Keep the release angle under 15° and use the same start/stop cue for the timer.



Data Collection Tables

Length (cm)	Trial #	Time for 10 swings (s)	Period = time $\div$ 10 (s)
20	1		
20	2		
20	3		
20	4		
20	5		
Length (cm)	Trial #	Time for 10 swings (s)	Period = time $\div$ 10 (s)
30	1		
30	2		
30	3		
30	4		
30	5		
Length (cm)	Trial #	Time for 10 swings (s)	Period = time $\div$ 10 (s)
40	1		
40	2		
40	3		
40	4		
40	5		
Length (cm)	Trial #	Time for 10 swings (s)	Period = time $\div$ 10 (s)
50	1		
50	2		
50	3		
50	4		
50	5		
Length (cm)	Trial #	Time for 10 swings (s)	Period = time $\div$ 10 (s)
60	1		
60	2		
60	3		
60	4		
60	5		

Summary Table

Length (cm)	Average Period (s)
20	
30	
40	
50	
60	

Pendulum STEM Investigation: Rubric

Category	Exceeds (4)	Meets (3)	Approaches (2)	Beginning (1)
Experimental Design	Variables clearly named; procedure standardizes length, angle, and timing; practice round completed; enough trials for fair comparison.	Variables named; procedure mostly consistent; trials completed.	Variables partially named or unclear; inconsistent procedure; fewer trials than planned.	Variables missing; no consistent procedure; very few trials.
Data Quality	All trials recorded neatly; totals match; periods computed; summary complete.	Almost all trials recorded; minor slips corrected; summary mostly complete.	Several omissions or unclear entries; summary incomplete or mismatched.	Many missing or unreadable entries; summary not usable.
Graphing & Analysis	Correct graph with labeled axes and title; points reflect each length; clear takeaway identifying longest period with numbers.	Graph present with labels and title; takeaway stated.	Graph present but missing some labels or clarity; takeaway vague.	No graph or incorrect graph; no takeaway.
Claim–Evidence–Reasoning	Clear claim naming longest period; evidence cites results; reasoning connects to square-root relationship and small-angle model.	Claim supported with basic evidence and some correct reasoning.	Claim present but weakly supported; reasoning unclear or generic.	Claim absent or unrelated to data; no reasoning.
Collaboration & Safety	Roles used effectively; area kept clear; students on task and respectful.	Mostly cooperative; safe behavior with minor reminders.	Uneven participation; repeated reminders for safety or focus.	Off-task or unsafe behavior; roles unclear.

What You Get

- **Teacher Guide:** setup, safety, pacing, and background science.
- **Student Packet:** clear, step-by-step build/setup instructions and blank data tables for 5 trials per length (time for 10 swings).
- **Summary & Graphing Pages:** average-by-length table and graph template (Average Period vs String Length) with included graph paper.
- **Printable Angle & Length Aids:** $\leq 15^\circ$ angle card and length-measuring guide (pivot to bob center) for consistent setup.
- **Analysis & Model Answers:** four prompts with sample data and exemplar CER responses.
- **Rubric & Extensions:** simplified rubric for easy grading plus optional investigations.