SCOPES-DF

# Medieval Castle Siege: The Physics of a Tabletop Trebuchet

Instructor-ready lesson • 60 minutes • Suggested ages 11–14 (adaptable to 8–11) • Students operate prebuilt equipment; they do not fabricate or assemble trebuchets.

## Lesson Summary

How did medieval engineers use gravity to challenge castle defenses? In this hands-on STEM lesson, students operate an instructor-built, laser-cut, tabletop counterweight trebuchet to explore energy transfer, levers, variables, measurement, and engineering design. After learning how trebuchets were used during medieval sieges, teams predict and measure the effects of preapproved counterweight settings on the travel distance and accuracy of soft pom-poms. Finally, students test a lightweight cardboard castle wall and recommend improvements to its defensive design. The laser cutter is used by the instructor before class; students focus on historical inquiry, safe experimentation, data analysis, and discussion.

## Subject Areas

Engineering; History; Mathematics; Science; Technology

## Age Ranges

11–14 (primary); 8–11 (optional simplified version).

## Fab Tools

Epilog Mini laser cutter (instructor use only); computer with laser-cutting design software; 3 mm laser-approved plywood or other manufacturer-approved material; basic hand tools for instructor assembly.

## Topic Tags

Trebuchet; Medieval Engineering; Siege Technology; Simple Machines; Potential and Kinetic Energy; Levers; Measurement; Experimental Design; Castles

## Curriculum Standards

Suggested alignment (confirm against your school/district requirements): NGSS MS-PS3-2 (models of stored potential energy); NGSS MS-ETS1-3 (analyze data from tests of design solutions); CCSS.MATH.CONTENT.6.SP.B.5 (summarize numerical data). The lesson supports these practices; specific grade-level alignment should be verified by the instructor.

## What You'll Need

- Before class: 1–3 instructor-built tabletop counterweight trebuchets, approximately 6–8 in tall, each securely fixed to a stable base; use an enclosed counterweight and limit launching energy. Test every setting in advance.
- Soft, lightweight pom-poms only (no stones, metal balls, hard wooden pieces, or sharp projectiles); a

shallow catcher/backstop; floor or tabletop launch lane approximately 3–4 ft long.
- 1 miniature castle target, approximately 10–12 in wide, made from loosely assembled lightweight cardboard panels; replacement wall sections.
- Three clearly labeled, instructor-approved low-energy counterweight settings (low/medium/high); students do not change mechanical components themselves.
- Measuring tape or meter stick; masking tape for launch line and target; safety boundary markings; recording sheets; pencils; calculator.
- Projector or printouts with an image of a medieval counterweight trebuchet and a simple lever/energy diagram.
- Instructor preparation: laser-approved plywood, cutting file, dowels, wood glue and hardware as appropriate for the chosen design. Follow the cutter manufacturer’s material, ventilation, fire-watch and training rules.

## Learning Outcomes

- Describe the historical purpose of a trebuchet in attacking castle defenses and distinguish a historical stone projectile from the soft classroom substitute.

- Identify the fulcrum/pivot, throwing arm, counterweight, base, and projectile holder in a tabletop trebuchet.
- Explain qualitatively how gravitational potential energy becomes kinetic energy and why a lever changes motion.
- Make a testable prediction, control launch conditions, collect trial data, and calculate an average launch distance.
- Compare launch-distance and target-hit results to explain tradeoffs in experimental performance.
- Use evidence from testing to propose one improvement to a miniature castle's defensive layout.

### Step 1, Title

Introduction: Medieval Castles and Siege Engineering

### Step 1, Brief Description

Students encounter the challenge of attacking a heavily defended medieval castle. They learn what a trebuchet is and why counterweight-based siege engines mattered. The teacher connects historical engineering to gravity and levers.

### Step 1, Instructions

1. Time: 10 minutes. Show an image of a historical counterweight trebuchet and castle; ask: "How could

an army attack a high stone wall before modern explosives?”
2. Explain that medieval counterweight trebuchets used a descending mass, pivoting arm, and often a sling to launch stones; repeated impacts and other siege methods could damage defenses.
3. Display the classroom model and identify its pivot, arm, counterweight, frame, and soft projectile cup. Explain that the classroom version models principles rather than replicating historical destructive force.
4. Ask students to predict which part supplies the energy and which part directs the projectile.

### Step 2, Title

Physics Demonstration and Safety Briefing

### Step 2, Brief Description

The instructor demonstrates one short, controlled launch. Students observe the movement of the counterweight and arm. Before testing, the class agrees on operating rules and makes predictions.

### Step 2, Instructions

5. Time: 10 minutes. Secure the trebuchet, confirm its enclosed weight and stable base, and check the clear launch lane and backstop. Use soft pom-poms only.

6. Demonstrate gravitational potential energy (raised counterweight) changing to kinetic energy (moving arm and pom-pom). Introduce pivot/lever and the idea of a fair test.
7. Demonstrate the designated release mechanism; the instructor resets/rearms the device and adjusts settings. Students operate only the approved release under direct supervision, one at a time.
8. Require students to stand behind the marked line, keep hands and faces away from moving parts, and never aim toward people. Stop immediately if equipment shifts or any part loosens.
9. Ask groups to predict which of the three teacher-tested settings will yield the longest distance and whether longest distance also means best accuracy.

### Step 3, Title

Launch, Measure, and Analyze

### Step 3, Brief Description

Teams conduct repeatable, low-energy launches at a paper landing zone. They measure travel distance and record whether the projectile hits the target. They compare outcomes across the preapproved settings.

### Step 3, Instructions

10. Time: 20 minutes. Mark a consistent launch line and soft backstop; tape a target to the end of the lane. Keep the device and target in the same position for all trials.
11. In each trial, the instructor selects one preset counterweight configuration and resets the arm. One student uses the supervised release; teammates measure and record the landing distance and whether the target was struck.
12. Use at least three trials per chosen setting if time allows; record each distance in centimeters. If time is limited, compare three launches total, one per setting, and describe the limited evidence.
13. Students calculate the mean for repeated trials using (sum of distances) ÷ (number of trials). Discuss patterns and sources of variation, such as projectile placement or release timing.
14. Prompt: “Did more counterweight always produce a more useful result? What evidence supports your answer?”

## Step 4, Title

Castle Wall Challenge and Reflection

## Step 4, Brief Description

Students test how a soft pom-pom interacts with a lightly assembled cardboard castle wall. They compare a fragile

wall and a reinforced arrangement. Teams use evidence to suggest how medieval defenders might improve fortifications.

## Step 4, Instructions

15. Time: 15 minutes for testing and 5 minutes for debrief. Replace the paper target with the loosely fitted cardboard castle within the same secured launch area.
16. Students first predict which wall configuration will remain standing longer. Use a single preapproved low-energy setting for fair comparison; the instructor prepares the walls and resets the launcher.
17. Allow one supervised launch per team per configuration as time permits; observe whether panels fall or remain upright. Do not increase projectile hardness or power to force the wall to collapse.
18. Discuss why real stone walls were not equivalent to light cardboard, and how wall thickness, support, shapes, and siege tactics affected historical outcomes.
19. Have students write an evidence-based claim: “Our better castle wall was ___ because our observations showed ___.”

## Reflection

Draft instructor reflection (revise after teaching; the Field Activity Assignment questions were not supplied): This activity makes historical engineering visible through a miniature physical model. Students can observe how gravity provides energy, connect the pivoting arm to the concept of a lever, and test predictions using simple measurements. Because the instructor constructs and prepares the trebuchets in advance, classroom time is reserved for inquiry, collaboration, data collection, and analysis rather than fabrication. The soft-pom-pom and cardboard demonstration is a deliberately low-energy analogy: a real medieval siege used much larger devices and heavy stone ammunition. I will evaluate student learning through their explanations of energy transfer, recorded trial results, and evidence-based castle-design recommendations. After implementation, I will note whether the timing, student operation protocols, and selected counterweight settings worked as planned and adjust future lessons accordingly.

## File Attachment - Label

Medieval Castle Siege student Observation and Data Sheet (to prepare as a separate PDF or printable handout).

## File Attachment - File

Attach the student worksheet once created. Optional: instructor-approved laser-cut SVG, model photograph, and

trebuchet diagram. Do not upload an untested cut file as ready-to-use.

## Student Data Sheet — Copy/Paste Appendix

Team: _____ Date: _____

Prediction:

_____

| Setting | Trial | Distance (cm) | Target hit? |
|---|---|---|---|
| **Low** | 1 | _____ | Yes / No |
| **Low** | 2 | _____ | Yes / No |
| **Low** | 3 | _____ | Yes / No |
| **Medium** | 1 | _____ | Yes / No |
| **Medium** | 2 | _____ | Yes / No |
| **Medium** | 3 | _____ | Yes / No |
| **High** | 1 | _____ | Yes / No |

| | | | |
|---|---|---|---|
| **High** | 2 | _____ | Yes / No |
| **High** | 3 | _____ | Yes / No |

Average distance for each setting: Low _____ cm; Medium _____ cm; High _____ cm.

Evidence-based claim:

_____

_____

Castle-design improvement:

_____

_____