Family edition

Catapult Lab: Is 45 Degrees the Best?

Ages 11-14 · about 45 minutes, in one sitting

Your child moves the stop of a spoon catapult in Catapult Lab through every angle and finds out whether 45 degrees really throws farthest.

What you need

- A computer or Chromebook with a current browser, and a mouse or trackpad.
- The lesson link: mytekdev.com/try/catapultlab?lesson=is-45-degrees-best&ref=fam-catapultlab-2. No account, no email and nothing to install.

Before you start: try it once yourself

Open mytekdev.com/try/catapultlab?lesson=is-45-degrees-best&ref=fam-catapultlab-2. A short guide opens over the app. The spoon catapult is on the table: a plastic spoon on an axle, a red band to a front post, and a cross-bar that stops the spoon. Where the cross-bar stops it, on the right, sets the launch angle.

1. **The first throw.** Move Pull back all the way: the strip says "Pulled back 78 mm". Press Let go. The spoon swings up, stops at the bar, and the pom-pom lands at 1.19 m.
2. **Every stop.** Pulled all the way back each time: 15 degrees 1.55 m, 20 1.61, 25 1.63, 30 1.59, 35 1.50, 40 1.36, 45 1.19, 50 1.00, 55 0.77, 60 0.54, 65 0.30.
3. **The chart.** Press Find the best angle: best 25 degrees, 1.63 m. The no-air line peaks there too. The sentences say why 45 is not the best, and that the launch speed went from 2.8 to 6.6 m/s across the stops.
4. **The stacked catapult.** Under Catapult, tap Stacked sticks and press Find the best angle: best 66 degrees with nine sticks, 1.48 m. It cannot throw any lower.

> The moment that lands is the chart: the no-air line peaks at the same 25 degrees. The air is not what moved the best angle here; the speed is.

The ideas, in plain words

The rule that 45 degrees throws farthest is true only when three things hold: no air, a throw that starts and lands at the same height, and the same launch speed at every angle. A catapult breaks the third. Every throw here is pulled back to the same place, so a stop closer to upright gives the band a longer stroke and the pom-pom leaves faster: 6.6 m/s at 15 degrees, 4.6 at 45, 2.8 at 65. Faster at a low angle beats slower at 45.

The stacked catapult is a different case: its arm rests at an angle set by the stack, and it throws back over the banded end steeply. With nine sticks it throws at 66 degrees, and that is as low as it goes, so its best is simply its lowest. Children who were told 45 in an earlier lesson are not wrong about the rule, only about when it applies. Catapult Lab works out each throw from the build: how stiff the stick and the bands are, how heavy the cup and the

projectile are, and the air. Two of its numbers are estimates still to be measured (how hard the bands hold the end down, and that they give back 75% of what was stored), so a real catapult can land well short of the drawing or past it. The app never claims more: every speed and energy is shown as "about".

Do it together

1. Open mytekdev.com/try/catapultlab?lesson=is-45-degrees-best&ref=fam-catapultlab-2 together. A short guide opens over the app. Move `Pull back` all the way and press `Let go`.

   > **You'll know it worked when:** The pom-pom lands at 1.19 m, thrown at 45 degrees.

2. Press the minus under Where the cross-bar stops it three times, to 30 degrees, and throw again.

   > **If you get stuck:** Pull back all the way every time, so only the stop changes.
   >
   > **You'll know it worked when:** It lands at about 1.59 m, farther than 45.

3. Press `Find the best angle`.

   > **You'll know it worked when:** The chart says the best is 25 degrees, 1.63 m, and why.

4. Ask: when would 45 degrees be best?

   > **You'll know it worked when:** Only if the throw left at the same speed at every angle, from the floor, with no air.

Talk about it

Ask these while you work together. A child who has understood it can answer them without help:

- Which stop threw farthest, and how far?
- Did the pom-pom leave at the same speed at every stop? How do you know?
- Why does a stop closer to upright throw faster?
- When would 45 degrees be the best?
- Why is the stacked catapult's best 66 degrees?

> The fourth question is the real test: a child who names the same speed at every angle has understood why the rule failed here.

For younger and older kids

Younger: For a younger child, set Grades 4 and 5 and try five stops, comparing the distances in centimeters.

Older: For a teenager, set High school, write down the launch speed at each stop, and see how it changes with the angle.

Keep going

- Set the level to High school and record the launch speed at each stop. Make a graph of speed against angle.
- Add a second band. Does the best stop move?
- Try the ping pong ball. Is its best stop the same as the pom-pom's?

Bring it into other subjects

- Math: graph distance against stop from the table. Where is the top, and is the curve the same on both sides of it?
- Math: in high school, use v squared sin 2 theta over g with the speeds from the app, and compare with the no-air line.
- Building: a real spoon catapult with a movable stop: test three stops five times each. Eye protection for everyone the whole time, building too. Light, soft things only: pom-poms, marshmallows, ping pong balls. Aim at a target on the floor, never at a person. A stick can snap and splinter, so press slowly.
- History: a counterweight trebuchet's sling sets its release angle. Read how builders tuned it.

For your records

Ready to copy into an hour log, a portfolio or a transcript.

LESSON	Catapult Lab: Is 45 Degrees the Best?
SUBJECTS	Physical science, Engineering
TIME	45 minutes
WHAT WE DID	Tested a catapult at eleven launch angles, found the best from the data, and explained why it was not 45 degrees.
SKILLS PRACTICED	Fair tests; Graphing; Engineering design

Activity sheet (optional)

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/catapultlab?lesson=is-45-degrees-best

Essential question: Is 45 degrees always the best angle to throw at?

Warm-up: To throw something as far as you can, what angle should it leave at? _____

1. **Vocabulary.** Launch angle, range, launch speed, variable, optimal: write each in your own words.

2. **The angle table.** For each stop from 15 to 65 degrees, by 5, pulled all the way back: how far _____ m. Best stop _____ degrees. Stacked catapult's best _____ degrees.

1. Which stop threw farthest? Was it 45 degrees? Why or why not?

2. When would 45 degrees be the best angle?

Quick check

Name: _____

1. On the spoon catapult, pulled back the same way each time, the best stop was (A) 45 degrees (B) about 25 degrees (C) 65 degrees

2. Why did a stop closer to upright throw faster? (A) The band pulled the spoon farther before it stopped (B) The air pushed it (C) The pom-pom was lighter

3. When is 45 degrees the best angle?

Answers

QUESTION	ANSWER	WHY
1	B	With one band, 25 degrees threw 1.63 m and 45 threw 1.19 m.
2	A	Pulled back to the same place, a stop closer to upright gives the band a longer stroke, so the spoon is moving faster when it stops.
3	Same speed at every angle, no air, from the floor	All three are needed. "When there is no air" alone is half: the no-air line here still peaks at 25 degrees.

If your state or umbrella school asks, this lesson covers NGSS MS-ETS1-4.

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The app this lesson uses is free and runs in the browser, with nothing to install and no account needed. It is at mytekdev.com.

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