Family edition

Catapult Lab: Until It Snaps

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

Your child adds rubber bands to a popsicle stick catapult in Catapult Lab until it snaps, then finds a stronger design.

What you need

- A computer or Chromebook with a current browser, and a mouse or trackpad.
- The lesson link: mytekdev.com/try/catapultlab?lesson=until-it-snaps&ref=fam-catapultlab-3. No account, no email and nothing to install.

Before you start: try it once yourself

Open mytekdev.com/try/catapultlab?lesson=until-it-snaps&ref=fam-catapultlab-3. A short guide opens over the app. The catapult is built with one band at the banded end. The shelf has Bands at the end (one to four) and Top stick (One stick, Two sticks banded, Two sticks glued).

1. **One to three bands.** Press all the way (to the base, 23 mm) each time: 0.39 m, 0.56 m, 0.66 m.
2. **The snap.** Four bands, one stick: move Press slowly. At about 21 mm the stick snaps over the stack and is drawn broken. The card says the stick gave out long before the bands did.
3. **Stronger tops.** Put on a new stick. Four bands: Two sticks banded 0.80 m, Two sticks glued 0.96 m, and neither snaps. Glued, the two act as one stick twice as thick.

> The moment that lands is the snap at four bands. Children expect more bands to mean more distance, with no limit.

The ideas, in plain words

Pressing the cup bends the top stick over the stack and lifts the banded end against the bands. Both store energy, like two springs one after the other. More bands make the banded end harder to lift, so the same press stores more energy and bends the stick harder. A standard craft stick is birch about 2 mm thick; the app breaks it when the wood is stressed past about 65 million pascals, a little under birch's strength, because wood varies.

Two sticks banded together share the load, so each bends less. Two glued act as one stick twice as thick, which is eight times as stiff and four times as strong in bending. Each extra band also adds less distance than the one before, because the stick bends more and the cup still has to be swung. 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=until-it-snaps&ref=fam-catapultlab-3 together. A short guide opens over the app. Move `Press` all the way and press `Let go`.

   > **You'll know it worked when:** One band: 0.39 m.

2. Add bands with the plus under Bands at the end, throwing after each.

   > **You'll know it worked when:** Two bands 0.56 m, three 0.66 m.

3. Add a fourth band and press slowly all the way.

   > **If you get stuck:** If nothing happens, press all the way to the right end of the slider.
   >
   > **You'll know it worked when:** The stick snaps at about 21 mm.

4. Press `Put on a new stick`, tap `Two sticks glued`, and throw with four bands.

   > **You'll know it worked when:** It holds, and throws 0.96 m.

Talk about it

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

- Did each band add the same distance? How do you know?
- What broke first, the stick or the bands?
- Why did two glued sticks hold four bands?
- What is your criterion, and what is your constraint?
- What did you give up to get your design?

> The fourth question is the real test: a child who can say "throw far" and "do not snap" in their own words, and judge a design by both, has the idea.

For younger and older kids

Younger: For a younger child, compare one stick with two glued, and talk about why two glued are stronger.

Older: For a teenager, set High school and see how much stored energy each band adds at the same press.

Keep going

- Set High school: the strip shows how many millijoules are stored. How much more does each band add?
- Try a jumbo stick. Does it snap with four bands?
- Find the most bands and the shortest press that still throws past 0.5 m. Why might a class want a short press?

Bring it into other subjects

- Math: graph distance against number of bands for each top. Which graph flattens first?
- Building: test real tops, single and glued, with one to three bands, five throws 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.
- English: write a short recommendation for a class contest, with your data and your trade-off.
- Careers: bridge and building engineers set a "factor of safety". Find out what it is, and what yours would be.

For your records

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

LESSON	Catapult Lab: Until It Snaps
SUBJECTS	Physical science, Engineering
TIME	45 minutes
WHAT WE DID	Tested a catapult design to its breaking point, stated the criterion and the constraint, and chose the strongest design that held.
SKILLS PRACTICED	Engineering design; Criteria and constraints; Recording data

Activity sheet (optional)

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/catapultlab?lesson=until-it-snaps

Essential question: How strong can you make a catapult before it breaks?

Warm-up: If one rubber band throws it 0.39 m, how far will four throw it? _____ m

1. **Vocabulary.** Criteria, constraint, stiff, stress, trade-off: write each in your own words.

2. **The band table.** For each top (one stick, two banded, two glued) and 1 to 4 bands, pressed all the way: how far _____ m, or "snapped".

1. My criterion is _____. My constraint is _____.

2. Which design would you build? What did you give up to get it?

Quick check

Name: _____

1. Adding a fourth band to one stick and pressing all the way (A) throws four times as far (B) snaps the stick (C) breaks a band

2. Two sticks glued together held four bands because they are (A) heavier (B) stiffer and stronger (C) longer

3. Name one criterion and one constraint for a classroom catapult.

Answers

QUESTION	ANSWER	WHY
1	B	With four bands the stick breaks at about 21 mm, before the cup reaches the base at 23 mm.
2	B	Glued, they bend as one stick twice as thick: much stiffer and stronger.
3	Criterion: throw far. Constraint: do not snap	Any fair pair counts, such as "lands in the target" and "uses 8 sticks or fewer". A criterion is what it must do; a constraint is a limit.

If your state or umbrella school asks, this lesson covers NGSS MS-ETS1-1, NGSS MS-ETS1-2.

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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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