COMPANION GUIDE · VOLUME 3 · LAUNCH LAB

the Shoebox Lab *Kit Series*

Launch Lab

Aim, Launch & Discover the Science of Flying Things

ADULT FACILITATOR COMPANION

AUDIENCE	GRADES	TIME	ACTIVITIES
Facilitator + Learner	3–5	~2¾ hrs	3 + Challenge

Welcome to Launch Lab!

GRADES	AGES	TIME	ACTIVITIES
3–6	8–11	about 3 hours	3 + Challenge

This kit is an engineering lab in a box. The child will build two launchers, test them, and use real data to win. They will learn

1. How bending and stretching can store energy
2. How a lever and its fulcrum fling things
3. How launch direction changes a flight
4. How to run a fair test and use your data to win

Everything you need is in the box. It is all the child's to keep. Keep the box — it needed in the Grand Challenge!

YOUR JOB IS SIMPLE: ASK QUESTIONS. DON'T GIVE ANSWERS.

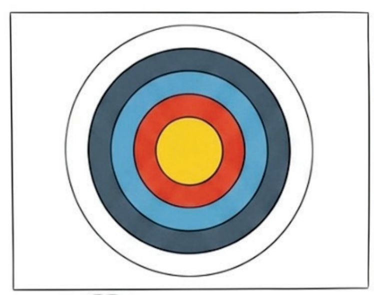
You do not need to be a science expert. The kit, the workbook, and the videos help the child learn.

WHAT IS IN THE KIT?

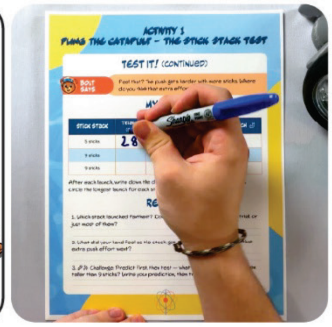
Check the box: is everything there?

- 13 craft sticks
- 7 rubber bands
- 2 cardboard tubes
- 5 felt balls
- Building bricks
- Workbook & a pencil
- Plastic spoon
- Pencil
- Bullseye target
- Tape measure
- Target cards

You will also need 6 thin books from home.



How It Works



1 BUILD	2 LAUNCH	3 WRITE	4 TALK
The child builds.	**The child tests it.**	**The child writes the distance.**	**You talk about it together.**

The workbook leads the child step by step. Children can do most steps alone. The best part? Doing it together. Who knows, you might learn something, too!

ONE TIP: DON'T CORRECT A GUESS BEFORE THE TEST!

Wrong guesses can be good science. – Let the launches show the answers.

Also: keep the push the same. Most odd results start with a different push.

WHAT TO SAY

"What do you notice?"

"How far do you think it will go?"

"Show me how it works."

"What changed?"

"Why do you think it went farther?"

"Great try — launch it again!"

Children often learn to read English fast. If they want, let the child read the workbook out loud to you!

Watch the Videos

SCAN ME

LL • All Videos
shoeboxlab.org/ll

LL • Activity 1	LL • Activity 2	LL • History Spotlight	LL • Activity 3	LL • Science Spotlight	LL • Grand Challenge

No reading is needed. Every step is in a short video. Scan a code with a phone camera. Watch together before you start. Each activity has its own code — find it in the table.

What are the Activities

Activities at a Glance

	Activity	WORKBOOK	THIS GUIDE	VIDEO
1	**#1: Fling the Catapult** *Build a catapult and test its stack*	pp. 5–10	p. 11	ll1
2	**#2: Pull Back & Sling** *Build a slingshot and test your pull*	pp. 11–14	p. 14	ll2
H	**History — Launchers Through History** *Same problem, different machines!*	pp. 15–17	p. 20	ll6
3	**#3: Angle Test** *Find out what tilting your catapult does*	pp. 18–21	p. 17	ll3
S	**Science Spotlight — Stored Energy** *The science behind your launches!*	pp. 22–24	p. 21	ll5
★	**Challenge — Siege the Fort** *Use your data to win two launch events!*	pp. 25–29	p. 23	ll4

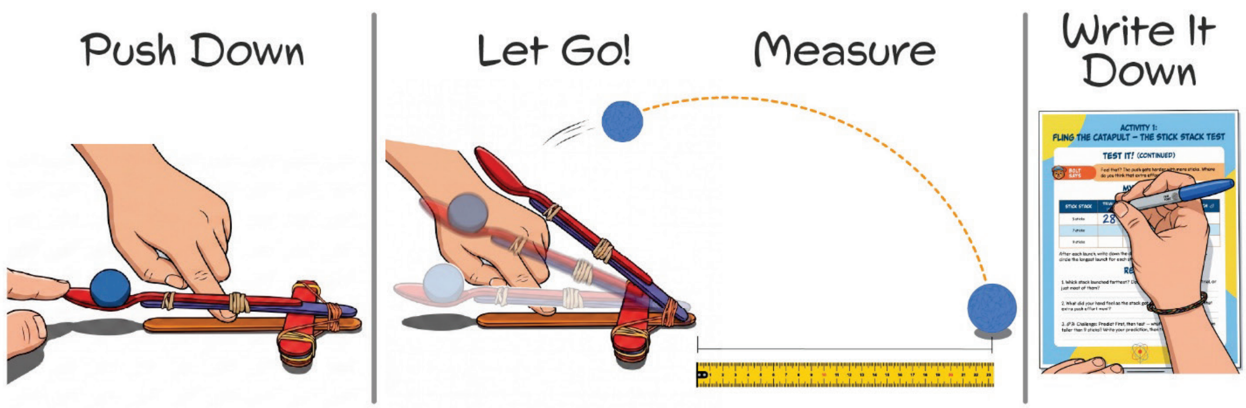
Safety First

✓ SAFETY RULES

1. Never aim at people, pets, or faces.
2. Keep your head beside the launcher, never over it.
3. Launch felt balls only — nothing hard.
4. Clear the launch zone before you fire.
5. Pick up balls and bricks between rounds.

✓ BEFORE THE FIRST RUN

Clear a 2 m floor lane. Have the tape measure and 6 thin books ready.•



YOU'RE READY!

Read page 3 of the workbook together first. Then turn to page 5. Bolt the Bear meets you there. Have fun

! IF SOMETHING GOES WRONG !

1. The spoon flops instead of springing back → tighten the rubber bands.
2. The ball rolls out of the spoon on a tilt → use fewer or thinner books.
3. A band slips off the tube → hook both bands on each side back into the slot.
4. Launches are all over the place → same push every time: push until the sticks touch.
5. You can't break the kit. Try again — that's what engineers do!

Need help?

The child is stuck → p 33.

Something sounds wrong (mix-ups) → p 31.

Check an answer → the end of each activity.

A science word → p 41.

A Note to the Facilitator

❖ HOW THIS GUIDE REFERS TO YOU AND THE LEARNER

A note on language used in this guide: the adult leading the session is called the facilitator, or “you” when addressed directly. The child doing the kit is called the learner. These terms are used throughout regardless of your relationship — adult facilitator, grandparent, homeschool educator, older sibling, or any other trusted adult.

Welcome — and thank you for taking the time to do this with the learner in your life. You don’t need an engineering background, a teaching degree, or any special equipment beyond what’s in this box and six thin books from a shelf. What you do need is curiosity, a willingness to ask questions rather than give answers, and a strip of floor where a felt ball can fly.

This kit is designed so the learner does the discovering. Your job as the facilitator is to set up each activity, ask the right questions at the right moments, and get out of the way. This guide gives you those questions, explains the science behind what’s happening, and tells you what to expect at each step — including when things don’t go as planned.

A few things worth knowing before you begin:

- You do not need to read this guide front to back. It is a reference. Section 2 (Activity Guide) is the part you will use most — work through it alongside the student workbook.
- Unexpected results are not failures. When a launch falls short or the 9-stick stack doesn’t win every trial, that’s engineering being real — and often the best teaching moment in the kit.
- The kit works equally well spread across several days or done in a couple of longer sessions. Session suggestions are in Section 1.

MEET BOLT THE BEAR

Bolt appears throughout the student workbook as a mascot and guide — in Launch Lab he wears his knight’s helmet. When the learner reads a “Bolt Says” box, feel free to read it together — they’re often the most important tips in that section.

How This Guide Is Organized

This guide has five sections. You don't need to read them in order — skim the table below, find what you need, and come back as questions come up.

Section	What It Contains	When to Use It
1 — Before You Begin *page 8*	Kit checklist and how to set up your launch lane — read this before Session 1.	*Read before Session 1*
2 — Activity Guide *page 11*	Step-by-step facilitation for each activity: learning goals, prep tips, questions to ask, and what good results look like.	*Use alongside the student workbook*
3 — Supporting the Learner *page 29*	Opens the For Teachers & Group Leaders pages: the science primer, grade tips, common mix-ups, and troubleshooting.	*Reference when needed*
4 — Standards & Awards *page 36*	Full Next Generation Science Standards (NGSS) alignment, math connections, and Cub Scout Adventure connections.	*For homeschool documentation or program tracking*
5 — Quick Reference *page 41*	Word Watch answer guide for every vocabulary term, plus suggested outside resources.	*Use after finishing the kit*

SECTION 1

Before You Begin

This section gives you everything you need to run the kit well: what's in the box, how to set up a launch lane, and how to pace the sessions. You don't have to read every word before Session 1 — skim what's useful and come back as questions come up.

1.1 Kit Contents

Confirm the following items are in the kit before your first session:

KIT ITEM	NOTES
Craft sticks (×13)	9 for the Activity 1 stick stack + 4 for the catapult arm
Rubber bands (×7)	Hold the catapult together; 4 power the slingshot (2 per side)
Plastic spoon	The catapult's launch arm
Cardboard tubes (×2)	Smaller tube with three rings marked + larger tube with slots cut — the slingshot
Pencil	The slingshot's handle (Activity 2)
Felt balls (×5, assorted colors)	The only things that are ever launched
Bullseye target	Goes inside the box for the Grand Challenge Box Shot
Building bricks (24 × 2×4)	The Grand Challenge wall — stack them, never snap them
Target design cards	Wall, Pyramid, Design Your Own
Tape measure	Every distance in the kit is measured in centimeters
The kit box	Keep it — with the lid open it is the Box Shot target
This companion guide	You're reading it!
Student workbook	For the learner participating

You will also need to supply:

- 6 thin books, each about as thick as the workbook (they tilt the catapult in Activity 3 — thicker books make the ball roll out)
- A pencil for the workbook
- Optional: masking tape or a strip of paper to mark the launch line

1.2 Setting Up Your Space

The ideal setup is a strip of hard floor about 2 meters long — a hallway or a cleared kitchen floor. Launches go farther than you might expect: a 9-stick catapult can fling a felt ball close to 2 meters. Hard floor beats carpet, because the learner measures where the ball first lands, not where it rolls.

Set the launcher at one end of the lane and keep breakables, pets, and people out of the far end. The kit box, lid open, becomes the Box Shot target in the Grand Challenge — keep it nearby.

IF YOU'RE WORRIED ABOUT MESS

There is nothing wet in this kit. The only mess is bricks and felt balls on the floor — and a brick underfoot hurts.

- Pick up balls and bricks between rounds.
- Keep the launch lane clear of feet.
- A shoebox lid or tray keeps the bricks together between sessions.

(Tip: a strip of masking tape makes a launch line the learner can see.)

MEASURE CAREFULLY, NOT PERFECTLY

The tape measure runs from the front of the launcher to where the ball first lands. Round to the nearest centimeter. If a trial looks odd, it is almost always the push — not the learner, and not the kit.

RUNNING THE KIT WITH MULTIPLE LEARNERS

If more than one learner is participating, assign roles for each launch: one launches, one spots the landing, one measures and records. Rotate roles between trials to keep everyone engaged.

⚠ SAFETY NOTES

- Felt balls are soft, but a spoon arm springing up or a ball bouncing back can still catch an eye. Keep every head beside the launcher, never above it, and never aim at a person, pet, or face.
- Only felt balls are ever launched — no coins, rocks, or bricks. Pick up bricks between rounds so no one steps on one, and keep small parts away from children under three.

Suggested Session Schedule

Now that your space is set up, here's a suggested pacing for getting through the kit:

Session	Activities	Estimated Time
Session 1	Activity 1 (Catapult) + Activity 2 (Slingshot)	~60 min
Session 2	History (Launchers Through History) + Activity 3 (Angle Test) + Science Spotlight	~60 min
Session 3	Grand Challenge (Siege the Fort!)	~45 min
Total		~2 hr 45 min

FOR HOMESCHOOL FACILITATORS

These three sessions map cleanly onto three lesson periods and can be spread across a week without losing continuity. Keep the built launchers between sessions — the Grand Challenge uses both, and rebuilding costs time.

Before You Open the Kit: What Your Learner Already Knows

Before you open the kit with your learner, spend three to five minutes in conversation. Their answers tell you where to pitch the activities and which ideas to reinforce. Don't correct anything yet — just listen, and jot a note if something surprises you. You'll come back to these same questions at the end. Think of them as conversation starters, not a quiz — there are no wrong answers yet.

- Have you ever used a slingshot, a bow, or a trampoline? What makes them work?
- Does a rubber band have any energy in it right now? What about when you stretch it?
- If you wanted to throw a ball as far as you could, would you throw it flat or up high?
- What would you like to find out by the end of this kit?

SECTION 2

Activity Guide

This section walks through each activity. Every activity has the same rhythm: a short build, a test with data, and a reflection. You don't need to read it all before starting. Work through it, one activity at a time.

Each activity opens with learning goals, standards, and a "Before the Session" checklist. While you work, use the Questions to Ask sidebar for prompts. The Answer Guide at the end of each activity covers the workbook's Reflect questions. Read it yourself before the learner gets there.

ACTIVITY 1

Fling the Catapult! The Stick Stack Test

LEARNING GOALS

For the learner to understand…

- How a bent stick stores energy and springs back to fling a ball
- That a taller stick stack (the fulcrum) bends the top stick farther — and flings farther
- How to keep the push the same so only the stack changes (a fair test)

STANDARDS AT A GLANCE

Primary: 4-PS3-1, 3-5-ETS1-3

Also supports: 4-PS3-4, 3-PS2-1

Full alignment details are in Section 4.

TIME BUDGET FOR THIS ACTIVITY

Build ≈ 10 min · Test & record ≈ 15 min · Reflect ≈ 5 min (≈ 30 min total)

The build is quick; the launches are where the time goes. Nine launches plus measuring is a comfortable 15 minutes.

✓ BEFORE THE SESSION

1. Clear the launch lane and have the tape measure and workbook at the near end. A strip of tape marks where the front of the catapult sits.
2. Read the Fair-Launch Rule on workbook p. 8 — hold the base, push the arm down until the sticks touch, let go. Same push every time is the whole trick.
3. If you have a minute, build and fire one yourself first so you know how the push should feel.

How the activity runs

The learner stacks 5 craft sticks and bands the ends — the stick stack. Four more sticks make the arm: banded at one end and opened like an alligator's mouth, with the stack slid inside as the pivot. The spoon is banded to the top sticks (workbook pp. 5–7). Then the test: three launches at 5 sticks, add 2 sticks (7), three more, add 2 more (9), three more — nine launches, each measured to where the ball first lands (workbook pp. 8–10). Figure 1 shows the finished catapult.

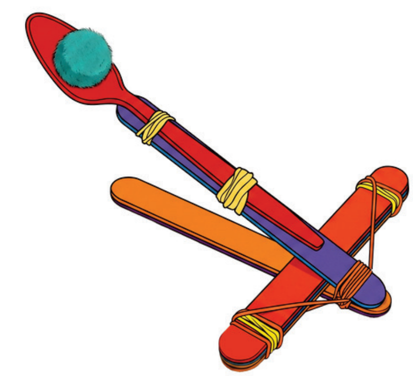


Figure 1. The finished catapult: the stick stack is the fulcrum, the top stick is the lever that bends and springs back, and the spoon carries the ball.

Your job during the test: guard the push. The only thing that should change between rounds is the number of sticks in the stack. Don't explain why the taller stack flings farther. Let the learner feel the push get harder and see the numbers grow.

WHY ADD STICKS, NEVER REMOVE THEM?

Taking sticks out means loosening the bands and rebuilding, and the arm rarely seats the same way twice. Adding two sticks into the middle of the stack keeps everything else the same — which is exactly what a fair test needs.

✎ QUESTIONS TO ASK THE LEARNER

Before the first launch: *Where does the ball's energy come from? Where is it stored before you let go?*

After adding sticks: *Did the push feel different? Where do you think that extra effort went?*

Looking at the data table: *Which stack flung farthest? Did it win every trial, or just most of them?*

Thinking it through: What did you keep the same every time? Why does that matter?

★ Challenge: *What do you predict for a stack even taller than 9? What might go wrong?*

○ WHAT GOOD RESULTS LOOK LIKE

A clear upward trend.
About 10–20 cm at 5 sticks, 75–90 cm at 7, and 1.5–1.8 m at 9. The push gets noticeably harder as the stack grows. One odd trial is normal. If every trial is short, the arm is loose — tighten the bands so the spoon springs back sharply. If the spoon flops, it isn't storing energy yet.

→ GOING FURTHER

- Try the ★ challenge for real if you have two spare craft sticks: an 11-stick stack. It usually flings farther — until the bands can't hold the arm. Finding that limit is real engineering.
- Slide the stick stack toward the spoon end, then toward the handle end. Same sticks, different fulcrum position — what changes?

Activity 1 — Answer Guide

These notes describe the type of thinking to listen for in each Reflect question *(workbook p. 10)* — they are not scripted answers. ★ marks the challenge question.

Q1: Which stack launched farthest? Does your data show that in every trial, or just most of them?

Key ideas: an accurate read of their own table — usually 9 sticks — and an honest look at the trials. A strong answer notices when one trial breaks the pattern and says so.

If stuck: "Circle the longest launch in each row. Which row has the biggest number? Did every trial in that row beat the others?"

Q2: What did your hand feel as the stack got taller? Where do you think that extra push effort went?

Key ideas: the push got harder, and that effort went into the stick — stored in the bend, then given to the ball. Any version of "the stick holds it, then gives it to the ball" is the idea.

If stuck: "Push the arm down and hold it. Is it pushing back on you? Where is that push coming from?"

★ Challenge: Predict first, then test — what happens with a stack even taller than 9 sticks?

Key ideas: a prediction that follows the trend (farther), then a test. Look for the learner noticing the limit: the push gets very hard, or the bands can't hold the taller stack.

If stuck: "Your table goes 5, 7, 9. What does the pattern say 11 would do? Now try it."

CARRYING FORWARD TO ACTIVITY 2

In Activity 1 the learner stored energy by bending a stick. In Activity 2 they'll store it a different way — by stretching rubber bands. Before starting, ask: "Is there another way to store energy besides bending something?"

ACTIVITY 2

Pull Back & Sling! The Pull-Back Test

LEARNING GOALS	STANDARDS AT A GLANCE
For the learner to understand… ▪ That stretched rubber bands store energy, just as a bent stick does ▪ That a longer pull-back means a bigger stretch — and a farther launch ▪ How marked rings make every pull the same (a fair test)	**Primary:** 4-PS3-1, 3-5-ETS1-3 **Also supports:** 4-PS3-4, 4-PS3-2 Full alignment details are in Section 4.

TIME BUDGET FOR THIS ACTIVITY

Build ≈ 8 min · Test & record ≈ 15 min · Reflect ≈ 7 min (≈ 30 min total)

If you run Activities 1 and 2 back to back, keep the catapult built and set it aside — the Grand Challenge needs it.

✓ BEFORE THE SESSION

1. Confirm the two tubes, the pencil, and 4 rubber bands are on hand. The smaller tube has three rings drawn on it and two holes near the back; the larger tube has slots cut.
2. A short conversation first: “Last time a bent stick stored the energy. What do you think will store it this time?”
3. Read the firing rule on workbook p. 12: pull until the ring you want just peeks past the back rim — then let go.

How the activity runs

The learner slides the pencil through the holes in the smaller tube, loops two rubber bands over each end of the pencil, slides the smaller tube into the larger one, and hooks the bands into the slots (workbook pp. 11–12). Then the test: three launches at the Short ring, three at Medium, three at Full, each measured to where the ball first lands (workbook pp. 13–14). The ✎✦ challenge on p. 14 takes one band off each side and launches again at Full.

Your job during the test: watch the rings. "Just peeks past the rim" is the rule, and it makes every pull the same. Let the learner discover that a farther pull means a bigger stretch — don't say it for them.

Background for the facilitator — two ways to store energy

This is where the kit's big idea starts to land. The catapult stored energy in a bent stick. The slingshot stores it in stretched rubber bands. Different material, same idea: something elastic is pushed out of shape, holds the energy, and gives it back when you let go. Figure 2 shows the loaded slingshot.

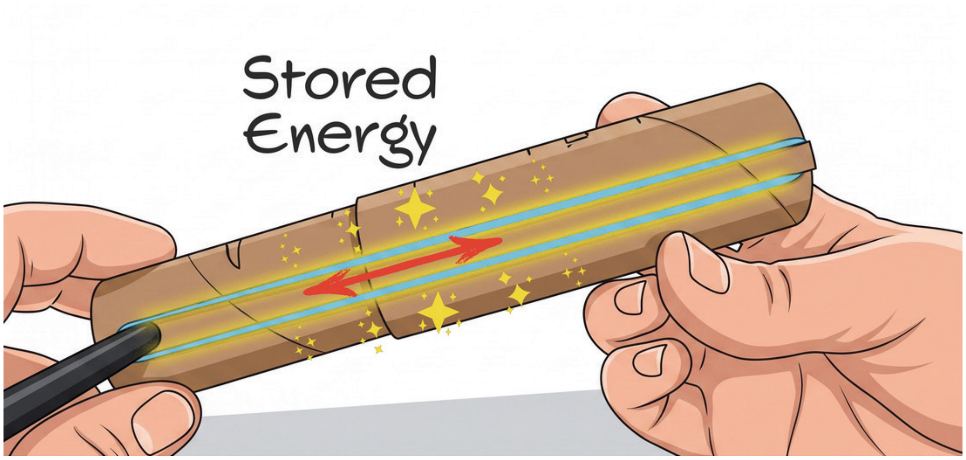


Figure 2. The slingshot at Full pull: the bands are stretched and the energy is stored. Let go, and the bands snap back and the ball zooms out of the tube.

✎ QUESTIONS TO ASK THE LEARNER

Before launching: *Where is the energy stored in this launcher? How is that different from the catapult?*

After the Short pulls: Predict Medium and Full before you try them. Bigger stretch — what will happen?

Thinking it through: *How do the rings make the test fair? What would go wrong without them?*

Challenge: *With one band off each side, what changed — the stretch, or the number of bands doing the pulling?*

○ WHAT GOOD RESULTS LOOK LIKE

A steady climb: about 15–20 cm at Short, 60–70 cm at Medium, and around 90 cm at Full (with the kit's two bands per side).

The band challenge: one band per side lands about half as far — roughly 45 cm. The kit ships two bands per side on purpose: three is too hard for small hands to pull.

→ GOING FURTHER

- Ask which launcher is easier to aim — then test it: three shots each at the bullseye from the same spot. That question comes back in the Grand Challenge.
- Pull to Full and hold for a count of three before letting go. Does holding change anything? (It shouldn't — the stretch, not the wait, sets the energy.)

Activity 2 — Answer Guide

These notes describe the type of thinking to listen for in each Reflect question *(workbook p. 14)* — they are not scripted answers. ★ marks the challenge question.

Q1: Did Full always beat Short? Check every single trial.

Key ideas: a trial-by-trial check, not a glance. The answer is almost always yes — and the habit of checking every trial is the point.

If stuck: "Put your finger on the smallest Full launch and the biggest Short launch. Which is bigger?"

Q2: Which launcher was easier to aim — your catapult or your slingshot? Why do you think so?

Key ideas: an opinion backed by a reason. Most learners find the catapult easier to aim — the spoon holds the ball and the base sits still. Either answer is fine if the reason is real.

If stuck: "Which one did you have to hold steady with two hands? Which one wobbled?"

★ Challenge: Take one rubber band off each side — then launch with the same Full pull. How much closer does it land?

Key ideas: about half the distance, and a reason: fewer bands means less stored energy for the same stretch. Look for the learner keeping the pull the same — that's the fair-test habit.

If stuck: "Same pull, fewer bands. Which part of the launcher was doing the work?"

CARRYING FORWARD TO THE HISTORY PAGES

The learner has now stored energy two ways: bending and stretching. The history pages show people doing the same thing for thousands of years — with lifting, squishing, and twisting, too.

ACTIVITY 3

Angle Test! Same Push, New Direction

A NOTE FOR THE FACILITATOR BEFORE YOU BEGIN

Heads-up: the distances climb all the way to 6 books, and then the ball starts rolling out of the spoon before the launch. That's a real result — every design has a limit. Resist telling the learner what the data "should" show.

LEARNING GOALS	STANDARDS AT A GLANCE
For the learner to understand… ▪ That the direction of a launch changes how far the ball flies, even when the stored energy stays the same ▪ How to change one thing (the angle) and keep everything else fixed ▪ That every machine has a limit — and finding it is part of engineering	**Primary:** 3-5-ETS1-3, 4-PS3-1 **Also supports:** K-PS2-2, 3-5-ETS1-2 Full alignment details are in Section 4.

TIME BUDGET FOR THIS ACTIVITY

Set up ≈ 5 min · Test & record ≈ 15 min · Sketch & reflect ≈ 5 min (≈ 25 min total)

✓ BEFORE THE SESSION

1. Have the catapult from Activity 1 set to 7 sticks, and the 6 thin books stacked at the launch line. Thin is the key word: books much thicker than the workbook tip the spoon too far.
2. The bullseye target comes out for the ★ challenge — keep it handy.
3. Encourage a written prediction first: "Flat, 2 books, 4, or 6 — which will fling farthest? Why?"

How the activity runs

The learner launches three times Flat, then props the spoon-side edge of the catapult on 2 books, then 4, then 6 — three launches each, the same push every time (workbook pp. 18–20). Only the angle changes.

Then they sketch two flight paths, Flat and 6 books, in the sketch box (workbook p. 21). Same stick, same bend, same push — different direction, different distance.

✎ **QUESTIONS TO ASK THE LEARNER**

Before starting: *What is the one thing we're changing this time? What are we keeping exactly the same?*

After the Flat launches: *Predict 2 books before you try it. Then predict 4.*

After 6 books: *Did the ball stay in the spoon? What would happen with 8?*

Looking at your data: *Did the distance keep climbing? By how much each time?*

Looking across all activities: *Which change made the biggest difference — sticks, pull-back, or angle? Can you back that up with numbers?*

○ **WHAT GOOD RESULTS LOOK LIKE**

A climb with each step:about 35 cm Flat, 40–50 cm at 2 books, 50–70 at 4, and 60–75 at 6 (with a 7-stick stack). The exact numbers matter less than the direction of the change.

If the ball rolls out of the spoon before the launch, the tilt is too steep — take a book away, or use thinner books. That limit is worth talking about, not hiding.

→ **GOING FURTHER**

- Add another book or two. When does the ball roll out? Ask the learner to describe the limit in their own words.
- Repeat the whole test at 9 sticks. Does the angle matter more or less when there is more stored energy?

Activity 3 — Answer Guide

These notes describe the type of thinking to listen for in each Reflect question *(workbook p. 21)* — they are not scripted answers. ★ marks the challenge question.

Q1: Which launch angle sent your ball farthest? How much did it beat Flat by?

Key ideas: an accurate read of the table — usually 6 books — and a subtraction: best 6-book launch minus best Flat launch. A strong answer gives a number.

If stuck: “Find your Best Launch for Flat and for 6 books. What’s the difference between them?”

Q2: The stick bent the same amount every time — so what changed between launches?

Key ideas:the direction. The stored energy never changed; the launch angle sent the same energy on a different path. Look for “same push, different direction” in the learner’s own words.

If stuck:“What did the books do to the catapult? Did they change the bend, or where the ball was pointed?”

★ Challenge: Put your bullseye target past your best Flat launch. Can you tilt your way to it?

Key ideas: choosing an angle from the data, then adjusting. There is no one right number — look for the learner using the table to pick a starting tilt instead of guessing.

If stuck: “Your table says how far each tilt goes. Which row reaches the target?”

CARRYING FORWARD

Three activities, two launchers, one big idea with two halves: how much energy is stored, and which way it goes. The Science Spotlight now gives the learner the words for what they saw, and the Grand Challenge puts both halves to work.

FACILITATED READING

Launchers Through History

This section is a change of pace on purpose: a reading and talking break (workbook pp. 15–17). It shows the learner that people have been storing energy to fling and lift things for tens of thousands of years — with bows, buckets, rubber balls, blankets, and enormous war machines. It ends with launchers in the kitchen, the park, and inside living things.

How to Approach It at Home

- have the learner read one vignette at a time. After each one, ask: "Where is the energy stored in this one?"
- Prefer read-aloud: take turns reading one entry each. The War Machines page (p. 16) is about the machines, not battles — steer talk toward "power, or better aim?"
- this reading links to social studies and history. The vignettes come from four continents and span 60,000 years — a good pairing with any unit on ancient tools.

✎ QUESTIONS TO ASK THE LEARNER

1. The bow bends, the shaduf lifts, the ball squishes, the blanket stretches. Which one is most like your catapult? Your slingshot?
2. The onager stores energy in twisted rope. Can you twist a rubber band and feel it store energy?
3. The trebuchet isn't elastic at all — it lifts a heavy box. Is there a launcher in our house that works by lifting?
4. Engineers had to choose: power, or better aim? Which would you choose for the Grand Challenge — and for which event?

BRIDGE BACK TO THE EXPERIMENT

After the discussion: "Every one of these builders was doing what you just did — storing energy first, then letting it go. You've built two of these machines yourself."

SCIENCE SPOTLIGHT

Stored Energy

The Science Spotlight comes after all three activities on purpose (workbook pp. 22–24). The learner has already bent a stick, stretched a band, and tilted a launcher. Now they get the words for it: elastic potential energy, kinetic energy, and the two halves of every launch — energy and direction. Experience first, then the words — that order makes learning stick.

Connecting it to the world outside the kit

The same ideas show up all over the house and the playground. A few prompts to help the learner notice them:

- **Stored energy is everywhere.**A wound-up toy, a drawn bow, a pulled-back swing, a squeezed spring in a click pen — all storing energy, waiting to let go.
- **Moving things have energy.** A rolling ball, a running dog, a thrown snowball — the faster they go, the more energy they carry.
- **Direction matters.** A basketball shot, a garden hose, a paper airplane — same push, different angle, different path.
- **Energy changes form.**The stick's bend becomes the ball's flight; the ball's flight becomes a bounce, a roll, a little sound, a little warmth. It is never simply gone.

A NOTE ON THE VOCABULARY

The key terms — elastic potential energy, kinetic energy, trajectory — are introduced with everyday examples. The learner doesn't need formal definitions; the goal is that they can use the words naturally: "the stick had stored energy, then the ball had moving energy." If they can say that in their own words, they've understood it.

✎ QUESTIONS TO ASK THE LEARNER

For the multiple-choice questions: *Don't just check the answer — ask "Why is B right?" and "Why is A wrong?" A correct answer without reasoning is less valuable than a thoughtful wrong one.*

For the Energy Team and the Direction Team: *Ask the learner to name one activity for each team. (Energy: Activities 1 and 2. Direction: Activity 3.)*

If the learner asks whether the energy is "used up" after a launch: *it isn't — it changes form. The ball's moving energy becomes a bounce, a roll, a little sound, and a little heat. Same energy, spread out.*

Background for the Facilitator — Key Ideas to Listen For

- **Elastic potential energy:**the learner ties it to something bent or stretched that will spring back — the stick, the bands — not to the ball.
- **Kinetic energy:**the learner says it belongs to something moving, and that faster means more.
- **Direction:**the learner can say, in their own words, that the same stored energy can go farther or shorter depending on the launch angle.

Science Spotlight — Answer Guide

The "Check Your Understanding" items (workbook p. 24) are answered below. All three are multiple-choice; the reasoning matters more than the letter.

Q1 — B. The catapult stores energy by bending its top stick. (A is the slingshot; C and D describe no launcher in this kit.)

Q2 — D. In the Angle Test the one thing that changed was the launch direction. (The stored energy, the ball, and the stick stack all stayed the same — that was the point.)

Q3 — C. A flying felt ball has kinetic energy, the energy of motion. B is the most common wrong answer: the energy was stored in the stick, but the ball has already let it go.

GRAND CHALLENGE

Siege the Fort! Two Launch Events

The synthesis moment (workbook pp. 25–29). The learner uses everything they have practiced. They tune both launchers with their own data. They write a prediction. Then they run two events — Box Shot (land felt balls in the open kit box) and Breach the Wall (knock down a stacked brick wall) — five shots per launcher per event, at 75 cm.

LEARNING GOALS	STANDARDS AT A GLANCE
For the learner to understand… ▪ How to use data from earlier tests to make an engineering choice ▪ That different jobs want different trajectories — flat and fast for a wall, high and floaty for a box ▪ How to predict, test, score, and compare fairly	**Primary:** 3-5-ETS1-2, 3-5-ETS1-3 **Also supports:** 4-PS3-4, 4-PS3-1 Full alignment details are in Section 4.

★ YOUR ROLE IN THE GRAND CHALLENGE

Step back. This is the learner's chance to be the engineer. If they reach for a setting, don't confirm or deny it — ask, "Which table is your evidence for that?" Let the data do the deciding. The one rule to enforce firmly: the prediction gets written before the first shot, and the wall gets rebuilt the same way for both launchers — a fair target for a fair test.

✎ QUESTIONS TO ASK THE LEARNER

Before tuning: *Which of your three data tables will help you reach 75 cm? What settings does it point to?*

Before the first shot: *Which launcher do you predict wins each event? Why?*

Between events: **The wall wants a different kind of shot than the box. What will you change?**

Final reflection: *Did the data predict the winner? What surprised you?*

What a Good Finish Looks Like

Listen for three signs of a strong finish:

- **Tuning from data.**The learner sets the stack, the tilt, and the pull-back by looking at their tables, not by guessing. For example: “My 7-stick, 4-book launch went about 75 cm.”
- **A prediction on paper.**They write it before the first shot — and then they let the score decide, without changing the prediction afterward.
- **Matching the shot to the job.**A strong learner notices that a flat, fast shot punches the wall and a high, floaty arc drops into the box — and chooses on purpose.

Marking the End Together

Ending the kit well takes just a few minutes. Pick what feels right:

- **Return to the opening questions.** Ask the same questions you asked before opening the kit (see “Before You Open the Kit” in Section 1). Note out loud how the learner’s answers changed.
- **Invite a “show and explain.”** Have the learner explain to someone else how they set up their winning launcher. Teaching someone is the strongest test of understanding.
- **Name something specific you were impressed by.** Avoid a generic “good job.” Instead: “You used your Angle Test table to pick 4 books — that’s exactly how an engineer would do it.”
- **Ask what they want to explore next.** “After doing this, what do you wonder about now?” Their answer is a gift — it points straight to the next thing worth learning about.

Grand Challenge — Answer Guide

These notes cover what to listen for in each Reflect question (workbook p. 29).

Q1: Which launcher won each event? Did that match your predictions?

Key ideas: an honest comparison of the score table and the prediction. Either result is a good result — "I predicted the slingshot and the catapult won, because it was easier to aim" is exactly the thinking you want.

If stuck: "Read your prediction out loud. Now read the totals. Do they agree?"

Q2: Look back at your data from Activities 1–3. What did you learn there that shaped your strategy today?

Key ideas: a specific link: the stack height from Activity 1, the pull-back from Activity 2, the tilt from Activity 3. A strong answer names a table and a number.

If stuck: "Which table did you look at when you were setting up? What did it tell you?"

★ Challenge: Rebuild your brick target to make it harder to topple — then test it. What changed, and why? (Build, test, improve — the engineering design cycle.)

Key ideas: a change with a reason — a wider base, a lower wall, bricks turned the long way — and a test of it. Look for the learner naming what they changed and what happened, not just "it was harder."

If stuck: "What made the wall fall last time? What would you change so that doesn't happen?"

For Teachers & Group Leaders

The pages after this one go deeper: the science behind the kit, common mix-ups, grade tips, and standards. Parents can stop here — or keep reading!

A Quick Science Primer for Facilitators

This section gives you just enough background to feel confident facilitating each activity. You don't need to read it all before you start — return to it as each topic comes up.

What is Stored (Elastic Potential) Energy?

Energy is what it takes to make something move or change. Some energy is stored, waiting. Bend a craft stick, stretch a rubber band, pull back a bow — the material is pushed out of shape and holds energy until you let go. Scientists call this elastic potential energy: "elastic" because the material springs back, "potential" because it hasn't done anything yet.

When the learner pushes the catapult arm down and feels it push back, that push-back is the stored energy. The taller stick stack makes the top stick bend farther, so it stores more — which is why the 9-stick launches fly farthest.

ON TELLING THE WAR-MACHINE STORIES

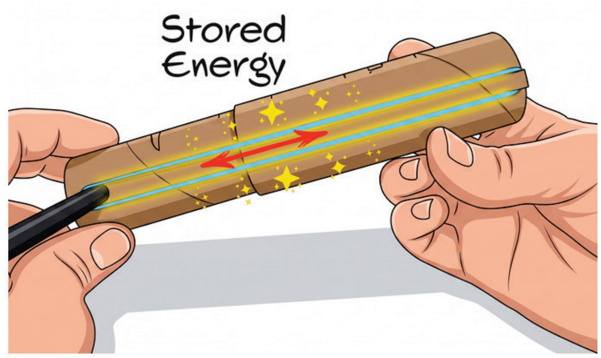
The history pages keep the belly-bow, onager, and trebuchet firmly about machines: how each one stores energy and what trade it makes (power, or better aim?). If the conversation drifts toward battles, the workbook's own question is the way back — "which would you choose, and for which event?"

What is Kinetic Energy?

Kinetic energy is the energy of motion. Anything that moves has it, and the faster it goes, the more it has. When the learner lets go of the catapult arm, the stick's stored energy pours into the ball, and the flying ball now carries kinetic energy.

Every launch in the kit tells the same story: elastic potential energy becomes kinetic energy. And the energy doesn't vanish when the ball lands — it becomes a bounce, a roll, a little sound, and a little warmth in the floor and the ball. Energy changes form; it isn't used up.

A useful framing: stored energy is a promise; moving energy is the promise being kept. (Note for you: "the ball runs out of energy and drops" is a common child's idea — in fact gravity pulls the ball down the whole time, which is why its path is a curve.)



Stored energy in the catapult and the slingshot. The bent stick and the stretched bands are pushed out of shape and hold energy — elastic potential energy — until the learner lets go. Then it becomes the ball's kinetic energy. Same idea, two materials: that is why the workbook calls the two launchers "cousins."

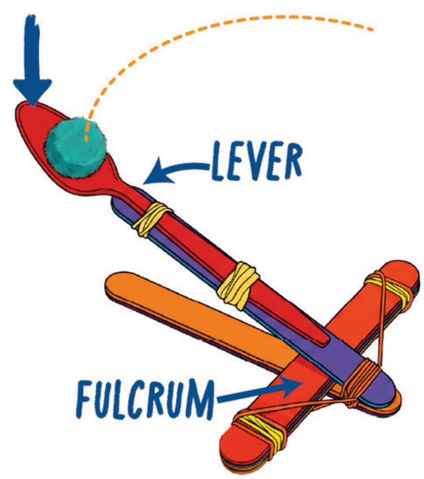
HOMESCHOOL NOTE

The formal vocabulary (elastic potential energy, kinetic energy, trajectory) is typically developed across Grades 4–8. This kit builds the intuitive foundation by letting the learner feel the push-back and see the flight first. They don't need the formal definitions — they need the hands-on memory the definitions will later attach to.

What do a Lever and a Fulcrum do?

A lever is a stiff bar that tips on a resting point, the fulcrum. The catapult's top stick and spoon are the lever; the stick stack is the fulcrum. Push one end down, and the other end goes up — that's how the spoon flings the ball.

Moving the fulcrum changes what a lever can do. Slide it one way and a small push lifts something heavy; slide it the other way and a big push flings something fast and far. The Activity 1 Fun Fact invites the learner to slide the stick stack and see this for themselves.



The catapult as a lever: the top stick and spoon tip on the stick stack (the fulcrum). Push the spoon end down, and the bend stores energy; let go, and the lever springs back flinging the ball.

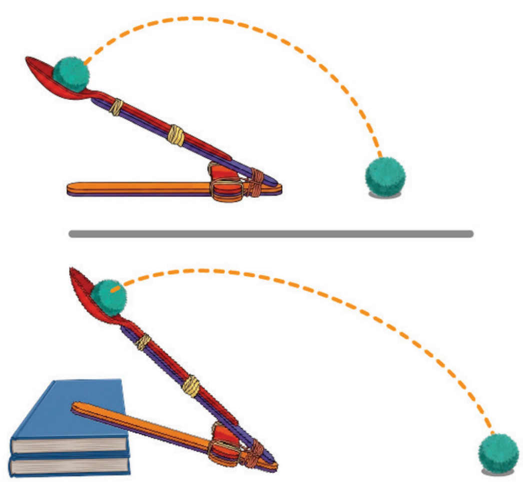
The shaduf on the history page is the same machine on a giant scale: a pole on a pivot, a bucket on one end, a weight on the other. Levers are one of the six classic simple machines — tools with few or no moving parts that make work easier.

What is a Trajectory, and Why Does the Angle Matter?

A trajectory is the curved path something follows through the air. The curve comes from gravity: from the instant the ball leaves the spoon, gravity pulls it down, so the ball rises, tops out, and falls in an arc. Every launch has one — a basketball shot, a garden hose, a felt ball.

The launch angle sets the shape of that arc. The Angle Test kept the stored energy the same and changed only the direction:

- **A flat launch** sends the ball fast and low — it hits the floor early, so it doesn't travel far. Good for punching a wall.
- **A tilted launch** sends the ball higher, so it stays in the air longer and lands farther away. A high, floaty arc drops into a box.
- **Too much tilt** and the ball goes up more than out — and with this catapult, it rolls out of the spoon first. Every design has a limit.



The Direction Team: same stored energy, three launch angles, three trajectories. The books tilt the whole machine; the angle shapes the arc; the arc sets the distance.

SECTION 3

Supporting the Learner

This section gives you three kinds of support: how to adjust the kit to the learner's grade level, a map of the most common misconceptions that come up, and a troubleshooting table for when something physical goes wrong.

3.1 Adapting the Kit by Grade

3rd Grade

The workbook is a slight stretch for many 3rd graders — but a productive one.

- Prioritize the launches and the feel of the push over formal explanation. "The stick pushed back harder and the ball went farther" is a complete, correct answer at this level — don't push for "elastic potential energy" language.
- Focus on accurate recording as the primary skill. Reading the tape measure and writing a neat, honest number in the data table is a genuine achievement.
- Read the build steps aloud and do the banding together — the alligator-mouth step and hooking the slingshot bands take some finger strength.
- The Grand Challenge prediction may work better as a spoken plan you write down together than as an independent writing task.
- The ★ challenge questions are optional — skip them if they create frustration. They are enrichment, not requirements.
- Build in more time, and let one trial stand in for three if attention fades — the trend still shows.

4th Grade

The workbook is calibrated for this level and should feel appropriately challenging without being overwhelming.

- Encourage vocabulary in written reflections — not as labels but in explanatory sentences ("it went farther because the taller stack stored more energy").
- Push gently on the "why" in reflection questions.
- The Grand Challenge prediction should be written before the first shot, with a reason.
- The ★ challenge questions are appropriate and worth attempting.

5th Grade

Push for precision: “by how many centimeters did 6 books beat Flat?” not just “it went farther.”

- Have the learner compare Best Launches across rows and explain what the difference means.
- Ask the learner to write a prediction before every change — each new stack, ring, and book count.
- The ★ challenge questions should be treated as required, not optional.
- Consider a short written “engineering report” after the Grand Challenge — what they tuned, what they predicted, what the scores showed, and what they’d change next.

MATH EXTENSIONS (GRADE 5)

Math extensions for homeschool facilitators who wish to add a math layer:

- **Compute the difference between Best Launches** (6 books minus Flat; 9 sticks minus 5 sticks) — connects to CCSS.MATH.4.NBT.B.4 (multi-digit subtraction).
- **Plot distance against stick count** (5, 7, 9) as a simple line graph — connects to representing and interpreting data (CCSS.MATH.3.MD.B.3).
- **Convert centimeters to meters** (177 cm = 1.77 m) — connects to CCSS.MATH.4.MD.A.1 (measurement units).

3.2 Common Misconceptions & How to Address Them

These are the most frequent misunderstandings that come up in this type of experiment. You don't need to raise them proactively — use this section when you hear them.

? "THE BALL FLIES STRAIGHT, THEN RUNS OUT OF ENERGY AND DROPS"

Why they think it: that's how it looks from the side, and it matches the idea that energy gets "used up."

The real science: gravity pulls on the ball the whole flight, so the path is a curve from the moment it leaves the spoon — that curve is the trajectory. The ball doesn't drop because it's empty; it was falling all along.

How to address it: "Look at the two paths you sketched. Where does the curve start — at the end, or right away?"

? "THE ENERGY IS GONE AFTER THE LAUNCH"

Why they think it: the ball stops, so the energy seems to disappear.

The real science: energy changes form; it isn't used up. The stick's stored energy became the ball's moving energy, and that became a bounce, a roll, a little sound, and a little warmth in the floor and the ball. It's spread out, not gone.

How to address it: "When the ball landed, what did you hear? What did it do next? Where do you think the energy went?"

? "THE STEEPEST TILT ALWAYS GOES FARTHEST"

Why they think it: in the Angle Test, every extra book helped — so more must always be better.

The real science: tilting up helps only so far. Point the ball too high and it goes up more than out; and with this catapult the ball rolls out of the spoon before that. The best angle is in the middle, and every design has a limit.

How to address it: "Add another book. What happens before you even launch? What does that tell you about the limit?"

? "THE BEST SHOT IS THE SAME FOR BOTH EVENTS"

Why they think it: the learner found one winning setup and wants to keep it.

The real science: different jobs want different trajectories. A flat, fast shot punches a wall; a high, floaty arc drops into a box. The same launcher may need a different tilt for each event.

How to address it: "The wall is tall and thin. The box is a hole in the floor. Which shape of flight fits each one?"

? "MORE STICKS OR MORE BANDS IS ALWAYS BETTER"

Why they think it: more sticks and more bands did fling farther in the tests.

The real science: more stored energy also means a harder push, a wobblier launch, and less control. Engineers trade power for aim all the time — the belly-bow and the onager on the history page made exactly that trade.

How to address it: "Which launcher was easier to aim? Which was stronger? For the Box Shot, which matters more?"

3.3 When Things Go Sideways: Troubleshooting

Use this table as a quick reference when something physical goes wrong mid-activity.

Problem	Likely Cause	What to Do
Spoon flops instead of springing back	Bands are loose	Tighten the bands on the arm and the stack; the arm should snap back sharply when pushed and released.
Arm comes loose after adding sticks	Stack not seated	Slide the stack back against the banded end of the arm; the stack's own bands act as blockers.
Launches are all over the place	The push changed	Fair-Launch Rule: hold the base, push until the sticks touch, let go. Same person launches all three trials.
Slingshot band slips off	Not seated in the slot	Hook both bands on each side into the slot; re-check after every few shots.
Ball sticks in the tube	Tube slightly crushed	Gently squeeze the small tube from the sides to round it out; the ball should slide without rattling.
Ball rolls out of the spoon on a tilt	Too steep	Take a book away or use thinner books. Above 6 thin books this is expected — it's the design limit.
Ball bounces back toward the learner	Head over the launcher	Kneel beside the launcher, never above it. Felt is soft, but eyes are not.
Wall won't fall	Bricks snapped, or out of range	Bricks are stacked, never snapped together. Check the 75 cm line and re-tune from the Activity 1 and 3 tables.

3.4 When the Learner Gets Stuck

Every kit has a moment where the learner goes quiet, shrugs, or says "I don't know." That is not failure — it is exactly where real thinking happens. The facilitator's job in those moments is to stay present without rescuing. These five prompts work across grade levels and activities. Use whichever feels natural.

- "Tell me what you're noticing so far." (Starts observation without demanding an answer.)
- "What would you try first if you could change one thing?" (Opens action without prescribing.)
- "Can you show me in the data where that happened?" (Anchors claims in evidence without telling them if they're right.)

- "That's a real question. What could we do to find out?" (Converts a confused moment into an experiment.)
- Silence and a patient nod. (The single most underused facilitation tool. Five to eight seconds of quiet is often what unlocks the answer.)

A note on resisting rescue: if you give the answer the moment the learner hesitates, you save them from the brief discomfort of not knowing — but you also take the learning with you. Research on productive struggle (sometimes called "productive failure") consistently shows that the effortful, uncertain part of a task is what builds the durable understanding. Waiting is a gift.

3.5 Adapting for Different Learners

Section 3.1 offered adjustments by grade. Learners also vary within a grade. The adjustments below draw on Universal Design for Learning (UDL) — none change what is being learned; they only change how the learner can access it. Use any combination that helps.

- **For a learner who reads below grade level:** read workbook instructions aloud and have the learner talk through their thinking rather than write it. The workbook can be filled in together with you scribing.
- **For a learner whose first language is not English:** the physical nature of the activities lets understanding show through action. Pair English terms with gestures — "bend," "stretch," "tilt" are easy to show; accept responses in either language; use photos as a record alongside written answers.
- **For a learner with attention or focus differences:** split each activity into 10–15-minute chunks — one stack height or one ring per chunk. The three-session structure can easily become six short sessions. A brief reset between chunks — water, stretch, a moment outside — is fine; it does not break the science.
- **For a learner with fine-motor challenges:** help with the banding, the alligator-mouth step, and hooking the slingshot bands. The science is in the predictions and the numbers, not the dexterity.
- **For a learner who is well ahead:** invite a self-designed extra test (a fourth ring on the tube, a new wall design, a different fulcrum position) and a short written engineering report.
- **For a learner who is quiet or shy:** pointing to a data row is a valid response. Let them write predictions down first; they can read them aloud afterward if they want.

3.6 Reading the Learner: When Behavior Is the Symptom

Section 3.3 troubleshoots the physical setup; this table does the same for the learner. If you see one of these behaviors, try the response on the right — and don't assume it means the learner isn't learning. It often means the opposite.

- **"I don't know" to every prediction.** Offer a forced choice: "Farther or shorter? Just pick one — the launch will tell us."
- **Rushing through without measuring.** Slow it down: "Before the next launch — where did that one first land? Write it down, then go."
- **Frustration when a launch falls short.** Normalize it: "Real engineers tune their machines all the time. What should we change?"
- **Constantly asking "is this right?"** Redirect to evidence: "What does your data table show? That's your answer."
- **One-word answers to Reflect questions.** Expand with their data: "Point to the row that flung farthest. What was different about it?"
- **Changing two things at once.** Require the fair test: "Let's change just the stack this time. Same push, same ball."

SECTION 4

Standards & Program Connections

This section maps the kit's activities to the national standards and program frameworks most relevant to its audience. Read the sections that apply to you — you don't need to work through all of them.

A NOTE ON ALIGNMENT

Standards *alignment* means the kit's activities touch the same concepts and practices the standards describe. Standards *achievement* is something a learner builds over many experiences, not a single kit. Treat the maps below as a signal of where this kit fits in a larger learning arc — not a checkoff list.

A NOTE FOR HOMESCHOOLERS

If you're homeschooling, use the grade-band maps that follow as guideposts. A strong reader in 2nd grade may work happily at the 3–5 level; a 5th grader new to energy vocabulary may benefit from the K–2 framing first. Adjust the support you give (hints, read-alouds, extra time) rather than the activity itself.

4.1 NGSS Alignment — Grades K–2

These standards apply if the kit is used with younger children, or as an informal framework for the foundational ideas being developed.

Code	Standard Name	What the Learner Develops	How This Kit Addresses It
K-PS2-1	Pushes and Pulls	Compare the effects of different strengths or directions of pushes and pulls on the motion of an object.	A bigger bend or a longer pull-back flings the ball farther; the Fair-Launch Rule keeps the push the same.
K-PS2-2	Changing Speed or Direction	Design a solution that changes the speed or direction of an object with a push or a pull.	The Angle Test changes the direction of the launch; the Grand Challenge tunes it for two jobs.
K-2-ETS1-3	Comparing Designs	Analyze data from tests of two objects designed to solve the same problem.	The catapult and the slingshot solve the same problem; the Grand Challenge compares them head to head.

4.2 NGSS Alignment — Grades 3–5 (Primary)

These are the primary targets for this kit.

Code	Standard Name	What the Learner Develops	How This Kit Addresses It
4-PS3-1	Energy and Speed	Use evidence to construct an explanation relating the speed of an object to its energy.	More stored energy (taller stack, longer pull) sends the ball faster and farther — the learner's own tables are the evidence.

Code	Standard Name	What the Learner Develops	How This Kit Addresses It
4-PS3-2	Energy Transfer	Make observations to provide evidence that energy can be transferred from place to place.	Energy moves from the bent stick or stretched bands into the flying ball, then into the bounce, the roll, and the bricks.
4-PS3-4	Energy Conversion Devices	Design, test, and refine a device that converts energy from one form to another.	Both launchers turn elastic potential energy into kinetic energy; the Grand Challenge refines them.
3-PS2-1	Forces and Motion	Investigate the effects of balanced and unbalanced forces on the motion of an object.	The lever tips on its fulcrum; the held-down arm is balanced, the released arm is not.
3-5-ETS1-2	Comparing Solutions	Generate and compare multiple solutions based on how well each meets the criteria.	Two launchers, two events, one score table: the learner compares solutions with data.
3-5-ETS1-3	Fair Tests & Variables	Plan and carry out fair tests in which variables are controlled.	Every activity changes one thing — stack, pull-back, angle — and keeps the rest the same.

4.3 Common Core State Standards (CCSS) Math Connections

The kit does not require formal math instruction, but it generates data that naturally connects to several math standards. These are noted for homeschool facilitators who wish to extend into math lessons.

Standard	Topic	Connection to This Kit
3.MD.B.4 / 4.MD.A.1	Measuring length; metric units	Every launch is measured in centimeters; converting to meters for the long ones.
3.MD.B.3	Represent & interpret data	Data tables in every activity; the sketch box; a line graph of distance vs. sticks (Grade 5 extension).
4.NBT.B.4	Multi-digit subtraction	Difference between Best Launches — 6 books minus Flat.
4.MD.A.2	Measurement word problems	“How many more centimeters do I need to reach 75?” — the Grand Challenge tuning question.

A NOTE ON AVERAGES

Computing the mean (average) of trial results is a Grade 6 standard (CCSS.MATH.6.SP.B.5) and has been intentionally excluded from the student workbook. The workbook uses “Best Launch” rather than average. If the learner asks about averaging, it’s fine to show the concept informally.

4.4 Cub Scout Program Connections

If the learner is a Cub Scout, this section is for you. Since the 2024 program update, Cub Scouting's science and engineering content lives in the rank Adventures themselves — and this kit fits several of them.

Adventure / Rank	How This Kit Connects
Engineer — Arrow of Light (5th grade), elective	Requirements 4–5: identify a project and build it using the engineering process. Building, testing, and tuning the catapult is a mechanical-engineering project made to order.
Modular Design — Webelos (4th grade), elective	Build models from modular pieces and write instructions for them. The Grand Challenge wall and design cards (stack, never snap) fit the building requirements.
Air of the Wolf — Wolf (2nd grade), elective	Fly two flying objects, record the distances, and compare — the same fair-test habit as Activities 1–3, sized for younger siblings.
Built It Up, Knock It Down — Lion (kindergarten), elective	Build something designed to be knocked down. Breach the Wall, at kindergarten scale.
What the kit does not cover	Requirements about blueprints, engineer careers, and sharing with the den. The kit supplies the hands-on build and the data.

The national STEM Nova awards were retired in June 2025; some councils now run their own local STEM Nova award, so ask your den leader. Adventure requirements change over time — confirm the current wording with your den leader or at scouting.org before recording anything.

4.5 Common Questions

A few questions come up again and again when learners — or other adults watching — get into this kit. Here's how we'd answer them.

Q: Isn't a catapult a weapon?

It's a launcher — a machine that stores energy and lets it go. Bows, catapults, and trebuchets were used in war, and the history page says so plainly; the kit itself launches felt balls at a box and a stack of bricks, with safety rules on page 3. The conversation to have is the engineer's one: power, or better aim?

Q: Why felt balls?

They're soft, light, and easy to see, and they don't bounce far — so "where it first lands" is easy to measure. Nothing else is ever launched.

Q: Why 75 centimeters?

It's the distance at which both launchers can score with the settings from the tests — hits are earnable but not automatic. Move the line and the challenge changes.

Q: My learner's data doesn't show the trend. Is the kit broken?

Almost never. A changed push is the usual cause — re-read the Fair-Launch Rule and try again. One odd trial in nine is normal; talk about it rather than erasing it.

Q: Can we build a bigger fort?

Yes — the workbook says so. More bricks, a wider wall, a new design: all fine. The one rule is stacking, never snapping the bricks together.

Q: My learner says, "I already know this."

Great — promote them to engineer. Have them predict every launch before it happens and explain the number afterward. Knowing that "a bigger bend goes farther" and showing it from their own data are different skills; this kit rewards the second.

SECTION 5

Quick Reference Materials

This section collects the kit's ready-reference material: the Word Watch answer guide for all vocabulary terms and a list of outside resources for extending the learner's curiosity beyond the kit.

5.1 Word Watch Answer Guide

For each vocabulary term in the student workbook, this guide shows what key ideas to listen for in the learner's response, and a follow-up question to extend the conversation.

Term	Listen for · Go deeper
Elastic (p. 5)	**Listen for: springs back to its shape after bending or stretching. Go deeper: Is the felt ball elastic? How could you tell?**
Lever (p. 6)	**Listen for: a stiff bar that tips on a resting point. Go deeper: Where is the lever on a seesaw?**
Fulcrum (p. 7)	**Listen for: the point the lever tips on — the stick stack. Go deeper: What happened when the fulcrum got taller?**
Projectile (p. 12)	**Listen for: anything thrown or launched through the air. Go deeper: Name three projectiles you saw today.**
Trajectory (p. 19)	**Listen for: the curved path something follows through the air. Go deeper: Draw the trajectory of your best 6-book launch.**
Elastic potential energy (p. 22)	**Listen for: energy stored in something bent or stretched. Go deeper: Where was it stored in each launcher?**
Kinetic energy (p. 23)	**Listen for: the energy of motion; faster means more. Go deeper: When did the ball have the most kinetic energy?**
Stored energy (glossary)	**Listen for: energy saved up and ready to use. Go deeper: What did you do to store energy in the slingshot?**
Energy (glossary)	**Listen for: what it takes to make things move or change. Go deeper: Where did the ball's energy come from?**

Term	Listen for · Go deeper
Launch angle (glossary)	**Listen for:** the direction of a launch — flat or high. **Go deeper:** Which angle won your Angle Test?
Fair test (glossary)	**Listen for:** change one thing, keep the rest the same. **Go deeper:** What did you keep the same in Activity 2?
Prediction (glossary)	**Listen for:** a best guess made before the test, using what you know. **Go deeper:** Which prediction of yours came true?
Data (glossary)	**Listen for:** information you collect and write down. **Go deeper:** Which table helped you most in the Grand Challenge?
Simple machine (glossary)	**Listen for:** a tool with few or no moving parts that makes work easier. **Go deeper:** Which simple machine is your catapult?
Engineer (glossary)	**Listen for:** a person who designs, builds, and tests to solve problems. **Go deeper:** What did you engineer today?
Engineering design cycle (glossary)	**Listen for:** plan, build, test, improve, and try again. **Go deeper:** What would you improve on your launcher next?

5.2 Suggested Resources

External resources for extending the kit. None are required — include any that fit the learner's interests.

For the Learner

Resource	Notes
Simple Machines: Wheels, Levers, and Pulleys (D. A. Adler)	A picture-book introduction to levers and the other simple machines.
National Geographic Kids — Forces and Motion	Accessible articles and photos on pushes, pulls, and energy.
PBS LearningMedia — Energy & Motion	Free interactives at pbslearningmedia.org — search "energy grades 3–5."

For Facilitators Who Want to Go Deeper

Resource	Notes
Khan Academy — Energy & Forces	Free, beginner-friendly lessons at khanacademy.org.
NGSS Standards Explorer	Full text of the standards at nextgenscience.org/search-standards.
NASA STEM — Launch and Motion Activities	Hands-on projectile and energy activities at nasa.gov/stem.

For Replacement Materials

Source	Notes
Household / craft store	Craft sticks, rubber bands (size 32 or 33), plastic spoons, and 1-inch felt balls are all common craft-store items. Any cardboard mailing tube pair that nests will do for the slingshot.
The kit's bricks	Any interlocking building bricks work — the wall is stacked, never snapped, so brand doesn't matter.

Launch Lab

Aim, Launch & Discover the Science of Flying Things

a the Shoebox Lab kit

Contact us at hello@shoeboxlab.org