

Portable Habitat

Teacher Guide · Grade 3

Hearts Invention Lab STEM Curriculum · Reverse Engineering Series · Simple systems and forces



A squat onion-shaped portable habitat with quilted silver-white walls, anchored on a stormy meadow

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How to use this guide

Safety rule first: People never ride a tornado. Go to a certified safe room or the hardened core pod. The fabric habitat is for storms, not tornadoes.

This guide has the Grade 3 unit. Each unit has 4 or 5 lessons. Students reverse-engineer the Portable Habitat: they explode it into parts, read each part's job, rebuild it and name their own version. Each unit then adds a hands-on activity using household and classroom items only.

- **Digital-only.** This curriculum is sold as printable, downloadable files. No kits or materials packs exist or are needed.
- **Facts and sources.** Every research fact carries a source tag [S#]. Parts or claims with no published source are marked “design reasoning, no source” (or “design idea, no source”) so students can see the difference between evidence and design ideas.
- **Practice values.** Some maths problems in grades 9–12 use clearly labelled practice values (PV). These are made-up numbers for the exercise, not source facts.
- **Standards.** NGSS and CCSS codes are given with paraphrased descriptions. Check them against your state's standards.
- **The app.** heartsinventionlab.com/app/ (Ages 5+). Open Reverse Engineer, then Portable Habitat. Lumet, the app's crystal guide, leads the teardown (Basic mode), the rebuild, naming your version and the material quiz (Advanced mode).
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The Portable Habitat at a glance

The Portable Habitat is a squat, onion-shaped shelter: a round, wide body with a pointy tip, held down all the way round. Its stiff walls are pumped-up panels built like an inflatable paddleboard [S1], covered by a skin kept tight so it can't flap [S2]. It is for storms, **not tornadoes**: in a tornado everyone goes into the small hardened core pod or a certified safe room. The shape is always an onion, never a tent or teepee. In the app it comes apart in 5 layers:

1. Outside (tight outer skin, pressurised wall panels)
2. Shape holders (hoop ribs for snow, rim ring and ground plates)
3. Anchors (shock-absorbing anchor lines, screw ground anchors)
4. Controls and hanging (pressure control unit, cliff hanging harness, quake and wind design note)
5. Safety core (hardened core pod)



1. Pressurised wall panels



2. Tight outer skin



3. Rim ring and ground plates



4. Shock-absorbing anchor lines



5. Screw ground anchors



6. Hoop ribs for snow



7. Pressure control unit



8. Cliff hanging harness



9. Quake and wind design note



10. Hardened core pod

Grade-band progression

Band	Focus
K-2	Weather and shelters, shapes, materials and taking apart
3-5	Wind forces and anchors, weather and earthquake hazards, air as matter
6-8	Snow load vs air pressure, anchor tests in soil, shock-absorbing lines and forces
9-12	Pressure and load maths, polymers in the cold, seismic force and hazards, full design review

Grade 3: Wind, Anchors and Holding On

4 lessons · about 165 minutes in total · © 2026 Hearts Invention Lab

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Overview

Third graders study how wind pushes and lifts and how anchors hold. They test how many anchor points a paper-bowl dome needs to stay put in fan wind, and where to put the strongest one: wind lifts a low dome hardest at the edge facing the wind [S3].

Learning objectives

Students will:

- Investigate balanced and unbalanced forces on a dome in wind.
- Find where a dome needs the strongest hold-down.
- Make a claim about a design that reduces a weather hazard.
- Name the anchor parts and their jobs.

Standards alignment

Framework	Code	What students do (paraphrased)	Status
NGSS	3-PS2-1	Plan an investigation of balanced and unbalanced forces on an object's motion (paraphrased).	Aligned
NGSS	3-ESS3-1	Make a claim about a design solution that reduces the impact of a weather hazard (paraphrased).	Aligned
NGSS	3-5-ETS1-3	Plan and carry out fair tests to find failure points (paraphrased).	Aligned
CCSS	3.MD.B.3	Draw scaled picture and bar graphs.	Aligned
CCSS	3.MD.A.2	Measure masses in grams.	Suggested alignment
CCSS	W.3.1	Write opinion pieces with reasons.	Aligned

"Aligned" means the unit directly addresses the performance expectation. "Suggested alignment" means a partial or supporting fit for the teacher to confirm.

Lessons and timing

Lesson 1: Explore the anchors (40 min)

1. Safety rule. Take apart Anchors and Shape holders.

Lesson 2: Anchor test (hands-on) (45 min)

1. See hands-on. Count anchors needed.

Lesson 3: Which edge lifts? (40 min)

FREE SAMPLE · © 2026 Hearts Invention Lab · Portable Habitat, Grade 3 · Free to download and print for your own home or classroom. Not for resale.

1. Tape tissue strips around the dome edge; fan it; watch which lift first.
2. Move your strongest anchor there.

Lesson 4: Claim and evidence (40 min)

1. Write a claim: where should the habitat's strongest anchors go?
2. Rebuild and name your version.

Materials (household and classroom items only)

- Paper bowls, tape, string, paper clips
- Play dough or coins as ballast
- A small fan (adult-controlled) or hand fan
- Tissue strips, kitchen scale

Nothing in this unit needs a purchased kit.

Hands-on activity: How Many Anchors?

1. Turn a paper bowl upside down on a table: the dome.
2. Attach string anchor lines to paper-clip stakes in play dough at 1, 2, 4 and 8 points around the edge.
3. Adult runs the fan on low from one side for 10 seconds. Did the dome lift or slide?
4. Record the fewest anchors that kept it still.
5. Link it: the real habitat is held down all the way round, with the strongest hold on the windward edge [S3].

In-app activity (Hearts Invention Lab app, Ages 5+)

Lumet, the app's crystal guide, walks students through each step. The app is free to open at heartsinventionlab.com/app/.

1. Open Reverse Engineer, then Portable Habitat. Read Lumet's safety rule first.
2. Explode the habitat; read every part card.
3. Basic mode: take it apart by layer and rebuild it; name your version.
4. Advanced mode: match each part to its material.

Every part: why this material, what it does, how it is built

Part (material)	Why this material was chosen	What the part does	How it is assembled in real life
Pressurised wall panels (Two coated-fabric skins joined by polyester threads)	Pumped-up panels with threads inside stay flat and stiff, like an inflatable paddleboard. [S1]	Stiff, insulated walls and roof in the onion shape.	Two coated skins are joined by thousands of threads, then pumped up hard. [S1]
Tight outer skin (Coated technical fabric, pulled taut)	Coated fabric is waterproof; pulling it tight stops flapping. In a cold test, loose skin cracked and blew away. [S2]	The weather layer.	Pulled taut over the panels. [S2]

Part (material)	Why this material was chosen	What the part does	How it is assembled in real life
Rim ring and ground plates (Steel or composite ring, wide plates, fixed ballast)	Steel or composite is strong; fixed weights grip best. [S3]	Spreads the wind's pull into the ground all round.	A base ring with wide plates and ballast fixed right to them. [S3]
Shock-absorbing anchor lines (Low-stretch lines, springy shock unit, small winch)	A springy shock unit softens sudden gusts. [S4]	Stays tight in calm weather and gives a little in gusts.	Low-stretch line plus a shock unit and a small winch. [S4]
Screw ground anchors (Galvanized steel screw anchors)	Galvanized steel won't rust quickly and grips soil. [S5]	The actual grip in the soil.	Twisted deep; grip depends on the soil, so they are tested on site. [S5]
Hoop ribs for snow (Carbon or glass-fibre hoops)	Carbon or glass fibre is light and stiff. [S6]	Keeps the shape when snow piles on.	Three hoops around the walls. (design idea, no source)
Pressure control unit (Pump, pressure sensors, relief valves, battery)	Sensors notice when pressure drops. [S7]	Keeps walls firm and never panic-pumps under snow.	Pump, sensors and valves connect to the panels. [S7]
Cliff hanging harness (Steel ring, sewn straps, locking connector, wall tethers)	Climbing gear is made to hold people. [S8]	Lets the shelter hang on a cliff.	One main anchor with backups; everyone clipped in; corner tethers. [S8]
Quake and wind design note (The whole light shelter)	A light shelter feels small earthquake forces. [S9]	Explains light vs wind.	A design note: anchors do the work in wind. [S3, S9]
Hardened core pod (Steel plate or tested composite panels on a concrete footing)	Steel plate is very strong. (design idea, no source)	The tornado hideout.	Built and tested like a certified safe room, bolted to concrete. (design idea, no source)

Tags in brackets [S#] point to the Sources list at the end of this guide. "No source" marks a design idea from the invention file that no published source backs up yet.

Real-world assembly sequence

This shelter has not been built. Its parts copy real, tested things, but the whole shelter is a new idea. (design idea)

1. Pour the footing and bolt down the hardened core pod. *[design idea, no source]*
2. Install the screw anchors and test them. [S5]
3. Lay the rim ring with plates and fixed ballast. [S3]
4. Inflate the drop-stitch panels into the onion shape. [S1]
5. Fit the hoop ribs and tension the outer skin. [S2]
6. Attach the shock-absorbing lines and tighten them. [S4]
7. Connect the pressure control unit; pump up early before snow. [S7]

The source files do not give a build order. Building the core pod and anchors first is design reasoning (the safest parts go in before the fabric). Students may argue for another order.

Vocabulary

Word	Meaning
Force	A push or a pull.
Balanced forces	Forces that cancel so nothing moves.
Lift	An upward push from moving air.
Windward	The side facing the wind.
Ballast	Heavy weight that holds something down.

Teacher's background (cited facts)

F3 is the anchor fact. Fans give a gentle model wind; real storm forces are much larger.

- Wind lifts a low dome hardest near the edge facing the wind (and near the top), so the rim needs the strongest hold-downs. A low shape cuts total wind force but still gets lifted. [S3]
- How hard a screw anchor can be pulled depends on the soil, the depth and the spacing, so anchors must be tested on site. [S5]
- Ocean moorings use load-reducing tethers; one design was modelled to cut peak pulls by up to about 90%. More give means more sway. [S4]
- Safety rule (design and guidance, not a cited figure): only a certified safe room is meant to protect people in a tornado. No fabric or inflatable shelter is rated as one. On a cliff there is no tornado-safe option, so people climb down. [S10, S11]

Discussion questions

1. Which edge lifted first?
2. Why do more anchors help?
3. What happens if one anchor fails?
4. Why does the habitat still need a safe room for tornadoes?

Assessment

1. Where does wind lift a low dome hardest?
2. How many anchors held your dome?
3. What is ballast for?
4. Write your claim with one reason.

Answer key

1. The edge facing the wind [S3].
2. Accept data-backed answers.
3. Extra weight that helps hold the shelter down.
4. Accept claim + evidence.

Rubric

Criterion	Not yet	Getting there	Got it!
Forces	None	Names a force	Explains balanced/unbalanced
Fair test	Many changes	Mostly fair	One variable changed
Claim	No reason	One reason	Reason with data

Differentiation and extension

- **Support:** Provide a recording chart with anchor pictures.
- **Challenge:** Test ballast mass against anchor number: which holds better per gram?
- **Extension:** Look for anchors and tie-downs in your neighbourhood (tents, flags, trampolines).

Safety note

Adult controls the fan; no fingers near blades. Stakes are paper clips in dough, not sharp tools.

Sources

All facts in this guide come from the Hearts Invention Lab Portable Habitat invention file and app data. Each link below was fetched or its DOI matched on 2026-10-20. Sources whose links could not be verified are left out, along with their figures:

- **[S1]** Drop-stitch inflatable panel study, Materials (2023), PMC10650755. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10650755/>
- **[S2]** U.S. Army ERDC, TEMPER air-beam shelter test (Greenland). <https://hdl.handle.net/11681/2603>
- **[S3]** Cheon et al., “Fluctuating Wind Pressure Characteristics of Dome Roofs with Low Rise-Span Ratio,” Buildings 13(7):1673, 2023. <https://doi.org/10.3390/buildings13071673>
- **[S4]** Thies et al., “A novel mooring tether for peak load mitigation: Initial performance and service simulation testing,” International Journal of Marine Energy, 2014. <https://doi.org/10.1016/j.ijome.2014.06.001>
- **[S5]** Yuan et al., “Field Experimental Study on the Uplift and Lateral Capacity of Deep Helical Anchors and Grouped Helical Anchors in Clays,” Buildings 14(3):662, 2024. <https://doi.org/10.3390/buildings14030662>
- **[S6]** Geiger Engineers, BC Place roof deflation engineer’s report (2007). <https://www.cbc.ca/bc/news/bc-080103-engineersreport.pdf>
- **[S7]** BC Place roof deflation investigation report (2007). <https://www.cbc.ca/bc/news/bc-080103-investigationreport.pdf>
- **[S8]** Alpine Savvy, “Portaledge set up: Top Tips”. <https://www.alpinesavvy.com/blog/portaledge-set-up-top-tips>
- **[S9]** UNESCO/IAEE, guide to earthquake-resistant construction (2014). <https://reliefweb.int/attachments/85ea8c20-7717-3c02-9a51-37f13c963b90/229059E.pdf>
- **[S10]** FEMA P-361, “Safe Rooms for Tornadoes and Hurricanes,” 4th ed., April 2021. https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf
- **[S11]** FEMA P-320, “Taking Shelter from the Storm: Building a Safe Room for Your Home or Small Business,” 4th ed., December 2014, sections on design wind speed and door missile tests (full text checked). https://www.weather.gov/media/bis/FEMA_P-320_2014_508.pdf

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