TALUS TUMBLE

Classroom Teacher Guide

A complete facilitation resource for bringing hands-on structural engineering into your classroom, no lab required.

Grades 3–8 · NGSS Aligned · 45–60 Minutes

SECTION 1: OVERVIEW

What Is Talus Tumble?

Talus Tumble is a tabletop building game using real hand-cut stones where students stack pieces onto a shared base, try not to knock it over, and learn, through their own hands, why things fall down and how to build them better.

Talus Tumble is a tactile structural engineering system where students take turns placing hand-cut natural stones onto a shared vertical structure. Each stone placement is a hypothesis. Each tumble is a data point. The game creates a natural engineering design loop, hypothesize, place, observe, analyze, iterate, without students needing to be told that is what they are doing.

The name comes from geology: talus describes the natural accumulation of rock debris at the base of cliffs, formed through repeated rockfall. That same physics, balance, mass, instability, lives inside every game.

Core Learning Objectives

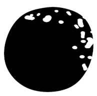
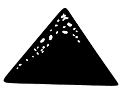
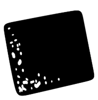
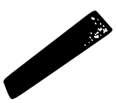
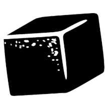
- Students apply center of mass concepts through direct physical manipulation
- Students practice iterative design by analyzing structural failures and adjusting strategy
- Students use engineering vocabulary naturally through embodied experience
- Students develop risk tolerance by reframing collapse as useful data
- Students collaborate around shared structural challenges

What You Need

Item	Quantity	Notes
Talus Tumble game set	1 per group of 2–4	Includes base, stones, game bag, die
Flat stable surface	1 per group	Avoid uneven or soft surfaces
Observation worksheets	1 per student	See included data sheet
Pencils	1 per student	
Timer	1 per room	Phone timer works fine

The 25 Pieces: What Is In Every Set

Each Talus Tumble set contains 25 hand-cut natural stone pieces. No two sets are identical, the hand-cutting process means every piece has unique surface texture, slight variation in weight, and minor dimensional differences. This irregularity is intentional: it prevents students from relying on memorized patterns and forces genuine analysis on every turn.

	Piece	Qty	Type	Key Property for Teaching
	The Face (base)	1	Foundation	Circular flat base, the control variable in every experiment. Defines the support area all other pieces must stay within. Never changes.
	Oval	4	Hard Stack	Curved underside, minimal flat contact area. Rolls under asymmetric load. Hardest piece to stabilize.
	Triangle	4	Hard Stack	Point-up placement creates extreme instability. Flat-side-down is more stable but limits height. Great for orientation experiments.
	Pentagon	4	Hard Stack	Irregular symmetry deceives students who assume more sides = more stability. Excellent for challenging assumptions.
	Square	4	Control Stack	Full flat faces, highest predictable contact area. Easiest to stack reliably. Best baseline for comparison.
	Rectangle Tower	4	Control / Wildcard	Most versatile teaching piece. Flat = very stable. Vertical = high torque. One piece, three orientations, three experiments.
	Cube	4	Control Stack	Equal faces in all directions. Consistent center of mass regardless of orientation. Ideal for demonstrating orientation independence.

Facilitator Tip: The Face is the control variable in every experiment. It never changes, which is what makes everything placed on top of it meaningful. Name this explicitly before any experiment begins. Students who understand The Face as a constant think more clearly about variables.

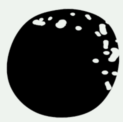
SECTION 2A: SHAPE-BASED EXPERIMENTS

Two Experiments Using Piece Geometry

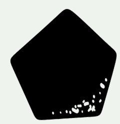
The six stackable shapes divide naturally into two groups by stability. Using these groups as the basis for structured experiments gives students a genuine comparative data set, not just open play. Run these experiments in sequence: Hard Stack first, Control Stack second. The contrast between the two rounds is where the deepest learning happens.

EXPERIMENT 1 Hard Stack Challenge

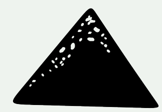
Shapes: Oval, Pentagon, Triangle. Stack as high as possible using only these three piece types



Oval



Pentagon



Triangle

Why these shapes:

- Oval: curved underside means contact with the piece below is a single line or point, not a flat face. Any shift in the center of mass above the oval causes it to roll rather than settle.
- Pentagon: its five-sided irregular symmetry creates an uneven contact footprint. Students who have used squares assume a "flatter side" exists, it does not in a meaningful way. This challenges geometric assumptions directly.
- Triangle: the only piece with a true point. Placed point-up it creates a single-point contact that amplifies every micro-shift in the center of mass. Placed flat-side-down it is more stable but adds very little height. Every triangle placement forces a genuine trade-off decision.

What students will discover:

- Height is extremely limited by contact area. These pieces cannot support each other reliably above 3–4 pieces without a precise center-of-mass strategy
- Placement sequence matters enormously. Which piece goes first changes what is possible above it
- Failure happens fast and informatively. Students will get more data points per minute than in any other configuration

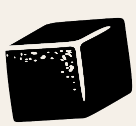
Facilitator prompts:

"Which of these three shapes do you want to place first, and why?" / "Where is the contact point between those two pieces?" / "What would need to be true for the oval to not roll?"

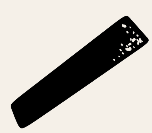
Time: 8 minutes build + 4 minutes reflection Goal: highest freestanding structure that stands 10 seconds Record: height in pieces, number of tumbles, piece sequence used

EXPERIMENT 2 Control Stack Challenge

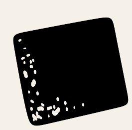
Shapes: Cube, Rectangle Tower, Square. Stack as high as possible using only these three piece types



Cube



Rectangle Tower



Square

Why these shapes:

- Square: full flat faces on every side. The contact footprint between a square and whatever is beneath it is maximized. Center of mass is easy to estimate because the geometric center and the mass center nearly coincide.
- Cube: equal in all three dimensions. Orientation is irrelevant; a cube placed any way up behaves identically. This is the "null hypothesis" piece: if a cube falls, the problem is placement position, not piece geometry.

- Rectangle Tower: the most instructive piece in the set. Placed on its large flat face it behaves like a stable platform. Placed on its narrow end it becomes a high-center-of-mass column that amplifies any lateral imbalance. Same mass, same piece, radically different stability. This is orientation-dependent stability in its clearest form.

What students will discover:

- Stacks go significantly higher than Experiment 1, creating a direct, visible data point about the effect of contact area on structural stability
- The rectangle tower creates a surprise. Students who orient it vertically to gain height will find the tower "wants to tip" even when perfectly centered
- Tumbles happen less often but teach more, because the pieces are more predictable, unexpected failures reveal subtle center-of-mass shifts that would be invisible with the Hard Stack pieces

Facilitator prompts:

"How does this feel different from Experiment 1?" / "Which orientation of the rectangle made the structure most stable, and why?" / "If you could only use cubes, how high could you go?"

Time: 8 minutes build + 4 minutes reflection   Goal: highest freestanding structure that stands 10 seconds   Record: height in pieces, number of tumbles, rectangle tower orientations tried

Cross-Experiment Comparison: The Core Learning Moment

- Ask each group: how many pieces high did you get in Experiment 1 vs Experiment 2? Record on the board.
- Ask: what is the ONLY thing that changed between the two experiments? (The pieces. Everything else, including The Face, the goal, the rules, was identical.)
- This is controlled variable experimental design. The students just ran it without being told they were doing science.
- Connect explicitly: "Contact area determines load distribution. Load distribution determines where the center of mass can be. Center of mass determines stability." That sentence is the whole physics lesson.
- For grades 6–8: ask students to calculate the approximate contact area difference between an oval and a square. Even a rough estimate makes the point.

Facilitator Tip: If time is limited, run Experiment 2 (Control Stack) first. Students will succeed quickly, feel confident, then Experiment 1 (Hard Stack) will genuinely surprise them. The order can be reversed for dramatic effect.

SECTION 3: 45-MINUTE LESSON PLAN

Suggested Classroom Flow

0–5 min	**The Hook: Physics You Can Feel** Before students touch anything, place one unstable stack at the front of the room. Ask: "What do you think will happen if I place this stone here?" Take predictions. Place it. Whatever happens, you have just run the first experiment together. Tell students: "What just happened is the whole lesson."
5–8 min	**Frame the Engineering Design Cycle** Briefly introduce five steps on the board: Hypothesize → Place → Observe → Analyze → Iterate. Tell students every turn in the game moves through all five steps. They are not playing, they are engineering.
8–20 min	**Round 1: Open Construction** Challenge: Build the tallest stable structure possible. Groups of 2–4. No adhesives, no repositioning after release, structure must stand for 10 seconds. Circulate and ask: "Why did you choose that spot? What did you predict? What did the tumble tell you?"
20–25 min	**Structured Reflection** Bring the class back together. Ask: Where was the heaviest part of the structure? What made it fall? What would you do differently? Introduce formal vocabulary: center of mass, load distribution, stability threshold. Connect their words to the science terms.
25–38 min	**Round 2: Constrained Iteration** Add one constraint (choose based on level): Option A: only 3 base contact points allowed. Option B: must increase height by 20% without widening the base. Students now design intentionally using what they learned in Round 1.
38–43 min	**Data Sheet Completion** Students complete their observation worksheets individually: record shapes placed, hypotheses, outcomes, and one design adjustment they would make next time.
43–45 min	**Closing Synthesis** Ask one student per group to share their best "failure data point", asking what did a tumble teach them? Close with: Every stack is an experiment. Every tumble is data.

Facilitator Tip: For shorter sessions (30 min): Run Round 1 only and use the last 5 minutes for reflection. The constrained iteration in Round 2 is valuable but not required for a first session.

SECTION 4: FACILITATION STRATEGIES

How to Get the Most from Every Tumble

Reframing Failure

The most important facilitation move is how you respond to a tumble. Resist the urge to say "oh no!" Instead, say: "Excellent, what did we learn?" Model genuine curiosity about failure. Students who see the teacher excited about a collapse quickly adopt the same mindset.

> **Facilitator Tip:** Write "FAILURE = DATA" on the board before the session starts. Leave it there the whole time. Students will start quoting it back to you.

Questioning Techniques

When	Ask
Before placement	"Where is the center of mass right now? What will change when you add this stone?"
During placement	"What are you feeling in your hands? Why did you hesitate there?"
After a tumble	"What stone was the tipping point? What would need to change to prevent that?"
During iteration	"How is your strategy different from Round 1? What evidence changed your thinking?"

Differentiation by Grade Level

Level	Modification
Grades 3–4	Use fewer stone shapes (3–4 per player). Focus on "heavy" vs "light" language before introducing center of mass.
Grades 5–6	Full game as designed. Introduce center of mass vocabulary during Round 1 reflection.
Grades 7–8	Add the constrained iteration in Round 2. Introduce torque and moment arm language. Ask students to diagram their force distribution.
Gifted / Extension	Challenge students to predict the exact tumble point before each placement and record accuracy over multiple rounds.

SECTION 5: ASSESSMENT IDEAS

Measuring What Students Learned

Observation Sheet

The included data sheet captures hypotheses, outcomes, and design adjustments in real time. Collect these as formative assessment artifacts.

Exit Ticket

Ask students to write one sentence completing: "I changed my strategy because..." This reveals whether iterative thinking occurred.

Force Diagram

For grades 6–8: have students draw a simple diagram showing where they believe the center of mass was before and after their most interesting tumble.

Verbal Debrief

Ask: "Tell me about your best failure." Students who can describe what the collapse revealed have internalized the core concept.

Prediction Accuracy

Advanced: track how often students correctly predict placement outcomes over multiple rounds. Improvement = evidence of learning.

Concept & Vocabulary Reference

Terms and definitions for classroom use, written for students and teachers

PHYSICS & MECHANICS

Center of Mass	The average location of all the weight in an object or system. A structure is most stable when its center of mass sits directly above the base support.
	In the classroom: Ask students to point to where they think the "heavy middle" of the stack is before each placement.
Load Distribution	How weight is spread across a structure. Wide, even distributions create more stable structures than narrow or lopsided ones.
	In the classroom: After a tumble, ask: "Was the weight spread evenly or was one side heavier?"
Stability Threshold	The tipping point at which a structure can no longer support itself and begins to fall. Exceeded when the center of mass moves outside the base support area.
	In the classroom: "What was the stone that crossed the threshold?" is a powerful post-tumble question.
Torque	A rotational force created when weight is placed away from the center of support. Heavy stones placed far from the vertical axis create strong torque.
	In the classroom: For grades 7–8: "Why did placing the stone on the outside cause a bigger tip than placing it in the center?"
Gravitational Force	The downward pull on every stone in the stack. The combined gravitational force of all stones is what the base must support.
	In the classroom: Simplify as: "Gravity is always pulling everything down. Your job is to balance those pulls."
Structural Failure	The point at which a structure can no longer maintain stability and collapses. In Talus Tumble, this is the tumble event.
	In the classroom: Reframe every failure as: "We just got data. What did it tell us?"
Base Support Area	The surface area the structure is resting on. Larger base = more stability. When center of mass moves outside this area, the structure falls.
	In the classroom: Show students the circular base and ask: "Why does the shape of the base matter?"

ENGINEERING DESIGN PROCESS

Hypothesis	A testable prediction made before an experiment. In Talus Tumble, every stone placement is a hypothesis about structural stability.
	In the classroom: "Before you place the stone, say out loud what you think will happen."
Iterative Design	The process of repeatedly testing and improving a design based on observed results. Each round of play is an iteration.
	In the classroom: "How did Round 2 change because of what you learned in Round 1?"
Failure Analysis	The examination of what caused a structure to fail, in order to improve the next design. Tumbles are the primary data source.
	In the classroom: "Which stone caused the fall? Why? What would you do differently?"
Constraint	A limitation that shapes how a design problem must be solved. In Round 2, adding "only 3 contact points" is a design constraint.
	In the classroom: Discuss: "Engineers always work with constraints. What are the constraints in this game?"
Prototype	An early version of a design used to test ideas. Each stone stack is a prototype, built, tested, and refined.
	In the classroom: "Your first stack is a prototype. Your second stack should be smarter because of it."
Trade-off	A design decision where improving one quality means sacrificing another, such as gaining height at the cost of stability.
	In the classroom: "What did you give up to get taller? Was it worth it?"
Feedback Loop	The cycle of testing, observing results, and using those results to improve the next attempt. Tumbles create feedback.
	In the classroom: Draw the loop on the board: Place → Observe → Adjust → Repeat.

GEOLOGY & MATERIALS

Talus	The natural accumulation of rock debris at the base of a cliff, formed by repeated mechanical weathering and gravitational transport of material from higher elevations.
	In the classroom: Show students: "The game is named after real geology, the same physics that moves boulders down a mountain is in your hands."
Natural Stone	The game pieces are hand-cut from actual stone, marble, soapstone, granite, and limestone. Each has slightly different weight and texture.
	In the classroom: Let students handle the pieces and describe differences: "Which feels heavier? Which feels smoother? Does that change how you place it?"
Density	How much mass is packed into a given volume. Denser stones feel heavier for their size. Dark stones in the set are often denser than light ones.
	In the classroom: "Do all the same-sized stones weigh the same? Why might that matter?"
Friction	The resistance between two surfaces in contact. Rougher stone surfaces have more friction, which can help or hurt stability.
	In the classroom: "Which stone surfaces grip each other? Which are slippery? How does that affect your strategy?"

GAME TERMINOLOGY (CLIMBING CULTURE)

Send It	Climbing slang for committing fully to a move without hesitation. In the game, "Send It" means placing multiple rocks in one continuous vertical stack.
	In the classroom: Before a bold placement: "Are you going to Send It?"
Rappel	In climbing, descending a rope. In the game, "Rappel" lets a player remove one stone and reverse play direction, a strategic retreat.
	In the classroom: "Sometimes the smart move is to retreat. What does a Rappel tell us about risk management?"
Broken Carabiner	A carabiner is a metal clip used in climbing. A broken one is a safety failure. In the game, this die action lets a player remove up to 2 stones from the stack.
	In the classroom: "When your carabiner breaks, you have to rethink your whole route."
Talus Tumble (Wild Card)	The wild card die result. Lets a player place any one remaining stone anywhere on the base, full creative freedom.
	In the classroom: "The wild card is your moment to try something unexpected. Use the data you have."
The Route	In climbing, the specific path up a wall. In the game, "The Route" die action means placing the specific shape shown on the die.
	In the classroom: "Every climb has a route. Every game turn has a route, follow what the die tells you."
Talus Titan	The title earned by the first player to place all their stones. The winner of the game.
	In the classroom: "What did the Talus Titan do differently? What can we learn from their strategy?"

NGSS SCIENCE & ENGINEERING PRACTICES

Asking Questions	The practice of identifying what needs to be solved. In Talus Tumble, the structural instability IS the problem to be defined.
	In the classroom: "What is the engineering problem in this game?" is the right first question.
Developing Models	Creating physical or conceptual representations of a system. Each stone stack is a physical model of a structural system under gravity.
	In the classroom: "Your stack is a model. What does it model?" Structural engineers do this every day.
Carrying Out Investigations	Designing and executing tests to gather evidence. Each round is a planned investigation with observable results.
	In the classroom: "What were you testing in Round 1? What did you investigate differently in Round 2?"
Analyzing Data	Making sense of observations and evidence. Tumble events generate data that must be interpreted to inform the next design.
	In the classroom: "The tumble is your data. What does it tell you about center of mass?"
Designing Solutions	Using evidence to create improved designs. Round 2 is explicitly a design improvement based on Round 1 evidence.
	In the classroom: "You are not just playing again. You are designing a better solution."

"Every stack is an experiment. Every tumble is data.™"

Chris Reichart, Creator | chris@talustumble.com | 703-855-8613 | linktr.ee/TalusTumble