Lesson 33

engineering

Test a structure fairly: which shape is strongest?

Lesson at a glance

Hold up three pre-made paper columns (round, triangle, square) and take a quick tally of which shape pupils think will hold most books. Drive the fair-test-planner interactive so the class places change, measure and keep-the-same cards, then groups build matched-height columns from identical A4 sheets. They stack the same books one by one until each column buckles, recording the book count immediately on the Investigation Journal page. Close with a talk on which shape won and where engineers use strong tubes.

Learning objectives

- Build paper columns with different cross-sections kept to the same height and paper
- Fair-test how much load each shape holds before it buckles
- Conclude which shape was strongest and link it to real structures

Before the bell — prep

Pre-make three sample columns (round, triangle, square) to hold up. Give every group three identical A4 sheets; lightly pre-crease triangle sheets into three panels and square sheets into four. Mark one class height (~21 cm). Gather matching lightweight books or thin magazines plus a shared reserve and spare sheets.

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Materials

Item	Qty	Per	Source	Low-cost substitute
identical A4 paper sheets (plain copier paper)	3	group	classroom	pages from a reused scrap paper pile, all the same full A4 size
masking tape or sticky tape	1	group	classroom	a short shared class roll passed between groups
lightweight books or magazines of similar size	15	group	classroom	exercise copies or thin reading books from the class library
30 cm ruler	1	group	classroom	a height mark drawn on the board or a strip of card cut to the agreed height
sample paper columns (round, triangle, square) for the hook	3	class	classroom	sketch the three end-shapes large on the board if samples are not ready
Investigation Journal page	1	pupil	classroom	plain paper with a simple three-row results table drawn ready

Safety watch-point

Stand back while stacking; keep fingers out from under books; catch books if a column fails suddenly; never stand on chairs to stack higher.

Teaching moves

- **What makes the test fair?:** Lead with the question and fair-test idea only. Point at the open tops of your three samples and call the end-shape the thing we change. Name buckle once so pupils know the end-point, then say the worked model aloud: change only shape, measure books held, keep paper, height and stacking the same.
- **Plan the fair test:** Open the fair-test-planner interactive in explore mode. Pupils call placements; you drag: Change = column shape; Measure = books held before buckle; Keep the same = paper sheet, column height, how we stack. Ask what would make the test unfair (extra tape, different paper, rough loading).
- **Build the three columns:** Demo once in ~30 seconds: fold a pre-creased triangle, then a square, then hold up a finished round tube. Stress one thin tape strip only — extra tape spoils the fair test. Check free-standing columns match the class height line before groups move on; rebuild short ones rather than stretch them.
- **Load until it buckles:** Agree the class buckle definition and the one counting rule on the board: record how many books are on top when it first folds. Groups test one shape at a time, books centred, and write the number on the Investigation Journal page immediately. Circulate asking which keep-the-same rule they are watching and whether the number is written yet.
- **Record our results:** Quick check only — three shapes, three numbers already on the page from the load step. Prompt strugglers aloud: 'The round column held... The triangle held... The square held...' Do not turn this into a conclusions write-up.
- **What does the evidence show?:** Collect a few group results and note the pattern on the board. Priority: which shape was strongest and what evidence shows it; what stayed the same; then one quick real-world link (scaffolding poles, lamp-posts, triangle frames in roofs/bridges). If a group's square won, treat it as data about joins and tape, not a wrong answer.

What it should show

Expect the round tube to hold the most books in most groups — the load spreads evenly around the wall. Square often buckles first at a face or edge; triangle can be strong but folds at a crease. Odd winners usually mean extra tape, uneven height or off-centre stacking. If all three fail very early, switch to thinner books or magazines.

Misconceptions & interventions

- **'We can use thicker paper or make one column taller if that shape needs it.'** — Hold the three identical A4 sheets and the height line again: only the end-shape changes. Anything else — paper, height, tape amount, stacking — would make the comparison untrustworthy.
- **'More tape makes a fairer, stronger join so we should reinforce the weak ones.'** — Point at the thin-strip rule on the sample columns. Extra tape changes the material, so it is no longer a shape test — rebuild with one clean join.
- **'If our square held more than round, the science is wrong.'** — Treat the result as real data. Ask about join neatness, height match and stacking. Neater building can beat a weaker shape — that is part of what engineers learn from fair tests.

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Differentiation

Emerging	Developing	Proficient
• Invite a less confident pupil to place a Keep-the-same card on the fair-test planner; give extra adult help at the tape join. • Use spoken stems at record time: 'The round column held… The triangle held… The square held…'	• Confident groups check finished height with a ruler and adjust before taping. • Ask during loading: which keep-the-same rule are you watching most carefully right now?	• Stretch on the planner: what else could we keep the same (same person stacking, same table surface)? • In the make-sense talk, critique whether join quality or tape amount may have skewed a group's ranking.

Cross-curricular hook

Link to Maths Data — compare the three book counts, find which shape was the mode winner across groups.