

CARDBOARD RACE CARS

Volunteer Instructions • Girl Scout STEM Workshop • K–12

Workshop goal: Participants design and build a small car from cardboard and simple materials, then race or test it on a ramp or track. The emphasis is on **motion, friction, wheel alignment, design choices, testing, and iteration.**

MATERIALS & SUPPLIES — KEEP IT SIMPLE

For each small team	Suggested amount
Corrugated cardboard	1–2 small pieces, about 8.5 × 11 in.
Bottle caps	4 for wheels
Wooden skewers or straight straws	2 axles
Drinking straws	2 short pieces for axle bearings
Masking tape or painter's tape	2–4 ft
Scissors	1 per team or shared
Pencils / markers	For design and decorating
Paper or cardstock	Optional decorations
Ruler	1 per team or shared
Ramp or smooth race surface	1 testing area
Pencils + worksheets	1 per participant

Minimum-material version: Cardboard, four bottle caps, two straight axles, two short straw pieces, and tape are enough. If bottle caps or skewers are unavailable, substitute other lightweight wheels and straight axle materials.

BEFORE THE TROOP ARRIVES

- **Choose the race format.** A ramp race is easiest: cars start from the same height and roll down onto a flat surface. A flat-surface push race also works.
- **Prepare the track.** Use a smooth floor, table, cardboard sheet, or other clear surface. Mark a starting line and finish line if desired.
- **Pre-cut axle-bearing straws** into short pieces if working with younger groups. Adults can also pre-cut cardboard bodies into simple rectangles for K–2.
- **Decide the challenge level.** Younger groups can focus on making a car that rolls. Older groups can measure distance, time, straightness, or consistency across multiple trials.
- **Print one worksheet per participant** (or one per team for very young participants).

THE CHALLENGE

Mission: Design and build a cardboard race car that rolls smoothly and travels as far or as fast as possible. You have limited materials, so you must make choices about the car body, wheels, axles, and alignment.

SUGGESTED 45–60 MINUTE FLOW

Time	Activity	Volunteer focus
5 min	Introduce the challenge	Ask what makes a toy car roll well and why some cars veer or stop.
5–10 min	Plan	Have teams sketch the car and decide where the wheels and axles will go.
15–20 min	Build	Encourage careful alignment and experimentation.

Time	Activity	Volunteer focus
10 min	Test	Run several trials from the same starting position.
5–10 min	Improve + retest	Change one feature and compare the result.
5 min	Share	Discuss what affected motion and which designs worked best.

HOW TO RUN THE BUILD

1. Introduce the problem

Explain that engineers design vehicles to move efficiently. Wheel size, axle alignment, friction, weight, and the shape of the car can all affect motion.

2. Set the constraints

Give each team the same basic amount of cardboard and the same number of wheels and axles. Decide whether decorations count toward the material limit.

3. Plan first

Have participants sketch their car. Ask where the axles will go and how they will keep the wheels from rubbing against the body.

4. Build

Attach two axle-bearing straws underneath the cardboard body, then insert the axles and wheels. Make sure the axles can rotate freely.

5. Test

For a ramp race, release every car from the same height without pushing it. For a flat race, use the same starting force as consistently as possible.

6. Record the result

Measure distance or time. For younger participants, simply record which car traveled farther or whether it rolled successfully.

7. Improve

Have teams change one feature—such as wheel alignment, axle placement, body shape, or friction at the wheels—and test again.

8. Compare

Discuss which changes helped and why. Emphasize that repeated testing makes the results more useful.

VOLUNTEER GUIDE: FACILITATING THE ENGINEERING

GOOD QUESTIONS TO ASK

- Why do you think your car rolls straight—or turns?
- What happens when a wheel is not lined up with the others?
- Where do you notice friction?
- How could you make the wheels spin more freely?
- What happens if you change only one part of the design?
- Which test result gives you the most useful information?
- How could you make your car more consistent from one race to the next?

KEY IDEAS TO EXPLAIN — ADJUST FOR AGE

Age range	Keep the explanation focused on...
K–2	Rolling and wheels: Wheels help objects roll. A car rolls better when the wheels can spin and are lined up.
3–5	Friction and alignment: Friction can slow motion. Misaligned axles or wheels can make a car turn instead of traveling straight.
6–8	Forces and motion: Gravity provides the force on a ramp, while friction and wheel/axle interactions affect acceleration and distance. Controlled tests make comparisons fairer.
9–12	Engineering optimization: Discuss rolling resistance, friction, mass, center of mass, axle alignment, repeatability, variables, measurement uncertainty, and controlled experiments.

TESTING RULES

- Use the same starting line, ramp height, and track surface when comparing cars.
- Run at least two or three trials when possible. A single race can be affected by a small bump or accidental push.
- For a ramp race, release cars without pushing them.
- If measuring time, use the same finish line and timing method for every team.
- If a car does not roll, help participants diagnose the problem rather than repairing it for them.
- For a fair competition, keep material quantities and testing conditions consistent.

OPTIONAL EXTENSIONS

- **Distance challenge:** Which car travels the farthest from the same starting point?
- **Speed challenge:** Which car reaches the finish line first?
- **Straight-line challenge:** Which car stays closest to a marked center line?
- **Consistency challenge:** Which car produces the most similar result across three trials?
- **Efficiency challenge:** Can teams improve performance without adding material?
- **Real-world connection:** Discuss how engineers design wheels, axles, bearings, and vehicles for predictable motion.

SAFETY & CLEANUP

- Scissors should be age-appropriate and supervised according to troop guidelines.
- Wooden skewers can have sharp ends; adults should trim or cover exposed ends for younger participants.

- Keep small wheels and axle pieces supervised around young children because they may be choking hazards.
- Keep the race track clear so participants do not trip while retrieving cars.
- Collect cardboard scraps, tape, and small parts after the activity.

Volunteer reminder: The goal is not simply to build the fastest car. Participants should practice predicting, building, testing, measuring, identifying variables, and improving a design using evidence.