

## Automotive Engineering

# How to Prepare for the Automotive Engineering Challenge

Use this guide to prepare, gather materials, and support girls as they build and test prototypes of alternative fuel vehicles for Steps 3-5 of the badge.

Background for the Design Challenge .....	1
Automotive Engineering Nuts N' Bolts .....	1
Vehicle Materials List .....	1
How to Assemble a Basic Vehicle.....	2
How to Prepare the Fuel Sources .....	2
How to Attach the Fuel Sources.....	3
How to Test the Alternative Fuel Vehicles.....	3
Checklist for <i>Automotive Engineering 1</i> .....	5
Checklist for <i>Automotive Engineering 2</i> .....	7

## BACKGROUND FOR THE DESIGN CHALLENGE

In the Automotive Engineering badge, Juniors work in pairs to engineer a vehicle that's powered by an alternative fuel. In *Automotive Engineering 1*, teams will create their alternative fuel vehicle engineering plans for Step 3. In *Automotive Engineering 2*, each team will build and test one vehicle for Steps 4 and 5.

Each team will choose 1 of 3 options for their fuel source to power their vehicle: balloon, mousetrap, or rubber band.

Each team will build one vehicle with 1 fuel source, 1 body, 4 wheels, and 2 axles (2 wooden skewers/dowels and 2 plastic straws).

You'll provide teams with an assortment of options to choose from for their bodies and wheels. Teams decide what type of fuel source. Each team will need 2 skewers/dowels and 2 plastic straws for their axles.

## AUTOMOTIVE ENGINEERING NUTS N' BOLTS

### VEHICLE MATERIALS LIST

Each vehicle will need:

- **1 fuel source:** 1 mousetrap (no prep needed!), balloon, or rubber band fuel source. See "How to Prepare the Fuel Sources" in this section for information on how to prep the balloon and rubber band fuel sources.

- **1 body:** 1 shoe box, tissue box, or some other kind of box, aluminum foil loaf pan, empty plastic water or soda bottles, empty half gallon plastic or paper milk or juice cartons
- **4 wheels:** 4 cardboard circles, cds, plastic bottle caps with holes punched in them, empty spools, plastic take-out container lids, or yogurt cup lids with holes cut in them
- **2 axles:** 2 wooden skewers (or thin dowels) and 2 plastic straws

**Important Note:** For the wheels to spin easily, make sure: 1) the width of each body is smaller than the length of the straw and 2) the skewers are longer than the length of the straw. If need be, you can cut the straws or skewers to make them the correct length.

### HOW TO ASSEMBLE A BASIC VEHICLE

1. **Gather materials.** Choose 1 body, 4 wheels, and 2 axles (2 skewers/dowels and 2 straws).
2. **Create your vehicle body.** Look at your vehicle body and decide what's the front, the back, the top, and bottom of the vehicle.
3. **Attach the axles to the vehicle body.** Tape the straws across the bottom of the vehicle body in a straight line. Make sure the straw is in a straight line across the body, so the vehicle will roll in a straight line.
4. **Connect a wheel and axle.** Take a wooden skewer or dowel and ONE wheel. If your wheel has a hole poked in it, put the axle through the hole. If it doesn't have a hole, use some of the clay or sponge to make a place in the wheel for the axle to stick.
5. **Connect the second wheel and axle.** Do Step 4 again with the second dowel or skewer, so you have 2 axles with 1 wheel each on them and 2 wheels left over.
6. **Connect the wheels and axles to the vehicle.** Feed the two axles with wheels through the straws. Then, attach the remaining wheels using clay or pieces of sponge.

### HOW TO PREPARE THE FUEL SOURCES

**Mousetrap:** No prep needed!

**Balloon:** Tape a balloon to a drinking straw so you can blow up the balloon with the straw.

**Rubber band:** Wrap 1 rubber band around a pen or pencil, making a loop. Then, feed the end of the rubber band through the loop, attaching the rubber band to a pencil or pen.



## HOW TO ATTACH THE FUEL SOURCES

### Mousetrap Fuel Source:

1. Attach the mouse trap to your vehicle body with the snap arm at the front of your vehicle.
2. Tie a piece of string to the snap arm with a knot. Lay the string over the length of your vehicle so that it's long enough to reach your rear axle (it might have to reach around the end and underneath). Trim the string to the length you want.

**Pro Tip:** The longer the string the farther, but slower, your vehicle will go.

### Balloon Fuel Source:

1. If you **haven't yet, tape the balloon to one end of the straw.**
2. **Attach** your balloon and straw to your vehicle, with the straw pointing toward the back of the vehicle.

**Pro Tip:** The size of your balloon will affect how much potential energy your vehicle has. When air is pushing out of the balloon, it will push out through the straw, moving the vehicle forward.

### Rubber Band Fuel Source:

1. Choose a rubber band to be your fuel source.
2. Attach a rubber band to the back axle of your vehicle by wrapping a rubber band around the center of the back axle, making a loop.
3. Feed the end of the rubber band through the loop, attaching the rubber band to the axle. Attach the loose end to some spot on the body of your vehicle using a paper clip, a flap cut out of your vehicle body, or something else.

**Pro Tip:** The thickness of the rubber band will affect how much potential energy it can hold. Try different rubber bands to see which make your vehicle move the farthest!

## HOW TO TEST THE ALTERNATIVE FUEL VEHICLES

### Mousetrap Fuel Source:

1. Carefully lift the snap arm of the mousetrap and hold it at the back of the vehicle.
2. While you're holding it down, wrap the string around the back axle.
3. Set your car down on the ground and let go of the snap arm.
4. When you let go, the spring will pop the snap arm forward and cause the string to unravel, moving your axle.

**Balloon Fuel Source:**

1. Blow up the balloon through the straw and pinch the straw closed with your fingers.
2. Set your car down on the ground and let go of the straw.
3. When you let go, you're allowing air to be pushed out of the balloon, moving the vehicle forward.

**Rubber Band Fuel Source:**

1. Wind the rubber band around the axle, stretching it tight.
2. Set your car down on the ground and let go of the axle.
3. When you let go, the rubber band will contract, making the axle spin.

## CHECKLIST FOR AUTOMOTIVE ENGINEERING 1

### PREPARE AHEAD: BEFORE THE MEETING...

- ☐ Use the “Vehicle Materials List” in the “Automotive Engineering Nuts N’ Bolts” section of this Guide to gather a sampling of vehicle materials, including: 1) an assortment of materials for the bodies, 2) an assortment of materials for the wheels, and 3) 2 wooden skewers (or thin dowels) and 2 plastic straws for the axles.
- ☐ Follow “How to Prepare the Fuel Sources” to gather and/or prep a sample of each fuel source (3 total: mouse trap, balloon, and rubber band).

### TIPS FOR THE MEETING

#### For Step 2: Engineer a Vehicle That Uses Alternative Fuel

In the activity, teams will create their automotive engineering plans. Use the grid below to tally up the number of fuel sources you’ll need for each team to build a vehicle in *Automotive Engineering 2*.

FUEL SOURCE TALLY GRID		
Fuel Source	Tally of Teams Using Fuel Source	Total # Needed
Mouse Trap		
Balloon		
Rubber Band		

If girls need help sketching their vehicles, use these “Tips for Sketching Vehicles”:

- **Imagine your vehicle.** Close your eyes and think about what your alternative fuel vehicle needs to do. What does it look like? How is the fuel source attached?
- **Make your vehicle sustainable and something your customer needs.** Remember why your customer needs an alternative fuel vehicle and how the vehicle will help them. Does your criteria and sketches reflect what your customer needs and wants from the vehicle?
- **Start simple, then add details.** First, draw the shape and size of your vehicle. Then, add in your criteria, including all the important parts and special features.
- **Design your vehicle for fuel efficiency.** What design choices can help your vehicle go farther with its alternative fuel?
- **Use tracing paper to try out different ideas.** See what a special feature looks like before adding it to your sketch by drawing the feature on a piece of tracing paper. Then, place the tracing paper over your drawing to see if you like it as part of your final design.
- **Sketch like a professional!** Draw more than one view of your vehicle: top, side, back, or front. This helps others to understand what your vehicle looks like from every angle. Try to use long, continuous lines when you draw. For most vehicles, the distance between the front and back wheels is three wheels wide.
- **Be bold!** Use markers or colored pencils to add color to your sketches.

**AT THE END OF AUTOMOTIVE ENGINEERING 1, MAKE SURE TO...**

- ☐ Fill out the “Fuel Source Tally Grid,” totalling up the number of teams who want to use each type of fuel source.
- ☐ Collect and save the Juniors’ **Criteria Checklists**, notes, and sketches for *Automotive Engineering 2*.



## CHECKLIST FOR AUTOMOTIVE ENGINEERING 2

### PREPARE AHEAD: BEFORE THE MEETING...

- ☐ **Gather vehicle materials for girls.** Bring an assortment of materials for the bodies and wheels (enough for each pair of girls to have 1 body and 4 wheels), 2 wooden skewers/thin dowels for each pair, and 2 plastic straws for each pair.
- ☐ **Prep and gather fuel sources.** Use the “How to Prepare the Fuel Sources” instructions under “Automotive Engineering Nuts N’ Bolts” and your “Fuel Source Tally Grid” from the last meeting to prepare 1 fuel source for each team, plus a few extras of each.
- ☐ **Build 3 basic vehicles.** Follow the “How to Assemble a Basic Vehicle” instructions under “Automotive Engineering Nuts N’ Bolts” to assemble 3 sample basic vehicles.
- ☐ **Create 3 testing tracks around the meeting space (one for each fuel source).** For each track, put a long piece of masking tape on the floor to mark the starting line.

### WHAT TO DO AT THE MEETING - AUTOMOTIVE ENGINEERING 2

#### For As Girls Arrive: Choose the Materials for Your Prototype

In the activity, teams will gather their vehicle materials. Each team of ~2 girls will need these materials to build one vehicle: 1 fuel source, 1 body, 4 wheels, and 2 axles (2 skewers/dowels and 2 plastic straws).

#### For Step 3: Build a Vehicle Prototype

In the activity, teams will build their alternative fuel vehicles. If they need help, follow the “How to Assemble a Basic Vehicle” instructions under “Automotive Engineering Nuts N’ Bolts” and in the meeting plan to demonstrate how to build a basic vehicle.

#### Here are a few other tips to support teams as they build their basic vehicles:

- **If the wheels aren’t staying attached,** have a variety of materials available for teams to stabilize and secure the wheels to the skewers/dowels, such as glue, modeling clay, pieces of sponge (to stick on the ends of the skewers/dowels), and rubber bands (to wrap around the ends of the skewers/dowels after the wheels are attached).
- **If the straws holding the axles don’t stay attached,** encourage the team to add more tape to the bottom of the vehicle.
- **If the axles don’t rotate easily,** ask the team to make sure the straws are short enough for the skewers/dowels and wheels to stick out a bit on each side. If they aren’t, trim the ends of the straws to allow the wheels to spin easily.

Later in the activity, teams will attach their fuel sources. Follow the “How to Attach the Fuel Sources” instructions under “Automotive Engineering Nuts N’ Bolts” and in the meeting plan to demonstrate how to attach one type of fuel source to each of your sample vehicles.

### For Step 4: Test and Revise Your Vehicle Prototype

In the activity, teams will use the tracks you prepared to test their alternative fuel vehicles. They'll test their vehicles for 1) forward and backward motion, 2) how far it can travel, and 3) for speed. Then, they'll use what they've learned from testing to improve their vehicle's design.

Follow the instructions below to demonstrate how to test each type of vehicle and support girls as they test their own.

**As girls revise their prototypes, here are a few tips to improve the vehicles:**

- **If the wheels don't spin**, check that the skewers/dowels inside the straws are able to spin freely. If not, trim the straws a little to make them shorter, creating more space between the wheels and the end of the straws.
- **If the vehicle doesn't roll straight**, check that the axles are attached straight across the vehicle body. Check to make sure the wheels are firmly attached to the axles.
- **If the wheels come off**, secure them with glue or modeling clay.
- **If your alternative fuel system doesn't work**, check to make sure all parts are securely attached: the string or rubber band should be able to move freely, or your balloon is taped to the straw completely so no air can leak out.
- **No matter what happens**, it's good when things go wrong when testing a prototype. That's how engineers find out what to fix!

### ENGINEERING CHALLENGE OPTIONS

**Compare alternative fuel vehicles.** After the three races, have a final race between the winning vehicles from each group, with a goal of either speed or distance. Then, discuss why that alternative fuel source was the most successful.

### For Step 5: Share Your Prototype and Testing Results

In the activity, teams will share their vehicle prototypes and testing results. They create milestone review presentations as a way to tell others about their work, give and get feedback on their project, and discover new ideas or ways to make their vehicle even better.

Here are the questions they'll answer, found in the meeting plan and on the **Present Your Alternative Fuel Vehicle** handout for girls:

1. Which kind of alternative fuel vehicle did you engineer?
2. Why did you choose this type of fuel? What other criteria did you include for your vehicle?
3. How did your vehicle do in the tests for: 1) forward and backward motion, 2) distance, and 3) speed?
4. How did you improve your prototype after testing?