



# Junior Automotive Engineering

Get behind the wheel and experience automotive design, engineering, and manufacturing by earning these three badges!

**Badge 1:**  
Automotive Design

**Badge 2:**  
Automotive Engineering

**Badge 3:**  
Automotive Manufacturing



This booklet gives girls an overview of the badge requirements and badge steps for all three Junior Automotive Engineering badges. It also includes interesting background information to spark girls' interest in automotive engineering. Volunteers can access the Volunteer Toolkit (VTK) to find complete meeting plans, including detailed activity instructions and handouts.

**Welcome** to the world of automotive design, engineering, and manufacturing. You're about to find out how vehicles go from being an idea to driving on the street.

When you've earned these three badges:

- You'll know how people turn their ideas into plans to design a vehicle.
- You'll know how people use science to make vehicles that are powered by eco-friendly fuels.
- You'll know how people organize factories and work together to build lots of vehicles.

You'll also explore how vehicles can help solve problems and how you can have a job to make cars that are safer and better for the planet.

Volunteers can access the Volunteer Toolkit (VTK) to find complete meeting plans, including detailed activity instructions and handouts.



# Badge 1: Automotive Design

**V**ehicles, like cars, trucks, and motorcycles, move people and things from place to place. They can be designed to work in all types of conditions, from snow to mud or even in water!

Do you want to take a ride in your dream car? Before you can do that, you need to design it! Discover how to create vehicles by sketching and sculpting a model.

## Steps

1. Explore mobility across time
2. Conduct automotive market research
3. Create your vehicle's design criteria
4. Sketch a vehicle to meet your criteria
5. Sculpt and share your vehicle

## Purpose

When I've earned this badge, I'll know about innovation and market research. I'll know how to create criteria and sketch and sculpt a vehicle.

## Design Power

Imagine a vehicle that solves problems—these designers did!

After Hurricane Katrina, many people were left without power or water. To help, the company that makes Tide laundry detergent designed and created mobile laundromats as part of their Loads of Hope program. These big trucks held 12–18 washing machines and dryers that could do hundreds of loads of laundry a day!

Students at Vanderbilt University designed a kid-sized car for kids with mobility challenges. For example, they changed the seat design to make it easier for the kids to get in and out.

The Oscar Mayer Wienermobile is a rolling advertisement for hot dogs! In 1936, Oscar Mayer's son, Carl, suggested they build a 13-foot-long mobile hot dog that he could drive around, giving away hot dogs. Today, six modern Wienermobiles have ketchup- and mustard-colored seats and "bunroofs." They make 1,400 stops around the country every year!

### STEP

## 1 Explore mobility across time

**Do you like to ride a bike or scooter?** Roller or ice skate? Have you ever ridden a horse or gone on a train? All of these things give you **mobility**, or the ability to move.

**Transportation** is how people move themselves and things from one place to another. When someone rides in a vehicle, they're a **passenger**, and if they carry things with them in the vehicle, those things are **cargo**.

Transportation is constantly changing. In the past, we used horses, today we use cars, and in the future, our cars might be able to drive themselves!

So, what's your favorite way to go places? How do you think this will change in five years? Ten years? If you can imagine what transportation will be like in the future, you're one step closer to turning it into a reality!

### STEP

## 2 Conduct automotive market research

**Have you ever thought of the perfect present for someone?** If you have, it's probably because you talked about it with them! Just like finding a gift someone will love, automotive designers ask their **customers**, the people who will be buying the cars, what they want and need.

Automotive designers use **market research**, where they conduct interviews or surveys to gather a lot of information, or **data**. They use the data to look for **trends** and find out what groups of people want.

Interviewing your customers can help you find out what they want and need. Then, you can make a vehicle that's just right for them.

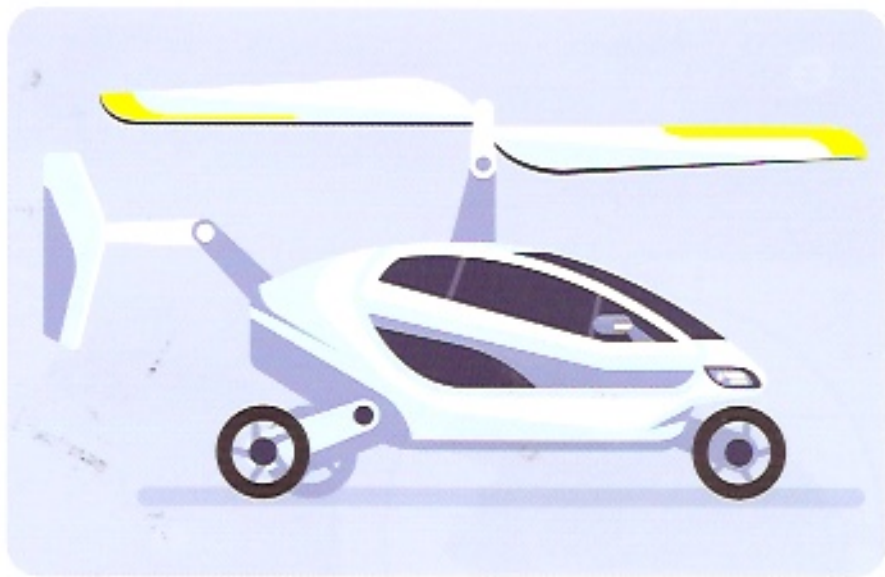
**STEP**

# 3 Create your vehicle's design criteria

**When you create something, it's fun to make it special!** For example, you might add a new flavor to a cake, a move to a dance routine, or bold colors to a painting.

**Creative designers** are the people who imagine what new vehicles will look like. They have the job of choosing the **design criteria** for new vehicles. The criteria include the parts all vehicles have, like an engine, wheels, and axles, and other parts, or **design features**, to make the new vehicle especially useful, fun, or different from other vehicles.

Once you know what vehicle parts to include and more about what your customer wants and needs, you can use what you've learned to choose the criteria for your specialized vehicle.



## Two Heads Are Better Than One

Cars that can think for themselves may sound like something out of science fiction, but the future of artificial intelligence (AI) and mobility is already here! AI is when computers and sensors are used to help guide machines.

Automotive designers add AI features to make cars safer. For example:

**Automatic brakes** sense when the car's getting too close to something and make the car slow down.

**Lane-drift sensors** can tell drivers if they're drifting out of their lane or if someone is passing in the lane next to them.

**Drowsiness detection** can tell when a driver is getting sleepy and starting to drift out of their lane. It causes an alarm to go off in the car to wake the driver.

**Pedestrian detection sensors** can "see" people walking on the street and predict what they'll do.

# PARTS OF A

Cars and other vehicles are made up of lots of parts. There are parts on the outside, or the **exterior**, and parts on the inside, or the **interior**.

## EXTERIOR

- 1 The **axles** connect two wheels and spin, causing the wheels to turn.
- 2 The **body** is the outside shape of a vehicle.
- 3 **Bumpers** cushion the front and back of the vehicle.
- 4 **Doors** open and close to let people get in and out.
- 5 **Headlights** help the driver see in the dark or bad weather.
- 6 **Taillights** help other drivers see when the vehicle is slowing down, turning, or backing up.
- 7 The **hood** can be opened to take care of the engine and other parts.
- 8 People store cargo in the **trunk** of a vehicle.
- 9 Most vehicles have 4 **wheels** with tires that roll to move the car.
- 10 **Windows** help people inside the vehicle see where they're going.
- 11 The **windshield** lets the driver see in front of the vehicle.
- 12 The **windshield wiper** slides back and forth to wipe off rain and snow.



# VEHICLE



## INTERIOR

**13** The **dashboard** shows the driver vehicle information like its speed, how much fuel it has, and what gear it's in.

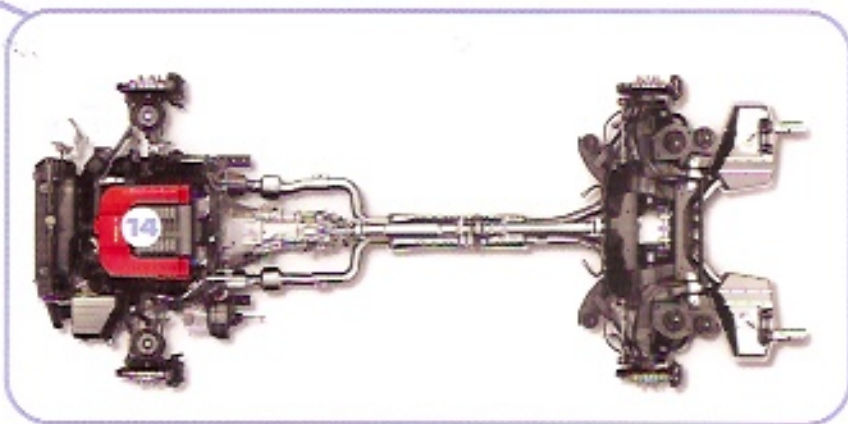
**14** The **drivetrain** transfers energy from the engine to the axles and wheels, making the vehicle go.

**15** The **engine** powers the vehicle to make it go.

**16** The driver uses a **gear shift** to make the vehicle go forward or backward.

**17** Each passenger sits in a **seat** with a **seat belt** to keep them safe if there's an accident.

**18** The driver rotates the **steering wheel** to make the vehicle turn.



## The Dream Design Team

A design team has lots of players! For example:

- The **interior creative designer** creates the inside of the vehicle, including the seats, dashboard, and steering wheel.
- An **exterior creative designer** imagines the outside of the vehicle, such as the body shape, wheels, bumpers, and doors.
- A **color and trim designer** works on the details, like the color of the seats and logos.
- A **clay sculptor** makes models of vehicles out of clay.
- A **digital sculptor** creates digital (computer) models using ideas from the designers and criteria from the engineers.
- A **fabrication shop technician** builds 3D models of different parts and puts them together to make a running model.
- Once the design is ready, a **studio engineer** turns the models into real parts that can be assembled.

## STEP 4 Sketch a vehicle to meet your criteria

**If you can imagine it, you can draw it!** Creative designers draw their vehicles to share their ideas and let people see the special features they're including. They use their design criteria as a list of things to include in their drawings.

So, show others your automotive design ideas with a sketch! Imagine what your special vehicle looks like and draw the interior and exterior. Choose different angles to draw—front, side, back, or from above. Start with the general shape and then add details!

## STEP 5 Sculpt and share your vehicle

**Sketches are a great way to show people your ideas, but they're flat, or two-dimensional (2D).**

A model, made of a material like clay or wood, lets people see your design's shape in 3D. Three-dimensional models help the designers to show their ideas from all angles.

Once you have a sketch of your vehicle, you can make a 3D model of your vehicle out of clay. You can then use your model, along with your sketches and design criteria, to share your automotive design!



**Now that I've earned this badge, I can give service by:**

- Teaching others how vehicles are designed.
- Listening to what others want and need and using what I learn to help them.
- Using what I learned about working as a team to help with a group project at school or a Take Action project with my troop.

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**I'm inspired to:**



# Badge 2: Automotive Engineering

**I**f designers imagine it, engineers build it! After designers come up with an idea for a vehicle, automotive engineers use what they know about math and science to build and test a working vehicle.

Find out how to turn a list of criteria into your own working model of a vehicle that's powered by an alternative fuel!

## Steps

1. Learn about simple machines in vehicles
2. Engineer a vehicle that uses alternative fuel
3. Build a vehicle prototype
4. Test and revise your vehicle prototype
5. Share your vehicle prototype and testing results

## Purpose

When I've earned this badge, I'll know how to use the Design Thinking Process to plan, build, test, and improve prototypes.

**STEP**

# 1 Learn about simple machines in vehicles

**Have you ever tried to move something heavy?** Did you wish there was a way to make it easier? A **simple machine** can help! It's a tool that makes work easier by using less force.

**Force** is the strength or energy that creates movement, like push and pull.

There are six kinds of simple machines: wheel and axle, screw, inclined plane, lever, pulley, and wedge. When two or more simple machines work together, they make a **compound machine**.

Now, where are the simple and compound machines in vehicles? You can find levers in the door handles and gear shift, pulleys in seat belts, and screws in gas caps, not to mention wheels and axles!

**STEP**

# 2 Engineer a vehicle that uses alternative fuel

**Can you imagine a car that runs on sunshine?**

Or leftover oil from making French fries? Sounds crazy, but these cars exist! These vehicles use **alternative fuel**, which means they run on a fuel other than gasoline or diesel.

When engineers build an alternative-fuel vehicle, they have to solve a bunch of new challenges, like how the fuel makes the vehicle move, how heavy the vehicle is, and how the vehicle gets refueled. Some of the parts stay the same, like the steering wheel and the windshield wipers. Other parts, like the battery or the shape of the body, might need to be reengineered for the alternative fuel.

Which changes would you make to a traditional vehicle so it can run on an alternative fuel?

## The 6 Types of Simple Machines

**WHEEL AND AXLE****INCLINED PLANE****SCREW****LEVER****PULLEY****WEDGE**

# FUEL UP!

**Our need to go places is unlimited, but our supply of fossil fuels to make gasoline isn't.** Even more, burning fossil fuels causes pollution. If we want to keep moving, we have to discover new ways to fuel our travel!

Here are some different alternative fuels we already use:

**Electricity** Electric cars are the most common type of alternative-fuel vehicle. Some plug in to an outlet to recharge. Others use a battery to store energy when the driver steps on the brakes. Then, when the driver steps on the accelerator, the engine uses the energy in the battery to make the car go.



*This electric vehicle's plugged in and charged to keep moving!*

**Solar and wind energy** If you live in a desert or another sunny place, a solar-powered car might be a great option! These vehicles have solar cells on the body that turn sunshine into electricity. If you live someplace that's usually rainy and windy, you might instead choose a wind-powered car. They exist, too!

**Used cooking oil** Have you heard of upcycling? It's when you take a waste product and turn it into something that's valuable or better for the environment. Used cooking oil is usually thought of as trash, but engineers have figured out how to turn it into biodiesel! This fuel can be used in specially engineered engines, like those in buses. Engineers can turn trash into transportation!

## STEP 3 Build a vehicle prototype

**How do you take an idea and turn it into the real thing?** Make a **prototype**! It's a working model that engineers use to test out their ideas and make improvements.

But how do you build a prototype that works? With the **Design Thinking Process**! Engineers start by defining their problem or project, like building a new vehicle that uses an alternative fuel. Then, they brainstorm and plan, build a prototype, test it, and improve it. It's how they see if their ideas work and share them with others.

Once you've finalized your criteria checklist, use your engineering plan to build a prototype of your alternative fuel vehicle!

## NOTES

### Eenie, Meenie, Miney, Mo . . .

When you're cooking, the ingredients you use matter. When you're engineering a vehicle, the materials you choose matter, too.

Engineers look for materials that are strong, light, and durable, so they can hold up under lots of use. Some might also need to be fireproof or have sound-proofing abilities.

Today, new materials are being invented all the time, and engineers are discovering new ways to use old materials.

To help power cars, **superthin solar cells** are being used in sunroofs, capturing solar power. Before they were this thin, solar cells didn't work well on vehicles.

Some vehicles now have **coconut husks as padding for seats** instead of plastic foam. The husks don't just make comfy seats. They're also good at deadening sound from outside the car, creating a quieter ride for passengers.

Other vehicle interiors are made of **bamboo** because it's inexpensive, strong, and more renewable than wood.



## STEP 4 Test and revise your vehicle prototype

### What's better—if your vehicle goes fast or far?

Automotive engineers want the vehicles they build to work well, be safe, and use as little fuel as possible. They have to test their designs for each of these things and look for ways to make them better.

Every time an engineer makes changes to the vehicle, that's called an **iteration**, or a new version of the design.

Once you have a prototype, test your vehicle to see how well it works. If you find problems with your vehicle, remember that it's a good thing! That means you know what needs to be fixed.

## Just How Tough Is That Car?

Who would drive a car into a wall on purpose? An automotive engineer testing a new vehicle! They drive them in crazy-hot and bitter cold weather, too. They even expose them to wind, rain, and chemicals.

Why? Because they want to know how the vehicle will work in all types of situations. They want their products to be high quality and safe. They also want to find issues and fix them before customers ever experience them.

**Extreme weather:** Engineers will take their vehicles to places like Death Valley to see how they respond to really hot weather. For cold weather, they'll test how the vehicle bodies respond to salt and other chemicals that are used on icy roads.

**Performance and handling:** Some cars get tested by driving them around cities for miles and miles. Others might go to a special racetrack, like the

Nürburgring in Germany. Car companies from all over the world bring their vehicles here to be tested at high speed on the curvy track.

**Safety:** To sell a car in the US, the vehicle has to pass its safety tests! For example, engineers test cars' brakes, measuring how long it takes them to stop. They also test what happens to the vehicle in crashes, focusing on passenger safety. They look at how the seat belts, airbags, windows, body, and other parts of the car react during an accident.

**Comfort:** Engineers will test things like how noisy it is inside the vehicle, how fast the heat or air conditioner turns on, and if the car shakes a lot at different speeds. They'll look at all parts of the vehicle's performance to make sure the vehicle will work and be something customers like.

## STEP

# 5 Share your vehicle prototype and testing results

**If you were an automotive engineer, you would make lots of iterations of your vehicle.** Eventually, you'd make a prototype with parts made of metal and other materials.

Once the final prototype passes all the tests you want it to, the next step in the automotive process is called **manufacturing**. Manufacturing is when a lot of a product is made in a factory to eventually be sold to customers.

Manufacturers use the final design from the engineering team to make lots of the same vehicle in a factory, over and over again. To get the manufacturing team started, the engineering team will share their plans and prototypes in a **milestone review**.

In this type of presentation, the automotive team presents their work to see if the vehicle can be moved along in the process, from design to engineering to manufacturing.

Sharing your ideas and getting feedback is an important part of the Design Thinking Process. It can help you identify problems and find ways to make your vehicle even better.



**Now that I've earned this badge, I can give service by:**

- Sharing with others about the need for and kinds of alternative fuels.
- Showing my prototype and giving a presentation at school about automotive engineering.
- Helping a friend make something better using the Design Thinking Process.

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**I'm inspired to:**



# Badge 3: Automotive Manufacturing

**Y**ou've designed and engineered a new vehicle, and now everybody wants to buy one. So, what do you do? Build a factory and start manufacturing!

Find out how people manufacture vehicles without wasting time and how they make sure the vehicles are safe and well made!

## Steps

1. Experience the manufacturing process
2. Learn about the automotive manufacturing process
3. Plan your own automotive manufacturing process
4. Manufacture a set of vehicles
5. Innovate your automotive manufacturing process

## Purpose

When I have earned this badge, I'll know how high-quality vehicles are manufactured.

STEP

## 1 Experience the manufacturing process

**Do you hate to waste time and effort?** So do manufacturers! When manufacturers make a set of products, they want to do it **efficiently**, without wasting time or materials.

The easiest way to do this is to use an **assembly line**, where workers, machines, and materials are arranged in a line to build a product.

So, imagine what it's like to have what you need to manufacture vehicles efficiently and how hard it might be without! An assembly line would help you to keep workers safe and not waste.



STEP

## 2 Learn about the automotive manufacturing process

**If you're going to sell something, you want it to be great!** Manufacturers want to make **high-quality** products that are safe, well made, and have no mistakes. When manufacturers check their products, that's **quality control**.

Manufacturers also want their products to be consistent. This means the product will be the same, of good quality, each time its assembled.

**5S** helps manufacturers to make high-quality products in a safe and efficient way. The 5 steps of 5S are: sort, set in order, shine, standardize (keep the same), and sustain (keep it going).

# USE 5S TO MAKE LIFE BETTER

What does 5S look like outside of manufacturing? Let's see with a vegetable garden! Then, choose another task and fill in how you can make it more efficient with 5S!

## THE 5S SYSTEM IN REAL LIFE

<b>5S STEP</b>	<b>TASK: GROWING A VEGGIE GARDEN</b>	<b>YOUR 5S TASK:</b> _____
<b>SORT</b>	Sort out seeds, tools, and other materials	
<b>SET IN ORDER</b>	Plan your garden beds and plant them, label your plants	
<b>SHINE</b>	Put your tools away, pull weeds, clean up after yourself	
<b>STANDARDIZE</b>	Set up a schedule for weeding, watering, and harvesting	
<b>SUSTAIN</b>	Take care of your garden according to your schedule, always put tools away, and clean up after yourself	

## These Women Were First. YOU Could Be Next!

**Mary Barra** is the first female CEO of a major automaker. She became CEO of General Motors in 2014. She studied electrical engineering and business administration and has worked her entire career at GM.

**Michelle Christiansen** was the first woman to lead a "supercar" design team. Working for Honda/Acura, Michelle led the development of their most expensive car, the NSX. As a kid, she learned about cars from her dad, and she loved drawing and art. She combined her passions to become Acura's first female exterior designer.

**Alicia Boler Davis** liked fixing broken things as a kid. She joined General Motors as a manufacturing engineer after studying chemical engineering, engineering science, and business administration. Alicia is the first African American woman to become a plant manager in an automobile manufacturing plant.

## STEP 3 Plan your own automotive manufacturing process

**Have you ever looked at something and thought, "How did they make that?"** Take anything, like a great cookie or a beautiful dance routine. If you look at the finished item and use what you know about baking or dancing, you can reverse engineer it to figure out how it was made.

You can also use **reverse engineering** to build a vehicle. Once you've figured out the steps, you can use them, over and over, to create an assembly line that's safe and efficient.

When you've decided on your manufacturing process, test it to see if it works.



## STEP 4 Manufacture a set of vehicles

**Ready, set, GO!** Once you've tested your assembly line, it's time to manufacture your set of model vehicles.

Quality, efficiency, and safety are important, and 5S can help with all three. 5S helps with quality by focusing on consistency, the line being organized and tidy, and everyone knowing and doing their jobs. If everything is moving smoothly because of 5S, the manufacturing process is efficient.

How do you think 5S helps with safety? Well, imagine what could go wrong on an assembly line without 5S!

## STEP 5 Innovate your automotive manufacturing process

**You've just created a manufacturing process that's efficient, safe, and makes high-quality products.** You're thinking like an automotive manufacturer.

Manufacturers are always innovating. Sometimes they change materials because the old ones aren't available or better ones have been created. Sometimes they have to figure out how to work with fewer people because there's a shortage of workers. When manufacturers make changes or improvements to their process, it's called **process innovation**.

Manufacturers also have other goals in mind, like protecting the environment and making the process safe for their workers. How could you innovate your process to reach these two goals?



# SMART FACTORIES

Robots welding car parts? People showing robots how to paint cars? It's happening right now in automotive manufacturing!

Manufacturers use AI to make assembly lines safer! Collaborative robots, or co-bots, are working alongside people in assembly lines doing jobs that are too dangerous, dirty, or boring for humans.



AI can also predict when there will be problems in manufacturing before they happen. Computers learn what the normal patterns are for machines and predict when they'll break down. This helps manufacturers plan for breakdowns and do maintenance in advance, limiting the amount of time an assembly line has to stop to fix a problem.

**Now that I've earned this badge, I can give service by:**

- Giving a presentation at school about process innovation.
- Using the 5S system for chores I do at home.
- Creating an assembly line to make something for others, like lunches or care packages.

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**I'm inspired to:**



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