



Brownie Automotive Engineering

Discover how to design, engineer, and manufacture vehicles 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 Brownie 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. When you've earned these three badges:

- You'll know how people imagine new vehicles and share what they'll look like.
- You'll know how people use science to choose materials and to build a vehicle.
- You'll know how people build vehicles in a factory that are safe to drive.

You'll also explore how vehicles move us from place to place and how you can make cars that are safer and better for our planet.

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



Badge 1:

Automotive Design

What's the difference between riding on a unicorn and in a car? You can imagine either, but you can only drive one on the road! A vehicle is a machine that moves people or things, like a car, truck, or motorcycle.

Find out how automotive designers come up with ideas for new vehicles. Then, design your own!

Steps

1. Explore how people move from place to place
2. Discover design criteria
3. Choose 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 how to design, sketch, and sculpt a vehicle.

STEP

1 Explore how people move from place to place

Have you ever ridden on a snowmobile, used a scooter, or paddled a canoe? When you move yourself—or something moves you—from place to place, that's **mobility!**

A snowmobile, scooter, and canoe are all different kinds of **transportation**. They help to move people and things from one place to another. When a person rides in a vehicle, they're a **passenger**, and if they carry things with them, those things are **cargo!**

Now, think about some places you like to go, like your friend's house or to the beach. What cargo do you take with you? What sort of things do you use to transport your cargo?

Where in the World Are You Going?

Where people live often makes a difference in the kind of vehicles they use.



There are no streets in **Venice, Italy**, only water-filled canals! You need to take a boat or gondola to get from one place to another.



In many places in **Asia**, people ride in tuk-tuks. They're small 3-wheeled vehicles that can easily move around in crowded cities.



You might take a chicken bus in **Guatemala**. These repurposed school buses move people and all kinds of cargo (like chickens and goats!).

STEP 2 Discover design criteria

All vehicles need some of the same parts—like an engine and wheels—to make them move.

Automotive designers also add other parts, or **design features**, that make the vehicle even more useful. For example, heated seats are great if you live in a cold place. Cupholders are helpful for people on the move.

The list of parts and design features is the vehicle's design criteria. **Criteria** are things that a product, such as a car, needs to have.

STEP 3 Choose your vehicle's design criteria

How do automotive designers choose their design criteria? They ask their **customers!** Those are the people who will be using what they design.

This is called **market research**. Through interviews, surveys, and product tests, designers can gather data (that's information!) to explore what kind of vehicle their customer would like. Then, designers analyze their data to find out what their customer wants and needs.

For example, they might find out that people want a car that uses less gasoline or would love a purple truck. Whatever it is their customers want, designers want to know!

Once you know who your customer is, you can create a list of criteria with parts and features that they want and need.

Problem Solvers

Automotive designers add criteria to help their customers with all types of problems!

• • •

PROBLEM: Groceries and take-out food can spill in moving cars. What a mess!

SOLUTION: Add special hooks to hang bags on.

• • •

PROBLEM: Gasoline is expensive and causes pollution!

SOLUTION: Design engines that run on electricity! Alternative-fuel vehicles are better for the environment.

• • •

PROBLEM: Sleepy drivers cause accidents.

SOLUTION: Engineer a special sensor that can alert the driver if they're dozing off!

• • •

PROBLEM: People sometimes get in their cars with muddy gear.

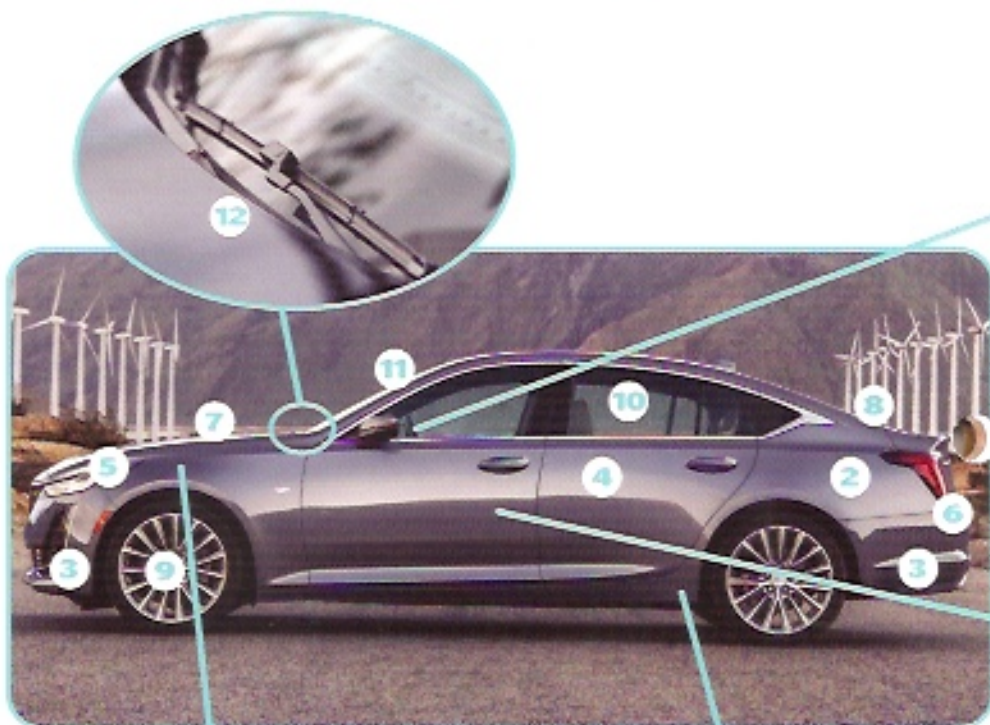
SOLUTION: Include storage bins to hold muddy shoes and gear. Even more, make them easy to remove and clean!

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.
- 3 **Bumpers** cushion the front and back.
- 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**.
- 9 Most vehicles have 4 **wheels** with tires that roll to move the car.
- 10 **Windows** help people see where they're going.
- 11 The **windshield** lets the driver see in front.
- 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 **engine** powers the vehicle to make it go.
- 15 The driver uses a **gear shift** to make the vehicle go forward or backward.
- 16 Each passenger sits in a **seat** with a **seat belt** to keep them safe if there's an accident.
- 17 The driver rotates the **steering wheel** to make the vehicle turn.



The Mobility Team!

It takes a lot of teamwork to create vehicles!

Automotive designers, engineers, and manufacturers work together to come up with ideas for new cars. They also work together to figure out how to make them and how to make enough for people to buy.

Just like a soccer team, everyone has an important part to play. Creative designers come up with the idea for a vehicle. Engineers use what they know about science and math to build the vehicle and make sure it works. Manufacturers figure out how to build lots of the vehicle in a factory to sell to customers.

STEP 4 Sketch a vehicle to meet your criteria

When you've imagined a great new vehicle, you want to share your idea with others. One of the best ways to do that is to draw it!

Creative designers sketch their vehicle in several different ways. They'll draw the **exterior**, or outside, from different angles: the front, top, sides, and back. They'll draw the **interior**, or inside, too. And if there's a feature they really want people to notice, like a new kind of seat or steering wheel, they'll even draw a special picture of that.

Once you have design criteria, use them to sketch your vehicle. Then, share your sketches with others to show them your design.

STEP 5 Sculpt and share your vehicle

What's better than a picture to help people understand your design? A model! An automotive designer uses her design criteria, sketches, and model to share her ideas with others.

Clay sculptors are the people who make models of new vehicles out of clay. Together with other designers and engineers, they figure out if it's possible to make the new vehicle to sell to people.

Like a clay sculptor, use your criteria and sketches to create a sculpted model of your vehicle.

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

- Teaching Daisies about the parts of a vehicle, special features, or design criteria.
- Sketching an idea for how I can help someone else.
- Sharing something I've made with others to ask for ideas to make it even better.

I'm inspired to:



Badge 2: Automotive Engineering

Once designers have an idea for a new vehicle, it's up to automotive engineers to figure out how to build it. They make a plan, build a working model, and test it to see if the vehicle works. They look for ways to fix the vehicle until it's safe to drive and works just the way they want it to.

Explore how to engineer your own model of an emergency vehicle!

Steps

1. Learn about simple machines in vehicles
2. Engineer a vehicle for safety based on criteria
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 automotive engineers plan, build, test, and improve vehicles.

STEP

1 Learn about simple machines in vehicles

What would you rather do: climb a rope to the ceiling or walk up a ramp? Climbing the rope might be more fun, but the ramp would make going the same distance easier. That's because a ramp is a type of simple machine called an inclined plane.

Simple machines make work easier by using less force in a different direction. **Force** is the strength or energy that creates movement, like a push or pull.

A vehicle is made up of lots of parts that work together so the vehicle can move. For example, a gas cap is a screw and the door handle is a lever. When simple machines like these work together, that's a **compound machine**.

The 6 Types of Simple Machines



Wheel and axle



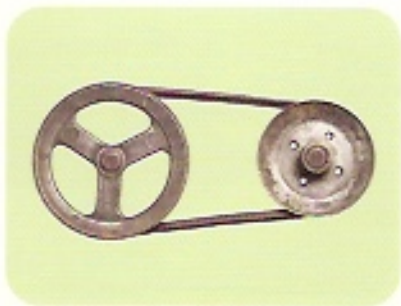
Inclined plane



Screw



Lever



Pulley



Wedge

STEP

2 Engineer a vehicle for safety based on criteria

Some vehicles are built to work in extreme conditions. Emergency vehicles that help people in floods, earthquakes, or blizzards need to be safe. They also need to work in difficult road and weather conditions, like snow, rocks, or heavy rain.

Automotive engineers use science and technology to figure out what materials work best and how to build the vehicle. They'll make sure their vehicle meets the designers' criteria, with all the important parts and features it needs to do its job.

Safety Champions

Many of the special features that make vehicles safer have been invented by women!

Windshield wipers In the past, people had to use their hands to wipe frost from the windshield. But, in 1903, Mary Anderson designed a hand operated lever inside the vehicle. It was the first windshield wiper!

Turn signals and brake lights In 1914, Florence Lawrence invented the first mechanical turn and brake signals. The turn signals were little flags that would pop up on the rear bumper, showing which way the driver was going to turn. The brake signal was a little sign that popped up in the rear window, saying "STOP" when the driver hit the brakes.

Kevlar tires A flat tire is dangerous because it can make a car crash. In the 1960s, Stephanie Kwolek invented Kevlar, a lightweight fiber that's stronger than steel. Kevlar helps make tires stronger without being so heavy. It's so strong that it's also used in motorcycle safety suits!

Rear door alert In 2017, Elsa Foley and Maria Mendoza invented a special alarm that reminds people to check their back seats. Before you start driving, a sensor notices if you open a rear door. Then, when you get out of your car, an alarm beeps if you don't open it again. This way, people won't accidentally leave groceries, babies, or pets in their back seat.

STEP 3 Build a vehicle prototype

Automotive engineers take ideas for vehicles and turn them into real working machines that can drive on the road. To do this, they need to make sure their plans make sense and their materials are the best choice for the design. They do this by building a prototype, or working model, of the vehicle.

Automotive engineers use the **Design Thinking Process** to build a vehicle. They:

- ▶ identify the problem or project: they need to build a new vehicle that works and is safe
- ▶ brainstorm and create a plan for how they'll build the vehicle
- ▶ build a prototype of the vehicle
- ▶ test the prototype
- ▶ find ways to improve it and make it better

In engineering, testing your prototype is the key to success!



An engineer at General Motors tests a car model in a wind tunnel.

In a Tough Spot? We Can Help!

Need to drive on a frozen river? In Siberia, truck drivers drive in ice and snow to deliver food and other things to towns above the Arctic Circle. One truck for the job has six big, very soft tires. It can easily roll in deep snow, go over rocks and fallen trees, or float in water. It's even polar bear proof!

Need to climb a snowy mountain? Snowcats have tracks to help them move easily through snow. Used instead of wheels, tracks are wide belts as long as the vehicle that turn and pull it along. This spreads out the vehicle's weight, so it doesn't get stuck.

Need to rescue people in a flood? An amphibious vehicle can drive on a road and move in water like a boat. One kind has a foam filling in its body to keep it from sinking. It also has two kinds of engines: one to power a boat and one to power a land vehicle!

STEP

4 Test and revise your vehicle prototype

Once engineers build a prototype, they need to test it! They'll test for safety and how well it drives in different weather or on different roads. Sometimes, they'll even test it to the point of failure—that's when the prototype breaks or doesn't work anymore.

After testing, the engineers can use everything they've learned to improve the vehicle. Every time they make a change, that's called an **iteration**, or a revised version of the design.

When you're testing your prototype, remember that something breaking or going wrong is a good thing! It shows you places where you can make your vehicle even better.

STEP

5 Share your vehicle prototype and testing results

You've engineered and tested a vehicle prototype.

Now what? You need to manufacture it! Manufacturing is when a lot of something is made in a factory to be sold.

When the engineering team knows their vehicle is safe and works, they share it with the manufacturing team. In a **milestone review**, the engineering team presents their prototype, test results, and detailed engineering plan for the vehicle.

This gives manufacturers a chance to make sure they have everything they need to assemble lots of the vehicle for customers.

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

- Teaching Daisies what I've learned about how engineers build vehicles.
 - Building a compound machine with my friends to help solve a problem.
 - Using what I know about the Design Thinking Process to make something for my family or friends.
-

I'm inspired to:



Badge 3: Automotive Manufacturing

First, designers imagine a new vehicle. Then, engineers build a model. After that, automotive manufacturers make a lot of the vehicle. They make sure they have people to help, clear instructions for what to do, and enough materials for the job. Discover how manufacturers build lots of vehicles that are safe and well made by earning this badge!

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. Share your automotive manufacturing process

Purpose

When I've earned this badge, I'll know how vehicles are manufactured in a factory. I'll also know how to make and test products for people to buy.

STEP 1 Experience the manufacturing process

Imagine you're on a team that has to manufacture thousands of vehicles in a small amount of time.

How would you do it?

When manufacturers make a product in a factory, they want to do it **efficiently**. That means making their product without wasting time or materials.

You'd first need a **factory**—that's a big building to hold all of the machines and materials.

Then, you can set up an **assembly line** to efficiently manufacture the vehicles. This is when everything in a factory is set up in order to build the cars, part by part.



Use 5S to Manufacture Vehicles

SORT

Manufacturers make sure they have the materials they need and only what they need.

SET IN ORDER

They put their materials in the order they'll be used.

SHINE

As they assemble the vehicle, manufacturers keep the materials clean and tidy in a line.

STANDARDIZE

Manufacturers make sure everyone knows their job. It's like everyone knowing the rules of a sport, like soccer, and what position you play, like goalie or forward.

SUSTAIN

For 5S to work, everyone on the manufacturing team has to keep it going!

STEP 2 Learn about the automotive manufacturing process

Think about something you're good at, like playing an instrument, shooting a free throw in basketball, or baking your favorite cake. If you're good at something, you're able to do it the same way almost every time.

Making sure things are done the same way every time is also important in automotive manufacturing. This helps manufacturers make sure the vehicles are well made and safe.

In an automotive factory, **die presses** are machines that stamp and cut metal into the shape of different vehicle parts. They help manufacturers make sure the same set of parts is used in every vehicle they're assembling.

Manufacturers organize all their people and machines using a special system called **5S**.

The 5 steps of 5S are:

- ▶ Sort
- ▶ Set in order
- ▶ Shine
- ▶ Standardize (keep the same), and
- ▶ Sustain (keep it going).

5S saves manufacturers time and materials (those cost money!). It helps them efficiently assemble the vehicles.

STEP

3 Plan your own automotive manufacturing process

Have you ever wanted to build something, like a fort or go-kart, but didn't know where to get started? A **launch engineer** figures out how the manufacturing team will assemble a new vehicle. She looks at the information from the engineering team and decides what changes need to be made to the factory.

She might add or take out machines. She might change the order for assembling the parts. And sometimes, she might need more, fewer, or different workers!

So, how can you design a way to assemble a set of model vehicles, like a launch engineer?



How Do You Make That?

Have you ever tried to figure out how something was made, like a broken toy or an old alarm, by taking it apart? You were reverse engineering!

Reverse engineering is looking at a finished product to figure out how it was made.

It's going backward in the design process. You deconstruct, or take apart, a product and examine it. You look at the different parts and how they work together. This lets you figure out how you could make it yourself.

STEP 4 Manufacture a set of vehicles

Assembly lines help the manufacturing process to be efficient, but it still takes a big team of people to manufacture a vehicle!

First, the launch engineer figures out how the new assembly line will work.

Then, the **manufacturing engineers** make sure the parts for the new vehicle can be made and put together successfully.

After that, an **industrial engineer** decides in what order the parts will be put together. This is called the assembly sequence.

Once the parts are made, the **assembly line operators** each add their part of the vehicle, like putting together the pieces of a puzzle.

To make sure the vehicles are ready for the customers, a **quality control leader** adds quality control checkpoints to the assembly line. She looks for problems that will make the customer unhappy and helps the team to fix them.



ROBOTS AND LASERS TO THE RESCUE!

In the future, more manufacturing processes will be automated, or done by machines, instead of people.



Lasers can cut metal vehicle parts and weld them together precisely and safely.



Robots can do boring, repetitive jobs, like trimming fabric or tightening tiny screws over and over again. They can also do dangerous jobs, like pouring melted metal into molds.

Instead of die presses, 3D printers are being used to create parts.



STEP

5 Share your automotive manufacturing process

Working together makes things better! When you want to get better at something, like playing basketball, you might ask someone who knows more about it for help. Your coach or friend could watch you and make suggestions about how to dribble better.

Manufacturers work together to find ways to improve how they make their vehicles. This helps them make sure their process is efficient and the vehicles are safe and well made. When manufacturers check their vehicles to make sure they're well made, that's **quality control**.



To check for quality, manufacturers might use robotic laser scanners to make a highly detailed color map of the vehicle.

Automotive teams present their work during a **review** to check quality and see what worked and what didn't. Reviews help them to find ways to make a vehicle of even better quality in a way that's even more efficient.

For example, they might learn they need to hire more workers, add another step for quality control, or buy more die presses.

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

- Creating an assembly line to make gifts for others.
 - Making a poster to teach my friends the steps of 5S.
 - Coming up with ways to make big tasks, like cleaning the house or planting a garden, more efficient.
-

I'm inspired to:



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