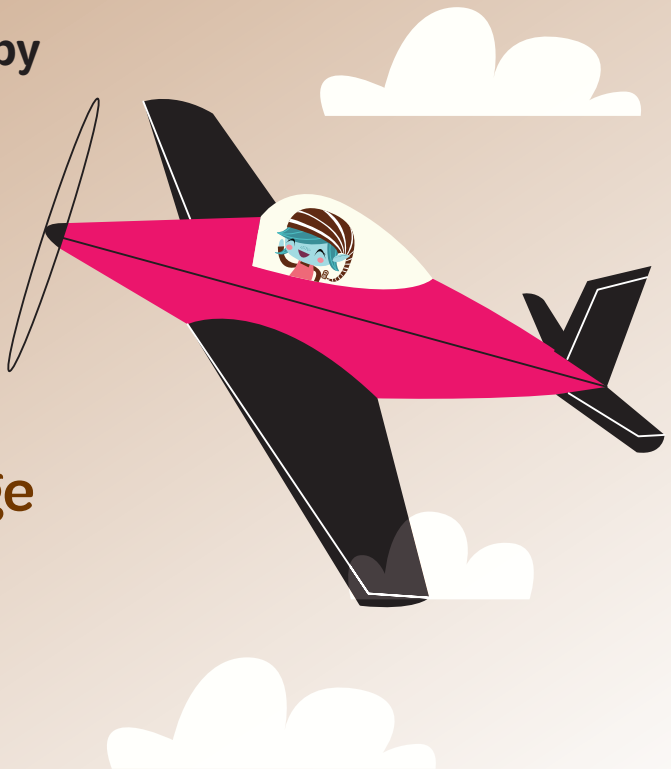
Brownie Mechanical Engineering

Explore mechanical engineering by earning these three badges!



Badge 1:
Leap Bot Design Challenge

Badge 2:
Fling Flyer Design Challenge

Badge 3:
Race Car Design Challenge

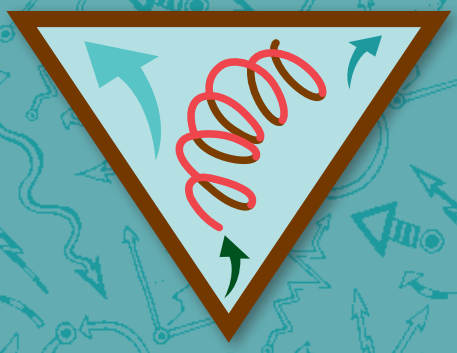
This Mechanical Engineering badge booklet for girls provides the badge requirements, information, and fun facts about engineering for all three Brownie mechanical engineering badges. It does not include all the information needed to complete the badges. Volunteers may access full meeting plans—including detailed activity instructions—on the Volunteer Toolkit (VTK) or by contacting their local council.

Welcome to the world of mechanical engineering!

When you've earned these three badges, you'll know about force and gravity and how they affect speed. You'll also know how engineers design, build, and test a new product.

Every day, mechanical engineers invent another machine that can do something new or solve a problem. What kind of machines will we have when you are grown up?

Well, you tell us! Once you know how engineers imagine, design, build, and test their inventions, you'll be able to come up with all kinds of cool ideas for new, problem-solving machines!



Badge 1: Leap Bot Design Challenge

Springs are fun inventions. They cushion your ride on a rough road, make you comfortable in bed, and can even bounce you way up high. By exploring springs and the way they use energy, you'll understand how they work. Then, you'll learn what engineers do by designing and building your own Leap Bot.

Steps

1. **Learn about springs**
2. **Build your Leap Bot**
3. **Create a way to test how well your Leap Bot performs**
4. **Record the results of your test**
5. **Share your results**

Purpose

When I've earned this badge, I will know how to build and test a Leap Bot and understand gravity, force, and energy.

STEP
1 Learn about springs

Springs store, or absorb, energy when they are pushed down, or compressed. When the spring pushes back out, it releases the stored, or potential, energy and turns it into kinetic energy, making the spring move. Your muscles or a rubber band can do the same thing: store and release potential energy.

BOING!

Springs are useful machines that also make fun toys.

Pogo Stick—Using a pogo stick requires good balance. Invented in the 1920s, pogoing quickly became a favorite pastime for kids. In the 1990s, a new sport, extreme pogo or Xpogo, was created, where players do tricks and jump more than 9 feet in the air.

Slinky—In 1943, a mechanical engineer wanted to invent a way to keep equipment from moving around on ships. When he was testing springs he knocked some off a shelf and noticed how one of the springs "walked down" instead of simply falling. This accidental discovery became the Slinky!

Trampoline—The trampoline was invented in 1936 to help tumblers, gymnasts, and divers. Soon, doing tricks on a trampoline became popular as its own sport. Today, the military and space program even use trampolines to let pilots and astronauts experience different body positions they may encounter in flight.

WORDS TO KNOW

- **Balanced forces** exist when forces are equal on an object. When forces are balanced, the object doesn't move.
- **Data** is information that engineers receive, collect, or observe during testing of their devices.
- **Drag** is the force (air molecules) that acts against something in flight.
- **Engineers** are people who like to know how things work. They design and build things that people use every day, like computers, phones, roads, bridges, and cars.
- **Features** are parts of a product that are designed to make it more useful.
- **Force** is the strength or energy that creates movement. Push and pull are examples of force.
- **Friction** is a force that slows moving objects.
- **Gravity** is a force that pulls objects toward each other and toward the earth.
- When potential energy is released, it becomes **kinetic energy,** causing bodies and objects to move.
- **Lift** is a force that pushes back up on the wings during flight.
- **Potential energy** is the energy stored in your body and everything else in our world.
- **Thrust** is the force that moves an object forward.
- **Unbalanced forces** exist when forces are unequal on an object. When the forces are unbalanced, the object moves in the direction of the greater force.

What's a Mechanical Engineer?

A mechanical engineer is a person who designs and creates machines to meet a special need or solve a problem.

For example, a mechanical engineer figured out how to heat a building by using a furnace and fans to blow warm air through tunnels, called air ducts. A mechanical engineer also had to design and build the machines needed to make the furnace, fans, and air ducts.

What special need or problem could you solve by building a machine?

STEP 2 Build your Leap Bot

When an engineer has an idea for a new machine, she has to figure out how to build it. Testing out different parts of the machine helps her to understand how the parts will work together and might even inspire her design. She could make more than one version, if she has more than one idea.

How can you use the materials you have to build a Leap Bot?

STEP 3 Create a way to test how well your Leap Bot performs

Once an engineer builds a product, she needs to test it to see if it performs the way she wants it to. First, she decides what to test. She might want to test how high her invention jumps. Or she might want to test how far it can jump. Or she might want to test whether her invention breaks when it's used.

What you want to know will determine how you test and how you measure the results. What do you want to know about your Leap Bot? Once you decide that, decide how you'll test and measure.

NOTES

SUPER JUMPERS

You know that rabbits, kangaroos, and frogs are big jumpers, but what other animals can jump?

The **impala**, an African antelope, can jump nearly 10 feet high over obstacles or other impala. The springbok and the klipspringer are two other fantastic African antelope jumpers.

Kangaroo rats live in the deserts of North America. They are tiny animals whose big hind feet and long tails allow them to jump nearly 9 feet in one hop to get away from predators.

When **spinner dolphins** swim in a spiral direction underwater, they build up speed and energy. When they come up and out of the water, they shoot through the air in a high, spinning arc. Researchers don't know why these dolphins like to jump. Some think it is a form of communication. Others think they jump to knock parasites off their bodies.

Jumping spiders can jump more than 50 times their body length. Unlike other spiders who use webs to catch their prey, jumping spiders pounce on top of their dinner. There are more than 5,000 species of jumping spiders, and they live all over the world.

Fleas may be tiny, but for their size, they are some of the world's best jumpers. Researchers found that fleas have developed a special stretchy pad on their back legs. This pad allows them to store up lots of muscle energy. When a flea pushes off from its toes and shins, it releases that energy into a really big jump.

Springs at Work

Springs absorb forces and release them in useful ways.

- A ballpoint pen uses a spring to move the tip of the pen in and out of the case.
- Mattresses and sofas use springs to absorb the pressure bodies put on them when a person sits or lies down. The springs push back against the bodies to provide support.
- Cars, motorcycles, and some bicycles use springs to absorb big bumps in the road, making a smoother ride.
- Springs make waffles and toast pop out of a toaster.

STEP 4 Record the results of your test

One of the most important parts of testing an invention is keeping track of the results. Engineers test their products and record their results to learn how their designs work. Sometimes they write down measurements of time or distance to compare later. Sometimes they make video recordings of a product in use, then watch the video in slow motion to see how it worked.

Testing different spring combinations will help you understand how your Leap Bot works. Test different combinations of springs more than once and write down your testing results.

RESULTS

STEP 5 Share your results

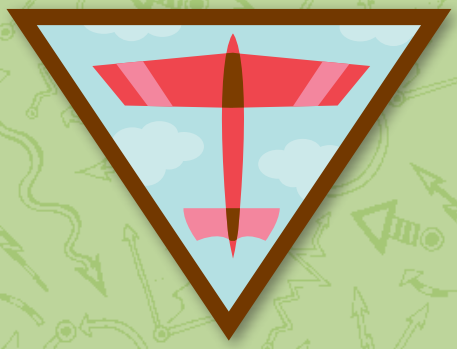
An important part of the Design Thinking Process is learning from what didn't work. If a product doesn't work, it's not a failure. The test results give you important information to make your design better.

After engineers test a new design, they like to share the results of their tests with others. It helps them get ideas to make their products better—and might even help someone else who is working on the same kind of problem.

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

- Showing Daisies that engineering can be fun by demonstrating my Leap Bot.
- Sharing what I learned about gravity, force, and energy with my friends and family.
- Doing a show-and-tell with my Leap Bot at school to tell others what engineers do.

I'm inspired to:



Badge 2: Fling Flyer Design Challenge

For thousands of years, people have been wondering how birds and insects fly. It wasn't until 1903 that the Wright Brothers figured out how it worked, and we've been flying ever since.

While building your Fling Flyer, you'll learn all about what keeps birds, planes, and people in the air.

Steps

1. **Learn about forces that affect flying**
2. **Design and build a Fling Flyer**
3. **Test your Fling Flyer**
4. **Analyze and share your results**
5. **Brainstorm ways to improve your design**

Purpose

When I've earned this badge, I will know how to build and test a Fling Flyer and understand lift, drag, thrust, and gravity.

STEP 1 Learn about forces that affect flying

Force is the energy that makes things move, and thrust is the special force that moves an object forward.

If you push a ball—applying thrust—it will roll along the floor away from you, but it won't fly. What is missing?

For something to fly, it needs a flat surface like a wing for air to push up against. That upward push is called lift, and lift is the secret to flight.

Now that you know what makes things move and fly, can you guess what makes things slow down or fall back to the earth?

STEP 2 Design and build a Fling Flyer

For hundreds of years, people have been using all different types of materials to try and make something that can fly. Engineers today are still trying to improve the flying machines we have and invent new ones like flying motorcycles or personal jet packs. Use the materials you have on hand and what you just learned about force, thrust, lift, drag, and gravity to create your own Fling Flyer.

DESIGN IDEAS

Firsts in Flight

- In Greek mythology, an inventor named Daedalus created wax wings for himself and his son, Icarus, to escape from the island of Crete. Icarus ignored his father's advice to not fly too close to the sun. His wings melted, causing him to fall into the sea.
- Records show that kites were used in China and Japan since about 500 BCE for many different purposes. One story from the 1500s tells of a thief using a kite to lift himself to the top of a castle to steal golden scales off a decorative fish.
- Artist Leonardo da Vinci was fascinated by flight, drawing more than 500 sketches of birds and ideas for flying machines. Most of his designs were "ornithopters," machines that use flapping wings (like birds), powered by a person's arms or legs.

Lift is the force pushing up on the bottom of the wing, keeping it in the air.

Drag is the force that act against a plane in flight, slowing it down.

Thrust is the force that moves a plane forward.

For a plane to fly, lift must be greater than drag.

STEP 3 Test your Fling Flyer

Engineers test their designs to see if they work as expected and to find ways to improve them. Even when they've worked long and hard on their designs, engineers don't expect their inventions to work perfectly. In fact, sometimes they learn more from a test when their designs fail.

Now that you've built your Fling Flyer, there are lots of different aspects of your Fling Flyer you can test: how far it can fly, how long it can stay in the air, how many tricks it can do.

STEP 4 Analyze and share your results

Two heads are better than one! Once an engineer has tested her product, she analyzes the results and shares them with others. Talking with other engineers about your design and analyzing the test results can help you better understand why a design performed the way it did. Use the brain power of others to understand your Fling Flyer!

STEP 5 Brainstorm ways to improve your design

After testing their designs, engineers think of new ways to improve them. This might mean using new scientific concepts, like lift and drag, analyzing test results, or getting feedback from other engineers.

All kinds of information can be used to make a design better, faster, or more efficient. What would you change or improve about your Fling Flyer?

NOTES FROM TESTING

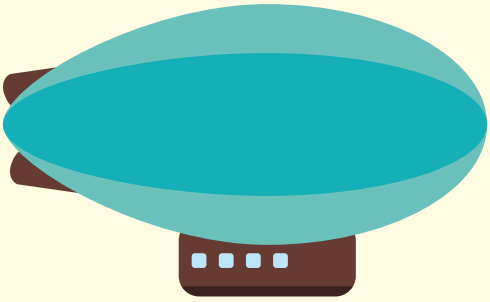
FLYING MACHINES

When we think of people flying, we usually think of airplanes, but people use other kinds of machines to fly as well.

Hot Air Balloons

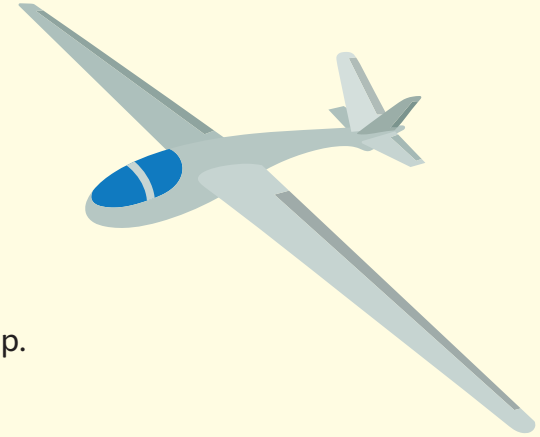
Hot air rises and if it's captured by something like a balloon, it will create lift. People have been riding in hot air balloons since the 1780s, and you can still take a hot air balloon ride today. One of the most famous hot air balloon rides is the one the character Dorothy takes in the story *The Wizard of Oz*.

Airships, Zeppelins, and Dirigibles



Over time, people have discovered gases that are lighter than air. Engineers made big balloons that carried engines to steer them and space for passengers. They filled the balloons with hydrogen gas and used these inventions to move people through the air. Today, the most famous of these big balloons is the Goodyear Blimp. You can see it flying over the Superbowl every year.

Gliders

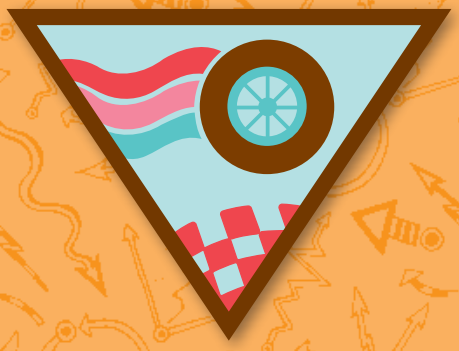


Gliders are simple airplanes without engines. They rely on special weather conditions and are designed to stay in the air. Some gliders get up in the air by being towed by another airplane. Others, like hang gliders, are launched by the pilot running downhill until wind catches the wings of the glider and lifts it up.

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

- Showing Daisies that engineering can be fun by demonstrating my Fling Flyer.
- Sharing what I have learned about the forces that affect flight with my friends and family.
- Showing friends how to make a Fling Flyer and then having a contest to see how far they can fly.

I'm inspired to:



Badge 3: Race Car Design Challenge

People use cars for all kinds of reasons. The kind of car you'd use to take kids to a soccer game would be different from the car you'd need for a racetrack. Engineers figure out what features each would need to be successful.

While building your race car, you'll learn about how design affects speed and how engineers design, test, and improve their inventions.

Steps

1. **Learn how design can affect speed**
2. **Design and build your race car**
3. **Design your racetrack**
4. **Conduct a fair test and record results**
5. **Share what you learned**

Purpose

When I've earned this badge, I will know how to build and test a race car and understand how force and friction affect speed.

STEP 1 Learn about how design affects speed

Force is the energy that makes something move. Friction is the resistance, or slowing down, that happens when two things move over each other.

If you want something to move fast, you need to figure out how to reduce or get rid of friction. Look at where the two objects are touching or rubbing against each other—that's where friction happens.

Which Way Does the Wind Blow?

When something is moving very fast, air is pushing against it, creating friction.

Engineers use wind tunnels to see how air moves around an invention. A wind tunnel is a long tube that has strong fans at one end.

Engineers put their invention in the tunnel, turn on the fans, and then watch to see which parts of the object disrupt more air, causing more friction.

Then, they improve their design to reduce friction. Engineers use wind tunnels to test cars, planes, boats, bikes, and even rockets.

STEP 2

Design and build your race car

When engineers are creating a new product, they think about what they want it to do and then imagine different features that will make it successful. Once they have imagined their product in detail, they build a model.

Now you understand how your design choices affect your race car's speed—so it's time to start designing and building. Think about things you can add or take away from a car to make it go faster.

CAR IDEAS

Women in Racing!

Milka Duno had a career as a naval engineer, but became a race car driver when she was 24. She loves learning—she's earned four master's degrees and started an organization to encourage kids to achieve academic excellence.

Milka is from Venezuela and has raced there and in the United States. She has raced in more kinds of cars and more different kinds of racing series than any other current female race car driver. She holds the record for the top female finisher of the Daytona 500.

STEP

3 Design your racetrack

There are all kinds of race cars: stock cars, hot rods, or Formula 1 cars, for example. All of them race on a different kind of track.

Some racetracks have special tilted curves or turns to help keep the cars from sliding off the course. Some have extra curves and turns to make the race more exciting.

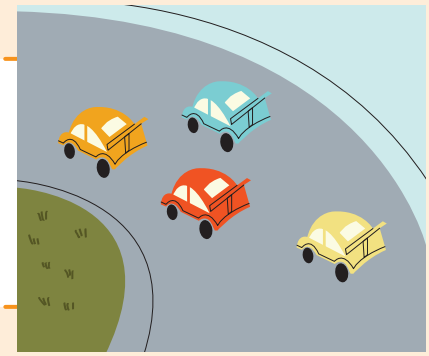
Your race car needs a ramp for it to go fast, so your racetrack will need a ramp or two. What kind of ramp will you build?

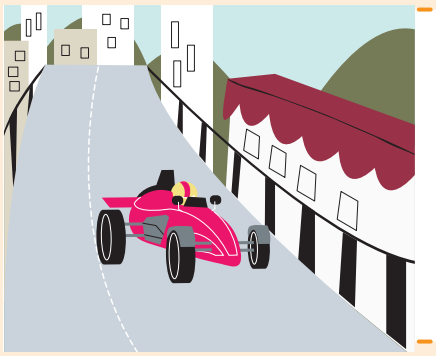
TRACK IDEAS

THE BEST PLACE TO RACE

What makes a great race course? Some races are run on specially designed racetracks. Some are run through city streets. Some are run in flat, wide-open desert spaces.

Daytona International Speedway in Florida is a famous NASCAR racetrack. The curvy turns on the track are banked, or tilted inward, to help keep the cars from slipping at high speeds.





Circuit de Monaco is a race course marked out along the narrow city streets of the tiny country of Monaco. Since 1929, Formula 1 race cars have been zooming through the city at speeds up to 160 miles per hour. One famous driver said racing in Monaco is like flying a helicopter in your living room.

Bonneville Speedway isn't really a racetrack at all. It's a wide-open stretch of salt flats in the Utah desert. Drivers have been racing there since 1912 and setting land speed records there since the 1930s.

Which one of these would you like to race on?

STEP

4 Conduct a fair test and record results

Brownies, start your engines!

Building a race car is fun, but so is racing one! Between races, real race car drivers make changes to their cars to try to make them faster. They may test them a little as they work on them, but the real test is on the racetrack.

It's time to see how fast your car can go. Remember to keep the test fair by only changing one thing at a time when testing your car.

RESULTS

STEP

5 Share what you learned

Once engineers have designed, built, and tested their product, they share the results with other people. Sharing and discussing her test results with others helps the engineer to figure out what worked and what didn't with her design.

Talk and listen to others about what your car did in the test and why you think it performed that way. How could you improve your car?

IMPROVEMENTS

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

- Showing Daisies that engineering can be fun by demonstrating my race car.
- Sharing what I have learned about gravity, force, and energy with my friends or family.
- Letting others know what engineers do by doing a show-and-tell with my race car at school.

I'm inspired to:

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