The Caped Crusader

STEM CONNECTIONS
Science: Forces and Motion
Technology: Innovative Design
Engineering: Developing and Optimizing Solutions
Math: Measurement & Data and Counting & Cardinality

DURATION
60 Minute Lesson

MATERIALS
• Batman Card
• Page pocket (1 per group) holding:
  • Supercar Build Plan
  • Balloon Mobile Engineering Page
• BrickLAB Bricks
• Wheel Set
• Balloons (1 per group)
• Cloth Tape Measure
• Dry Erase Markers

SCHEDULE
• The Batmobile (5 minutes)
• Supercar Build (10 minutes)
• Rocket Powered Cars (15 minutes)
• Balloon Mobile Design Challenge (25 minutes)
• Examining Blueprints (5 minutes)
OBJECTIVE
Apply knowledge of forces to improve the design of balloon powered brick cars!

ALIGNED STANDARDS
• NGSS 3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
• NGSS 3-PS2-2 Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion.
• NGSS K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
• NGSS K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
• NGSS K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
• ISTE-S.4.a Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
• ISTE-S.4.c Students develop, test and refine prototypes as part of a cyclical design process.
• CCSS.MATH.CONTENT.K.CC.B.5 Count to tell the number of objects.
• CCSS.MATH.CONTENT.2.MD.A.1 Measure and estimate lengths in standard units.

21ST CENTURY SKILLS
• Creativity and Innovation
• Critical Thinking and Problem Solving
• Communication and Collaboration

HABITS OF MIND
• Questioning and Posing Problems
• Thinking and Communicating with Clarity and Precision
• Taking Responsible Risks

KEY TERMS
• Elastic: an object or material that can return to its original shape after being moved, changed or distorted.
• Force: movement as a result of a release of energy.

BACKGROUND INFORMATION
Do you know The Caped Crusader? He lurks in the shadows fighting crime. He only wears black and has no superpowers. He’s a billionaire. He’s strong, smart and clever. He’s one of the most recognizable superheroes in the world. He spends his time perched above the fictional city of Gotham, protecting it from a whole slew of bad guys. He made his entrance in 1939 in Detective Comics #27, and he’s been taking names ever since. He’s…. Batman!
Living life in the shadows, Batman stands out from the rest of the superhero universe. He is one of only a few characters without any real superpowers! Instead, he relies on his quick wit, billionaire bankroll and the science of all his gadgets to fight crime. He may not have x-ray vision, but his martial arts background and cleverness definitely makes him someone you want to stay on the good side of!

When he's not fighting crime, The Caped Crusader is busy working on his next addition to his utility belt. Each of his gadgets has gone through a system called The Engineering Design Process. This design approach starts with an idea for an invention. As the idea slowly transforms into an object, the process questions if it's being built in the best way possible. Could it be made from something different? Should the shape change? It's these questions that Batman asks many times of all of his gadgets. He needs to make sure they will always work correctly! From their original sketches to their tests and improvements, these tools help him stop The Joker, Bane and any other bad guy in Gotham.

THE ENGINEERING DESIGN PROCESS

1. ASK
   • What are the Problems?
   • What are the Constraints?

2. IMAGINE
   • Brainstorm Ideas
   • Choose the Best One

3. PLAN
   • Draw a Diagram
   • Gather Needed Materials

4. CREATE
   • Follow the Plan
   • Test it Out!

5. IMPROVE
   • Discuss What Can Work Better
   • Repeat Steps 1-5 to Make Changes

Did you know our real-world engineers use this same system when they're designing things? It's just like how Batman needs to rely on his utility belt to always perform correctly. Our engineers need to know that their designs will work, otherwise they need to redesign it. Whether it's a bridge or a skyscraper, it's important to always brainstorm, test and improve any idea. You want to make sure it's the best it can possibly be, right? Can you think of anything in your bedroom that has gone through the engineering design process?

One of Batman's most important gadgets is his supercar, the Batmobile. Over the years, it's had many different designs. It's even made its way into the sea and the air! From the comics to the movies, the jet black Batmobile is almost as iconic as Batman himself. The Batmobile constantly goes through the engineering design process as new challenges arise in the streets of Gotham. Today, we're going to put your skills to the test and put the Batmobile through The Engineering Design Process once more. Can you build the best supercar?
DAILY PREP

• Gather today’s materials, prep page pockets with the Supercar Build Plan and Balloon Mobile Engineering Page and read through the Background Information and lesson plan.

• Be careful to not spoil the guessing game by giving away today’s hero.

• Today is all about the engineering design process as campers move through different supercar build challenges, learning to improve upon their designs.

• Be ready to split campers into groups of two or three.

• Balloons are used today, but they should not be tied shut. Be sure to designate one student in each pair as the Balloon Inflater to avoid spreading germs.

• A large and open area is needed to test supercars and balloon mobiles.

• Make a plan for distributing bricks and wheels to campers. One option is to spread the boxes around at four “supply stations” where they can pull the bricks they need. Another is to break the bricks and wheels into smaller plastic bins. There are only four large rubber wheels, so you may want to remove them to avoid a scramble over which pair gets the biggest wheels.
THE SCIENCE OF SUPERPOWERS

STEP-BY-STEP DIRECTIONS FOR INSTRUCTORS

THE BATMOBILE

Welcome campers back to The Science of Superpowers! Sharpen your Batarangs, deepen your voice and start today by testing everyones’ Batman knowledge. The first paragraph of the Background Information is a superhero teaser — use this hint-guide to get everyone excited about the day’s lesson! Keep the conversation going by either continuing to read directly from the Background Information or by letting the discussion flow more organically, adding info or ad-libbing in your own words every step of the way. Then, it's time to get everyone excited about supercars.

When you think of superhero cars, what comes to mind? Batman’s Batmobile is probably the most famous superhero or villain car around. Batman doesn’t have any superpowers, so instead he uses his intelligence to outsmart villains and fight crime, relying heavily on the Batmobile. Covered in special gadgets and weapons, the Batmobile has gone through a lot of changes over the years as its design and capabilities have been improved.

- What do you know about the Batmobile? (Answers will vary. There are a lot of different Batmobiles and Batmobile incarnations.)
- Can you think of any other superhero or villain cars?

SUPERCAR BUILD

Break campers into small groups of two or three, set out the BrickLAB bricks and pass out the Supercar Build Instructions. As teams work together to complete the build, ask questions about their construction, the Batmobile and different superhero cars or share more details from the Background Information.

Remind campers that the car build and challenge is a team effort, and teams need to share in the building process and listen to each other’s ideas! Campers can take turns adding new bricks or take on different roles, such as Brick Counter or Build Plan Leader.

ROCKET POWERED CARS

Pass deflated balloons around and have campers look at and touch them, analyzing and describing what they see. Then, blow up a balloon and hold it shut.
• What did I just do? How did it affect the balloon?
• What does the balloon look like?
• What does it feel like? (The balloon is bigger than before and the walls are harder or more sturdy.)

So, we know that we are surrounded by air, it’s how we breathe. Now that I’ve blown up this balloon, it’s also full of air — there is air pressing against the outside and the inside of the balloon.

• Is the air pushing evenly or unevenly against the balloon? (The air inside and outside the balloon is pushing evenly, or balanced, against each other.)
• How do we know? (The balloon is staying inflated and keeping its shape.)

Now, release the balloon.

• Why did the balloon fly through the air and deflate? (Once the end of the balloon is released, the air is no longer pushing evenly against the balloon and the higher air pressure inside wants to escape.)

As the air is escaping, it has a lot of force, which is what causes the balloon to fly through the air. Now, let’s see if we can harness that force and make a balloon powered car!

Small Groups

Break campers back into groups of two or three and have them work together with one supercar.

• First, put the balloon through the hole in the back of the model so that the nozzle is facing away from the car, then set the car on the ground.
• To inflate the balloon, campers need to lie on their stomachs, pinching the nozzle between breaths so that the balloon does not immediately deflate.
• When ready, release the nozzle and watch the car move. Have campers observe how the car moves and let them make any adjustments to their design.

DISTANCE CHALLENGE:

Place the measuring tape on the ground and line cars up behind a designated starting line. Have campers blow up their balloons and release them at the same time. If there is not enough room, send the cars off one or two at a time. Have campers look at the measuring tape and record how far their supercar travels on the Balloon Mobile Engineering Page.

Each group needs to measure their distance at least three times and average the distance. For younger campers, round to the nearest foot or half foot. For older campers, round to the nearest tenth of a foot.

• Which group’s car went the furthest overall?
• Which went the shortest distance?
• Can you think of any reasons why some cars went further than others?
• Is there anything special or different about the car that went the furthest compared to the other cars? (Increasing the wheel size increases the distance the car is capable of traveling. Blowing up the balloon more also makes the car go faster.)

• So, what’s happening with the balloon? Why did the car move forward or have thrust? (Thrust is created when air escapes from the balloon. As air is pushed out of the balloon, the same amount of force pushes the car forwards.)

**SPEED CHALLENGE (OPTIONAL):**

How fast can your car go? Mark a start and finish line. The finish line should be close enough that all cars can complete the race.

• Do this at least three times, having campers watch a clock or count out loud.

**BALLOON MOBILE DESIGN CHALLENGE**

The Balloon Mobiles are already pretty fast, but superheroes need their cars to be SUPER fast.

• How could the Balloon Mobile go faster?

• Do you remember the four forces that affect flight? (Gravity, thrust, lift and drag/aerodynamics.)

• Do these forces affect cars? If so, how? (Gravity keeps the cars on the ground. Thrust moves cars forward. If cars stay on the ground, no lift is needed. For cars to go fast, they need to reduce drag.)

• How do these forces affect the distance traveled or the speed of a car?

• How could you improve the design to make the car go further and faster? (Reduce weight, improve aerodynamics and increase the size of the wheels.)

Let’s try it! Improve the design of your car so it goes further and faster. Be sure to leave a space for the balloon. Write or draw out your ideas on the Balloon Mobile Engineering Page, then test your design and make any modifications. You can erase your old designs and draw your next idea in the same place on the Engineering Page.

Give campers about 15 minutes to plan, build, test and improve their cars. The only constraints are that the cars must be powered by the balloon alone and only use the bricks and wheels. Test how far the new designs travel, or, as a fun alternative, how fast the new cars can go!

For the final race, make sure all the balloons are the same size before the race starts and talk about why this is important to make sure the race is fair.
Group Discussion

EXAMINING BLUEPRINTS
Deconstruct builds and collect bricks and wheels to use again.

• What did you change about your design?
• Why is it better than the original car?
• How did you improve drag, thrust, aerodynamics or the weight of the car?
• Were cars with larger wheels better than those with smaller wheels?

CHECK FOR UNDERSTANDING

• How are airplanes and cars similar? How are they different? (There are many answers.)
• What modifications were made to the cars to make them go further and faster?

EXTENSIONS

Balloon Mobile 2.0
Let’s roll a can with static electricity! Either have campers bring their own cans from home, or pull a few from the recycling bin. If there aren’t enough to go around, lead a demonstration and then split campers into groups that can take turns sharing a can.

Place an empty can on the ground. Take a blown up balloon and rub it on your head or the carpet, generating static electricity. Hold it close to the can and it should start rolling towards the balloon. Experiment with different levels of static electricity and where you rub the balloon. A wool sweater is a great alternative! For an additional challenge, build a car that can hold the can.

Engineering Challenge: Off-Roading
Materials:
• Small objects that cars can roll over, such as pencils, small rocks or clothing.

Challenge campers to modify their supercar for off-roading.

Distance and speed are just two factors to consider when building a car. What other factors do engineers need to consider? How would a superhero or villain use their car?

Captain America uses his motorcycle and Wolverine his truck to go off-roading. This means that they drive over sand, dirt, rocks, logs and anything else on the ground. Off-road vehicles aren’t meant to go very fast, instead build to withstand big bumps, jumps and even water. To be able to drive over rocks and logs, these vehicles have very large wheels which keep the it safe as it moves over tough obstacles.

How does your supercar handle off-roading? Can it roll over things with ease or does it get stuck? Let’s find out! Place small items on the ground to see if your car can make it over them without getting stuck or damaged.

Note: Campers don’t have to use balloons for thrust. They can push their car or place it on a ramp.