HISTORY

MANUFACTURING IN VERMONT

BACKGROUND

Imagine it's 1845. There is no electricity. **Manufacturing**, the process of making things, is done mostly by hand.

Complex objects, such as rifles, are made of many carefully hand-crafted pieces, so each rifle is slightly different. If one part of your rifle breaks, it is very difficult to fix or replace.

You're about to learn how inventors in Vermont created a new system of manufacturing!

THE CHALLENGE

In 1844, the US government was looking for something better. They needed to purchase a large number of muskets for their growing army and they needed the muskets to be reliable and easy to repair.

The military searched for companies that could provide them with a solution to their problem.

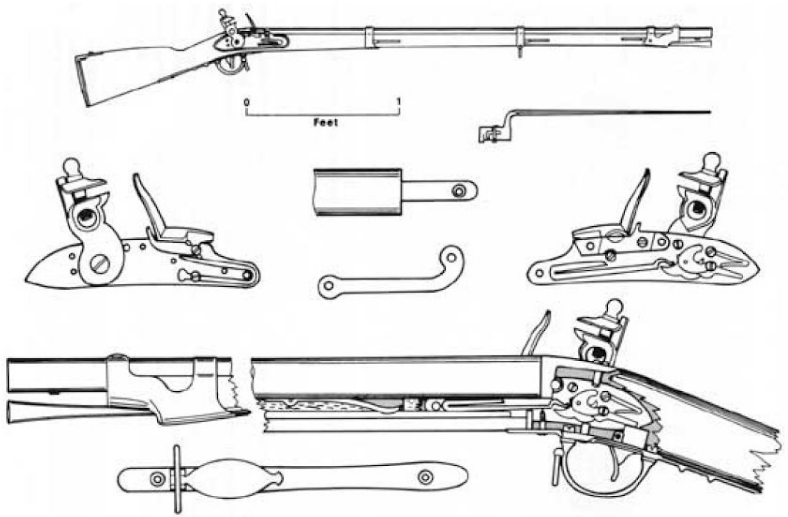
Samuel Robbins, Richard Lawrence, and Nicanor Kendall were three Vermonters who had a vision on how to solve the government's problem!

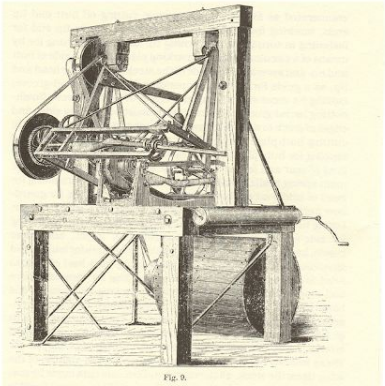
THE SOLUTION

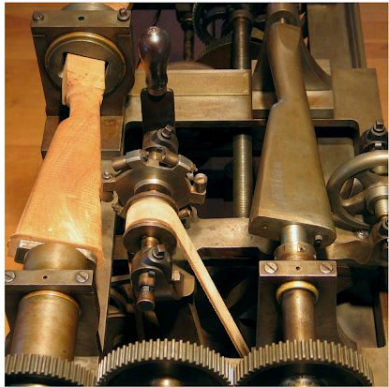
Robbins, Lawrence, and Kendall designed a system of **interchangeable parts**, meaning that if one part of a musket broke, it could be replaced with another identical part. If you've ever changed a wheel on a skateboard or assembled a toy like legos, you've used interchangable parts!

To do this, their muskets had to be identical to each other, which was impossible to do by hand.

To solve this problem, the engineers designed **machine tools**, large machines that carve metal and wood. Machine tools could make perfectly identical parts. After making a deal with the government to manufacture 10,000 rifles using interchangeable parts, they built a factory in Windsor, Vermont.

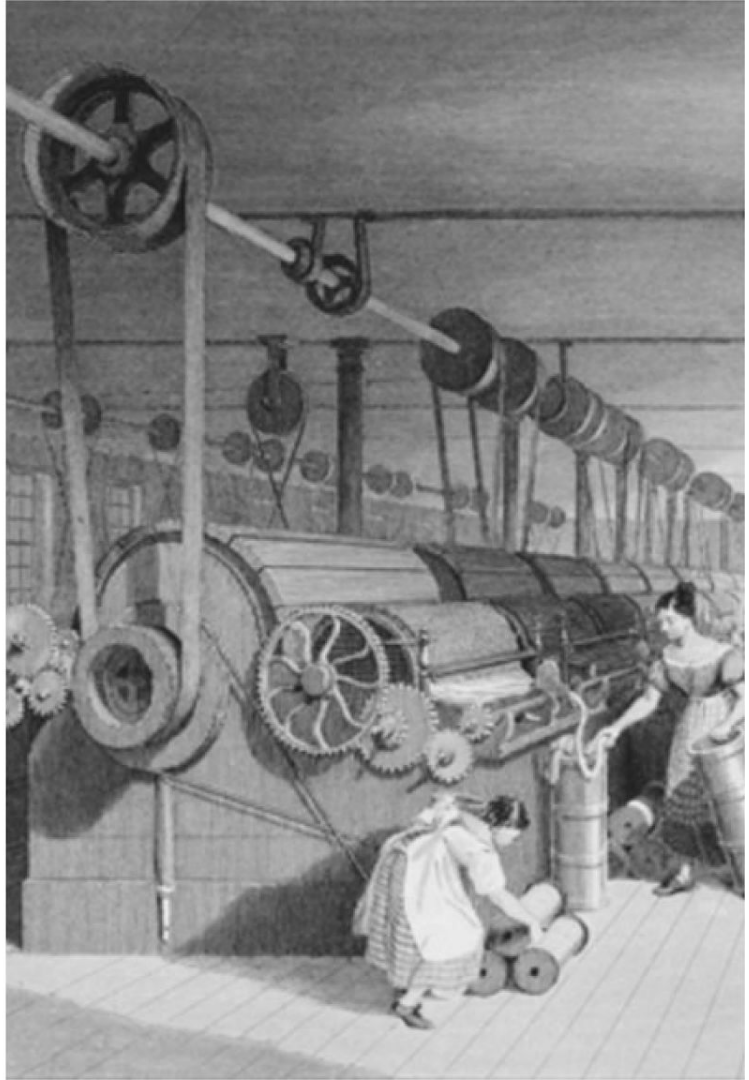


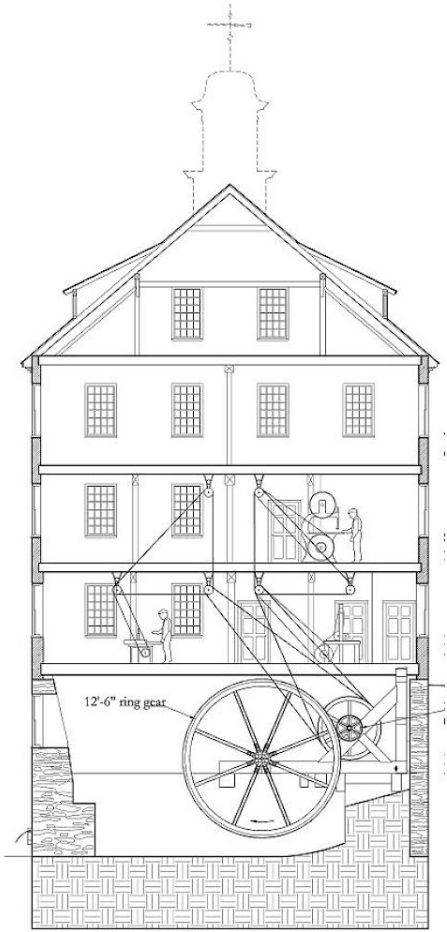




POWERING A FACTORY

Before electricity, manufacturers relied on different sources of power. Our inventors built the **Robbins & Lawrence Armory** next to a brook to harness **hydropower**. Water was directed through the lower level of the building, turning a giant water wheel as it flowed through. Engineers connected the water wheel to belts and pulleys to transfer motion and run the machines.





Conjectural Belting Diagram

Showing power arrangement ca. 1846

INTERNATIONAL SUCCESS

In 1851, they were invited to the **Crystal Palace Exhibition** in London to showcase 25,000 rifles made with interchangeable parts. The British government was so impressed that they ordered thousands of rifles as well as the machine tools used to make them!

Machine tools made it possible to create all kind of inventions with a new level of **precision**, or exactness.

IMPACT

Robbins & Lawrence had a huge impact on the way we make things! Their method became known as the **American System of Manufacturing**, which has two parts:

1. Designing inventions with interchangeable parts.

2. Manufacturing those parts using machine tools.

This system is still how almost all large quantities of things are manufactured. However, machine tool technology has come a long way. Modern machine tools are powered by electricity and can be controlled by computer programmers!

THE ARMORY TODAY

In 1964, the Armory became home to the **American Precision Museum**, a space that celebrates our history of manufacturing!

The building tells the story of inventors and problem-solvers whose ideas shape our lives to this day. In the exhibits, you can explore tools that are hundreds of years old as well as the most modern machines!

In this unit, you'll explore different scientific and historical themes from this story!

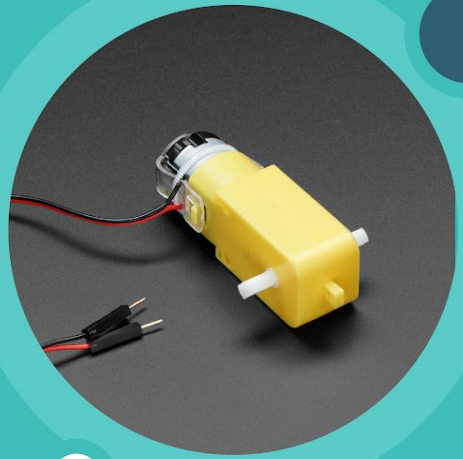
TRUE OR FALSE

Read each statement below and decide if it is true or false. **Draw a circle around your choice.**

True	False	Before 1845, most things were hand crafted.
True	False	Robbins & Lawrence found international success in Paris.
True	False	The Robbins & Lawrence Armory still makes rifles today.
True	False	Modern machine tools use electricity and computer technology.
True	False	The American System of Manufacturing revolutionized how things are made.

REFLECT

Why do you think it's impossible to make identical parts by hand?



STEM & ELECTRONICS

ENERGY TRANSFER

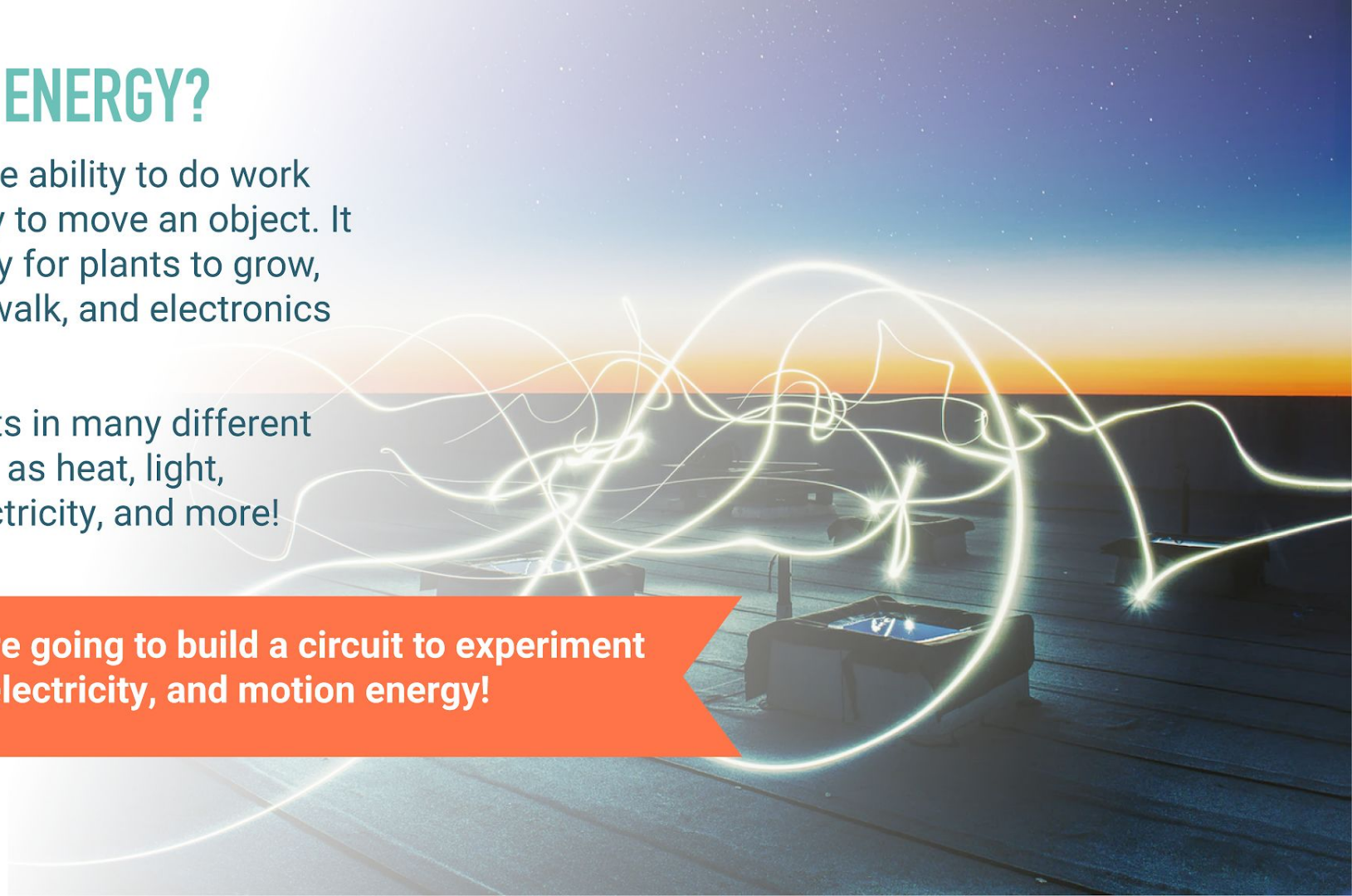
SPARK SHOP

WHAT IS ENERGY?

Energy is the ability to do work or the ability to move an object. It takes energy for plants to grow, animals to walk, and electronics to work.

Energy exists in many different forms, such as heat, light, motion, electricity, and more!

Today you're going to build a circuit to experiment with light, electricity, and motion energy!



ENERGY TRANSFER

Energy transfer is when energy moves from one place to another. When you throw a ball, energy transfers from your hand to the ball. Energy transfer also describes when energy changes forms, like when solar panels transfer light and heat from the sun into electricity.

Sometimes, energy is not available in the form you need. Imagine needing to plug in a computer on a desert island!

Engineers create inventions to transfer energy into forms that are useful to us!

PROTOTYPING ACTIVITY

Practice converting energy!

KEY VOCABULARY

A **motor** is a machine that converts electrical energy into motion.

A **dynamo** is a machine that converts energy from motion into electrical energy.

A **battery** is a device that stores electrical energy

A **circuit** is a path of wires and electronic parts that electricity can flow through.

LED stands for light emitting diode, which is a type of light.

Today you're going to build two circuits and use a motor and dynamo to convert energy!

GOALS

1. Use electrical energy to create motion
2. Use energy from motion to create electrical energy

MATERIALS

- Yellow motor/dynamo
- Red LED with black and red wires
- AAA battery
- White wheel with black tire

PART 1 – MOTOR CIRCUIT

Follow along with the video below:

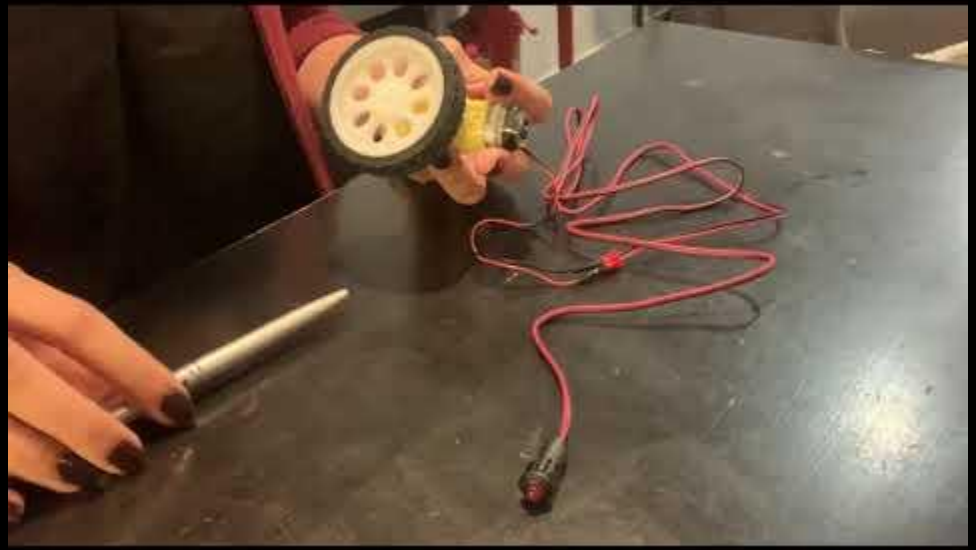
REFLECT

What was the hardest part of building your motor circuit?

List two products that use electricity and motors to create motion:

PART 2 – DYNAMO CIRCUIT

Follow along with the video below:



REFLECT

A dynamo lets you create electricity without needing batteries or a plug in the wall. What is one situation where a dynamo would be useful?

REFLECT

What evidence did you see that energy was converted in your circuits?

STEM + HISTORY

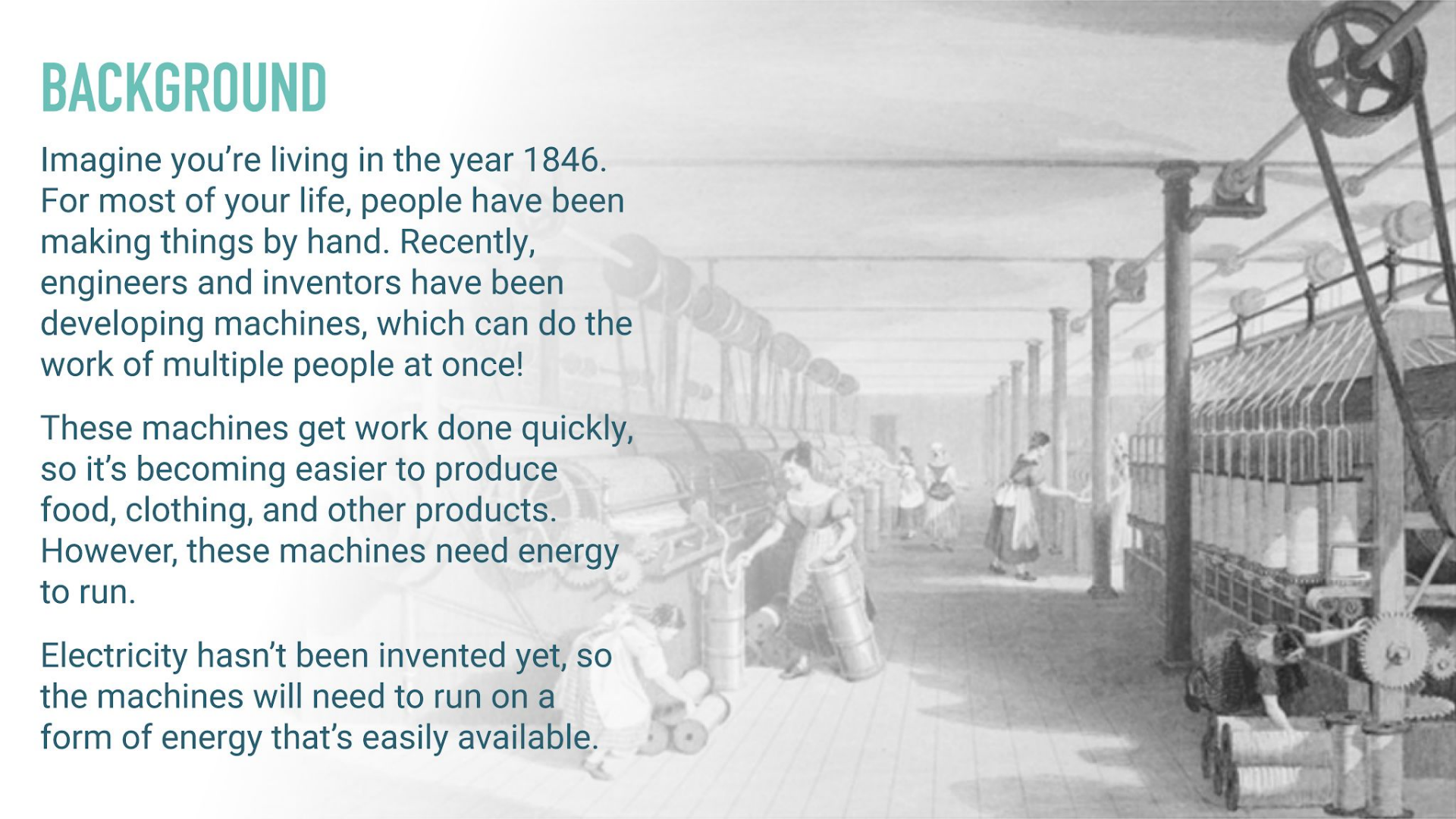
WATER WHEELS

BACKGROUND

Imagine you're living in the year 1846. For most of your life, people have been making things by hand. Recently, engineers and inventors have been developing machines, which can do the work of multiple people at once!

These machines get work done quickly, so it's becoming easier to produce food, clothing, and other products. However, these machines need energy to run.

Electricity hasn't been invented yet, so the machines will need to run on a form of energy that's easily available.

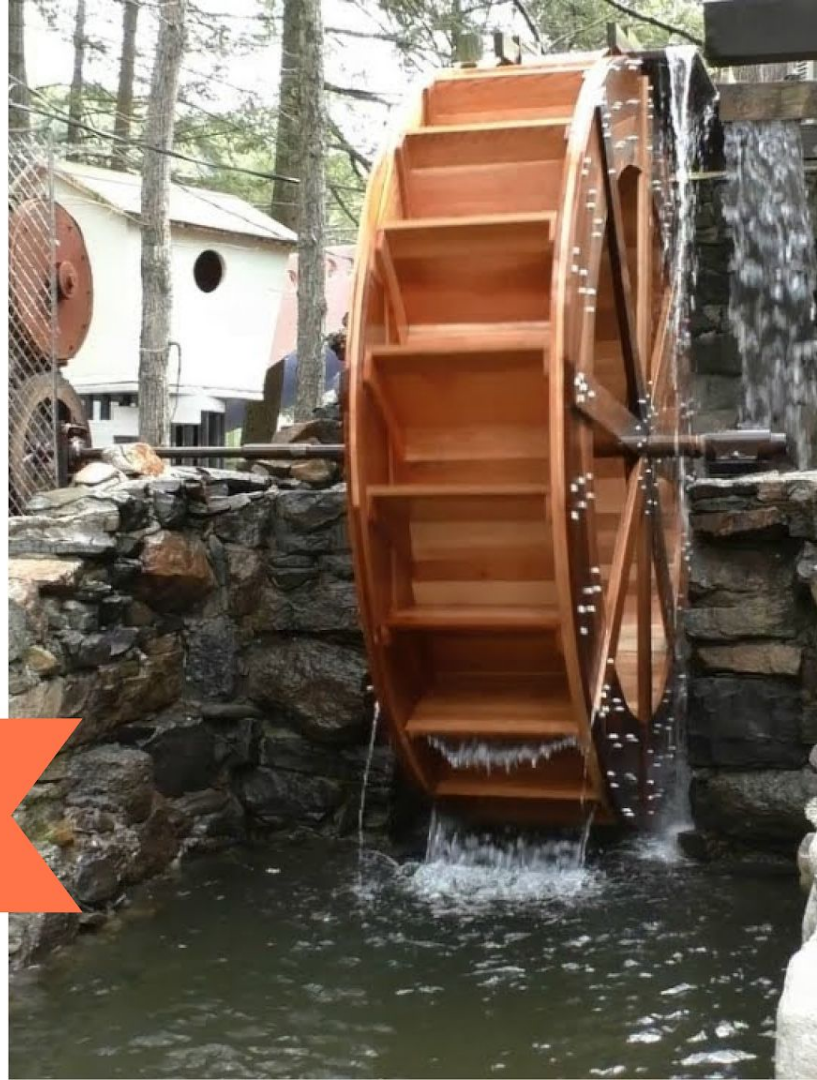


THE WATER WHEEL

The invention of the water wheel let factories power their machines with **hydroenergy**, which is the energy in fast-moving water. Flowing water causes a water wheel to spin, creating kinetic energy that can be transferred to machines.

Business owners like Robbins & Lawrence built factories next to rivers and waterfalls so they could use hydroenergy and water wheels.

Today you're going build a model of a water wheel to observe energy transfer.



ENERGY TRANSFER IN A WATER WHEEL

Watch the video below and look for evidence of energy transfer:

APM'S WATER WHEEL

Did you remember the the Robbins and Lawrence Armory was built by a brook to harness hydroenergy?

The original builders created a water wheel with a diameter of 18 feet! It was installed in the basement and was turned by water that was redirected from the brook to flow through the building. When the water flowed by, it would turn the wheel creating kinetic energy for the factory.

PROTOTYPING ACTIVITY

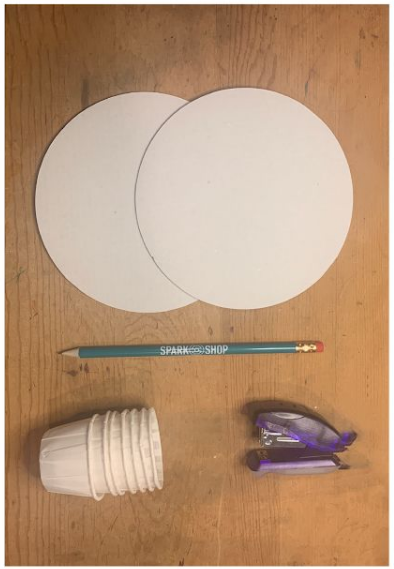
Build a model waterwheel!

GOAL

Create a model of a waterwheel that transfers hydroenergy into kinetic energy.

MATERIALS

- 2 6-inch cardboard circles
- 7 sauce containers
- 1 sharpened SparkShop pencil
- 1 stapler



BUILD YOUR WATER WHEEL

Follow along with the video below:

OBSERVE

What happened when flowing water hit your water wheel?

Did anything unexpected happen during your experiment?

REFLECT

What evidence did you see that energy was transferred by your water wheel?

WRITING + STEM

SCIENCE FICTION

SCIENCE FICTION

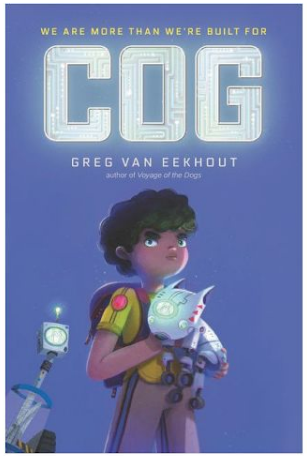
Science fiction is a genre where stories are set in imaginary environments with technology that is more futuristic or advanced than ours today.

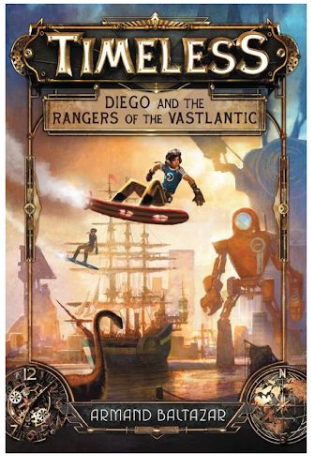
Science fiction can be set in the future, on other planets, in outer space, or even in alternate realities!

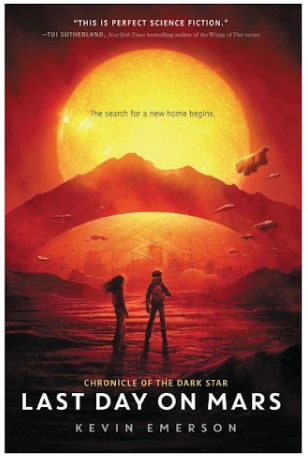
Today you're going to make predictions about future technology and write a science fiction story!

EXAMPLES OF SCIENCE FICTION

The three books below are all examples of science fiction writing.







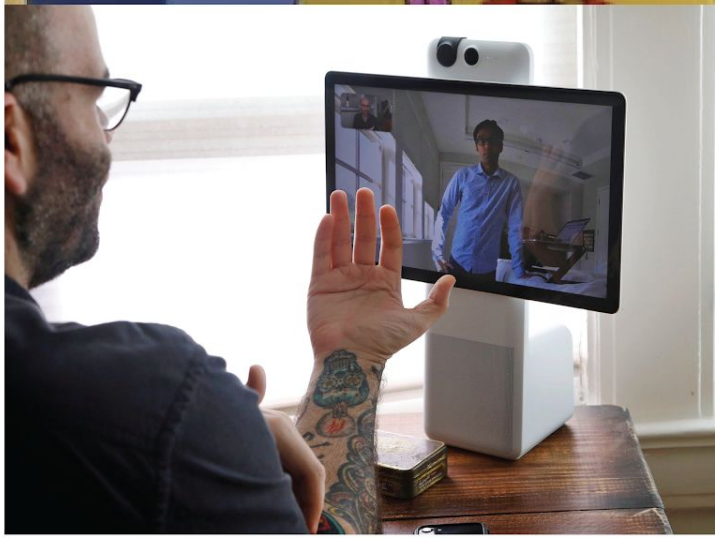
What futuristic technology do you see in the cover art for these books?

PREDICTIONS FROM SCIENCE FICTION

Science fiction writers create new worlds and technology without today's constraints. Some science fiction writers have even predicted modern technology!

Jules Verne wrote From Earth To The Moon in 1865. In this science fiction novel, he described a space expedition where people would land on the moon. NASA's project Apollo 11 actually reached the moon 104 years later.

The TV show The Jetsons was made in the 1960s and set in the 2060s. The characters used a video phone, which seemed impossible at the time. Today, we use technology like FaceTime and Zoom to communicate all the time.



WRITING ACTIVITY

Practice Science Fiction Writing

MAKE PREDICTIONS

Imagine our world 100 years in the future. Where will our energy come from? What technology will we use for communication, transportation, or entertainment? Be creative!

Write your predictions here:

OUTLINE YOUR PLOT

Science fiction defines the setting, but you still need a story! Will it be about adventure, love, mystery, or something else? Summarize your plot in the boxes below.

Beginning

Middle

End

WRITE YOUR STORY

In a journal or on lined paper, write your short science fiction story. Include details about the technology that your characters use.

OPTIONAL

- Type up your story and share it with a friend or your teacher.
- Use their feedback to edit your story and improve it.

DANCE & STEM

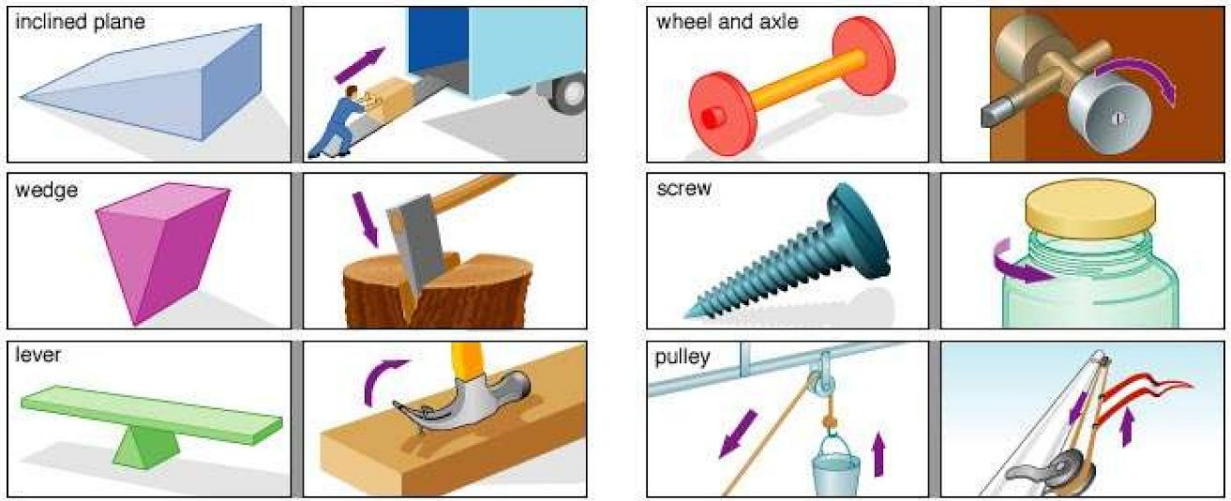
SIMPLE MACHINES

MEET ELLA!

SPARK SHOP

WHAT ARE SIMPLE MACHINES?

A **simple machine** is a device that changes either the direction or amount of a force. There are 6 types of simple machines. Can you find examples of these machines around you right now?



LEARN THE MOVES

PRACTICE WITH MUSIC

MAKE UP YOUR OWN DANCE!

WRAP UP

Use the box below to write about the dance you came up with. What was it inspired by? What were the moves? You can add attach a picture if you'd prefer to.

Describe your dance

CAREER PROFILES IN STEM

JESSE TRINQUE

SPARK SHOP

MEET JESSE

Jesse Trinque is an engineer who lives in Tolland, Connecticut. He works for CNC Software Inc, a company that builds machines used in manufacturing. Jesse is an **applications engineer** who teaches customers how to apply his company's technology to solve problems.

Let's watch a video to learn more about Jesse and his career!

JESSE'S CAREER IN MANUFACTURING

RECALL

Which school subjects does Jesse use in his job?

Name 2 skills that Applications Engineers need to be successful:

REFLECT

In the video, Jesse said talked about the importance of **resilience**, which is the ability to recover from difficulty and keep going.

Describe a time in your life when you showed resilience:

IMAGINE

Would you enjoy working in a job like Jesse's? Why or why not?