CACHE ARTS

Presents

Cirque Mechanics *Zephyr: A Whirlwind of Circus*

Thursday, October 19 from 10-11am

Ellen Eccles Theatre 43 South Main, Logan

How To Attend

- Arrive 15-25 minutes before the start of the show.
- Bus parking will be reserved along 100 South between Main and 100 West.
- As you enter the theatre, look for an usher holding a sign with your school name on it. They will show you to your seats.

Please arrange for accommodations in advance.
Call 435-554-7065 or email Education@CacheARTS.org

Tip: If noise can be overwhelming for you, you may bring noise cancelling headphones or ask about earplugs at the concessions counter.

Audience members have an important role at a live performance.
Your attention helps the performers do their best.
There are no pause or rewind buttons. It exists only in the present moment.

Brainstorm behaviors that will help you and your neighbors get the most out the experience.

Hint: What should my eyes, ears, mouth, feet, and hands do?

Help us keep this 100 year old facility looking it's best.

The Phoenix

"The phoenix is a legendary bird born out of fire... For many ancient peoples, this fabulous bird represented death and rebirth...From the ashes of the fire, a new phoenix was born."
https://kids.britannica.com/kids/article/phoenix/390048

In Logan, George Thatcher built the Thatcher Opera House in 1890 which burned down in 1912. His sons built the Ellen Eccles Theatre in 1923. The phoenix is a reminder of the rebirth of their father's dream of creating a home for the arts.

Thank you!

Every dollar counts. Each school's payment plus grants, sponsors, and donations helps us provide opportunities for students to have a live theater experience by professional touring artists, just for them. CacheARTS spends between $14 and $27 per student for these school shows. The support of school administrators, principals, teachers, and parents tells us it's worth it!

WESTAF

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arts.gov

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LOGAN CITY UNITED IN SERVICE
ESTABLISHED 1866

STUDY GUIDE

INTRODUCTION

Zephyr was inspired by a family trip to a working grist mill nestled on a field in central England, where we met its sweet and charismatic owner, Nigel and had a tour of the inside of the windmill. We were impressed and lulled by the symphonic whoosh of the windmill sails, the turning and cranking of the internal gears and mechanisms that milled the grist into flour. Nigel was like an athletic Maestro conducting a symphony of sorts, but also like a mad mechanic running up and down the tower, adjusting levers, inspecting, and repairing. It was an energizing visit, which led us to imagine, explore and wonder the world inside and around the windmill as Zephyr - A Whirlwind of Circus.

The study guide has three discussion sections:

SECTION ONE

WINDMILL HISTORY AND PRODUCTION INSPIRATION

This section outlines a brief history of windmills to help students understand the evolution and uses of this ancient machine. They will also learn vocabulary and terms associated with windmills. Plus, they'll learn little known fun facts about windmills.

Plus, students will be learning the meaning of the show's title Zephyr and its ties to wind and Greek Mythology. They will be introduced to the art that inspired the creators of Zephyr from across media platforms and genres. These include whirligigs, Don Quixote de la Mancha, The Jetsons, "Silent Movie" by Mel Brooks with mime Marcel Marceau, Otto Messner's "Charlie Chaplin on the Windmill" and most notable, the TV commercial titled "Mr. Wind" by Epuron.

SECTION TWO

SOCIAL STUDIES, ENGLISH AND SYMBOLISM

The Industrial Revolution - The show references the introduction of progress and modernization and its effects on industry. This section introduces students to the Industrial Revolution in America, it's consequences for climate and the use of renewable, clean energy sources, like wind power.

Figurative Language in Theater - Personification, Metaphors and Symbolism.
This section will define these terms and show examples of its uses in the performance.

SECTION THREE

THE SCIENCE OF WIND AND CIRCUS: NEWTON'S LAWS

The acrobats in Zephyr perform extraordinary feats that require an understanding of the basic principles of physics like gravity, inertia, and motion. The contraptions in the show are based on simple machines that rely on the same principles to seemingly help the acrobats defy physics.
This section will provide students with hands on STEM activities, making boomerangs and kites.

SECTION ONE

WINDMILL HISTORY AND PRODUCTION INSPIRATION

WINDMILLS DEFINED

A windmill is a structure that converts wind power into rotational energy by means of vanes called sails or blades. Early windmills were used for exactly what their name implies — they were mills run by wind (gristmills). Wind would spin the vanes, or blades, of the windmill, rotating a center shaft, which then spun a grain mill, usually made of large, flat stones, to produce flour and other grain products. The term is also extended to windpumps, wind turbines, and other applications. A windmill is a type of working engine.

The energy made by windmills can be used in many ways. These include grinding grain or spices, pumping water and sawing wood. Modern wind power machines are used to create electricity. These are called wind turbines by engineers or windmills by the average person.

HOW WINDMILLS WORK

The blades or sails of the windmill are turned by the wind. Gears and cogs makes the drive shaft inside the windmill turn. In a windmill used for making flour, this turns the grinding stones. As the stones turn, they crush the wheat (or other grain) between them.

In a windmill used for pumping water, turning the drive shaft moves a piston. The piston can suck up and push out water as it moves up and down.

In a windmill used for generating power, the drive shaft is connected to many gears. This increases the speed and is used to turn a generator to make electricity.

GEARS AND COGS INSIDE AN OLD WINDMILL

HISTORY OF WINDMILLS

Harnessing wind has been a part of our human history since early civilizations.

People used wind energy to propel boats along the Nile River as early as 5,000 BC.

Our earliest civilizations learned about the ability of wind to be transformed into mechanical force. Some of the earliest examples of their experiments were of course ships sails, some archeologists point that they were first used even as far back as 6000-4300 BC in ancient Mesopotamia and after 3200 BC in Egypt.

Redirecting the force of the wind not on sail canvas but on a mechanical wheel happened much later, in the 1st century AD when Greek engineer Heron of Alexandria created first a wind-driven device (not a windmill but a musical instrument, an organ).

The first practical windmills were in use in Sistan, a region in Iran and bordering Afghanistan, at least by the 9th century and possibly as early as the mid-to-late 7th century.

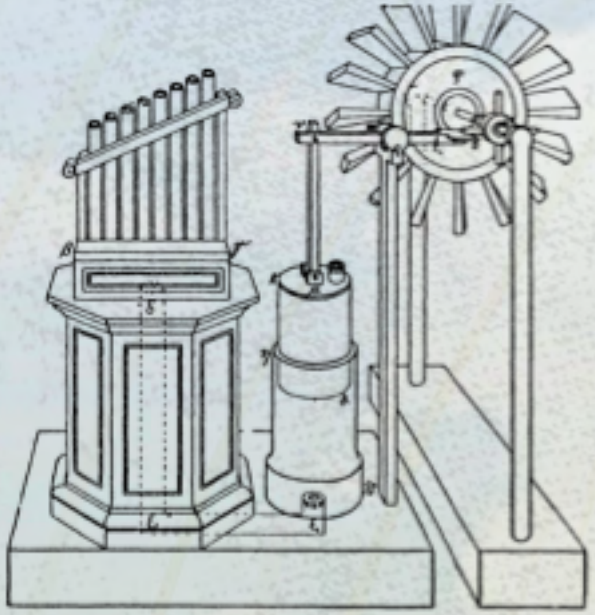
One of the first windmills were probably invented by a Greek, Tesibius, who lived from 285 to 222 BC. Also, the earliest known wind powered grain mills with woven-reed blades were used by the Persians in A.D. 500–800 and simple wind-powered water pumps were used by the Chinese in A.D. 1200.

Around the 4th century AD, the Tibetans and Chinese started using wind-driven prayer wheels, and the first horizontal windmills of limited capacity started appearing in Persia after the 7th century AD.

The most important use of the windmill was for grinding grain. In certain areas its uses in land drainage and water pumping were equally important.

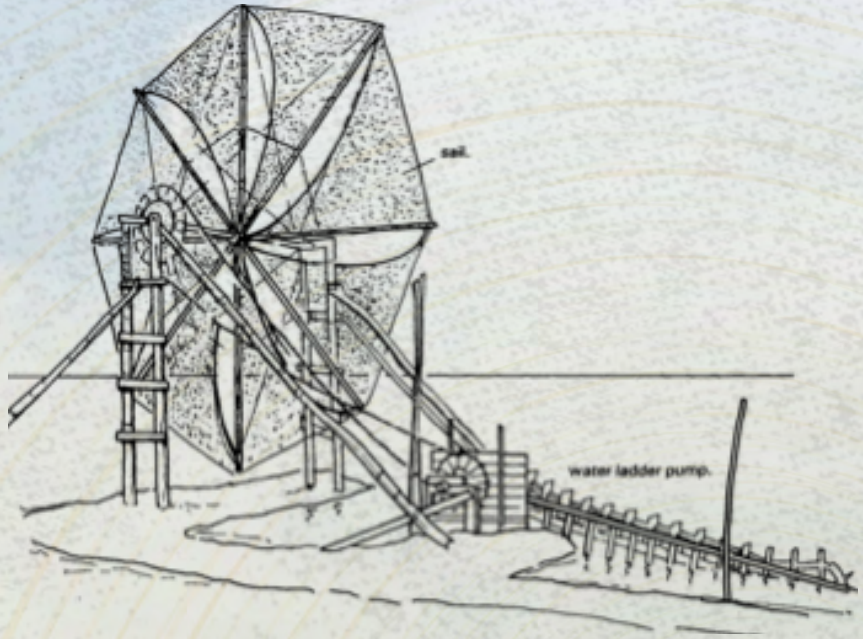
The windmill (turbine) has been used as a source of electrical power since Poul La Cour's mill, built in Denmark in 1890 with patent sails and twin fantails on a steel tower.

Poul La Cour developed an electricity-generating wind turbine and later figured out how to supply a steady stream of power from the wind turbine by use of a regulator, a Kratostate. By 1895, La Cour had converted his windmills into a prototype electrical power plant.



HERON’S WIND ORGAN

TIBETAN PRAYER WHEEL



ANCIENT CHINESE WATER PUMP

Over the next 500 years windmills gained many diverse applications beyond just water-pumping and grinding grain including irrigation, drainage pumping, saw milling of timber, and processing tobacco, spices, cocoa, paints, and dyes.

POUL LA COUR IN FRONT OF HIS WIND TURBINES

WINDMILL SHAPES

By 19th century when steam and electricity started being dominant source of power for industry, windmills were created in three most basic shapes:

Post Mills that had fixed sail wheel that could not rotate.

Tower Mills that were built from stone or bricks and had rotating wooden cap that could rotate and take advantage from wind that changes direction.

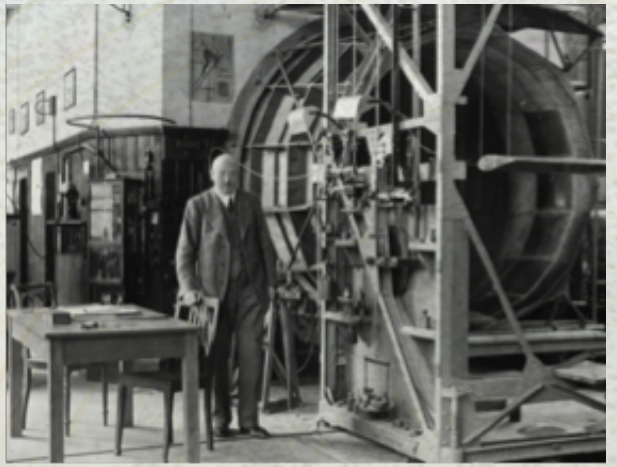
Smock Mills who had strong base and wooden body which also featured rotating roof.

After proliferation of electricity and internal combustion engines, the need for wind powered machines reduced dramatically all around the world, but some wind-powered machines never became obsolete.

For example, water pumps powered by wind are extremely self-sufficient, requiring small amount of wind to start pulling water from deep wells, and requiring very little maintenance.

Wind turbines that create electricity became much more attractive after it became apparent that oil prices would become more and more expensive after 1970s.

Wind Energy is a clean and renewable source of energy that comes from the wind. There are different ways to harness this energy like windmills. It can be used as a source of electricity, and it constantly replenishes itself. It does not require any water during the production and causes minimum pollution and operational costs are minimal.



The theory of wind energy was discovered in 1919 by a German physicist **Albert Betz**.

WHEN YOU WATCH THE SHOW:

What type of windmills can you spot?

What product do they generate?

TEN FUN FACTS ABOUT WINDMILLS

1. The largest historic windmills in the world are in the Netherlands, near the town of Schiedam.
2. In 2021, wind turbines were the source of about 9.2% of total U.S. utility-scale electricity generation.
3. First windmill in America was created in 1888 by Charles Brush in Cleveland, Ohio.
4. A collection of wind turbines in the same location is known as a wind farm.
5. Most of the wind turbines have 3 blades that can reach up to a speed of 200 miles per hour.
6. The largest wind farm in the United States is the Shepherds Flat Wind Farm in Oregon.
7. Modern wind turbines are complicated machines. One wind turbine can have as many as 8,000 different components.
8. A single wind turbine can produce enough electricity to power around 600 homes.
9. Wind energy can be an alternative to fossil fuels.
10. The largest wind turbine in the world is in Hawaii, United States. It is 20 stories high and has rotors that have length of entire football field.

WHY ZEPHYR?

Zephyr is a gender-neutral name of **Greek origin**. Rooted in mythology, this fluid name means “west wind” and refers to the seasonal breeze controlled by the ancient god Zephyrus.

A Zephyr is a soft, gentle, warm breeze.

Zephyrus was the god of the west wind and the messenger of spring in **Greek mythology**. He was known as one of the four Anemoi, or wind gods, each of whom represented a cardinal direction and, except for Eurus, a season. Zephyrus was often thought of as the gentlest of the four, although he possessed a capacity for jealousy.

RELIEF OF ZEPHYRUS

In myth, Zephyrus could be both helpful and vindictive.
As the bringer of spring, he was often looked upon favorably by classical writers and poets who wrote of his sweet westerly breeze. He had three different wives, depending on the story, and had offspring with each, including Balius and Xanthus, the immortal horses who pulled **Achilles' chariot** during the **Trojan War**.

Zephyrus is often depicted in classical art as a handsome and winged youth. Many ancient **Greek** vase paintings which depict unlabeled figures of a winged god embracing a young man are often identified as Zephyrus and Hyacinthus, the youth whose love Zephyrus rivalled **Apollo** to receive. Zephyrus is also known by the anglicized name of Zephyr and by the name of his **Roman** counterpart Favonius.

WHEN YOU WATCH THE SHOW:

Can you spot a character that may be like Zephyr?

WHIRLIGIGS

Whirligigs are whimsical, and colorful. Their depiction of farm living and their interactions with wind inspired costumes and the playfulness of the acrobats with the machines.

A whirligig is an object that moves or spins, like a pinwheel, a weathervane, or a spinning toy. They are usually colorful pieces of yard ornamentation and usually boast rural motifs and tend to depict iconic, small-town tasks like herding sheep, churning butter, or harvesting corn.

Whirligigs are considered folk art; they are kinetic sculptures that interact with the wind.

Folk Art: Art originating among the common people of a nation or region and usually reflecting their traditional culture, especially every day or festive items produces or decorated by unschooled artists.

The word whirligig derives from two Middle English words: “whirlen” (to whirl) and “gigg” (top), or literally “to whirl a top,” and the first usage of the word appears around 1440 CE.

There are two famed American Whirligig folk artists, Reuben Aaron Miller (1912-2006) and Vollis Simpson (1919-2013). They are both described as American “outsider” folk artists known for their kinetic sculptures called “whirligigs”. Their sculptures have been viewed and enjoyed by millions at art museums and exhibits around the world.

Outsider Art: Art made by self-taught artists with typically little or no contact with the conventions of the art worlds.

- In 2013 Simpson’s Whirligigs were named North Carolina’s official folk art. You can see Simpson’s creations at Vollis Simpson Whirligig Park in Wilson North Carolina https://www.wilsonwhirligigpark.org/
- In 1984, rock group REM filmed a twenty-minute video, *Left of Reckoning*, on Miller’s hilltop. Miller is acknowledged as one of the more notable senior folk artists in the United States.

WHEN YOU WATCH THE SHOW

Can you find the whirligigs on stage?

A Whirlwind of Circus

DID YOU KNOW?

Even **George Washington** collected and bought whirligigs from farmers and artists at Mt. Vernon when he returned home from the Revolutionary War.

William Shakespeare wrote "*and thus the whirligig of time brings in his revenges"* in Twelfth Night (V.1.373–374) referring to time as a child's toy (a top to be spun) which goes around in circles (or cycles).

DON QUIXOTE

Don Quixote inspired the use of a windmill and some of the elements of humor in Zephyr.

Don Quixote de la Mancha is a novel by the Spanish author Miguel de Cervantes Saavedra. It is one of the earliest novels in a modern European language and many people consider it the finest book in the Spanish language. Published in two parts in 1605 and 1615 respectively.

The story is about Alonso Quixano, a rich middle-aged man. Quixano, having read many tales about chivalry and knights, goes crazy and believes that he is a knight named Don Quixote. He rides around the country with his squire, Sancho, having adventures. He believes his adventures are real, but everyone else laughs at his antics.

Squire: a young nobleman acting as an attendant to a knight before becoming a knight himself.

One of the most famous stories in the book is Don Quixote's fight with windmills. He mistakes windmills for oppressive giants sent by evil enchanters. He attempts to fight them riding his steed, Rocinante, but repeatedly fails. Even when told by Sancho, he does not believe them to be windmills

The adjective "quixotic", meaning "idealistic and impractical", derives from the protagonist's name, and the expression "tilting at windmills" comes from this story.

DID YOU KNOW?

The idiom *Tilt at Windmills* came from Don Quixote? (To Fight Windmills) It means to attack imaginary enemies or opponents, to go on a wild-goose chase; to persistently engage in a futile activity.

SILENT MOVIE

“Silent Movie” by Mel Brooks with mime Marcel Marceau

In this film we see one of the most brilliant and playful ways to interact with the wind. The only way we can see wind is when affects things, in this scene, the door and the curtains, Marcel Marceau’s miming as he walks into the wind, lets us know that the wind is there without the need for sound!

Silent Movie is a 1976 American satirical comedy film co-written, directed by, and starring Mel Brooks, released by 20th Century Fox in the summer of 1976.

In the movie, Marcel Marceau reprises his “walking into the wind” routine while trying to lift a phone. Although Marceau never spoke on stage, he did once famously speak in Brooks film when he shouted the only word in the film: “Non!”.

Off stage, he was a very talkative man, “Never get a mime talking,” he once said.

MARCEL MARCEAU

Marcel Marceau
(Born Marcel Mangel; 22 March 1923 – 22 September 2007)

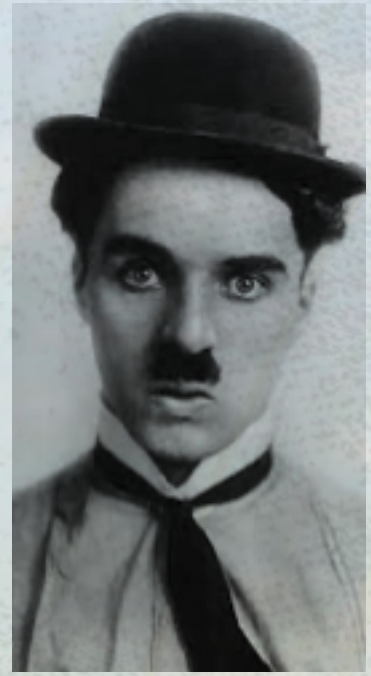
Marcel Marceau was a French actor and mime artist most famous for his stage persona, “Bip the Clown”. He referred to mime as the “art of silence” and he performed professionally worldwide for over 60 years. When the Studio Chief asks what his answer was, Mel Funn cowardly replies that he doesn’t understand French.

WHEN YOU WATCH THE SHOW:

Can you spot the moments that use miming?

Would you consider Zephyr a Silent Show?

CHARLIE CHAPLIN



Sir Charles Spencer Chaplin, Jr.
KBE (16 April 1889 – 25 December 1977)

Sir Charles Spencer Chaplin, better known as Charlie Chaplin, was a British comedy actor. Chaplin became one of the most famous performers as well as a notable director and musician in the early to mid-Hollywood cinema era. He is considered to be one of the finest mimes and clowns ever caught on film.

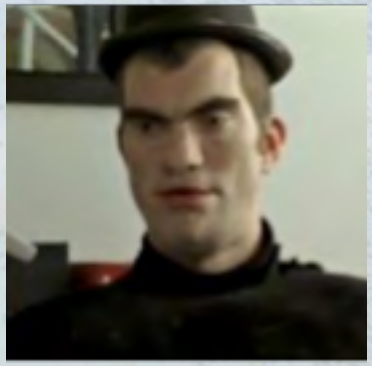
His principal character was “The Tramp” (known as “Charlot” in France, Italy, Spain, Greece, Portugal and Turkey), a vagrant with the refined manners and dignity of a gentleman. The character wears a tight coat, oversized trousers and shoes, a derby, carries a bamboo cane, and has a signature toothbrush mustache.

Faded fragments of the Charlie Chaplin cartoon titled “Charlie on the Windmill” produced in 1915 by animation pioneer Otto Messner, creator of Felix the Cat.

In the fragment of less than two minutes of film, we mostly see, a very large windmill going around and around with a tiny figure clinging to one of the sails. When it stops, with him at the top, a large man on the ground blows a big wind and makes it turn around a couple more times. Then it stops again, and we get a close enough shot to see the cartoon version of Charlie’s “Little Tramp.” He gives his signature shrug, and several other familiar body movements, while the large man, now joined by a woman, throws bricks at him! All of them miss, but when the man throws a bicycle, it knocks Charlie off. That’s all we have.

Otto Messmer, (born August 16, 1892, Union City, New Jersey, U.S.–died October 28, 1983, Teaneck, New Jersey), American animator who created the character Felix the Cat, the world’s most popular cartoon star before Mickey Mouse.

MR. WIND



Mr. Wind by Epuron

A hulking and intimidating yet misunderstood man is the metaphor at the heart of Nordpol Hamburg's short film promoting the wind energy division of German company Epuron, the two-minute web film offers poignant, clever storytelling without coming off as didactic, following our black-clad gentle giant whose various actions mimic those of actual wind. Somber piano music plays while the wind man spills his frustrations from people's unfriendly reactions to his handiwork, until eventually, he finds someone who understands. There's a place for his type of energy in this world after all. "Power of Wind" garnered a Cannes Gold Lion and was one of the main contenders for the Grand Prix and earned a 2008 Creativity Award.

MOOD BOARD

A mood board is a type of visual presentation or “collage” consisting of images, text, and samples of objects in a composition. It can be based on a set topic or can be any material chosen at random. A mood bord can be used to convey a general idea or feeling about a particular topic.

CLASS ACTIVITY:

Prepare a mood board representing a book or film of your choice. Or prepare a mood board of goals for yourself this school year?

SECTION TWO

SOCIAL STUDIES, ENGLISH AND SYMBOLISM

SOCIAL STUDIES

The Industrial Revolution

The Industrial Revolution took place over more than a century, as production of goods moved from home businesses, where products were generally crafted by hand, to machine-aided production in factories. This revolution, which involved major changes in transportation, manufacturing, and communications, transformed the daily lives of Americans as much as— and arguably more than—any single event in U.S. history.

An early landmark moment in the Industrial Revolution came near the end of the eighteenth century, when Samuel Slater brought new manufacturing technologies from Britain to the United States and founded the first U.S. cotton mill in Beverly, Massachusetts.

The technological innovation that would come to mark the United States in the nineteenth century began to show itself with Robert Fulton's establishment of steamboat service on the Hudson River, Samuel F. B. Morse's invention of the telegraph, and Elias Howe's invention of the sewing machine, all before the Civil War.

Following the Civil War, industrialization in the United States increased at a breakneck pace. This period, encompassing most of the second half of the nineteenth century, has been called the Second Industrial Revolution or the American Industrial Revolution. Over the first half of the century, the country expanded greatly, and the new territory was rich in natural resources.

American inventors like Alexander Graham Bell and Thomas Alva Edison created a long list of new technologies that improved communication, transportation, and industrial production. Edison made improvements to existing technologies, including the telegraph while also creating revolutionary new technologies such as the light bulb, the phonograph, the kinetograph, and the electric dynamo. Bell, meanwhile, explored new speaking and hearing technologies, and became known as the inventor of the telephone.

For millions of working Americans, the industrial revolution changed the very nature of their daily work. Previously, they might have worked for themselves at home, in a small shop, or outdoors, crafting raw materials into products, or growing a crop from seed to table. When they took factory jobs, they were working for a large company. The repetitive work often involved only one small step in the manufacturing process, so the worker did not see or appreciate what was being made; the work was often dangerous and performed in unsanitary conditions. Some women entered the work force, as did many children.

The Industrial Revolution is a complex set of economic, technological, and social changes that occurred over a substantial period. Teachers should consider the documents in this collection as tools for stimulating student thinking about aspects of the Industrial Revolution.

WHEN YOU WATCH THE SHOW:

Can you spot the character that represents the Industrial Revolution?

Can you name a positive effect of progress?

A negative one?

The Industrial Revolution and Windmills

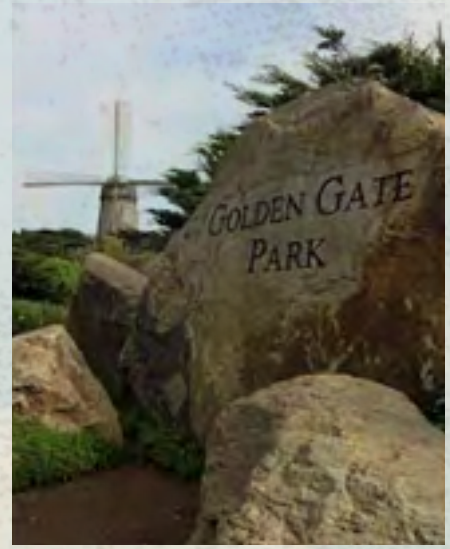
In the 1700s, windmills started to become irrelevant due to the Industrial Revolution. However, in the early 1800s the settlers of the Great American plains had a new idea. The Great American plain settler used windmills to pump water along the western frontier.

Throughout the Industrial Revolution, windmills were increasing their number of how many people wanted them. They were at the time, the largest machine created within the Industrial Revolution. Millwrights would carry plans and bring along their tools to help build the windmills and would start building at that moment.

The use of wind power declined sharply in the 19th century with the spread of steam and the increasing scale of power utilization. Windmills that had satisfactorily provided power for small-scale industrial processes were unable to compete with the production of large-scale steam-powered mills.

DID YOU KNOW?

The Largest windmill ever built is in the United States.



The two Dutch windmills with the largest sail diameter are standing in the Golden Gate Park in San Francisco, built between 1903 and 1905. The largest one, the “Murphy Windmill”, stands 95 ft tall with sails 114 ft across. The stocks were cut from one single log. It was used to pump water to irrigate the park, completed in 1908, the Murphy Windmill was placed on the San Francisco Designated Landmark list in 2000.

Human activity has rapidly increased the emission of greenhouse gases to the atmosphere. Since the start of the Industrial Revolution, in about 1750, human activities such as burning fossil fuels, including coal and oil, have increased greenhouse gas concentrations in our atmosphere.

However, since the industrial revolution, humans have expelled copious amounts of carbon dioxide into the atmosphere. This has triggered an unnatural warming that has seen the Earth's temperature rise dramatically over a short period of time. The average global temperature was 12˚C during the Last Glacial Maximum.

A higher population leads to increasing product demand, as well as increased levels of consumption and output. This correlates to increasing activity including industrialization, which eventually results in higher quantities of greenhouse gases.

Most significantly, the concentration of CO2 has been rising exponentially (at a rate of about 0.17% per year) since the industrial revolution, due mainly to the combustion of fossil fuels but also to large-scale tropical deforestation which depletes the climate system's capacity for photosynthesis.

The Industrial Revolution was powered by burning coal, and big industrial cities began pumping vast quantities of pollution into the atmosphere. London's concentration of suspended particulate matter rose dramatically between 1760 and 1830.

Air pollution continued to rise in the 1800s, causing respiratory illness and higher death rates in areas that burned more coal. Worse yet, the burning of fossil fuel pumped carbon into the atmosphere. A study published in 2016 in Nature suggests that climate change driven by human activity began as early as the 1830s.

Despite all these ills, the Industrial Revolution had positive effects, such as creating economic growth and making goods more available. It also helped lead to the rise of a prosperous middle class that grabbed some of the economic power once held by aristocrats and led to the rise of specialized jobs in industry.

Pollution from copper factories in Cornwall, England. **Circa 1887**

WHEN YOU WATCH THE SHOW:

Can you spot ways in which older technology like windmills could help reverse or balance the negative effects of Industrialization?

ENGLISH

Figurative Language in Theater

Figurative language is the language that expresses one thing in terms of another by analogy, extension, or other association. A critical approach to drama written in verse requires the knowledge of not only meter but also the function and purpose of the various figures of speech.

There are lots of different types of figures of speech, but broadly speaking these can helpfully be divided into two groups: tropes and schemes.

A trope is a figure of speech that uses words or phrases in a way in which the intended meaning extends beyond the literal meaning of the words used. Some of the most used tropes include personification.

Personification is a special type of metaphor where human actions or feelings are ascribed to a non-human thing. When we talk about something that isn't human as if it was, then we are personifying it – that is, making it into a person. This figurative use of language is most associated with poetry and literary fiction, but we can often find it in our daily speech too.

WHEN YOU WATCH THE SHOW:

Which character best represents personification?
(Hint: Do you see the wind?)

Which human characteristics can you apply to the wind?
Can wind be angry, strong, and soft?

SYMBOLISM

In theatre, symbolism is the use of one or more objects to represent something else. The object may represent an idea, a feeling, or a physical entity. Symbols allow playwrights to convey messages to audiences that would be difficult to communicate through dialogue or action alone.

Some symbols are specific to a particular culture or era, while others are more universal. A rose, for example, is often used to symbolize love, while a skull can represent death. The choice of symbols depends on the playwright's intent and the audience's understanding of the symbols.

Symbolism can be used to create mood, atmosphere, or tension in a play. It can also be used to advance the plot or to reveal character traits.

When used effectively, symbolism can add depth and richness to a play. When used poorly, it can be confusing or even offensive to audiences.

WHEN YOU WATCH THE SHOW:

What characters or items can you find that represent a symbol?
(Hint: The red engine? Could it symbolize PROGRESS or INDUSTRY?)

NIGEL, ZEPHYR or FUEL?

NIGEL: Symbolizes Humanity

ZEPHYR: The earth or Natural Resources

FUEL: Progress or Industry

What could WHEAT symbolize? What about the FLOUR sacks? The DOOR? The WINDMILL itself?

SECTION THREE

THE SCIENCE OF WINDMILLS AND BOOMERANGS

SIMPLE MACHINES

There are two basic principles of science we will focus on: Simple Machines and Motion (Basic Physics). We will also define the differences between a windmill and a turbine and briefly outline the physics of boomerangs. Plus, to encourage young people to think like engineers, we have a brief outline of the Engineering Design Process.

Simple Machines - Simple machines are tools that make work easier. They have few or no moving parts. These machines use energy to work. There are many Simple Machines and examples of each throughout Zephyr.

Pulley - This simple machine is made up of a wheel and a rope. The rope fits on the groove of the wheel. One part of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns, and the load will move. Pulleys let you move loads up, down, or sideways. Pulleys are good for moving objects to hard-to-reach places. It also makes the work of moving heavy loads a lot easier.

Pulleys in Zephyr: *Hair Hang* – this pulley system elevates and lowers our aerialist

Wheel and Axle - The wheel and axle is another simple machine. The axle is a rod that goes through the wheel. This lets the wheel turn. It is easy to move things from place to place with wheels and axles.

Wheel and Axle in Zephyr: This axle, wheel turns the turbine blades. There is also one turning the wheel on the engine.

WHEN YOU WATCH THE SHOW:

Can you find the largest example of a wheel and axle?

Answer: The windmill itself!

Inclined Plane - An inclined plane is a simple machine. It is a flat surface that is higher on one end. You can use this machine to move an object to a lower or higher place. Inclined planes make the work of moving things easier. You would need less energy and force to move objects with an inclined plane.

Lever - A lever is a board or bar that rests on a turning point. This turning point is called the fulcrum. An object that a lever moves is called the load. The closer the object is to the fulcrum, the easier it is to move.

Inclined plane and lever in Zephyr:
Nigel's Bowl routine takes place using incline planes

Wedge - A wedge is a simple machine used to push two objects apart. A wedge is made up of two inclined planes. These planes meet and form a sharp edge, which can split things apart.

Screw - A screw is a simple machine that is made from another simple machine. It is an inclined plane that winds around itself. A screw has ridges and is not smooth like a nail. Some screws are used to lower and raise things. They are also used to hold objects together.

Although not visible, there are hundreds of screws that hold machines, props and staging together.

The central machine of Zephyr:
This is an example of multiple simple machines working together.

WHEN YOU WATCH THE SHOW:

Try to find other examples of simple machines.

Teachers - Visit Edheads.org for lesson plan ideas on Simple Machines

NEWTON'S LAWS OF MOTION

Sir Isaac Newton
(4 January 1643 – 31 March 1727)

Sir Isaac Newton was an English physicist, mathematician, astronomer, natural philosopher, and alchemist. His treatise Philosophiae Naturalis Principia Mathematica, published in 1687, described universal gravitation and the three laws of motion, laying the groundwork for classical mechanics, which dominated the scientific view of the physical universe for the next three centuries. He showed that the motion of objects on Earth and of celestial bodies are governed by the same set of natural laws by demonstrating the consistency between Kepler's laws of planetary motion and his theory of gravitation, thus removing the last doubts about heliocentrism (the sun at the center of the universe) and advancing the scientific revolution.

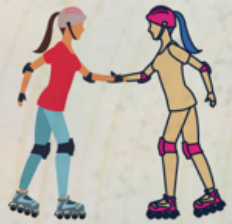
Motion - Motion is one of the key topics in physics. Everything in the universe moves. It might only be a small amount and very slow, but movement does happen. Don't forget that even if you are standing still, the Earth is moving around the Sun and the Sun is moving around our galaxy. The movement never stops. Scientists also use the term mechanics to describe motion. Over the years, scientists have discovered several rules or laws (like Newton's Laws of Motion) that explain all motion you might find.

Moments of Motion/Mechanics in Zephyr - There are many examples of motion in Zephyr both human and mechanical. There is motion in dancing and acrobatics and even in setting the stage and shifting scenery and props.

Newton's Laws of Motion -

A body in motion remains in motion or a body at rest remains at rest, unless acted upon by a force.

Force equals mass times acceleration: F = m*a



For every action, there is an equal and opposite reaction.

1st Law - Every object in a state of uniform motion tends to remain in that state of motion unless acted upon an external force.

Once moving at a steady speed…in a straight line…it will continue moving…at a steady speed… in a straight line. Once standing still…it will stay still.

1st Law of Motion in Zephyr: Delivery man runs around the windmill, gets stopped by Hair Hang artist

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2nd Law - Acceleration is proportional to the force and inversely proportional to the mass (F=ma). Simply stated, a force causes an object to accelerate.

It accelerates in the direction… that you push it. If you push twice as hard… it accelerates twice as much. If it gets twice the mass…it accelerates half as much.

2nd Law of Motion in Zephyr: Juggling the flour sacks, hats, pins and umbrellas.

3rd Law - For every action there is an equal and opposite reaction. *If you push on it…it pushes on you.*

3rd Law of Motion in Zephyr: In Hoop Diving, the acrobats push off the floor and the floor pushes back. Also, the moment when Zephyr is pushing Nigel on the swing.

Simple and Complex Movement - There are two main ideas when you study mechanics. The first idea is that there are simple movements, such as if you're moving in a straight line, or if two objects are moving towards each other. Ideas like acceleration and velocity are simple ideas to physicists.

Simple Movement in Zephyr: Zephyr crossing the stage.

There are also more complex movements for which not all the laws apply. Ideas like work or complex combinations of forces fall into this category. Examples of complex motion include motion that happens in a circular direction.

Complex Movement in Zephyr: Hair Hang spinning or Neck spin during Perch Pole.

WINDMILLS VS. WIND TURBINE

Windmill - A windmill is a machine that harnesses the power of the wind. Windmills may be used to grind grain into flour, to pump water, or to produce electricity.

A windmill has several blades that spin around when wind blows on them. The blades are mounted on a tall tower or building. They are connected to a vertical shaft, or rod. When the blades spin, they turn the shaft. The turning shaft powers a device that does work—for example, a water pump or millstones, which grind grain. The shaft also may provide power to a machine called a generator, which produces electricity. **Shaft:** a long, narrow part or section forming the handle of a tool or club, the body of a spear or arrow, or a similar implement.

Turbine - A wind turbine works the opposite of a fan. Instead of using electricity to make wind, a turbine uses wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Physics of Boomerangs: A boomerang is an example of gyroscopic precession. The boomerang throw gives it angular momentum. This angular momentum is caused to precess by the fact that the top edge is traveling faster with respect to the air and gets more lift. The cross-section of the boomerang is an airfoil which gives it more lift on the top, leading edge than on the bottom. This gives it a torque, which always acts to precess the boomerang counterclockwise as seen from above. Since it will tend to "fly" in the direction of the airfoil, the precession causes it to fly in a curved path, circling back toward the thrower.

Gyroscopic precession: the resultant action or deflection of a spinning object when force is applied to this object.

Airfoil: a structure with curved surfaces designed to give the most favorable ratio of lift to drag in flight, used as the basic forms of wings, fins and horizontal stabilizer of most aircraft.

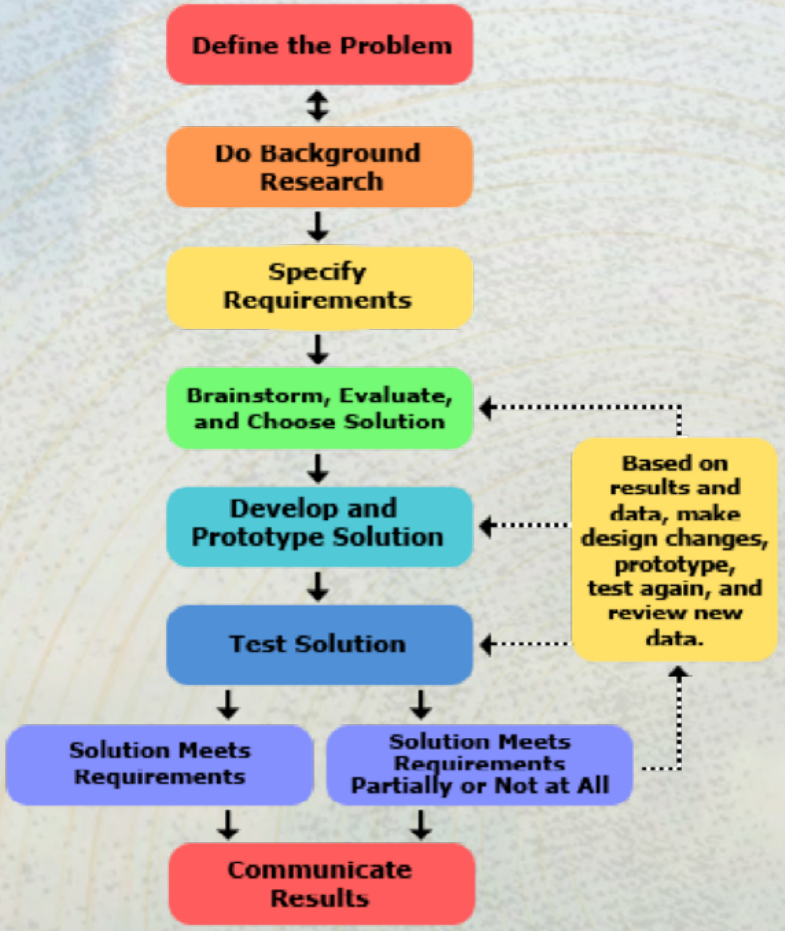
Torque: A twisting force that tends to cause rotation.

THE ENGINEERING DESIGN PROCESS

The engineering design process is a series of steps that engineers follow to come up with a solution to a problem. Many times the solution involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task.

If your project involves designing, building, and testing something, you should probably follow the Engineering Design Process.

The steps of the engineering design process are to:



Engineers do not always follow the engineering design process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change to your design. This way of working is called iteration.

You can see this simplified process represented during Zephyr with multiple devices from the windmill, wheel of destiny and the ladders.

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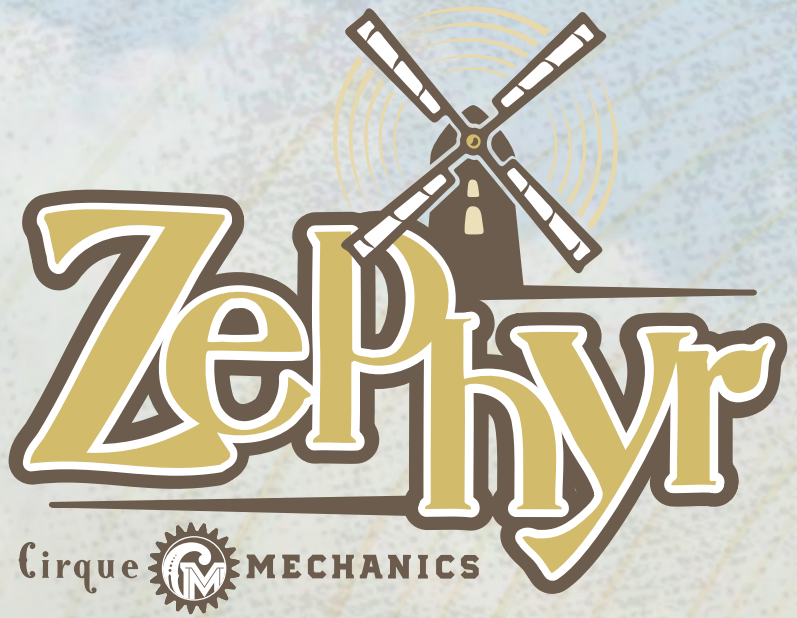

A Whirlwind of Circus