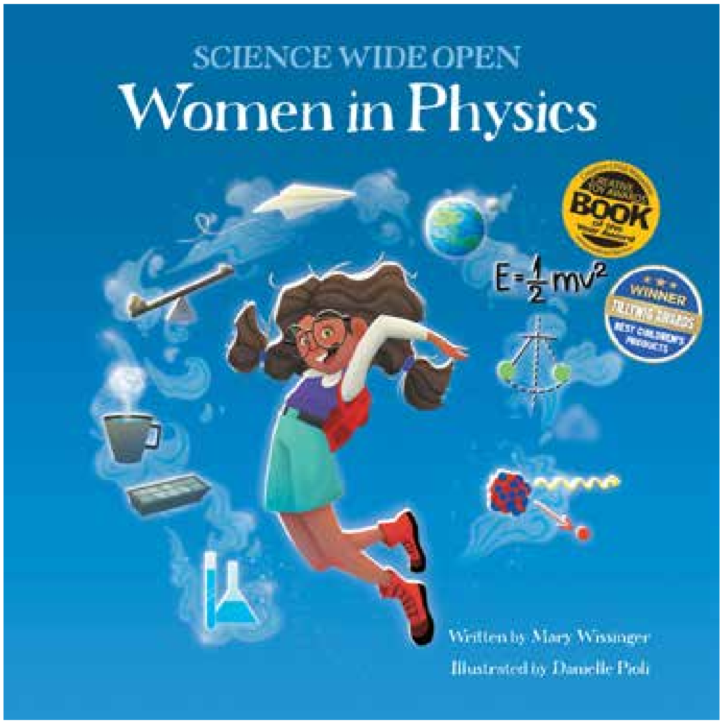
Women in Physics Teacher's Guide

Written and designed by Emma Ferdinandi



To be used with *Women in Physics/ Las mujeres en la física*
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Illustrated by Danielle Pioli

English editions:
Hardback ISBN: 978-1-945779-11-4
Paperback ISBN: 978-1-938492-34-1
eBook ISBN: 978-1-945779-14-5
Spanish editions:
Paperback ISBN: 978-1-938492-35-8
eBook ISBN: 978-1-938492-36-5

Science, Naturally! - An imprint of Platypus Media, LLC
Sparking curiosity through reading
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Sparking curiosity through reading

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The Science Wide Open Series

Dear Reader,

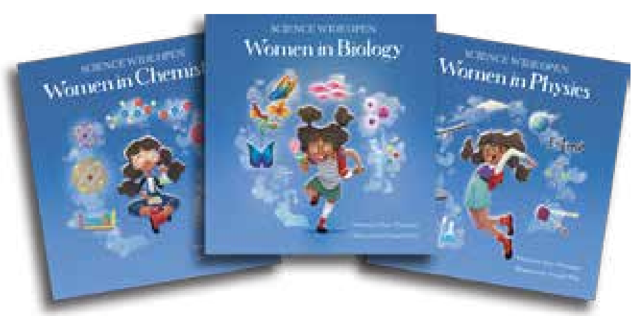
We're excited to introduce you to *Women in Physics/Las mujeres en la física*, part of our *Science Wide Open* series. The beautifully illustrated, information-packed titles in this series introduce elementary age children to the fascinating world of science through important female figures in history.

Scientific curiosity begins in childhood, with young minds thirstily absorbing information about the world around them. Exposure to physics—whether in nature or in a book—is often at the root of a child's interest in science. Physics is a gateway to many important conversations, including space, energy, atomic structure, and medicine. As the many activities in this guide will prove, it also provides the perfect opportunity for education to become hands-on and interactive.

Physics might be a complex subject for them, but introducing children to challenging subjects early in life makes it easier for them to succeed later on. From a young age, Marie Curie had an affinity for math and, which led her to go on to be the only person to be awarded Nobel Peace Prizes in two different sciences. For Stephen Hawking, with both parents being doctors and Oxford graduates, he was encouraged to follow his passions and went on to shock the science community with his research about black holes. Spark curiosity in a child and watch them develop a lifelong enthusiasm for learning!

More than an educational primer, these stories also illustrate and explore the vital role women have played in history. Showing young girls such role models empowers them to follow their passions and enter a field typically dominated by men. But regardless of gender, *Science Wide Open* books encourage all children to make real-world connections that sharpen their analytical skills and give them a head start in STEM (science, technology, engineering, and math).

An easy choice for the home, library, or classroom, our *Science Wide Open* series has something to spark or sustain budding curiosity in any child and the series is growing! Watch for *Women in Space Science*, *Women in Zoology* and *Women in Engineering* coming soon.



Enjoy!

Dia

Dia L. Michels
Publisher, Science Naturally

Meet the Women

Women in Physics/Las mujeres en la física introduces children to the fascinating world of physics through the lens of some of the most important women in scientific history. As readers learn about each woman's accomplishments and their methods of research, they will be able to see the immense impact physicists have had on everyday life. Readers will discover the diverse subjects of physics and become confident in starting their own experiments and satisfying their own curiosities.

Women in Physics/Las mujeres en la física explores the discoveries of the following women:

Émilie du Châtelet
A physicist whose gift with languages allowed her to translate one of the most important scientific texts.

Laura Bassi
Bassi fought hard against gender discrimination and became the first female university professor.

Marie Curie
Curie's work with radiation led her to discover two new elements and win the Nobel Prize.

Irène Joliot-Curie
Joliot-Curie's discovered how to artificially make radioactive material.

Chien-Shiung Wu
A physicist whose work with radiation was proof that a widely accepted law was incorrect.

About the Author: Mary Wissinger

Mary was born in Wisconsin where she spent most of her childhood singing, reading, and daydreaming. She dove into storytelling through acting, singing, and writing (and writing and writing).

While spending time as a classroom teacher sharing the magic of music, she saw firsthand the incredible life-changing power of stories. The stories children read become the stories they play, and then the stories they tell.

Mary can now be found at her standing desk in St. Louis, MO, writing stories that inspire curiosity about the world and connection with others. (But don't worry, she still sings with the Saint Louis Symphony Chorus.)

Mary is also the author of *Women in Biology/ Las mujeres en biología* and *Women in Chemistry/Las mujeres en química. Women in Medicine, Women in Engineering*, and *Women in Botany* will be released in the fall of 2021. She can be reached at Mary.Wissinger@ ScienceNaturally.com.

About the Illustrator: Danielle Pioli

As children usually do, Danielle Pioli always loved drawing. The idea of creating a whole universe—from her mind to paper—made her fall in love with art and storytelling. She also always felt like a healer at some level. As a child in Sao Paulo, Brazil, she was so drawn to magic—what she calls Quantum Physics now—that she was certain she could heal and help people. Because of this, she grew up to become an Artist and Hypnotherapist/Energy Healer.

Danielle is also the illustrator of *Women in Chemistry/Las mujeres en química* and *Women in Biology/Las mujeres en biología*. She can be reached at Danielle.Pioli@ ScienceNaturally.com.

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Science Naturally would like to thank the following people
for their hard work, invaluable insight, and dedicated time in creating
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Section 1: Book-based Activities

The activities in this section use only the book and conversation as tools to take advantage of the diversity of subjects in science and to explore key concepts about physics and the natural world at large.

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Pre-Reading: English Physics Glossary

Women in Physics delves into the many different disciplines in physics, introducing children to complex subjects, such as energy, radiation, force, gravity, and research. With these new concepts comes a new set of vocabulary. Over the course of reading this book, children will master these words and consequently understand scientific information while learning new terms with which they may express themselves.

The following glossary can be found on pages 36 and 37 of *Women in Physics.*

Atoms: The building blocks that put together our universe. Different kinds of atoms are made by combining different numbers of protons, neutrons, and electrons.

Einstein, Albert: One of the most famous scientists in history, known for his theories of relativity (which changed our understanding of gravity) and mass-energy equivalence (E=mc2). He was born in 1879 in Germany. He received his education in Italy, and moved to the U.S. in 1933.

Electrons: Very teeny particles with a negative electric charge. Electrons travel around the nucleus of every atom.

Element: A basic substance made of one type of atom that usually cannot be separated into simpler substances.

Energy: The cause of any movement or change. The greatest source of energy on Earth is the Sun. Other forms of energy include thermal, mechanical, electrical, chemical, gravitational, sound, and nuclear.

Experiment: A test to collect information about the world to see if a hypothesis is correct.

Force: The push or pull on something when it interacts with something else. A force can cause an object to move faster, slow down, stay in place, or change shape.

Fulcrum: The pivotal point that supports the movement of a lever, such as the center point of a see-saw.

Gravity: A force that attracts ALL objects toward each other. This force gets bigger as the objects get bigger, which is why our bodies feel the force of gravity from the Earth, but not from a spoon or apple.

Hypothesis: An educated guess that a person makes to explain something they think is true or will happen.

Mass: A measure of how much matter is in an object. Mass is usually measured in kilograms (1 kg = a little over 2 pounds). Mass is different from weight because the mass of an object never changes, but its weight will change based on its location in the universe.

Matter: Anything that takes up space and has mass.

Neutrons: Very teeny particles with no electric charge, found in the nucleus of most atoms.

Newton, Isaac: An English physicist and mathematician credited with the development of calculus and modern physics, including the laws of motion and the theory of gravity. He was born in 1642 and published his most important work, the Principia, in 1687.

Nobel Prize: A set of very prestigious annual international awards recognizing academic, cultural, and scientific advances. The awards are named for Swedish scientist Alfred Nobel and were first awarded in 1895.

Observation: Using our senses to collect information about the world around us.

Physics: The study of matter and energy, and how they interact. Physicists observe everything from tiny particles to the whole universe and use mathematics to develop theories for why certain things happen.

Radioactivity: The particles and energy an atom gives off when its nucleus is broken apart. It is measured in a unit called the "curie," abbreviated as "Ci," after Marie Curie and her physicist husband, Pierre Curie.

Research: To investigate and study something in order to learn new things about it.

X-Ray: Invisible waves of energy that can pass through solid objects. X-ray images can show the inside of an object, like a suitcase or a person's body.

Pre-Reading: Spanish Physics Glossary

Las mujeres en la física delves into the many different disciplines in physics, introducing children to complex subjects, such as energy, radiation, force, gravity, and research. With these new concepts comes a new set of vocabulary. Over the course of reading this book, children will master these words and consequently understand scientific information while learning new terms with which they may express themselves.

The following glossary can be found on pages 36 and 37 of *Las mujeres en la física*.

Átomos: Los bloques fundamentales que forman nuestro universo. Las distintas combinaciones de protones, neutrones y electrones forman diferentes tipos de átomos.

Einstein, Albert: Es uno de los científicos más famosos en la historia. Conocido por su teorías de relatividad (Lo que cambió nuestro entendimiento de la gravedad) y la equivalencia demasa energía (E=mc2). Einstein nació en Alemania en 1879, recibió su educación en Italia y se trasladó a Estados Unidos en 1933.

Electrones: Partículas muy pequeñas con una carga eléctrica negativa. Los electrones viajan al rededor de el núcleo de cada átomo.

Elemento: Un elemento es una sustancia compuesta de un tipo de átomo que usualmente no puede ser separado en otras substancias más simples.

Energía: La causa de cualquier movimiento o cambio. La mayor fuente de energía en la tierra es el sol. Otras fuentes incluyen: la energía térmica, mecánica, eléctrica. química, gravitacional, sonido, nuclear.

Experimento: Es un estudio para recolectar información acerca del mundo para ver si una hipótesis es correcta.

Física: El estudio de la materia y la energía y cómo interactúan entre ellas. Los físicos observantodo, desde las partículas más pequeñas a la materia más grande en el universo, y usan las matemáticas para desarrollar teorías de porqué y cómo pasan las cosas.

Fuerza: El empuje o atracción hacia algo cuando interactúa con algo más. Una fuerza puede causarque un objeto se mueva más rápido, más despacio, se quede en su lugar o cambie de forma.

Fulcro: El punto pivote que soporta el movimiento de una palanca, como el punto central de un balancín.

Gravedad: Fuerza que atrae a TODOS los objetos entre sí. Esta fuerza se hace más grande conforme los objetos se hacen más grandes, y por eso nuestros cuerpos sienten la fuerza de la gravedad de la tierra, pero no de una cuchara o una manzana.

Hipótesis: Es una suposición hecha por un persona para explicar algo que se piensa cómo verdadero o posible.

Investigación: Hacer un estudio de algo con el fin de aprender nuevas cosas.

Masa: La masa es una medida de cuánta materia existe en un objeto. La masa es usualmente medida en kilogramos (1 kg = un poco más de 2 libras).

Materia: Todo lo que tiene masa y ocupa espacio.

Neutrones: Son partículas muy pequeñas con ninguna carga de electricidad. Los neutrones se encuentran en la mayoría de los átomos.

Newton, Isaac: Un físico inglés y matemático acreditado con el desarrollo del cálculo en la física moderna, incluyendo las leyes del movimiento y la teoría de la gravedad. El nació en 1642 y publicó su trajo mas importante Principia en 1687.

Observación: Usar nuestros sentidos para recopilar información sobre el mundo a nuestro alrededor.

Premio Nobel: Es un conjunto de prestigiosos premios internacionales que ocurren anualmente y son reconocidos por la academia, cultura y los avances científicos. Los premios son nombrados por el científico Suizo Alfred Nobel y fueron otorgados por primera vez en 1895.

Radioactividad: Las partículas y la energía que un átomo emite cuando su núcleo se rompe. Se mide en una unidad llamada ““curie”, abreviada como ““Ci”.

Rayos X: Ondas de energía invisibles que pueden atravesar objetos sólidos. Las imágenes de Rayos-X pueden mostrar el interior de un objeto, como el esqueleto humano.

Pre-Reading: Book Walk

Grades: K–5
Subject: Reading, language arts
Skills: Active listening, critical thinking, making predictions
Common Core English Language Arts: CCSS.ELA-LITERACY.CCRA.R: Key Ideas and Details

A book walk is a pre-reading activity that aids in reading comprehension and builds curiosity and enthusiasm about reading this book. It prepares students to think about the important questions they should be asking as they read. For younger students, this book walk (or picture walk) also helps develop their reading skills. They learn to use the visual text of the pictures to understand what the story means and make educated guesses about unfamiliar words.

Get set up for story time. Have students sit in a circle so they can all see you and can talk with one another.

Tell your students that you will be reading a book called *Women in Physics/Las mujeres en la física*. Discuss and ask them: What do you think this book will be about?

If you have gone over the terms first, this is a perfect time to review. Ask your students questions. What is physics? What words do you know that are related to physics?

Then, show them the book's cover and ask them new questions. Now what do you think it will be about? Can they be more specific than before? Can you name the objects on the cover? What is the girl holding? What do these items have to do with physics?

Slowly flip through the book, page by page (or looking at a few pages you selected in advance), without reading any of the words. Ask your students questions about the pictures they see. What is going on here? What are the women doing on the page? What animals and plants do you see? What objects do you recognize? What relationship do all of these things have with science? What don't you recognize?

Give vague responses that don't give away the story. Say things like, "Are you sure about that?" or "That's possible!" or "What makes you think that?" This will plant the seed for an enthusiastic discussion while you read the book or when the reading is done.

Flip the book over and read the back cover, then start your usual read-aloud session.

Activity: Exploring Physics

Grades: 2–5

Subject: Physics, scientific careers

Skills: Identifying, sorting, observation, active reading

Materials: *Women in Physics/Las mujeres en la física*

Common Core English Language Arts
CCSS.ELA-LITERACY.CCRA.R: Key Ideas and Details

Background

Physics, the study of the nature and properties of non-living matter and energy, is a huge, diverse branch of science. It focuses on everything from big questions, like how the universe began, to small particles, such as individual atoms. Classical physics focused mainly on light, sound, waves, heat, and electricity. After the discovery of the atom, subjects within physics increased. Modern physics endeavors to study the smallest of particles, like those in the quantum realm. Different topics include space, radiation, lasers, plasma, and nanotechnology.

Mechanics: The study of motion.

Molecular Physics: The study of the physical properties of atoms.

Nuclear Physics: The study of atomic nucleus structures and the radiation from unstable nuclei.

Mathematical Physics: Applying math to physics to solve problems.

Quantum Physics: The study of behavior in particles even smaller than atoms.

Thermodynamics: The physics of heat and energy.

Activity

1. Review the background information with your students.

2. Read through the book together, paying special attention to the images and the stories of the women. Ask the following questions: What kind of physicist would study this discipline? Is it more than one? How does this woman's work fit into the classifications above?

Possible Answers

Mechanics: Gravity, force, etc.	**Scientists:** Émilie du Châtelet & Laura Bassi
Molecular Physics: Atoms and molecules, etc.	**Scientists:** Marie Curie, Irene Joliot-Curie, & Chien-Shiung Wu
Thermodynamics: Heat, energy, etc.	**Scientists**: Laura Bassi
Nuclear Physics: Radiation, atoms, etc.	**Scientists**: Marie Curie, Irene Joliot Curie, & Chien-Shiung Wu
Mathematical Physics: Euations, etc.	**Scientists**: Émilie du Châtelet

Discussion

Talk to your students about the ease or difficulty of the activity. The distinctions between the different groups are not always clear, and the scientists might be able to fit into several categories. Ask your students if they believe this overlap is a good or bad thing.

Information adapted from the article, "The Different Fields of Physics"

Activity: Careers in Physics

Grades: 2–5

Subject: Physics, research, compare and contrast

Skills: Researching and organizing

Materials: *Women in Physics/Las mujeres en la física*, worksheet

Next Generation Science Standards: ETS1:B Developing Possible Solutions

Background

All of the women featured in *Women in Physics/Las mujeres en la física* are physicists. They all study how everything in the universe moves and works. This is because there are several branches of physics, like engineering and quantum physics, which means there are a variety of career paths for physicists. Below are just some career paths/jobs for physicists:

Nuclear Physicist	***Health Physicist***
Astronomer	***Technical Writer***
Patent Agent	***Process Engineer***
Meteorologist	***Physics Teacher***
Laser Engineer	***Seismologist***
Optical Engineer	***Energy Policy Analyst***
Solar Physicist	***Science Journalist***

Activity

1. Read *Women in Physics/Las mujeres en la física* to your students, as well as the background information above.

2. Have students choose and research two careers from the list above. Ask them to take notes on how those careers are similar and how they are different. Some categories to pay attention to are educational requirements, skills needed, and branch of physics.

3. Ask the students to fill out the template found on the next page, to compare and contrast the two careers.

Discussion

Ask your students why they chose these two particular careers. What was similar about them and what was different? What did they like and dislike about them? Do they think that either career is one they would like to pursue when they grow up?

Information adapted from: https://www.trade-schools.net/articles/jobs-for-physics-majors

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Name____________________ Date:_______

Compare and Contrast: Careers in physics!

____ and

________________________________ are similar because...

____

____

____

____ and

________________________________ are different because...

____

____

____

Activity: Branches of Physics

Grades: 2-5

Subject: Physics, research, sorting

Skills: Researching and Organizing

Materials: *Women in Physics/Las mujeres en la física*

Next Generation Science Standards: ETS1:B Developing Possible Solutions

Background

Physics is the scientific study of matter and energy, and how they interact. Rarely is there a physicist who studies just one branch of physics, just like the women in *Women in Physics/Las mujeres en la física*. There are different branches of physics that scientists can specialize or work in. Take a look at the list below:

Astronomy and Astrophysics: the study of the behavior, physical properties, and dynamic processes of matter and objects outside of Earth's atmosphere.
Biophysics: the study of how the laws of physics apply to biological matter and objects.
Chemical Physics: the branch of science that studies chemical processes from a physics perspective.
Cosmology: a science that uses both theory and observation to study the physical universe.
Engineering Physics: the combined discipline of engineering, physics, and math to better understand concepts such as electricity, statics, thermodynamics, and more.
Geophysics: the study of the physics of the Earth.
Medical Physics: the use of physics principles, methods, and techniques to improve human health and well-being through research and practice.
Optics: the study of the behavior and properties of light, including how it interacts with matter.
Particle Physics: the study of subatomic particles and their properties, relationships, and interactions.
Quantum Computing: the use of quantum theory, which explains the behavior of energy and material on atomic and subatomic levels, to develop computer technology.

Activity

1. Read *Women in Physics/Las mujeres en la física* to your students, as well as the background information above.
2. Ask students to get into pairs or groups to discuss the different branches of physics. Specifically, ask them to come up with careers in each branch. Once they have had time to come up with specific careers, ask them to come up with information about one career for one branch. Ask them to present their findings to the class.

Discussion

Ask your students why they chose that particular career. What did they like or dislike about their chosen career, and what did they like or dislike about the other chosen careers? What did they find similar or different about their careers and others?

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Activity: Tools of the Trade

Grades: 2-5

Subject: Problem-solving, scientific tools, physics

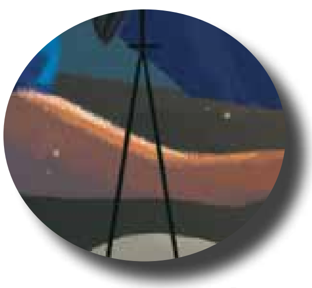
Skills: Identifying, sorting, observation, active reading

Materials: *Women in Physics/Las mujeres en la física*

Next Generation Science Standards:
LS4.D: Biodiversity and Humans
ETS1.A: Defining and Delimiting an Engineering Problem
ETS1.B: Developing Possible Solutions

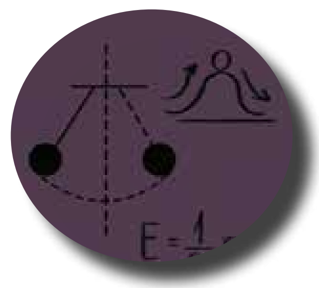
Background

All science is about problem-solving. Part of that process is deciding on which tools will help scientists find the solution. A tool is an object used to extend the ability of an individual to modify features of the surrounding environment. A number of species can use tools including monkeys, apes, elephants, birds, and sea otters. There are many types of equipment to help scientists observe, measure, collect and gather data. Once all of the data have been gathered, different tools are used to make sure the information is logical, clear, and concise, so that it can be shared with the world.



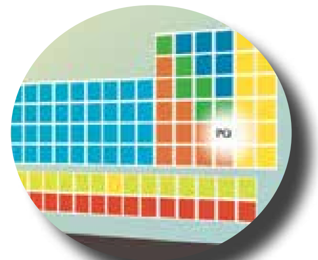
Protractor, Scale, Hardware Tools
These tools are used to make accurate measurements.

Glassware
Beakers and test tubes are useful for mixing and measuring liquids.



Math
Physicist requires a lot of prior math knowledge.

Charts, Diagrams, Drawings, Journals
Physicists use these to record, organize, and present their research.



Periodic Table:
The periodic table is a great resource for knowing all of the elements and their properties.

Activity

1. Go over the background information and types of tools with your students.
2. Read *Women in Physics/Las mujeres en la física*, paying specific attention to the kinds of tools the scientists are using. Ask your students the following questions: What tool is this? How and why is it being used? Do we have the tools in our school? Could a different tool be used here? How does this tool help you?

Expand the Activity

To cement the students' knowledge, name organisms or objects not in the book and ask what tool they would use to study it. Try to get them to think out of the box and use tools that weren't in the book either. For example, pick something in the room that is high up and too big to move. Can your students recognize that they will need some sort of ladder?

Discussion

Biologist Jane Goodall found that some primates, such as chimpanzees, use tools like humans. Do students know other animals that use tools? Most animals have adapted over time to find or make tools to help them survive. A dog's nose, the shape of a bird's beak, and opposable thumbs are all useful tools. The first tools a scientist uses are often some combination of their five senses: touch, taste, smell, sight, and hearing. Ask your students what tools they think are the most useful. What other natural tools can they name?

Section 2: In the Lab with the Women

The women in this book have been carefully chosen to illustrate the importance of women's contributions in physics and the world. Their discoveries play an essential role in the way we go about our daily lives, impacting our understanding of everything from medicine to clean energy.

The activities in this section allow students to delve further into these women's discoveries and conduct experiments of their own.

Émilie du Châtelet

1706–1749

France

Natural philosopher, mathematician, physicist

Most known for her translation and backing of Isaac Newton's physics.

Information adapted from the December 2008 edition of APS News', "This Month in Physics History"

Homeschooled
Unlike most women at the time, Du Châtelet received a wonderful education at home. She was able to speak six languages by the age of 12 and had even taken fencing lessons. Still, her interest in science and math were not accepted for a lady at that time, and her mother threatened to send her to a convent if she kept it up. Du Châtelet's father, however, used his wealth and connections to help her discuss and learn about science and math with prominent scientists.

Winning Streak
Du Châtelet was able to use mathematics skills to her advantage in games of chance. She was so good at gambling that she was able to use her prize money to buy books and laboratory equipment to help further her research.

Life as a Woman
Du Châtelet was not able to receive a typical university education because of her gender, but she continued her studying by inviting scientists to her home for scholarly conversation. At 18, Du Châtelet married an army officer, who was frequently away from home. This left Du Châtelet free to conduct her research secretly. At 42, she became pregnant with her fourth child. Knowing that childbirth for a woman her age often had deadly complications in that historical era, she began to work 18 hours a day on her biggest project, translating Newton's Principia, until she finished. As she suspected she would, Du Châtelet died in childbirth.

Newton's *Principia*
In 1687 Issaac Newton published one of the most important works in scientific history: Philosophiæ Naturalis Principia Mathematica (Latin for Mathematical Principles of Natural Philosophy). Commonly referred as the Principia, this work established laws and theories of motion and force that are still used in today's science. In it, Newton covered topics such as gravity, friction, force, motion, and the solar system. From his work come the famous ***Newton's Laws of Motion***.

Activity: Get the Ball Rolling

Grades: K–5

Subject: Motion, force

Skills: Active listening, critical thinking, inference

Materials: Foam ball, table, pipe cleaner

Next Generation Science Standards
PS3.C: Relationship Between Energy and Forces

Background

Isaac Newton's three laws of motion are fundamental concepts in physics. He formed these conclusions by using mathematical equations which heavily influenced calculus. A simplification of these laws is found below. In this activity, students will be introduced to these laws in an easy and simple manner.

1. If an object is not moving, it will not start moving by itself. If an object is moving, it will not stop or change direction unless something pushes it.

2. Objects will move farther and faster when they are pushed harder.

3. When an object is pushed in one direction, there is always a resistance of the same size in the opposite direction.

Activity

1. Go over the background information with your students and read Emilie du Châtelet's Biography on page 26 of this guide.

2. To demonstrate the first law, set the foam ball on the stationary desk. Ask students why the ball is not moving, and what law of motion is being observed. Then, push the ball and ask students why it moved.

3. To demonstrate the second law, let the ball free-fall to the ground and ask students how fast it fell. Next, throw the ball (with force) to the ground and repeat the question. Students should realize that the more force you put into throwing the ball, the faster it will go.

4. To demonstrate the third law, push on the ball with a pipe cleaner so that the ball rolls forward and the pipe cleaner bends with the force. Ask students why they think the pipe cleaner bent. Explain that the ball exerted force on the pipe cleaner, just as the pipe cleaner did to the ball.

Expand the Activity

Have students break into three groups and hand out poster-making materials. Assign each group a law and have them design a poster that explains each law and provides an example. Hang posters around the class as a resource during other lessons.

Activity: Flick It!

Grades: K–5

Subject: Inertia, gravity

Skills: Active listening, critical thinking, inference

Materials: Index cards, pennies, cups of water

Next Generation Science Standards
PS3.C: Relationship Between Energy and Forces

Background

Inertia is a simple term that refers to the same principle described in the first law of motion: an object resists changes to its state of motion. This concept can be observed in everyday life by noting objects do not move unless acted on by an outside force. An object's inertia is directly related to its mass. The more mass an object has, the more it resists changes in its state of motion.

Activity

1. Go over the background information with your students. This activity can be done as a demonstration for younger students.

2. Give each student five pennies, an index card, and a cup of water. Tell them to stack four of the pennies, leaving one out.

3. Tell students they will flick that one penny at the stack of pennies. Before they do this, ask them what they think will happen. If done correctly, only one penny from the stack will fly off when flicked.

4. Next, have students place an index card on top of the cup of water. Tell them to place the stack of pennies on top of the card.

5. Tell students they will be firmly flicking the index card away from the cup. Ask them to predict what will happen before doing it. If done correctly, the index card will move away from the cup, but the pennies will fall in.

Discussion

Ask students why they think the pennies behaved the way they did. Encourage them to reflect on the concept of force, gravity, and inertia. In both demonstrations, the stack of pennies stay in the same place because of inertia. While force is applied to the index card and the bottom penny, the stacks are held in place by gravity.

Activity adapted from the article, "Easy Inertia Science Experiments with Pennies."

Laura Bassi

1711–1778

Italy

Physicist, philosopher, mathematician

Most known for being the first female university professor.

First in the World

Bassi broke through numerous boundaries over the course of her life. In the 1700s women were discouraged from higher education and enthusiasm for the sciences. In fact, the world of academia was widely seen as an exclusively male environment. This did not stop Bassi. She was the first woman to earn a doctorate, the highest degree one can earn in education, in science; she was the second woman, however, to earn a doctorate in philosophy. Bassi was also the first female, salaried teacher at a university. In 1732 she was elected to the Academy of the Institute for Sciences in Bologna, where she was the first and only female member. Despite her accomplishments, Bassi found the restrictions on women teaching in public so frustrating that she began offering private lessons in her home.

Bassi and Newton

Bassi was widely acclaimed for being one of the earliest scientists who understood and taught Newtonian physics. One of Bassi's biggest accomplishments was her explanation of Newton's prism experiment and ***refraction***, which demonstrated that light could bend and was made up of a spectrum of colors.

Missing Pieces

Though it is clear Bassi was an important figure in scientific history, it is not clear just how influential she was. While the Bologna Academy archives contain a list of 32 research papers that Bassi presented, all but one of her unpublished papers were lost during the turmoil of the Napoleonic era.

The Fight for Equality

Pope Benedict XIV wanted to restore glory to the Bologna Academy where Bassi worked. He created an elite group of scholars called the Benedictines, who would be given annual sums of money to pursue and present research. 24 Benedictines were chosen; they were all men. Frustrated with the representation, Bassi wrote to the Pope and asked him to include her in the group. The Pope agreed, but her male colleagues were not entirely welcoming. Bassi was not given full privileges of membership; she did not have voting rights and couldn't attend every meeting. Despite this, the men in the group were impressed with her research and brilliance, and they began to admit more women as honorary members, including Emilie du Châtelet.

Information adapted from the article, "Laura Bassi and the city of learning."

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Activity: Make a Rainbow

Grades: K–5

Subject: Light, color spectrum, waves

Skills: Active listening, critical thinking, observation

Materials: Shallow pan, mirror, water, flashlight, white paper

Next Generation Science Standards
PS4.A: Wave Properties

Background

Light can behave like waves. Two defining factors of light are ***wavelength***, or distance between two peaks, and ***frequency***, or how fast the wave vibrates. Color directly corresponds to light and waves. Because each color has a different wavelength and frequency, it bends in different ways. Refraction refers to the way that light bends when it passes through different mediums, such as air or water. This means that when a wave of light passes from air to water, it will change directions.

Activity

1. Go over the background information with your students and read Laura Bassi's Biography on page 31 of this guide.

2. Fill the pan halfway with water. Place the mirror in the water at an angle.

3. Ask students what color they think light is. Mention neon lights to have them consider if light is more than one color.

4. Then, shine the light at the part of the mirror that is submerged in water. Hold the white paper above the mirror and adjust the angle until a rainbow of colors appears on it.

5. Now, repeat the question. What is the color of light? Answer: Light is a combination of all colors.

Expand the Activity

Demonstrate refraction to younger students by placing a pencil in a clear cup of water. The part of the pencil in the water should appear shifted. This can be done as a demonstration or individually by students.

Discussion

Ask students if this looks like the rainbow they are familiar with. Tell them to guess why that might be and how a rainbow might be formed. Ask them to think about the type of weather that typically comes before a rainbow. When it rains, all of the different water puddles refract, or bend the light so that it separates into the full color spectrum, causing a rainbow to form.

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Activity: Warm Colors

Grades: 3–5

Subject: Light, color spectrum, waves

Skills: Active listening, critical thinking, observation, measuring

Materials: Sunny day, black, white, red, and blue construction paper, tape, thermometers, timer, Time Sheet (page 39)

Next Generation Science Standards
PS4.A: Wave Properties
PS3.B: Conservation of Energy and Energy Transfer

Background

When we see an object, we are really seeing reflected light. When light hits an object, some of the light is absorbed, and some is reflected. Different wavelengths and frequencies produce different colors. When something looks red to us, that means that object is absorbing all colors of light except for red. Black objects reflect almost no light, while white objects reflect every color the same.

Activity

1. Go over the background information with your students and read Laura Bassi's Biography on page 31 of this guide.

2. Divide students into groups and give each group a thermometer, timer, each color of paper, and a Time Sheet (page 37 of this guide).

3. Then, instruct students to fold each piece of construction paper in half lengthwise. Have students tape the bottom and side shut so that a skinny pocket is formed. Repeat for each color.

4. Head outside and tell students to take the temperature of each pocket. Ask them to record their findings and hypothesis on the Time Sheet.

5. Every ten minutes, for a total of 30 minutes, have students take the temperature of each pocket and record their findings.

6. Discuss the conclusions as a class or within groups. Which pockets heated the fastest? Why?

Discussion

Ask students what the relationship between light and heat is. Where there is light, there is most often heat. Ask students if they were surprised by the results. Remind them that the color black is a reflection of almost no light, while white is a reflection of every color. When light is not reflected, it is absorbed.

This activity was adapted from the article, "Which Color Absorbs the Most Heat."

Name: ________________ **Date:** ______

Question: ______________________________

____

Hypothesis: ______________________________

____

Materials

Black:

10 min: ______ temp: ______

20 min: ______ temp: ______

30 min: ______ temp: ______

Red:

10 min: ______ temp: ______

20 min: ______ temp: ______

30 min: ______ temp: ______

White:

10 min: ______ temp: ______

20 min: ______ temp: ______

30 min: ______ temp: ______

Blue:

10 min: ______ temp: ______

20 min: ______ temp: ______

30 min: ______ temp: ______

Conclusion: ______________________________

____

____

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Activity: Giant Bubbles

Grades: K–5

Subject: Surface tension, molecules, attraction

Skills: Active listening, critical thinking, observation

Materials: Bubble solution, wire coat hanger, shallow tub or tray, yarn (optional)

Next Generation Science Standards
PS4.A: Wave Properties
PS2.B: Types of Interactions

Background

Surface tension refers to the strong attraction between water molecules. When droplets of water form, it is because water molecules are naturally attracted to each other. When soap is added to water, a chemical reaction occurs so that the surface tension, or attraction between water molecules, lessens. Bubbles are able to form because the lower surface tension allows the molecules to spread out. Still, the water molecules are attracted to each other, and the bubble will pull as tightly as it can, like a stretched balloon, so that the molecules can stay close together.

Activity

1. Before the activity begins, bend the coat hanger into a flat hoop with the hook sticking up at an angle to use as a handle. If you have trouble picking up soap with the hanger, you can wrap yarn around the metal.

2. Go over the background information with your students and read Laura Bassi's section in W*omen in Physics*.

3. Fill the shallow tray with bubble solution and submerge the hoop in it. Gently lift the hoop from the tray then swing it through the air. To close the bubble, twist the hoop to seal it off.

4. Ask students to describe the shape of the bubbles and the various patterns and colors they see inside.

Expand the Activity

Give students a penny, a pipette, and a cup of water for another activity on surface tension. Tell students to slowly place drops of water on a penny. Have them count the number of droplets that can fit on the penny's surface. What number is too many? At some point, the attraction of the water molecules will not be strong enough to overcome gravity.

Additional Information

Ask students what kind of colors they see in the bubbles. Light waves are reflected by the soap and water differently. The thicker the layer of soap, for example, the more red light will be absorbed, meaning that only blue and green colors will appear. Consider pairing this activity with Warm Colors (page 35 of this guide) to help students fully understand the relationship between color, light, and waves.

This activity was adapted from the Exploratorium *website.*

Marie Curie

1867–1934

Poland

Physicist, chemist

Most known for discovering two elements and being the first woman to win the Nobel Prize and only woman to win two Nobel Prizes.

A Rough Start

Curie faced many challenges throughout her life, beginning with her mother's death when she was only 10. Curie was born and raised in Poland, which was occupied by Russia at the time. She attended a secret school that changed locations frequently to avoid being caught by the Russians. Curie named one of the elements she discovered, polonium, after her homecountry.

Perfect Match

Curie married a well-known physicist, Pierre Curie, in 1895. Pierre was known for discovering a type of electricity called piezoelectricity with his brother. He was amazed by Curie's brilliance and encouraged her to pursue scientific research—a field which was not typically accepting of women. Unfortunately, the Curies worked with radiation in their laboratory so frequently that they had many health issues.

A Working Mother

At the time, mothers were expected to dedicate all of their time to their children. Curie faced criticism from many people who believed that she spent too much time in the laboratory and not enough time with her daughters. Curie ignored such criticism, and she and her children all went on to do amazing things. One of her daughters, Irene, also won a Nobel Prize! Read more about Irene on page 47 of this guide.

Radioactive

Curie's main focus was on ***radioactivity***, or when small particles emit energy, or other particles. Over the course of her research, she discovered two radioactive elements which she named polonium and radium. The energy produced from radioactive material can be harmful, causing health issues like cancer, or helpful, like when it is used in technology. Curie's research was vital to the development of x-rays in medicine. In World War I, Curie helped equip ambulances with x-rays, and she even drove them to the front lines.

Sexism in Science

Though Curie was awarded the Nobel Prize alongside her husband, many people believed that, as a woman, she was merely an assistant. For many years after her accomplishments, she was not given the recognition that she deserved. When her husband died, she applied for membership at the French Academy of Sciences, where her husband had been a member. She was denied by two votes and told that women could not be part of the Institute of France. When she won her second Nobel Prize, she made it very clear that her work was her own, so that no one could claim her husband had done the true work.

Information adapted from the article, "Madame Curie's Passion."

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Activity: Radiation Shield

Grades: 3–5

Subject: Radiation, scientific method

Skills: Active listening, critical thinking, experimentation

Materials: Flashlight, metric ruler, white copy paper, white tissue paper, white construction paper, white cardstock, Shielding Worksheet (page 45)

Next Generation Science Standards
PS2.B: Types of Interactions
PS3.B: Conservation of Energy and Energy Transfer

Background

When scientists first began studying radioactive material, they did not understand how harmful radiation was to humans. Everyone is exposed to radiation during their lives—the sun, medicines, different building materials, and more—those who worked closely with radiation experienced too much. Now that scientists know that radiation has the potential to be dangerous, they use barriers such as magnetic fields, liquid hydrogen shielding, and special clothing to protect themselves.

Activity

1. Before the activity begins, cut the different paper materials into squares of the same size. They should be large enough to cover the beam of the flashlights.

2. Go over the background information with your students and read Marie Curie's Biography on page 41 of this guide.

3. Tell students they will be trying to solve a problem: what material will block the most simulated radiation? Then, divide students into groups of three and hand out a set of materials to each group, making sure they all have a small stack of each paper.

4. Have students make a hypothesis about which material will block out the most light, which represents a ray of radiation. They can write their findings on the Shielding Worksheet on page 45 of this guide.

5. Have one student turn the flashlight on and hold it against the table, so that it points up.

6. The second student will select one material and stack sheets of paper over the flashlight's beam until it is completely blocked.

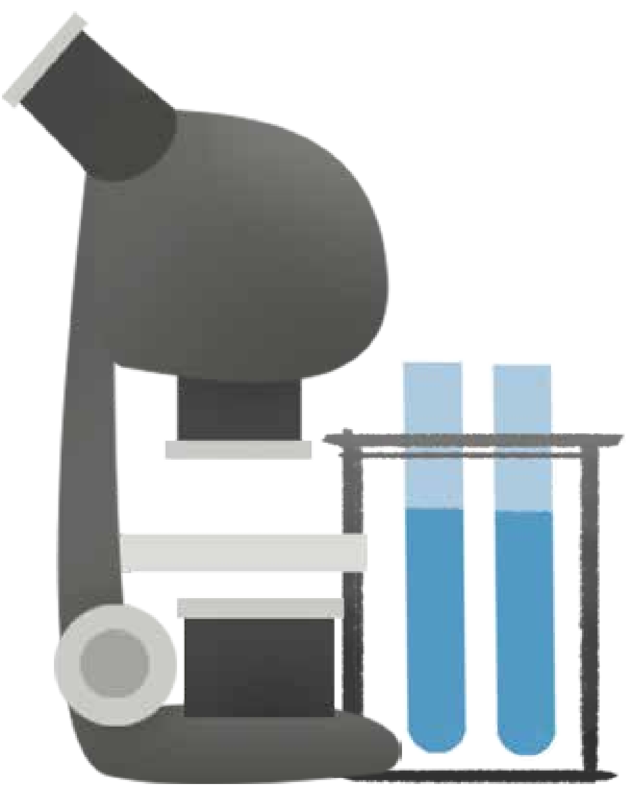
7. A third student will record the number of sheets it takes for each material to block out the beam.

8. Instruct students to repeat steps 5–7 for each material. Students should rotate positions for each new material.

Activity continues on the following page.

Additional Information

Astronauts are another group of people who have to be extra cautious about getting radiation poisoning. Space radiation comes from the Sun and other stars, so NASA, the National Aeronautics and Space Administration, and other space programs must find the best way to protect astronauts during their trips to space. The ozone layer in Earth's atmosphere blocks most of the radiation from the sun, but people wear sunscreen to protect themselves from the rays that do enter. Astronauts fly above the ozone layer, so their spaceships and spacesuits must be made out of strong material that can block radiation. Another way NASA protects astronauts is by limiting the number of times an individual can go into space.



Shielding Worksheet

Question: ______________________________

____

____

Hypothesis: ______________________________

____

____

Materials

Printer Paper

Number of Sheets:_______

Construction Paper

Number of Sheets:_______

Tissue Paper

Number of Sheets:_______

Cardstock

Number of Sheets:_______

Conclusion: ______________________________

____

____

Irène Joliot-Curie

1897–1956

France

Chemist, physicist

Most known for her discovery of induced, or artificial, radioactivity.

In Her DNA

Joliot-Curie was the daughter of Marie and Pierre Curie (read more about them on page 41 of this guide). Together with her husband, Frédéric Joliot-Curie, she was awarded the Nobel Prize in Chemistry for their discovery of artificial radioactivity. This made the Curies the family with the most Nobel laureates—five in total. Marie Curie received two, her husband one; the Joliot-Curies won one; and her second daughter was the director of the United Nations Children's Fund (UNICEF) when it won a prize in 1965.

Wartime

World War I interrupted Joliot-Curie's college studies. When she was 18, she joined her mother in supporting wartime efforts. Marie Curie had established 20 mobile field hospitals equipped with X-ray equipment she had developed. Joliot-Curie ran the hospitals for her as they both served as nurses and radiographers. Unfortunately, their exposure to radiation—in the hospitals and their research—caused the mother and daughter duo to have many health issues, which they both eventually passed away from.

Power Couple

Joliot-Curie met her husband, Frédéric, in a radiochemical laboratory. They combined their research together and focused on studying nuclei (the plural of nucleus) in atoms. In 1934, the couple discovered how to create radioactive material from stable elements.

An Important Discovery

The Joliot-Curie's discovery of how to create radioactive material was a very helpful and timely scientific breakthrough. Partly due to Marie and Pierre Curie's research, the use of radiation in medicine and technology was rapidly growing. Artificial radioactivity allowed people to make materials quickly and cheaply. Their research also led to the discovery of nuclear fission, which is now used to create clean energy.

Information adapted from the website, History of Scientific Women.

Activity: Nuclear Fission

Grades: 3–5

Subject: Fission, nuclear power

Skills: Active listening, critical thinking

Materials: Balloons

Next Generation Science Standards
PS2.B: Types of Interactions
PS3.B: Conservation of Energy and Energy Transfer

Background

Nuclear fission is the process by which a large atom is split into smaller atoms when it is hit by a neutron. When the split occurs, a large amount of energy is released as radiation and heat, because the smaller atoms don't need as much energy as the larger atom did. When the particle splits apart, two or three neutrons are released with the energy and a chain reaction occurs. When the reaction is controlled properly, the energy can be used to generate electricity. To slow down and manage the reaction, scientists use ***control rods***, which control the amount of neutrons in the reaction.

Activity

1. Go over the background information with your students and review Irene Joliot-Curie's biography on page 47 of this guide.

2. Tell students that the balloons in this activity will represent neutrons. Give each students two inflated balloons and have them stand together in a tightly packed group.

3. Tell students that when a balloon, or neutron, hits them, they should demonstrate nuclear fission by throwing their own two balloons in the air.

4. Grab your own balloon. The reaction starts when you toss the balloon above the students. When it hits a student, that student should throw their own two balloons up. A chain reaction will occur.

5. Repeat the activity. This time, designate different people as "control rods." These students will grab balloons out of the air, imitating the way that control rods absorb neutrons. Before beginning, ask students what they believe will change.

6. Repeat the activity with different amounts of "control rods." Keep increasing the number until the reaction proceeds very slowly, or not at all.

Discussion

Ask students to think about what represented energy in the activity. The balloons signified neutrons, and their energy could be seen in the motion of the balloons. Do your students think that there is more energy or less energy when control rods are present? End the discussion by reminding students that energy is present wherever there are moving objects, sound, light, or heat. When objects collide, like neutrons and a nucleus, energy is transferred or released.

This activity was adapted from Nuclear Science Week

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Chien-Shiung Wu

1912–1997

China

Physicist

Most known for her work on the Manhattan Project and the Wu Experiement.

Symmetry
Wu demonstrated that the Law of Conservation of Parity could be broken. This law stated that nature tended to be symmetrical, meaning that it mirrored itself. One piece of evidence for this was the behavior of magnets. Wu believed that parity, or symmetry, was not always true.

Hard at Work
Wu was supposed to go on vacation with her husband when she had the idea for the experiment that would prove the Law of Conservation of Parity wrong. She sent her husband off without her and conducted the experiment in the days between Christmas and New Year's.

The Wu Experiment
Wu's work is known as the Wu Experiment. Her specialty was in beta decay, which is a type of radiation. To prove parity was not a law, she investigated radioactive decay of Cobalt-60, which spins and emits particles as it decays. Because cobalt-60 spins, the same number of particles should be released on all sides of the atom (think of a sprinkler that turns), according to parity. This wasn't the case. Wu demonstrated that more particles were released on the left side of cobalt-60 than the right.

Mixed Results
Proving parity wrong was such a huge discovery that many people believed Wu had made a mistake. It was only after many people replicated the experiment that Wu's research was accepted. Wu shared her findings with her research partners, Lee and Yang, who published a paper on the topic. Lee and Yang won the Nobel Prize for their work, but like many women at the time, Wu received little to no acknowledgment. Many believe that she should have received the award as well.

Information adapted from the National Park Service *website.*

Activity: Radioactive Decay

Grades: 4–5

Subject: Radioactive decay, half-lives

Skills: Active listening, critical thinking, inference

Materials: Balloons, pennies

Next Generation Science Standards
PS2.B: Types of Interactions
PS3.B: Conservation of Energy and Energy Transfer

Background

Radioactive decay refers to the changes in an atom when the particles become unstable and start to emit energy. The energy that is released from an unstable atom is called radiation. Radioactivity is measured in a unit called the "curie," after Marie and Pierre Curie, who discovered the element radium. A ***half-life*** is the average time it takes for half of the atoms in a sample to decay. For example, the half-life of carbon-14 is 5,730 years. This means that if you had a carbon-14 sample with 100 atoms, 50 of those atoms will have decayed after 5,730 years.

Activity

1. Go over the background information with your students and review Chien-Shiung Wu's Biography on page 51 of this guide.

2. Tell students that their balloons will represent radioactive material that is decaying. Have each student blow up their balloon without tying it off. They should hold the balloon with one hand.

3. At 30-second intervals, have students flip their coins. Those who get tails will have radioactive decay and should let go of their balloon, letting it fly through the air.

4. Record the number of people who had radioactive decay on a place visible to everyone.

5. Repeat steps 3 and 4 until all of the radiation has been released, that is, until all of the balloons are deflated.

Discussion

Ask students to note where the radiation, or balloons, landed when they were released. Was anyone hit by radiation? Have students discuss how many balloons decayed each coin flip. Were students able to predict exactly when they were going to decay? Why or why not? Could they predict where the radiation would go?

Information adapted from Ducksters. *Activity adapted from* Nuclear Science Week.

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Section 3: Hands-on Activities

Eager for more? Physics is the perfect way to introduce children to the world of science. These activities will introduce students to the basic concepts of science through some of the many subjects in physics, laying a foundation for success when these concepts are reintroduced later in their education.

Activity: Physicist Biography

Grades: 2–5

Subject: Physics, research, biographies, presenting and sharing information

Skills: Researching, presenting, organizing

Materials: Physicist Biography (page 59)

Next Generation Science Standards
ETS1.B: Developing Possible Solutions

Common Core English Language Arts
CCSS.ELA-LITERACY.CCRA.R: Key Ideas and Details
CCSS.ELA-LITERACY.CCRA.SL Presentation of Knowledge and Ideas

Background

Now that your students have read *Women in Physics/Las mujeres en la física*, they are ready to create reports of their own. The ability to research, organize, and present information is vital to academic success. Children who begin developing these skills at a young age are better prepared for the future.

A ***biography*** is an account of someone's life. A life story can be presented in many different ways, but the most common is through writing. There are many famous people, both in history and modernity, who have made important scientific contributions to the world. A biographical report is one way to explore and learn more about these people; it helps ensure their accomplishments do not go unrecognized. New solutions and problems are discovered by learning and building upon what people have already done.

Activity

1. Read *Women in Physics/Las mujeres en la física* and go over the background information with the students. Let them know before that they will be making a biographical report about a physicist of their choice.

2. Have the students choose and research their own physicist, filling out the biographical report template, provided on the following page, as they go.

3. When all of the students have finished their reports, have them present their physicist to the class.

Discussion

The goal of this discussion is to have students recognize that a biographical report is just one way to present information. A book, such as *Women in Physics/Las mujeres en la física*, is another way. Ask students how they decided to choose the information that they did. Was there a lot of information to choose from? By choosing the most important information, they put together a short report; the more information you choose to include, the longer their report would be. Is a report the best way to present a biography? For example, would a movie or drawing be just as good, better, or worse?

Physicist Biography

Biography of: ______________________________

Born: _______________ **Died:** ________________

Field in Physics: ____________________________

(The study of _____________________________ **)**

Most Known For: __________________________

____

Photograph or drawing

Early Life:

Education:

Scientific Contributions:

Fun Facts:

Quotes:

Time Line of Major Events:

Report Author:____________ Date:____

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Activity: Scientific Method

Grades: 3–5

Subject: Scientific method, accuracy, research, experimentation

Skills: Researching, presenting, organizing

Materials: Experiment Template (page 63)

Next Generation Science Standards
LS1.D: Information Processing
ETS1.A: Defining and Delimiting an Engineering Problem

Common Core English Language Arts
CCSS.ELA-LITERACY.CCRA.R: Key Ideas and Details
CCSS.ELA-LITERACY.CCRA.SL: Presentation of Knowledge and Ideas

Background

The ***scientific method*** is the process of experimentation that almost all scientists use to observe and test their subjects. In science, accuracy is important; following these steps ensures that other scientists can repeat an experiment and make sure that the results are reliable. The method has six basic steps:

Observe and Ask Questions: What do you notice in the world that interests you? The questions you ask will help determine which mystery to solve.

Make a Hypothesis: A hypothesis is a possible answer to the question you propose. A hypothesis must be testable, meaning that you can prove it correct or incorrect through experimentation.

Experiment: In this stage, the hypothesis is tested. If you think plants will grow healthier with mineral water or tap water, you would get two plants and water one plant with mineral water and the other with tap water. Then you would wait and see which plant grew the to be healthiest.

Analyze the Data: A scientist records information as their experiment progresses. Once you have all of the **data**, you can analyze it to discover if your hypothesis was correct or incorrect.

Repeat: To ensure results are not accidental, the experiment should be repeated three times.

Share the Results: A scientific discovery isn't useful if it isn't shared with the world. Making sure that the scientific method was followed will help other scientists see the value and accuracy of an experiment and test the hypothesis themselves.

Activity

1. Go over the background information with the students.

2. Select, or have your students select, an experiment to conduct. For a younger group, the entire class can complete the experiment together, while older groups can work individually or in smaller divisions. Give them the Experiment Template provided (page 63 of this guide).

3. Have students present their reports to the class.

Experiment Template

Question:

Hypothesis:

Materials

Method (What steps did you follow?)

Data (What did you observe?)

Conclusion

Activity: Transferring Energy

Grades: 2–5

Subject: Energy, motion

Skills: Active listening, critical thinking, inference

Materials: Rulers with grooves down the middle, marbles

Next Generation Science Standards
PS3.B: Conservation of Energy and Energy Transfer

Background

In science, laws are theories that have been tested many times and are supported by an abundance of evidence. One such law is the law of conservation of energy, which states that the amount of energy in a system never changes. It might seem improbable that energy is never created or destroyed, but it is easier to grasp if we remember that energy is never created or destroyed in a system. The system includes the entire Earth and universe; energy is simply transferred to different objects in many different ways. Most commonly, energy is transferred as heat, light, or motion.

Activity

1. Go over the background information with your students.

2. Divide students into groups and give each a ruler and five marbles.

3. Instruct students to place the marbles on the groove in the middle of the ruler, so that they are touching each other in a line. They should leave one marble out, which they place on the end of the ruler.

4. Ask students what they think will happen when they flick the lone marble at the line. Which marble(s) will move? After hearing their thoughts, tell them to give a firm flick to the marble; only one marble should roll away.

5. Repeat the experiment with different configurations. What happens when you flick two marbles at three?

How It Works

This activity demonstrates the conservation of energy. In this case, the form of energy is motion and momentum, a measure of weight and speed. Remember that energy is neither created nor destroyed. When the marbles collide, the momentum cannot just disappear. Instead, it transfers through the other marbles until it reaches the last marble. When two marbles are flicked, two marbles on the opposite end will move, because the energy of two marbles is transferred.

This activity was adapted from the article, "Transfer of Energy Science Experiment."

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Activity: Exploding Watermelon

Grades: K–5

Subject: Energy

Skills: Active listening, critical thinking, inference

Materials: Watermelon, large rubber bands, safety goggles, cleaning supplies, bucket, towels

Next Generation Science Standards
PS3.B: Conservation of Energy and Energy Transfer

Background

Potential energy is the amount of energy an object has stored because of its position or state. Energy can take many forms, such as heat, light, or motion. An easy way to think of potential energy is in comparison to kinetic energy. ***Kinetic energy*** is the energy of motion. A bike placed on top of a hill has a lot of potential energy, but it doesn't have kinetic energy until it starts moving. A ball held above your head has potential energy, but only has kinetic energy when you throw it.

Activity

1. Go over the background information with your students, then bring your class outside. This activity can be done as a demonstration or with the help of students, depending on the age group.

2. Set the bucket upside down on the towels; then, place the watermelon on top of the bucket.

3. Hold up a rubber band and stretch it out. Ask your students if the stretched band has more or less potential energy when it is stretched. ***Answer:*** It has more.

4. Have everyone put on safety goggles.

5. Begin stretching rubber bands over the watermelon. The rubber bands will tend to spread out as more get added; try to keep them around the center as much as possible.

6. When the watermelon starts to split, remember that pieces will fly through the air. Consider having students back away while you add the last bands.

7. Ask students if the explosion had kinetic or potential energy. ***Answer:*** It had kinetic.

8. Clean up the watermelon with cleaning supplies. Enjoy the fruit if desired.

Discussion

Ask your students what the relationship between potential and kinetic energy is. Have them discuss their thoughts until they realize that potential energy is converted into kinetic energy. Help them by instructing them to imagine a car driving over a hill. When does the car have the most potential energy? Answer: At the top. What do they think happens to the energy when the car moves down the hill?

This activity was adapted from the website Fizzics Education.

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Activity: Egg Drop

Grades: 3–5

Subject: Gravity, force, air resistance, momentum

Skills: Active listening, critical thinking, engineering

Materials: Raw eggs, high place, such as a ladder or roof; optional: various packing materials, bags, string, etc.

Next Generation Science Standards
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions

Background

Acceleration is a measurement of the change in an object's ***velocity***, which means speed. When an object's speed changes in a consistent fashion, it is called constant acceleration. An example of this is a free fall. When an object is dropped, ***gravity*** causes the object to fall at a constant speed. Yet an object that is dropped also encounters ***air resistance***. Though we can't see it, air is all around us, and it moves as we walk through it. When an object is dropped, the air resists moving, though it isn't a very strong force. Parachutes utilize air resistance to keep people from falling very quickly.

Activity

1. Go over the background information with your students. Explain that they are trying to create a way to drop an egg from a high place without it breaking.

2. Break them into groups and give each an egg. Depending on the age of the students, have them design and build their egg carrier at home, with their own materials, or in the classroom, with materials that have been provided.

3. Instruct students to build a parachute, box, or other device to protect their eggs when they fall.

4. After their carriers have been built and the eggs inserted into their designs, drop the carriers from a high place.

5. Examine the results. Which designs worked and which didn't? Can your students make guesses as to why some worked and some didn't?

Additional Information

Gravity is the downward force that draws bodies to an object's center. Gravity in our solar system is what causes the planets to orbit the sun and keeps our feet on the ground. Anything with mass has gravity; the more mass an object has, the more gravity it has.

This activity was adapted from the website Fizzics Education.

Activity: Suspended Rice

Grades: K–5

Subject: Friction, forces

Skills: Active listening, critical thinking

Materials: Small plastic bottle, uncooked rice, pencil, large bowl

Next Generation Science Standards
PS2.B: Types of Interactions
ETS1.A: Defining and Delimiting Engineering Problems

Background

Friction is a type of force. It is the resistance of motion when objects rub together. The rougher a surface is, the more friction it will have. This is why tires and shoes are not completely smooth—without friction, objects would slip and slide. In contrast, ice is a smooth surface; it is slippery because it produces less friction.

Activity

1. Go over the background information with your students. This activity can be done as a demonstration or in groups.

2. Fill a bottle with uncooked rice and place it in the large bowl, which is there to catch any spilled rice.

3. Stab a pencil straight down into the bottle. Try to lift the bottle by just the pencil. This should not work.

4. Stab the pencil in and out about 30-40 times at different heights. The goal is to compact the rice.

5. Again, try lifting the bottle using just the pencil. Ask students why this works now?

How It Works

The more contact there is between two surfaces, the more friction there is between them. When the pencil is repeatedly plunged into the bottle, the rice compacts and air is pushed out of the container. Eventually, your pencil is so surrounded by rice that the friction prevents the bottle from falling off of the pencil. At that point the force of friction is greater than the force of gravity.

This activity was adapted from the website Fizzics Education.

Activity: Tin Foil Boats

Grades: K–5

Subject: Density, buoyancy

Skills: Active listening, critical thinking, engineering

Materials: Large tray or pool of water, pennies, aluminum foil

Next Generation Science Standards
PS2.B: Types of Interactions
ETS1.A: Defining and Delimiting Engineering Problems

Background

Density is a measure of how heavy something is compared to its size. One way to consider an objects density is to place it in water. If it is less dense than water, it will float; if it is more dense than water, it will sink. ***Buoyancy*** refers to an object's ability to float in water. Buoyancy is the force of water pushing up on an object. It relies on both how much water an object displaces and how dense an object is. The less dense an object is, and more water it displaces, the more buoyant it is.

Activity

1. Go over the background information with your students.

2. Give each student a sheet of aluminum foil with which to make a boat. Instruct them that they are trying to build a boat which will hold the most pennies before sinking.

3. After students are done building, direct their attention to the body of water. Put 15 pennies in some tinfoil and ball it up. Ask students if they think it will float, then test it.

4. Next, have them come up in small groups to test their boats.

5. Begin by placing the foil boats in the water. Add pennies one by one, keeping track of how many the boat can hold before sinking.

6. Compare the designs together as a class. What worked? What didn't?

Expand the Activity

Teach students more about density with a saltwater density demonstration. Fill two glasses with warm water and add salt to one, mixing it up until it dissolves. Ask student if they think an egg will float or sink in regular water and saltwater. Then, place an egg in each glass. The egg in the saltwater will float while the other sinks. Adding salt to water makes the water denser; as the salt dissolves the water gains mass. Remember that objects float when they are less dense than the liquid they are in. When the water mixes with salt, the egg becomes less dense than the mixture.

This activity was adapted from the website Little Bins for Little Hands

Glossary

Air Resistance: The force of resistance air causes as an object moves through it.

Atoms: Atoms are like the building blocks that put together our universe. Different kinds of atoms are made by combining different numbers of protons, neutrons, and electrons.

Buoyancy: An objects ability to float in water.

Density: A measure of how heavy something is compared to its size; determined by dividing mass by volume.

Element: A basic substance made of one type of atom that usually cannot be separated into simpler substances.

Energy: The ability to do work.

Experiment: A test to collect information about the world to see if a hypothesis is correct.

Force: The push or pull on a thing when it interacts with another thing.

Frequency: How fast a wave vibrates, or peaks and falls.

Friction: A force of resistance when two objects rub together.

Gravity: A force that attracts ALL objects toward each other. This force gets bigger as the objects get bigger, which is why our bodies feel the force of gravity from the earth, but not from a spoon or apple.

Half-Life: The average time it takes for half of the atoms in a sample to decay.

Hypothesis: A scientific guess that a scientist makes to explain something they think is true or think will happen.

Inertia: An object's resistance to changes in their state of motion

Mass: A measure of how much a thing resists being moved.

Matter: Anything that takes up space and has mass.

Newton's Laws: Three laws of motion that explain the behavior of objects and forces.

Nobel Prize: An award given for amazing work in chemistry, physics, physiology or medicine, literature or economics. Being given a Nobel Prize is one of the greatest honors a scientist can get!

Observation: Using our senses to collect information about the world.

Physics: The study of matter, energy, and how they interact.

Radioactivity: The particles and energy an atom gives off when its nucleus is broken apart.

Refraction: The manner in which light bends as it passes through different mediums, such as air or water.

Research: To investigate and study something in order to learn new things about it.

Wavelength: The distance between two peaks of waves.

X-Ray: Invisible rays of high energy and short wavelength that can pass through things and make it possible to see inside them.

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