

SGENIUS THEN NOW TOMORROW

"Towering genius disdains a beaten path. It seeks regions hitherto unexplored." – Abraham Lincoln

Dear Educator,

For 140 years, the 92nd Street Y (92Y) has been serving its community and the world in a remarkable way, providing exceptional programs across the spectrum — in the arts and culture, Jewish life and education, health and fitness, personal growth and travel, and in classes for adults, families, and children. In the 1870s, 92Y began offering free adult education classes, and later went on to pioneer new programs, including a nursery school (1938), activities for senior citizens (1950), a parenting center (1978) and an Educational Outreach center (1989). Groundbreaking programs in the arts, religion, and public affairs enable diverse audiences to pursue a variety of interests here, while educational outreach programs share 92Y's resources with students in the city's public schools.

New ideas keep individuals growing. 92Y is honored to present the **7 Days of Genius Festival**, www.92Y.org/Genius, a dynamic and groundbreaking exhibition of ideas and inquiry that will attempt to unravel the complicated nature of the concept of Genius. We will bring people together in New York City and across the globe in live events, educational forums, and online conversations to discuss new ideas, innovations, and solutions to some of today's grand challenges.

Genius: Then, Now, Tomorrow is a supplementary STEM literacy curriculum aligned with the NYS Science Standards and Common Core Standards that strengthens middle school students' skills in English Language Arts while reinforcing STEM concepts. We have created "instant lessons" designed to appeal to diverse learning styles. The lessons and tasks focus on ten widely recognized geniuses: Galileo Galilei, Marie Curie, Sir Isaac Newton, Leonardo da Vinci, Albert Einstein, Nikola Tesla, Srinivasa Ramanujan, Johannes Kepler, Thomas Edison, and Niels Bohr, and will trace the impact of their contributions from the past to the world our students live in today and inherit tomorrow. Throughout the curriculum, denotes primary sources, videos and additional texts that can be found on the attached USB drive. This inquisitive STEM literacy curriculum unfolds some of the mysteries of the universe through inquiry and project based learning.

Best wishes to you and your students as we explore Genius together!

Larisa Gelman Educational Outreach Center, Director



Table of Contents

Guide	Curriculum Guiding Questions3		
	Lesson 1 – Curie and Bohr4		
	Lesson 2 – Einstein9		
	Lesson 3 – Newton, Kepler, Galileo, Einstein11		
	Lesson 4 – Leonardo da Vinci17		
	Lesson 5 – Ramanujan23		
receives	Lesson 6 – Tesla & Edison26		

Contributors to the Curriculum

Authors Naomi Dubin Larisa Gelman Robin Konigsberg

Editors Jessica Carleton Naomi Dubin Larisa Gelman

Design Francesca Faber Eden Gerson

Video Contributions Sarah Miller Caldicott Hank Green Erin McCarthy Bill Nye

Video Producers/Editors Karen Y. Chan Julie Mashack Paolo Mastrangelo

Genius: Then, Now, Tomorrow generous support from the John Templeton Foundation.

GENIUS THEN NOW TOMORROW

2

Guiding Questions for Students for Each Lesson:

1. How does this genius's work impact our world today?

2. What was this genius's greatest contribution to our society? Use evidence from the text to explain why.

3. What personal traits and qualities are unique to this genius? Explain how these traits and qualities empowered the genius to impact our world.

4. Discuss whether or not you think this person is a genius. Use evidence to support your argument. Watch the video of Bill Nye's response to the question "What is genius?" and discuss.

5.Regarding the quote on each genius's biography page: What are the experiences or circumstances in this person's life and work that bring meaning to those words?



NIELS BOHR



"Every great and deep difficulty bears in itself its own solution. It forces us to change our thinking in order to find it." – Niels Bohr Born on October 7, 1885, in Copenhagen, Denmark, Niels Bohr became an accomplished physicist who derived a revolutionary theory on atomic structures and radiation emission.

Niels Bohr first began to distinguish himself as a scholar when he entered a scientific competition for a method to test the surface tension of liquids in 1905. Not only did he have to make his own glassware and other pieces of laboratory equipment, but he also took his experiments well beyond the competition's requirements, earning himself the prize.

With the progression of his career, Bohr founded the Institute of Theoretical Physics (now called the Niels Bohr Institute) in Copenhagen in 1918. Then in 1922, he received the Nobel Prize in Physics for his work on atomic structures. However, physicist Albert Einstein did not fully agree with all of Bohr's assertions, and their public talks and debates became renowned in the scientific communities. Bohr continued his work with a group of scientists who were studying nuclear fission during the late 1930s, and contributed his liquid droplet theory. This theory explains how the nucleus of an atom holds together like a droplet of water. He also discovered that electrons orbit the nucleus of an atom, similar to the way that planets orbit the sun.

As Adolf Hitler rose to power, Bohr was able to offer German Jewish physicists refuge at his institute in Copenhagen. Once Nazi forces occupied Denmark, the Bohr family escaped to Sweden before coming to the United States. Bohr then worked with the Manhattan Project in Nevada, where scientists were working to create the first atom bomb. Bohr, however, had concerns about how the bomb could be used, and made appeals for future international arms control and active communication about the weapon between nations — ideas met with resistance by Winston Churchill and Franklin D. Roosevelt.

After the end of World War II, Bohr returned to Europe and continued to call for peaceful applications of atomic energy. In his "Open Letter to the United Nations" from June 9, 1950, Bohr envisioned an "open world" mode of existence between countries that abandoned isolationism for true cultural exchange. Outside of his pioneering ideas, Bohr was known for his wit and warmth, and the humanitarian ethics that informed his later work.



The Bohr Model of the hydrogen atom

MARIE CURIE



"Nothing in life is to be feared, it is only to be understood. Now is the time to understand more so that we may fear less." – Marie Curie Marie Curie was a physicist, chemist, and one of the first scientists to study radiation. As a result of this pursuit, she discovered the elements polonium and radium. Together, she and her husband Pierre were awarded the Nobel Prize for Physics in 1903, and she received another one, for Chemistry, in 1911 making her the first person to receive two Nobel prizes in different disciplines.

Maria Salomea Sklodowski (Marie Curie) was born in Warsaw, Poland, on November 7, 1867, the youngest of five children. Her parents were both educators and insisted that all their children receive an education, regardless of their gender. Both Marie and her sister, Bronia, wished to attend college, but the University of Warsaw did not accept women. Since the sisters wanted to pursue scientific research, they were forced to leave Poland to continue their education. Marie moved to France where she earned her master's degree in physics in July 1893 at Sorbonne in Paris, and another degree in mathematics in 1894.

In July 1898, Marie and her husband Pierre published their conclusion to the research they had conducted together: the bismuth compound they were studying contained a previously undiscovered radioactive element which they named polonium, after Marie's native country, Poland. By the end of the year, they had discovered a second radioactive element which they called radium, from the Latin word for rays, *radius*. Then in 1902, they successfully extracted purified radium.

In June 1903, Marie became the first woman in Europe to earn a doctorate in physics. In November of that year the Curies, together with physicist Henri Becquerel, were named winners of the Nobel Prize in Physics for their contributions to the understanding of atomic structure. The nominating committee originally refused to include a woman among the Nobel Laureates, but Pierre insisted that Marie performed the original research. Then in 1911, after Pierre's death, Marie was even awarded a second Nobel Prize in Chemistry for her discovery of polonium and radium. She continued her research in radioactivity, but after the start of World War I in 1914, she suspended her studies and organized a fleet of portable X-ray machines for doctors on the front. After the war, she worked diligently to raise money for her Radium Institute, which allowed her to travel to the United States. However, by 1920, Marie began suffering from medical problems, likely due to her years of exposure to radioactive materials. On July 4, 1934, she died of aplastic anemia, a blood disease often caused by too much exposure to radiation.

The Curies were posthumously honored in 1944 with the discovery of the 96th element on the Periodic Table, which was named curium.



Marie Curie and Niels Bohr

OBJECTIVE: Students will study atomic structure and the processes scientists use to discover new elements, and create a curriculum vitae that reflects the career of a modern female scientist.

VOCABULARY: Chemistry, Compounds, Curriculum Vitae, Elements, Periodic Table

NYS SCIENCE STANDARDS: Elements and compounds PS 3.3e, f; Atoms and molecules PS 3.3a-d; The Periodic Table as a way of organizing the elements PS 3.3g, 4.3.3a, e, f, g

COMMON CORE STANDARDS: RST.6-8.1, WHST.6-8.1, WHST.6-8.4, WHST.6-8.9, L.RI.6.4

PRIOR KNOWLEDGE: Structure of atoms, periodic table of elements

TASK

DISCOVERING ELEMENTS



THE FUTURE FOR ELEMENTS – HOW MANY CAN WE DISCOVER?

DESCRIPTION

- Read biographies of Bohr and Curie, pp. 4 and 5, and watch videos.
- Discuss Bohr and Curie's contributions to science.
 - o Why were their discoveries important?
 - How do they influence our current understanding of atoms?
- Read article about the discovery of element 115. \square
- In pairs or small groups, students use their knowledge of Bohr and Curie's accomplishments to discuss who had a greater influence on modern scientists' discovery of element 115.
- Students write an essay explaining the influence that Bohr and Curie had on modern scientists who have discovered new elements.

RESOURCES

- 😠 USB Resources for this lesson:
- Element 115 Articles
- > Albert Einstein's letter to Marie Curie
- Curie's Curriculum Vitae
- Mental Floss's Curie video
- Hank Green's Bohr video

Bohr's atomic structure helped create a better understanding of atoms' composition and how they interact to create artificial elements.

Curie discovered radium No. 88 and polonium No. 84 in 1898, extracted in 1910 in its metallic form.

TASK

THE FUTURE FOR ELEMENTS (CONT'D.)



CURIE'S
CURRICULUM
VITAE (CV)

EINSTEIN'S LETTER OF SUPPORT

CREATE A CV

DESCRIPTION

- Students should connect Bohr and Curie's influence specifically to the discovery of element 115.
- Students can also discuss Curie's discoveries of two new elements, paving the way for the discovery of element 115.
- Based on students' knowledge of elements, discuss as a class what qualities future newly discovered elements would have. Ask students to assign a number and name to these future elements.
- Students interpret Curie's infographic curriculum vitae, Curriculum Guide p. 8.
- Read the primary source: Albert Einstein's letter to Marie
 Curie.
 - Determine the meaning of words and phrases
 Einstein uses, and how his writing style impacts the message he is trying to send.
 - Why would Einstein write to Curie at this point in her career?
- Research a woman who is making contributions in a STEM field today. Create a CV for her, drawing on her achievements, goals, and challenges.

RESOURCES

Pity the Poor Scientists With All the Elements Found

Now that "Eka-Iodine" the missing element, No. 85, has been discovered, thus com-

pleting the periodic table of elements, I presume scientists will devote their spare time searching for new vitamins to complete the alphabet. But do you suppose that all the elements have been discovered? Even so there are many fields left for scientists to work in without trying to prove



that man came from a monkey or his face from a fish.—H.E.A., Richmond, Me.

Curriculum Vitae: A written overview of a person's experiences and qualifications.

Students can focus on: <u>Maryam Mirzakhani</u> – First woman and first Iranian to win a Fields Medal <u>Jane Goodall</u> – Primatologist and chimpanzee expert <u>Megan Smith</u> – Chief Technology Officer of the United States <u>Reshma Saujani</u> – Founder of Girls Who Code





ALBERT EINSTEIN

Photo Credit. Ferdinand Schmutzer

"Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid." – Albert Einstein Albert Einstein was a theoretical physicist whose work transformed our understanding of the forces at work in the universe, from mass-energy transformation, to quantum mechanics, and gravitation.

Albert Einstein was born in Germany on March 14, 1879. He had a typical German middle-class upbringing, raised by non-observant Jewish parents, learning violin and piano, and graduating high school at age 18. Einstein moved to Italy for a brief period, and then Switzerland, where he experienced what has come to be known as an "Annus Mirabilis" ("miracle year") in 1905. Not only did he complete his Doctorate degree in physics from the University of Zurich, but he also published four groundbreaking papers, one of which discussed the Theory of Special Relativity, including e=mc². This equation for mass-energy equivalence is often referred to as the world's most famous equation, and explains that mass and energy can be transformed into one another because they are the same physical entity (i.e. small amounts of matter can be converted into very large amounts of energy). The Theory of Special Relativity also explains that motion is relative, and it is impossible to determine you are moving unless you can compare your motion to another object.

Over the next several years, Einstein worked as a professor throughout Europe, in cities such as Bern, Zurich, Prague, and Berlin. In 1915, ten years after his Annus Mirabilis, Einstein published his Theory of General Relativity, a theory of gravitation that has become seminal in the field of astrophysics. In 1916, he was appointed president of the German Physical Society, a position he held for 2 years.

Einstein was awarded the 1921 Nobel Prize in Physics for his work on the photoelectric effect (*not* for general relativity, which was still under debate amongst physicists), and it was after his receipt of this award that Einstein became a household name around the world. He continued teaching and traveling abroad, until he moved to the United States in 1933 as a result of the Nazi Party's rise to power in Eastern Europe, which created a very dangerous and restrictive climate for Jews.

In the fall of 1933, Albert Einstein accepted a position at Princeton University, and attained American citizenship in 1940. He reluctantly became involved in the Manhattan Project in 1939, when he wrote a letter to President Roosevelt warning him about the possibility of Germany's construction of an atomic bomb. Though he was a pacifist who believed that "war is a disease," his letter to the President spurred the government's research into uranium and associated chain reactions, leading to the development of the atomic bomb.

Einstein remained at the Institute for Advanced Study at Princeton until his death in 1955, leaving a legacy of multiple essential contributions to the field of theoretical physics and an eccentric personality.

Albert Einstein

OBJECTIVE: Students will write a letter to the president detailing and advising on the dangerous applications of modern discoveries and inventions.

VOCABULARY: Atom bomb, Nuclear power, Primary source, Uranium, 3D printing

COMMON CORE STATE STANDARDS: CCSS.ELA-Literacy.RH.6-8.2, CCSS.ELA-Literacy.RH.6-8.6, CCSS.ELA-Literacy.RH.6-8.8

TASK	DESCRIPTION	RESOURCES
EINSTEIN'S LETTER TO FRANKLIN D. ROOSEVELT	 Read biography of Einstein on p. 9 and watch video. Read the primary source: Albert Einstein's letter to Franklin D. Roosevelt. Determine the central idea of Einstein's letter and provide an accurate summary distinct from prior knowledge or opinions. Identify aspects of the letter that reveal Einstein's point of view on the use of uranium and his purpose in writing it. Distinguish among fact, opinion, and reasoned judgment in the letter. 	 USB resources for this lesson: Albert Einstein's letter to President Roosevelt President Roosevelt's reply to Einstein Time Magazine: Man of the Century Mental Floss's Einstein video
WARNING FOR TOMORROW – LETTER TO THE PRESIDENT	 Discoveries and inventions have had an undeniable impact on the future of our world. Choose a modern discovery or invention and write a letter advising the President on the dangerous applications of your subject in the future. Example subjects include: 3D printing Genetic engineering Wireless electricity 	 Examples of advisories against 3D printing: Ecological impact of heavy use of plastics Licensing and copyright of designs Gun control laws

JOHANNES KEPLER

"I much prefer the sharpest criticism of a single intelligent man to the thoughtless approval of the masses."

- Johannes Kepler

Johannes Kepler was a German mathematician, astronomer, and astrologer who made key contributions to the scientific revolution, and is best known for his laws of planetary motion.

Kepler was born into a poor German family in 1571, and showed an interest in math and astronomy from a very young age, when his mother took him to observe the Great Comet of 1577, and a lunar eclipse in 1580. Unfortunately, he contracted smallpox later in childhood, which weakened his vision and crippled his hands, making the study of astronomy very difficult for the rest of his life.

Kepler entered the University of Tübingen in 1589 with intentions of becoming a minister after he graduated. His aptitude for mathematics was undeniable, and he became fascinated with Copernicus's studies and ideas of a heliocentric universe. In 1594, Kepler accepted a position to teach mathematics and astronomy at the University of Graz instead of entering the Lutheran ministry.

Two years later, Kepler became the first person to publish a defense of the Copernican system, titled *Mysterium Cosmographicum*. However, the Counter Reformation forced him to leave the University of Graz in 1600 because he was Lutheran, where upon he relocated to Prague. In Prague, Kepler met astronomer Tyco Brahe, who died one year later, leaving him to fill his position as Imperial Mathematician to the Holy Roman Emperor. Using his predecessor's precise calculations and data, Kepler discerned that Mars orbited in an ellipse, and published his first two laws of planetary motion in a work called *Astronomia Nova*.

Kepler was forced to move again in 1612 due to religious strife, and briefly settled in Linz before returning home to Württemburg, where he published *Harmonices Mundi* in 1619, containing his third planetary law. In 1621, he published his most significant work summarizing all of heliocentric astronomy, *Epitome Astronomiae*. For the next several years, Kepler continued working with data that Tyco Brahe had collected and his own mathematical formulae to track and predict planetary motion. He died in 1630, leaving behind several published works and theories that made him a central figure in the scientific revolution, and provided the foundations for the laws of universal gravitation that Isaac Newton formulated several decades later.

SIR ISAAC NEWTON

"If I have seen further, it is by standing on the shoulders of giants." -Sir Isaac Newton

Sir Isaac Newton was an English mathematician and physicist who had an immense impact on the scientific revolution, invented infinitesimal calculus, and laid important foundations in classical mechanics.

He was born in 1642 to a family of poor farmers in England. His childhood was very difficult – his father died before he was born, and his mother left him to be raised by his grandmother. His mother returned a few years later and pulled him from school to work on the farm, but it was readily apparent that 11-year-old Isaac was not suited to farm life. Luckily, after a few more years in the country he was able to attend Cambridge University by working to earn his tuition, and eventually he was offered a scholarship.

While at Cambridge, Newton studied mathematics and philosophy, earning average grades, until the university briefly closed in 1665 because of the Great Plague. He then spent two years in the countryside until he could return to school, and it was during this period away from the classroom that he made some of his greatest discoveries. Legend has that Newton was sitting in his garden when an apple fell from a tree, causing him to question the extent and power of forces of gravity. During his time away from Cambridge, Newton developed mathematical theories leading to the invention of calculus, laid foundations for his theories of light and color, and began formulating his first published work, *Philosophiae Naturalis Principia Mathematica*.

Newton returned to Cambridge in 1667 and quickly earned a position as a professor of mathematics, which was followed by his election to the Royal Society. However, Newton often found himself in conflict with other members of the society, and after several arguments Newton withdrew. After an emotional breakdown and the death of his mother in the late 1670s, Newton threw himself into intense research and study, and finished writing the three volumes of *Principia*, published in 1687. This work is often considered one of the most important books in the history of science, and includes his famous three laws of motion (Newton's Laws). The first is the law of inertia, which states that an object will continue its pattern of motion unless a force acts upon it. Newton's second law states the relationship between force, mass and acceleration (F=ma), and his third law states that every force has an equal and opposite force.

He continued to work in the fields of optics, mechanics, and mathematics, resulting in the laws of gravitation, the laws of motion, the invention of calculus, and numerous other significant discoveries. Though Newton often delayed publishing his findings, he nonetheless died with a powerful legacy of contributions to mathematics and science in 1727.

¹² GENIUS THEN NOW TOMORROW

GALILEO GALILEI

"All truths are easy to understand once they are discovered; the point is to discover them." – Galileo Galilei Galileo Galilei was an Italian physicist, mathematician, astronomer, and philosopher who played a foundational role in the scientific revolution. His achievements number improvements to the telescope (and subsequent astronomical observations) and support of Copernicanism – the idea that the earth revolves around the sun. Some of the observations that most strongly supported this theory include that the moon is a sphere, not flat; that Venus has phases like the moon (proving that it rotates around the sun); and that Jupiter's moons revolve around Jupiter, not earth. As a result, Galileo has been dubbed the "father of modern observational astronomy" and the "father of modern physics and modern science".

Born on February 15, 1564, in Pisa, Italy, Galileo Galilei was accused of heresy two times by the church for his heliocentric beliefs, and even wrote books explaining his ideas. In 1604, Galileo published *The Operations of the Geometrical and Military Compass*, revealing his skills with experiments and practical technological applications. He also constructed a hydrostatic balance for measuring small objects.

In the early 1600s, Galileo continued work on his theories of motion and falling objects, and developed the universal law of acceleration, which all objects in the universe obey. He also began to openly express his support of the Copernican theory, which challenged Aristotle's geocentric doctrine and the established order set by the Catholic Church. In 1612, he published his *Discourse on Bodies in Water*, again refuting Aristotle and his explanation of why objects float in water, saying that it was not because of their flat shape, but instead the weight of the object in relation to the water it displaced. The following year, Galileo published his observations of sunspots, which countered previously held beliefs that the sun was perfect.

In 1616, Galileo was ordered by the Holy Office not to "hold, teach, or defend in any manner" the theory of heliocentrism. While he obeyed the order for seven years (partly to make life easier and to prove his devotion to the Church), he was again brought to trial for these views in 1633, and as a result was placed under house arrest for the remainder of his life.

Galileo died in Arcetri, near Florence, Italy, on January 8, 1642, after suffering from a fever and heart palpitations. In 1758, the church lifted the ban on most works supporting Copernican theory, and by 1835 dropped its opposition to heliocentrism altogether.

Johannes Kepler, Galileo Galilei, Isaac Newton, Albert Einstein

OBJECTIVE: Students will synthesize the research of four geniuses to disprove geocentric conspiracy theories. VOCABULARY: Conspiracy, Geocentric, Gravity, Heliocentric, Inertia NYS SCIENCE STANDARDS: 4.1.1 a, 4.1.1b, 4.1.1c, 4.1.1h; 4.5.1a-d; 4.5.2a, 4.5.2d COMMON CORE STANDARDS: WHST.6-8.1, WHST.6-8.4, WHST.6-8.9, RST.6-8.8 PRIOR KNOWLEDGE: Kepler and Galileo's evidence that the earth revolves around the sun, Newton's three laws of motion, Newton's laws of gravity, Einstein's theory of special relativity, Scientific Revolution.

TASK

CONSPIRACY BUSTERS

DESCRIPTION

- Read the biographies of Einstein, Kepler, Galileo, and Newton on pp. 9 and 11-13, and discuss how their work impacted each other's discoveries.
- Review Newton's Laws and Einstein's theory of special relativity.
- Students choose one of several conspiracy theory websites which state that the earth remains still in the center of the universe (geocentric model).
- Students write a response to these websites, formatted as a letter to the site's creators, using their knowledge of these four genius's work to refute specific claims.

RESOURCES

- **With Service and Services and**
- Conspiracy theory websites
- Explanation of Newton's Laws
- Explanation of the Theory of Relativity

Examples of conspiracy theory websites

TASK

DESCRIPTION

LETTER WRITING

- Students' letters should include the following as support:
 - Kepler and Galileo used observations and 0 calculations to explain that the Earth revolves around the Sun, concluding that the Sun moves across the sky because the Earth is rotating.
 - Newton's first law of motion and law of gravity 0 explain why Earth revolves around the Sun. Inertia and the Sun's gravity keep earth moving along its orbit.
 - Einstein's theory of relativity explains why we 0 cannot feel the Earth moving. Motion is relative and can only be explained with reference to other objects. Since everything on Earth is moving with us, we cannot feel the motion.
 - We can use Newton's second law of motion 0 (F=ma). Since the Earth moves at a constant speed around the Sun, there is no acceleration. If the acceleration is zero, then there is no force.
- Students research Isaac Newton and his three Laws of Motion, and create a poster presenting their research. See rubric p. 16.

RESOURCES

• Newton's Laws

Newton's Laws in Latin, 1687 edition.

Theory of Relativity

POSTER PROJECT

Newton's Laws Poster Project:

Research Isaac Newton and his three laws of motion and create a poster presenting your research.

Work Product - Submit a poster that contains the following information:

- o Information on Isaac Newton;
- o Each of Newton's three laws of motion;
- o An explanation of each law of motion; and
- o Examples of each law of motion.

Rubric:	1	2	3	4
Accuracy	Work shows no accuracy with many factual errors.	Work shows little accuracy with some factual errors.	Work shows accuracy with few factual errors.	Work shows accuracy with no factual errors.
Research	Research does not answer any relevant questions.	Research answers some relevant questions.	Research answers some relevant questions and includes a few other interesting facts.	Research answers most questions and includes many other interesting facts.
Attractiveness	Work is illegible.	Work is legible, although sloppy.	Work is legible and neat.	Work is legible and includes attractive illustrations and diagrams.
Newton's 1 st Law	1 st law is incorrectly explained and/or does not have correct examples	1 st law is explained with at least one example but may have some incorrect information	1 st law is explained with at least one example	1 st law is clearly explained with at least three examples.
Newton's 2 nd Law	2 nd law is incorrectly explained and/or does not have correct examples	2 nd law is explained with at least one example but may have some incorrect information	2 nd law is explained with at least one example	2 nd law is clearly explained with at least three examples.
Newton's 3 rd Law	3 rd law is incorrectly explained and/or does not have correct examples	3 rd law is explained with at least one example but may have some incorrect information	3 rd law is explained with at least one example	3 rd law is clearly explained with at least three examples.

LEONARDO DA VINCI

Oo

"The noblest pleasure is the joy of understanding." - Leonardo da Vinci Leonardo da Vinci was an Italian inventor, artist, and polymath who lived during the Renaissance period. He was born in 1452 in the town of Vinci, Italy to Piero da Vinci and a peasant woman named Caterina. As the illegitimate son of an Italian gentleman, young Leonardo received an informal education in Latin, geometry, and mathematics. At age 14, he became an apprentice to one of the best artists in Florence, Verrocchio. It was in Verrocchio's workshop that Leonardo most likely learned a wide variety of artistic skills, including metallurgy, leather working, painting, sculpting, mechanics, and chemistry. Even once he acquired his own workshop and qualified as a master in an artists' guild, he continued to collaborate with his master teacher until 1476.

Leonardo's professional career began as an artist, and to this day he is perhaps best known for artistic works such as *Mona Lisa*, *The Last Supper*, and his drawing of the *Vitruvian Man*. He also created over 13,000 pages of notes and drawings in journals throughout his lifetime, a habit begun in the early 1490s. Some of these journals included artistic sketches, while others ranged from studies of human anatomy to a variety of machines and inventions.

It is only within the last century that Leonardo has been recognized as an engineer and inventor of great skill. Previously, he was known to the world primarily as an artist. He sketched ideas for numerous inventions that were not capable of being constructed during his lifetime, such as the flying machine, armored vehicle, several musical instruments, and hydraulic pumps. However, Leonardo also worked on many smaller pieces that were manufactured during his time, such as a bobbin winder.

Leonardo is now recognized as a true polymath, or "Renaissance man," who displayed expertise in an exhausting number of different fields, including anatomy, civil engineering, mechanical engineering, drawing, painting, sculpture, chemistry, geology, geometry, hydrodynamics, mathematics, optics, physics, pyrotechnics, zoology, inventing, and more. He is also known for such unique habits as his meticulous journals, writing backwards, and exhuming corpses (illegally) in the middle of the night for anatomical studies. He continued making scientific advances and discoveries until his death in 1519, though he never published his findings and the immediate succeeding generations had little knowledge of his work.

Leonardo Da Vinci

OBJECTIVE: Students will find connections between Leonard's sketches and modern car engines by digitally re-creating his inventions with an interactive iPad app.

VOCABULARY: Apprentice, Mechanics, Polymath NYS SCIENCE STANDARDS: 4.5.2c, 4.2.5f, 4.2.5g COMMON CORE STANDARDS: RST.6-8.7, WHST.6-8.1, WHST.6-8.4 PRIOR KNOWLEDGE: Simple machines, Complex machines

TASK

LEONARDO'S APPRENTICE

DESCRIPTION

- Read Leonardo's biography, p. 17.
- Review components of simple and complex machines.
 - o Gear, belt, lever, pulley, wheel, axel
 - Reference images of Leonardo's inventions
 from provided website as aids
- In small groups, students will explore common elements of Leonardo's machines through the interactive iPad app *Da Vinci's Demons: Apprentice*.
 - Students list components of simple and complex machines they encounter while playing the game.

RESOURCES

USB resources in this lesson:
 Machine sketches

Leonardo created over 13,000 pages of notes and drawings, some of which were incomplete, and most of which were never realized. These journals encompassed studies in disciplines as varied as anatomy, civil engineering, mechanical engineering, drawing, painting, sculpture, chemistry, geology, geometry, hydrodynamics, mathematics, optics, physics, pyrotechnics, zoology, and inventing.

Download Da Vinci's Demons: Apprentice for iPad from the iTunes store.

Images of Leonardo's inventions

TASK

•

FUTURISTIC INVENTIONS

DESCRIPTION

- Study Leonardo's sketch for an automobile and part of a flying machine, p. 20.
- Compare and contrast these sketches with blueprints for a 1917 Model T Ford engine and a BMW v12 engine, pp. 21 and 22.
- Based on your study of various engines and machines, what are the necessary components of an engine?

Flying Machine, 1488

RESOURCES

Leonardo drew sketches of various machines, including a flying machine, automobile, helicopter, and an armored vehicle – all complex machines.

Sketch of an automobile and a flying machine

The Model T Ford was in production from 1908 – 1927. BMW has been manufacturing v12 engines since 1986.

Leonardo's Self-Propelled Cart

Model T Ford Engine

Fig. 11.—Part Sectional View of the Ford Four Cylinder Unit Power Plant Showing Important Parts of the Power Generating and Transmission System.

22 GENIUS THEN NOW TOMORROW

BMW v12 Engine

SRINIVASA RAMANUJAN

"I have not trodden through the conventional regular course which is followed...but I am striking out a new path for myself."

- Srinivasa Ramanujan

Srinivasa Ramanujan was one of the world's greatest mathematical minds. He made substantial contributions to the analytical theory of numbers and worked on elliptic functions, continued fractions, and infinite series.

Ramanujan was born in 1887 in his grandmother's house in Erode, a small Indian village. By the time he was 13 years old, he had begun to work on developing his own mathematical formulas. After Ramanujan was shown how to solve cubic equations in 1902, he went on to find his own method to solve quartic equations (a quartic equation is a polynomial that adds a variable to the fourth, third, second and first powers (such as $y = ax^4 + bx^3 + cx^2 + dx + e$). Then, because of his upbringing in a small village and limited access to the work of other mathematicians, he began trying to solve quartic equations on his own (not knowing they could not be solved by radicals).

Ramanujan received a scholarship to study at Government College in Kumbakonam, which was later rescinded when he failed his nonmathematical coursework. As a result, he transferred to another college to pursue independent mathematical research, while working as a clerk in the Accountant-General's office at the Madras Port Trust Office to support himself. From 1912 to 1913, he sent samples of his theorems to three professors at the University of Cambridge in London, including a man named G.H. Hardy. Hardy, recognizing the brilliance of these papers, invited Ramanujan to visit and work with him in London. Ramunujan then became a Fellow of the Royal Society and a Fellow of Trinity College, Cambridge.

Although a mathematical genius, Ramanujan was frequently criticized for his style of work. According to Hardy, Ramanujan utilized a "process of mingled argument, intuition, and induction, of which he was entirely unable to give any coherent account." The English mathematician was therefore able to help provide sound mathematical support where Ramanujan had only used intuition.

In 1920, at the age of 32, Ramanujan died of illness, malnutrition, and a liver infection. During his short lifetime, he independently compiled close to 3,900 results (mostly identities and equations) and nearly all his claims have now been proven correct. He stated results that were both original and highly unconventional, such as the Ramanujan prime and the Ramanujan theta function, which have inspired a vast amount of further research.

In December 2011, in recognition of his contribution to mathematics, the government of India declared that Ramanujan's birthday (December 22) should be celebrated every year as National Mathematics Day, and also declared 2012 the National Mathematics Year.

Srinivasa Ramanujan

OBJECTIVE: Students will work as a team to accomplish a task as a means of understanding how even geniuses like Ramanujan need to collaborate to achieve great work.

VOCABULARY: Mathematician, Polynomial, Prodigy, Quartic equations

NY STATE SCIENCE STANDARDS: 5.1e

COMMON CORE STANDARDS: SL.6-8.1

PRIOR KNOWLEDGE: Newton's third law of motion, norms for collaboration

TASK	DESCRIPTION	RESOURCES
WHO IS SRINIVASA RAMANUJAN?	 Read biography of Srinivasa Ramanujan, p. 23, and discuss the nature of the partnership between him and G.H. Hardy. 	 USB resources in this lesson: More about Hardy and Ramanujan's Collaboration
SPAGHETTI- MARSHMALLOW CHALLENGE	 o What did each mathematician contribute? o Was G.H. Hardy necessary for Ramanujan's success? Students separate into teams of 3 or 4. Each team is given 50 grams of uncooked spaghetti and 25 grams of mini marshmallows. Teams are given 30 minutes to plan and construct the tallest tower they can. After time is called, towers must stand for a full 60 seconds before judging begins. 	With the second secon

TASK

POST-ACTIVITY DISCUSSION

DESCRIPTION

- Each team briefly presents their tower, and the approach they took in constructing it.
 - How long did you spend on planning?
 - How many people physically constructed the tower?
 - Did you adapt ideas as you worked?
 - What strengths and weaknesses were present on your team?
 - Do you think you could have built a better tower individually?
- Class discusses how the most successful teams collaborated and worked together.

RESOURCES

Successful collaborations for students to explore further:

- James Watson and Francis Crick (using data from earlier scientists, constructed the double-helix structure of DNA)
- Marie and Pierre Curie
- Larry Page and Sergey Brin (Co-founders of Google)
- Ben Cohen and Jerry
 Greenfield (Ben and Jerry's)

NIKOLA TESLA

"I do not think there is any thrill that can go through the human heart like that felt by the inventor as he sees some creation of the brain unfolding to success... such emotions make a man forget food, sleep, friends, love, everything." – Nikola Tesla Nikola Tesla was born in 1856 in present-day Croatia to Serbian parents, and became a renown inventor, mechanical and electrical engineer, physicist, and futurist. His aptitude for mathematics and memorization was readily apparent throughout his early education, and he continued to pursue the study of engineering in university, earning the highest marks possible. However, he worked himself nearly to death, and dropped out just before suffering a nervous breakdown, working various jobs for telegraph companies before moving to the United States in 1884.

When he first moved to the U.S., Tesla worked briefly with Thomas Edison, though the men parted ways due to differences in personality, working style, and business philosophy. In 1893, Tesla conducted demonstrations of one of his bestknown inventions, the modern alternating current electricity supply system. AC soon became the standard power system of the 20th century, and has remained the worldwide standard ever since. Two years later, in 1895, Tesla designed the first hydroelectric power plant at Niagara Falls, an event which was publicized worldwide.

Tesla was a pioneer in many fields. The Tesla coil is widely used today in radio and television sets, and his alternating current induction motor is considered one of the ten greatest discoveries of all time. Among his other discoveries are the fluorescent light, laser beam, wireless communications, wireless transmission of electrical energy, remote control, robotics, wind turbines and vertical aircraft take-off. He also has over 700 patents registered worldwide. As a futurist, his visions included explorations of solar energy, the power of the sea, interplanetary communications, and satellites. Tesla's concept of wireless electricity was used to power ocean liners, destroy warships, run industry and transportation, and send communications instantaneously all over the globe.

In 1931, on his 75th birthday, *Time* Magazine featured Tesla on its front cover. However, due to financial constraints on some of his most experimental projects, he died poor and reclusive in January of 1943. His legacy however, has been thriving for more than a century and will undoubtedly live on for decades to come.

Time magazine, Volume 18 Issue 3, July 20, 1931

THOMAS EDISON

"Genius is one percent inspiration and ninety-nine percent perspiration." – Thomas Edison Thomas Alva Edison was an American inventor and businessman. Edison, the last of seven children, was born on February 11, 1847, in Milan, Ohio to Samuel and Nancy Edison. His father was an exiled political activist from Canada, and his mother was a school teacher, which greatly influenced his own education. A highly energetic child prone to distraction, he was deemed "difficult" and possibly "mentally slow" by his teachers, but his mother recognized his true capabilities and homeschooled Edison for the majority of his education. At age 12, Edison convinced his parents to let him sell newspapers to passengers along the Grand Trunk Railway, and soon he began publishing and selling his own small newspaper, called the *Grand Trunk Herald*, with up-to-date articles that were a hit with passengers. This was the first in a lifetime of entrepreneurial ventures in which he was able to identify a need and capitalize on opportunity.

In 1869, Edison moved to New York City and created his first invention, an improved stock ticker which synchronized several stock tickers' transactions called the Universal Stock Printer. By the early 1870s, Edison earned a reputation as a first-rate inventor, and built an independent industrial research facility incorporating machine shops and laboratories in 1876 in Menlo Park, New Jersey. The following year, Edison developed a method for recording sound: the phonograph. Though not commercially viable for another decade, the phonograph nonetheless brought him worldwide fame. After being granted a patent for the light bulb in January of 1880, Edison began to develop a company that would deliver the electricity to power and light the cities of the world. That same year, he founded the Edison Illuminating Company—the first investor-owned electric utility.

The Menlo Park laboratory was the site of Edison's most renown inventions, including the telegraph, phonograph, electric light bulb, alkaline storage batteries, and Kinetograph (a camera for motion pictures). Through his pioneering work, he broadened the notion of invention to encompass what we now call innovation - invention, research, development, and commercialization - and invented the industrial research laboratory. His role as an innovator is evident not only in his two major laboratories at Menlo Park and West Orange in New Jersey, but in more than 200 companies formed worldwide to manufacture and market his inventions. Many of these carried the Edison name, including some 200 Edison illuminating companies.

Thomas Edison died of complications of diabetes on October 18, 1931, in West Orange, New Jersey. Edison had received 1,093 U.S. patents and a staggering 1,293 international patents, totals still untouched by any other inventor.

Nikola Tesla and Thomas Edison

OBJECTIVE: Students will study Tesla and Edison's contributions to electricity and modern electronic devices, and write an essay explaining why modern electronic devices function and look the way they do.

VOCABULARY: Alternating current, Direct current, Engineer, Entrepreneur, Futurist, Innovation, Inventor

NY STATE SCIENCE STANDARDS: WHST.6-8.1, WHST.6-8.4, WHST.6-8.7, WHST.6-8.8

CORE CURRICULUM STANDARDS: 4.4.4d, e; 4.4.5b

PRIOR KNOWLEDGE: Energy transformations, electricity

DESCRIPTION RESOURCES TASK As a class, make a list of electronic devices or other uses **FIFCTRONIC** USB resources in this lesson: Video on Thomas Edison **DEVICES TODAY** of electricity that are essential to our daily lives. Hank Green's Tesla video o Smartphones, television, lights, subway, medical Mental Floss's Tesla video devices, computers, etc. Students should explain that electrical Choose four devices as options for the following writing current is a force, and that the energy in electricity can be changed into other assignment. types of energy, such as light and sound. Students should then discuss Thomas Edison's numerous improvements of the light bulb, telephone, and movies, as Read biographies of Thomas Edison and Nikola Tesla, ELECTRIC well as Nikola Tesla's improvements on the delivery of electricity. CONNECTIONS: pp. 26 and 27. FSSAY o Discuss overlaps in the two genius's work. • Watch videos about Tesla and Edison Students write essays discussing: o How their chosen device uses electricity The specific contributions of both Edison and 0 Tesla to that device: inventions that served as precursors to their device Tesla in his lab 1899

²⁸ GENIUS THEN NOW TOMORROW

GENIUS THEN NOW TOMORROW

7 Days of Genius receives generous support from individuals and organizations, including the John Templeton Foundation

92Y IS A WORLD-CLASS nonprofit community and a cultural center that connects people at every stage of life to the worlds of education, the arts, health and wellness, and Jewish life. Through the breadth and depth of 92Y's extraordinary programs, 92Y enriches lives, creates community and elevates humanity. More than 300,000 people visit 92Y annually and many more connect through digital and social media, live webcasts of events, and an extensive archive of stage programs and original content produced for the web, all available on 92YOnDemand.org. Founded in 1874, 92Y is a proudly Jewish organization that embraces its heritage and welcomes people of all perspectives and backgrounds. For more information, visit 92Y.org

VENTURE INTO THE EXTRAORDINARY #7DAYSOFGENIUS