92Y

GENIUS

THEN AND NOW

CURRICULUM GUIDE

"**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. In March 2014, 92Y is honored to present the **Seven Days of Genius Festival**, www.92Y.org/Genius, a dynamic and groundbreaking exhibition of ideas that will attempt to unravel the complicated nature of the concept of Genius. We will bring people together to discuss new ideas, inventions, and solutions to some of today's biggest questions.

Genius, Then and Now is a supplementary curriculum aligned with the NYS Science Standards and Common Core Standards for middle school students and educators. 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. This inquisitive curriculum unfolds some of the mysteries of the universe with hands on activities and project based learning.

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

Sincerely,

Larisa Gelman
Educational Outreach Center, Director

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Genius, Then and Now receives generous support from the John Templeton Foundation.

Guiding Questions for Students for Each Lesson:

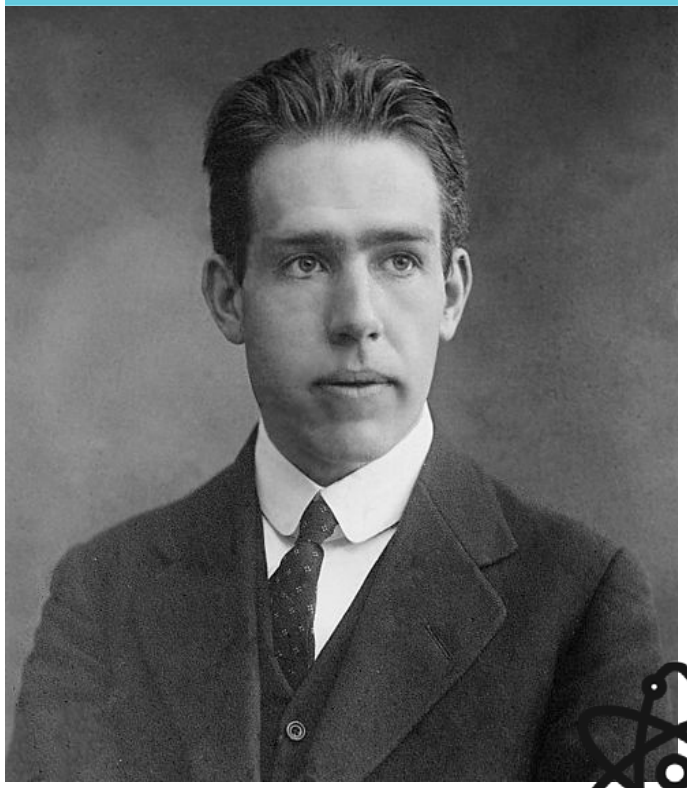
1. **How does this genius's work impact our world today?**

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.

NIELS BOHR



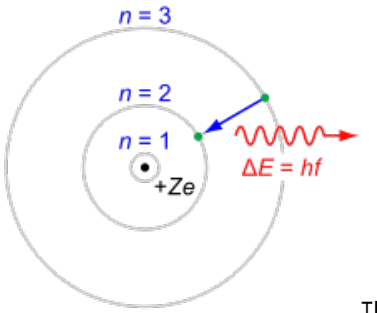
Born on October 7, 1885, in Copenhagen, Denmark, Niels Bohr became an accomplished physicist who derived a revolutionary theory on atomic structures and radiation emission. After working on the Manhattan Project in the United States, Bohr called for responsible and peaceful applications of atomic energy across the world.

Bohr received the 1922 Nobel Prize in Physics for his work on atomic structures. 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 went on to work with the group of scientists who were at the forefront of research on nuclear fission during the late 1930s, to which he contributed the 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. Outside of his pioneering ideas, Bohr was known for his wit and warmth, and his humanitarian ethics that informed his later work.

With Adolf Hitler's rise in 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 with Niels and his son, Aage, eventually making their way to the United States. Bohr then worked with the Manhattan Project in Nevada, where the first atom bomb was being created. Because he had concerns about how the bomb could be used, he called for future international arms control and active communication about the weapon between nations — an idea met with resistance by Winston Churchill and Franklin D. Roosevelt.

After the end of the 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," dated June 9, 1950, Bohr envisioned an "open world" mode of existence between countries that abandoned isolationism for true cultural exchange.

"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*



The Bohr Model of the hydrogen atom

MARIE CURIE

Marie Curie was a physicist, chemist and a pioneer in the study of radiation. 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 Nov. 7, 1867, the youngest of five children. Her parents were educators and insisted that their girls be educated as well as their son. Marie graduated from high school first in her class at the age of 15. Marie and her older sister, Bronia, both wished to attend college but the University of Warsaw did not accept women. Their interests were in scientific research, and to receive an education, they would have to leave the country. Marie moved to France where she earned her master's degree in physics in July 1893 at Sorbonne in Paris and a second degree in mathematics in 1894.

In July 1898, Marie and her husband Pierre published a conclusion to their joint research: the bismuth compound they were studying contained a previously undiscovered radioactive element that they named polonium, after Marie's native country, Poland. By the end of that year they had isolated a second radioactive element they called radium, from *radius*, the Latin word for rays. In 1902, they announced success in extracting 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 Henri Becquerel, were named winners of the Nobel Prize in Physics for their contributions to the understanding of atomic structure. The nominating committee objected to including a woman as a Nobel Laureate, but Pierre insisted that the original research was Marie's. In 1911, after Pierre's death, Marie was awarded a second Nobel Prize in Chemistry for her discovery of the elements polonium and radium. She continued to do research in radioactivity but when World War I broke out 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 tirelessly to raise money for her Radium Institute, including a trip to the United States. By 1920, she began suffering from medical problems, likely due to her exposure to radioactive materials. On July 4, 1934, she died of aplastic anemia, a blood disease that is often caused by too much exposure to radiation.

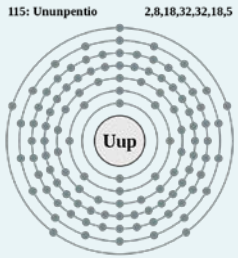
The Curies received another honor in 1944 with the discovery of the 96th element on the Periodic Table of the Elements, which was named curium.

"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*

Soviet postage stamp

Marie Curie and Niels Bohr

OBJECTIVE: Students will study atomic structure and the processes scientists use to discover new elements.
VOCABULARY: Chemistry, Compounds, Elements, Periodic Table
NYS SCIENCE STANDARDS: PS 3.3e, f; PS 3.3a-d; 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
PRIOR KNOWLEDGE: Structure of atoms, periodic table of elements

TASK	DESCRIPTION	RESOURCES
DISCOVERING ELEMENTS 	• Read biographies of Bohr and Curie, pp. 4 and 5. • Discuss Bohr and Curie's contributions to science. o *Why were their discoveries important?* o *How do they influence our current understanding of atoms?* • Read article about the discovery of element 115. • 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.	Video biography of Marie Curie: http://youtu.be/Spa1DQPw4rU Element 115 Articles: • http://news.nationalgeographic.com/news/2013/08/130828-science-chemistry-115-element-ununpentium-periodic-table/ • http://www.ibtimes.com/scientists-discover-new-element-115-super-heavy-ununpentium-confirmed-researchers-1401147 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 – HOW MANY CAN WE DISCOVER?

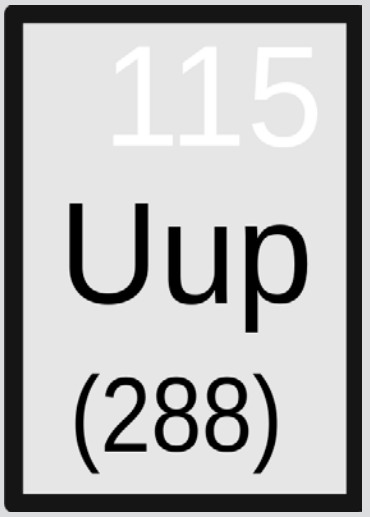
DESCRIPTION

- Students write an essay explaining the influence that Bohr and Curie had on modern scientists who have discovered new elements.
    - 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.

Extension:

- 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.

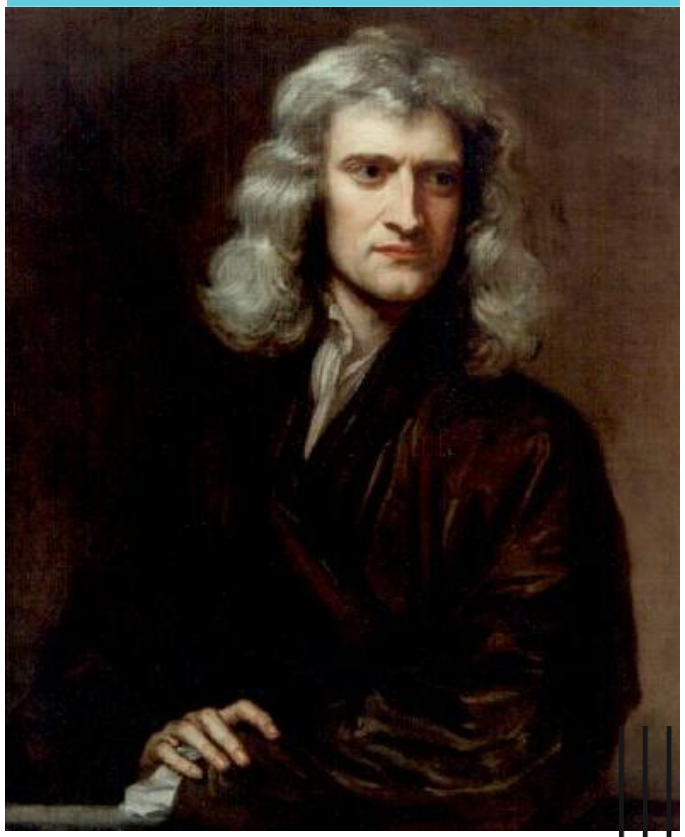
RESOURCES



Pity the Poor Scientists With All the Elements Found

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

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.

"I can calculate the motion of heavenly bodies, but not the madness of people."
–Sir Isaac Newton

JOHANNES KEPLER

Johannes Kepler was a German mathematician, astronomer, and astrologer who make 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. However, 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.

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

Illustration from *Astronomia Nova,* chapter 1

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 major role in the scientific revolution. His achievements include improvements to the telescope and consequent astronomical observations and support for Copernicanism – the idea that the earth revolves around the sun. The most supportive of these observations were 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 revolved around Jupiter, not earth. Galileo has been called 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 twice of heresy by the church for his beliefs, and wrote books on 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.

That same year, Galileo refined his theories on motion and falling objects, and developed the universal law of acceleration, which all objects in the universe obeyed. Galileo began to express openly his support of the Copernican theory that the earth and other planets revolve around the sun. This challenged Aristotle's geocentric doctrine and the established order set by the Catholic Church. In 1612, he published his *Discourse on Bodies in Water*, refuting the Aristotelian 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. One year later, Galileo published his observations of sunspots, which further refuted 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 Copernican theory regarding the motion of the earth. He obeyed the order for seven years, partly to make life easier and to prove his devotion to the Church. The Inquisition proceedings lasted from September 1632 to July 1633, and during most of this time, Galileo was treated with respect and never imprisoned. However, in a final attempt to break him, Galileo was threatened with torture, and he finally publically stated that he supported Copernican theory, but privately held that his own statements were correct.

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.

ALBERT EINSTEIN

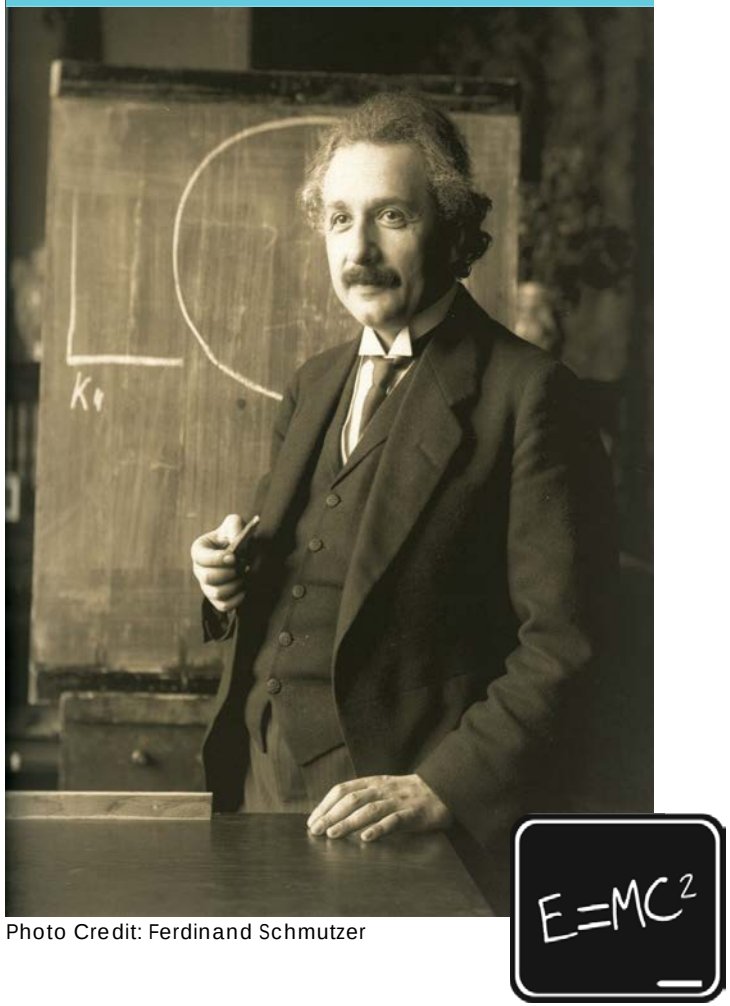


Photo Credit: Ferdinand Schmutzer

"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 completely changed 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 $e=mc^2$. 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.

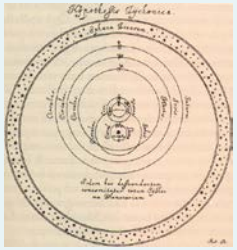
Einstein was awarded the 1921 Nobel Prize in Physics for his work on the photoelectric effect (*not* for general relativity, which was still under debate amongst physicists), and it was after his receipt of this award that Einstein became a household name around the world. He continued teaching and traveling 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.

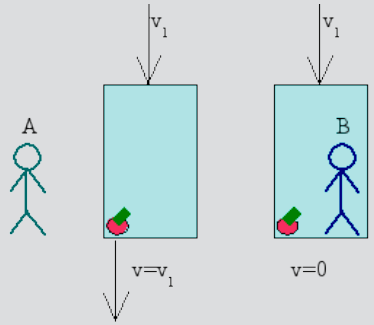
In the fall of 1933, Albert Einstein accepted a position at Princeton University, and attained American citizenship in 1940. He reluctantly became involved in the Manhattan Project in 1939, when he wrote a letter to President Roosevelt warning him about the possibility of Germany's construction of an 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.

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.

TASK	DESCRIPTION	RESOURCES
CONSPIRACY BUSTERS 	• Read the biographies of Kepler, Galileo, Newton, and Einstein on pp. 8-11, 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.	Examples of conspiracy theory websites: 1) http://www.atlanteanconspiracy.com/2011/12/geocentricity-vs-heliocentricity.html 2) http://galileowaswrong.com/ 3) http://www.fixedearth.com/

TASK	DESCRIPTION	RESOURCES
LETTER WRITING 	• Students' letters should include the following as support: o Kepler and Galileo used observations and calculations to explain that the earth revolves around the Sun, concluding that the sun moves across the sky because the Earth is rotating. o Newton's first law of motion and law of gravity explain why Earth revolves around the Sun. Inertia and the Sun's gravity keep earth moving along its orbit. o Einstein's theory of relativity explains why we 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. o We can use Newton's second law of motion (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.	**Newton's Laws:** http://teachertech.rice.edu/Participants/louviere/Newton/law3.html  Newton's Laws in Latin 1687 edition. **Theory of Relativity:** http://www.kidsastronomy.com/academy/lesson210_assignment3_8.htm 

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 -

- Information on Isaac Newton;
- Each of Newton's three laws of motion;
- An explanation of each law of motion; and
- 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 1st Law	1st law is incorrectly explained and/or does not have correct examples	1st law is explained with at least one example but may have some incorrect information	1st law is explained with at least one example	1st law is clearly explained with at least three examples.
Newton's 2nd Law	2nd law is incorrectly explained and/or does not have correct examples	2nd law is explained with at least one example but may have some incorrect information	2nd law is explained with at least one example	2nd law is clearly explained with at least three examples.
Newton's 3rd Law	3rd law is incorrectly explained and/or does not have correct examples	3rd law is explained with at least one example but may have some incorrect information	3rd law is explained with at least one example	3rd law is clearly explained with at least three examples.

LEONARDO DA VINCI

Leonardo da Vinci was an Italian inventor, artist, and multi-talented genius 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 even chemistry. Even after he attained 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.

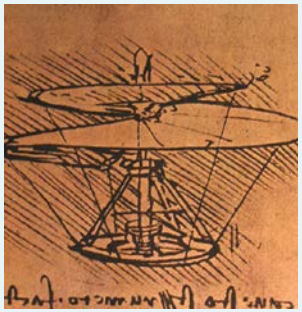
It is only within the last century that Leonardo has been recognized as an engineer and inventor of great skill. Previously, he was known to the world primarily as an artist. He sketched ideas for numerous inventions that were not capable of being constructed during his lifetime, such as the flying machine, 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.

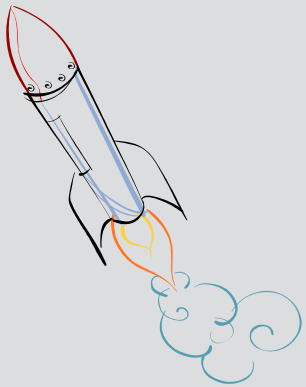
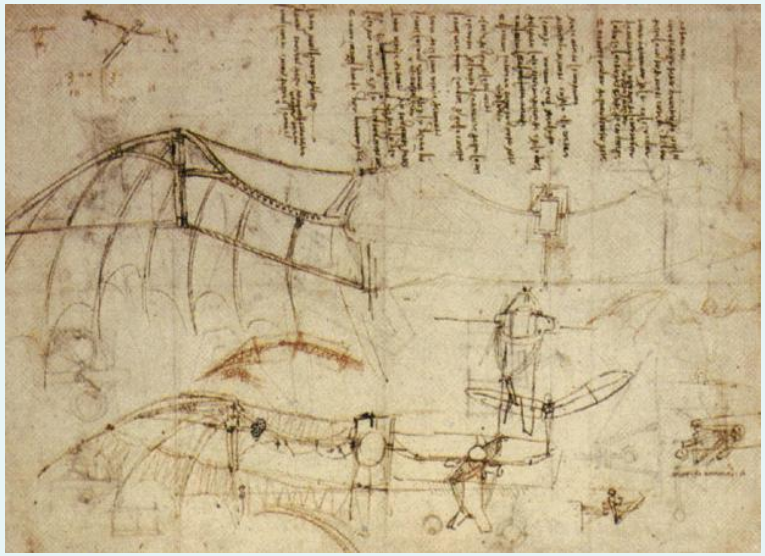
Leonardo is now recognized as a true polymath, or "Renaissance man," who displayed expertise in an exhausting number of different fields, including anatomy, civil engineering, mechanical engineering, drawing, painting, sculpture, chemistry, geology, geometry, hydrodynamics, mathematics, optics, physics, 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.

"The noblest pleasure is the joy of understanding."
– *Leonardo da Vinci*

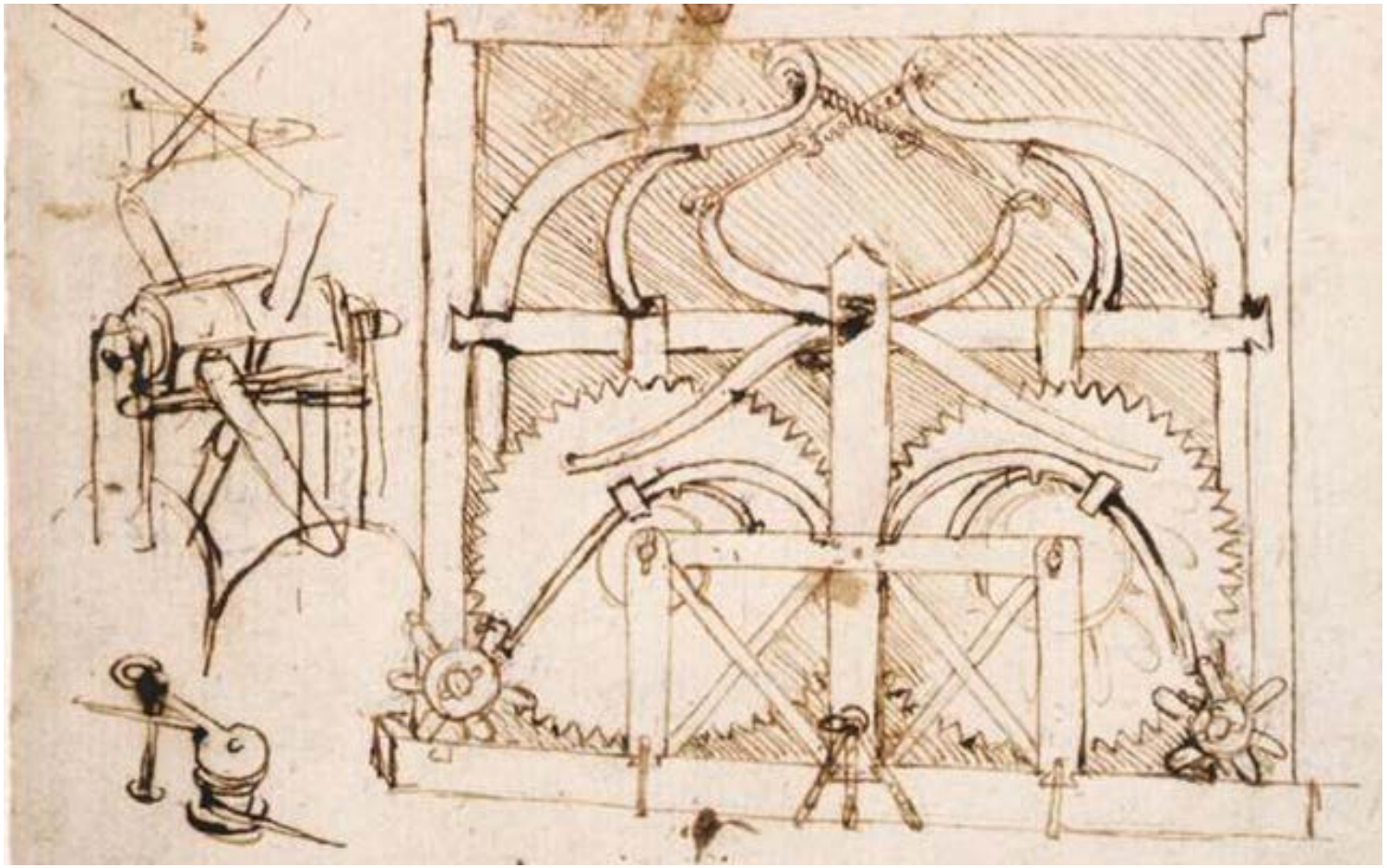
Leonardo Da Vinci

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
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	DESCRIPTION	RESOURCES
LEONARDO'S APPRENTICE  Helicopter	• Read Leonardo's biography, p. 15. • Review components of simple and complex machines o Gear, belt, lever, pulley, wheel, axel o 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*. o Students list components of simple and complex machines they encounter while playing the game.	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: www.leonardoda-vinci.org

TASK	DESCRIPTION	RESOURCES
FUTURISTIC INVENTIONS 	• Study Leonardo's sketch for an automobile and part of a flying machine, p. 18. • Compare and contrast these sketches with blueprints for a 1917 Model T Ford engine and a BMW v12 engine, pp. 19 and 20. • *Based on your study of various engines and machines, what are the necessary components of an engine?*  Flying Machine, 1488	Leonardo drew sketches of various machines, including a flying machine, automobile, helicopter, and an armored vehicle – all complex machines. Sketch of an automobile: http://www.leonardoda-vinci.org/Automobile-large.html Sketch of a flying machine: http://www.leonardoda-vinci.org/Flying-Machine-large.html 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

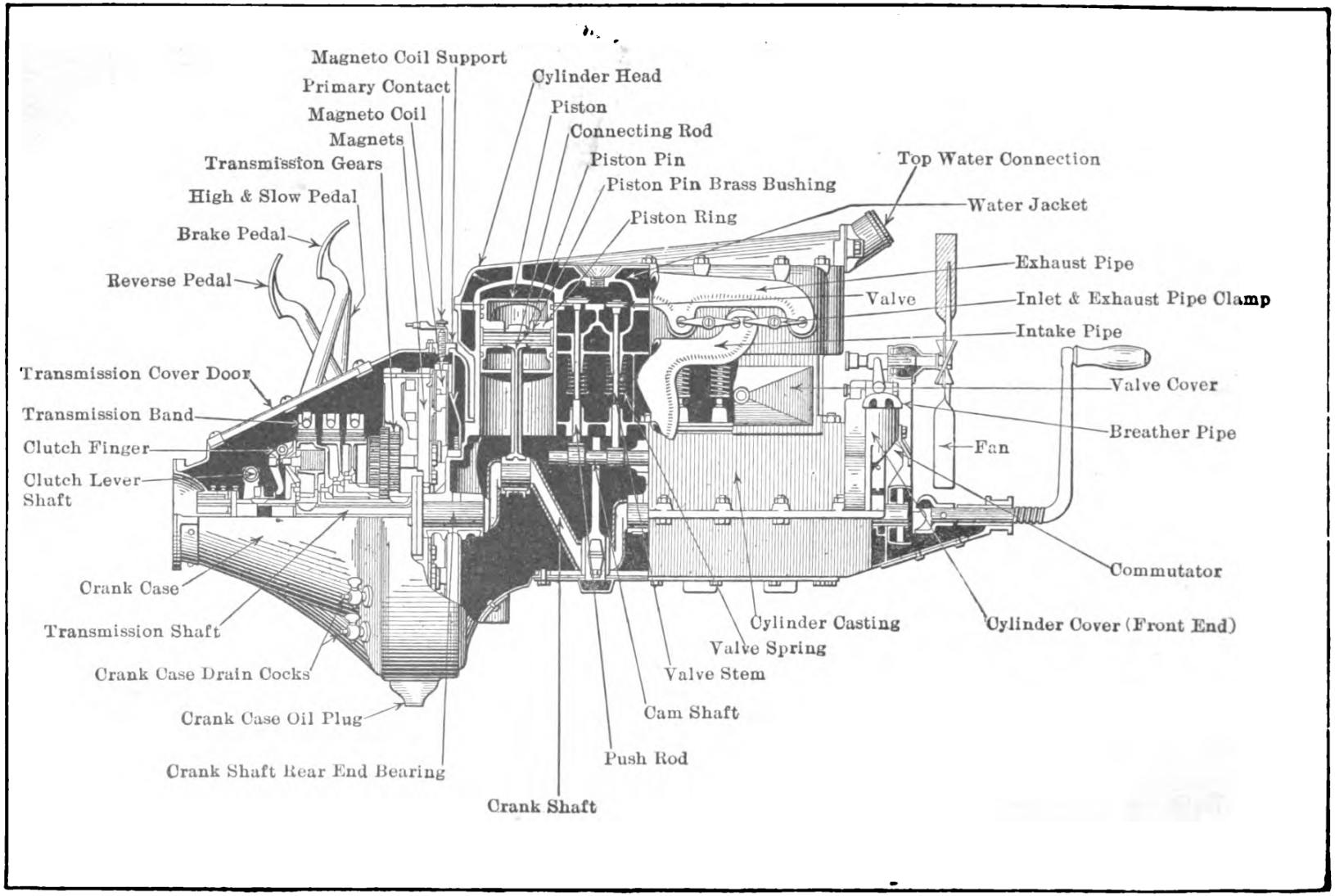
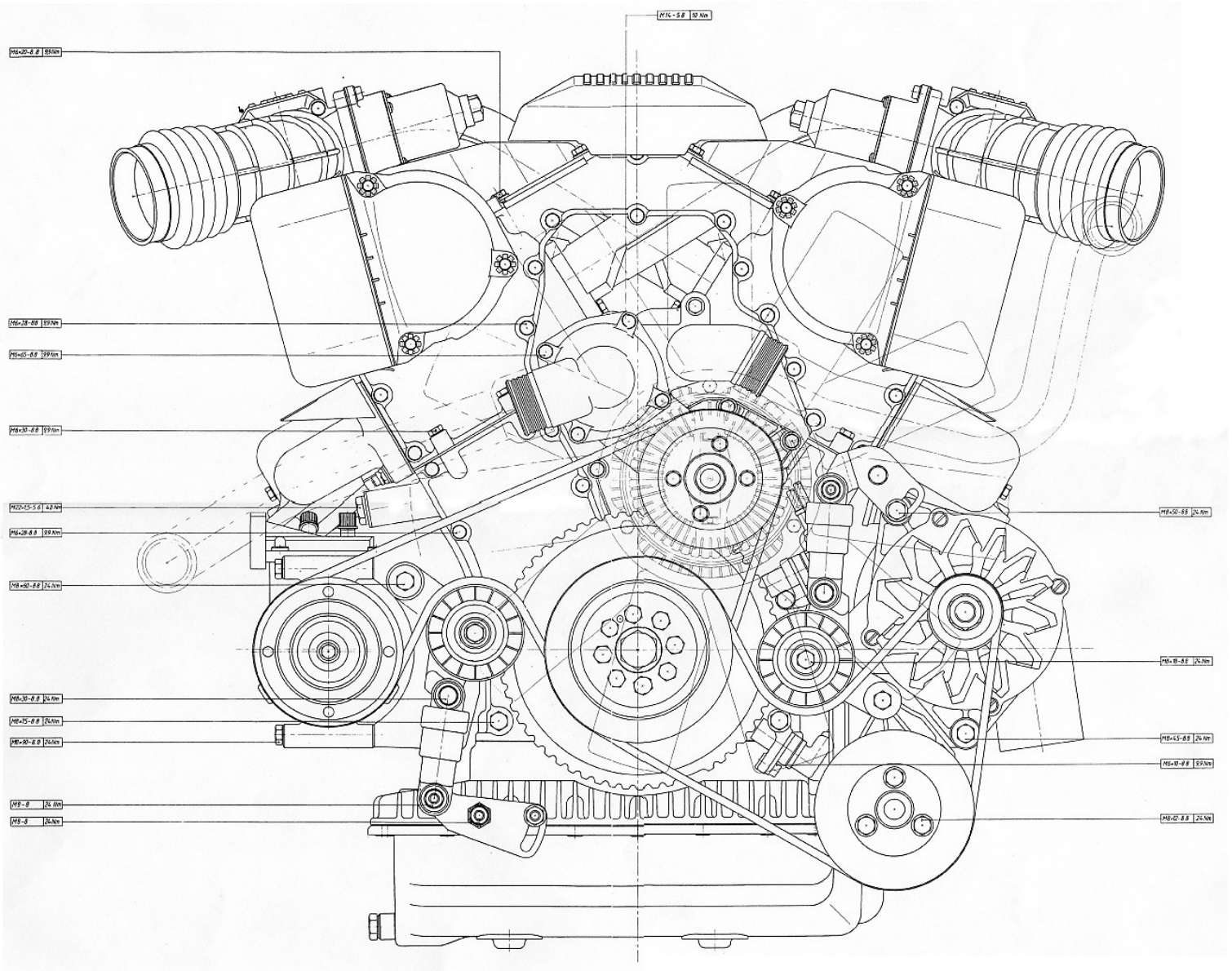


Fig. 11.—Part Sectional View of the Ford Four Cylinder Unit Power Plant Showing Important Parts of the Power Generating and Transmission System.

BMW v12 Engine



SRINIVASA RAMANUJAN

Photo Credit: Konrad Jacobs

“1729 is a very interesting number; it is the smallest number expressible as a sum of two cubes in two different ways, the two ways being 13 + 123 and 93 +103.”
– Srinivasa Ramanujan

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

Ramanujan was born in his grandmother's house in Erode, India, a small village about 400 km southwest of Madras, in 1887. By the age of 13, he began to work on developing his own on 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 $y= ax^4 + bx^3+cx^2+dx+e$). The following year, not knowing that quintic equations could not be solved by radicals, he tried on his own to solve it.

Ramanujan received a scholarship to study at Government College in Kumbakonam, which was later rescinded when he failed his non-mathematical coursework. He matriculated his coursework 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 1912–1913, he sent samples of his theorems to three academics at the University of Cambridge in London, including a man named G.H. Hardy. Hardy, recognizing the brilliance of his work, invited Ramanujan to visit and work with him in London. He became a Fellow of the Royal Society and a Fellow of Trinity College, Cambridge.

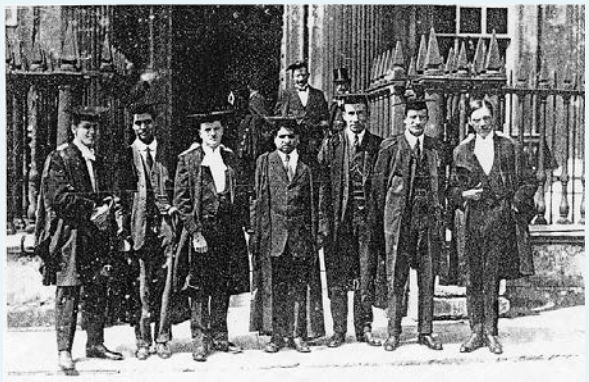
Although a mathematical genius, Ramanujan was frequently criticized for his style of work. According to Hardy, Ramanujan utilized a “process of mingled argument, intuition, and induction, of which he was entirely unable to give any coherent account.” The English mathematician was therefore able to help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

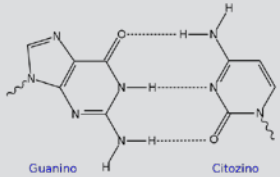
At the age of 32, Ramanujan died of illness, malnutrition, and a liver infection in 1920. During his short lifetime, he independently compiled close to 3,900 results (mostly identities and equations) and nearly all his claims have now been proven correct. He stated results that were both original and 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. 21, and discuss the nature of the partnership between him and G.H. Hardy. o *What did each mathematician contribute? Was G.H. Hardy necessary for Ramanujan's success?*	Hardy and Ramanujan's Collaboration: http://www.storyofmathematics.com/20th_hardy.html
SPAGHETTI-MARSHMALLOW CHALLENGE 	• Students separate into groups of 3 or 4. • Each group is given 50 grams of uncooked spaghetti and 25 grams of mini marshmallows. • Groups 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.	 Srinivasa Ramanujan (center) together with his colleague Godfrey Harold Hardy (extreme right) and other scientists at Trinity College at the University of Cambridge.

TASK	DESCRIPTION	RESOURCES
POST-ACTIVITY DISCUSSION  	• Each team briefly presents their tower, and the approach they took in constructing it. o *How long did you spend on planning?* o *How many people physically constructed the tower?* o *Did you adapt ideas as you worked?* o *What strengths and weaknesses were present on your team?* o *Do you think you could have built a better tower individually?* • Class discusses how the most successful teams collaborated and worked together.	**Successful collaborations for students to explore further:** • James Watson and Francis Crick  • Marie and Pierre Curie  • Larry Page and Sergey Brin (Co-founders of Google) • Ben Cohen and Jerry Greenfield (Ben and Jerry's) 

NIKOLA TESLA

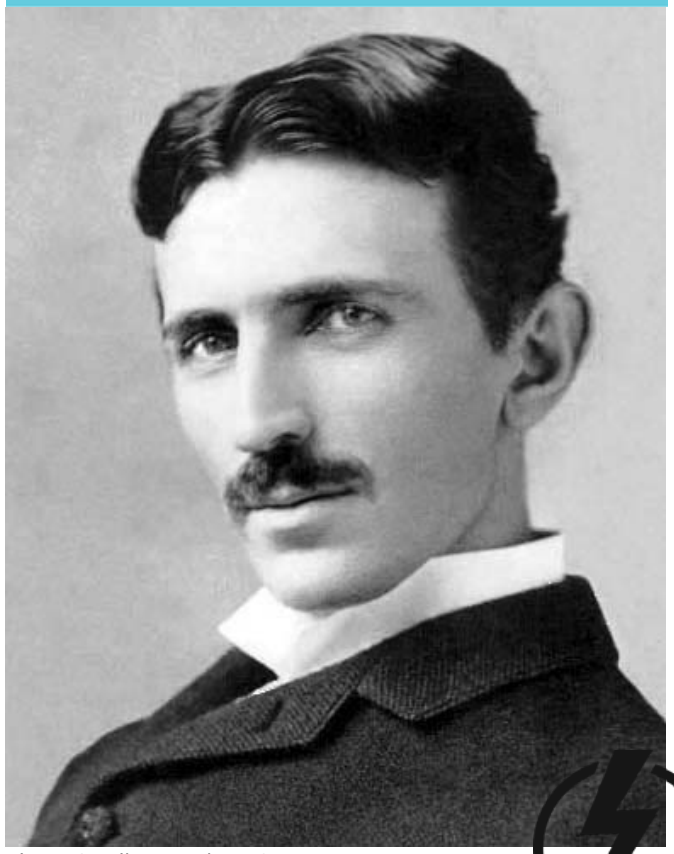


Photo Credit: Napoleon Sarony

"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 a Serbian American inventor, electrical engineer, mechanical engineer, physicist, and futurist best known for his contributions to the design of the modern alternating current electricity supply system. In 1893, Tesla conducted demonstrations of his AC system, which 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, a feat that was highly publicized throughout the world.

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 is considered the father of the radio and the modern electrical transmissions systems and has over 700 patents registered worldwide. His futurist vision included exploration 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 the inventor appeared on the cover of *Time Magazine*. Poor and reclusive, Nikola Tesla died at the age of 86 on January 7, 1943 in New York City – where he lived for nearly 60 years. 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

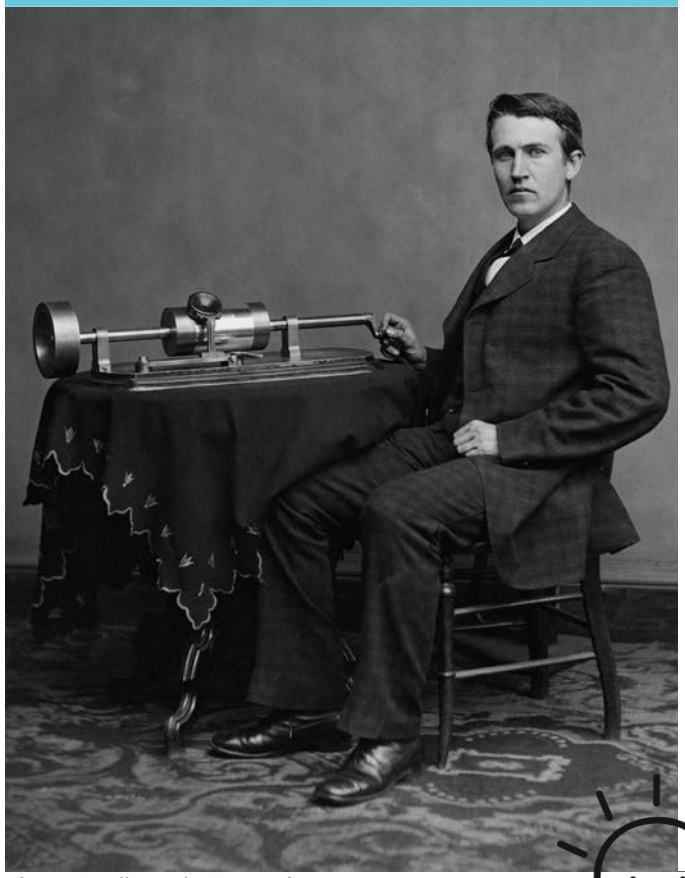


Photo Credit: Levin C. Handy

Thomas Alva Edison was an American inventor and businessman. Born on February 11, 1847, in Milan, Ohio, Thomas Edison rose from humble beginnings as the last of the seven children of Samuel and Nancy Edison. His father was an exiled political activist from Canada. His mother, an accomplished school teacher, was a major influence in Edison's early life. A hyperactive child, prone to distraction, he was deemed "difficult" by his teachers. At age 12, Edison convinced his parents to let him sell newspapers to passengers along the Grand Trunk Railway. Thomas soon began publishing his own small newspaper, called the *Grand Trunk Herald,* with up-to-date articles that were a hit with passengers. This was the first of what would become a long string of entrepreneurial ventures where he saw a need and capitalized on opportunity.

Setting up a lab in Menlo Park, New Jersey, he developed products including the telegraph, phonograph, electric light bulb, alkaline storage batteries and Kinetograph (a camera for motion pictures). Edison 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 300 companies formed worldwide to manufacture and market his inventions. Many of these carried the Edison name, including some 200 Edison illuminating companies.

In 1869, Edison moved to New York City and developed his first invention, the Universal Stock Printer, an improved stock ticker which synchronized several stock tickers' transactions. By the early 1870s, Thomas Edison had acquired a reputation as a first-rate inventor. In 1876, he moved his expanding operations to Menlo Park, New Jersey, and built an independent industrial research facility incorporating machine shops and laboratories. In December of 1877, Edison developed a method for recording sound: the phonograph. Though not commercially viable for another decade, the invention brought him worldwide fame. After being granted a patent for the light bulb in January 1880, Edison set out to develop a company that would deliver the electricity to power and light the cities of the world. That same year, Edison founded the Edison Illuminating Company—the first investor-owned electric utility—which later became the General Electric Corporation.

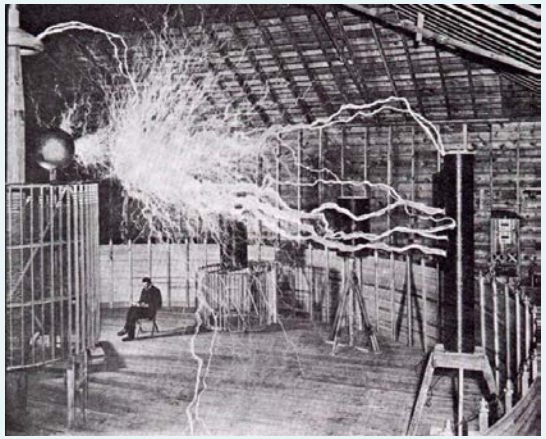
Thomas Edison died of complications of diabetes on October 18, 1931, in West Orange, New Jersey. Edison had received 1,093 U.S. patents, a total still untouched by any other inventor.

"Genius is one percent inspiration and ninety-nine percent perspiration." – *Thomas Edison*

Nikola Tesla and Thomas Edison

OBJECTIVE: Students will study Tesla and Edison's contributions to electricity and modern electronic devices.
VOCABULARY: Alternating current, Direct current
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

TASK	DESCRIPTION	RESOURCES
ELECTRONIC DEVICES TODAY 	• As a class, make a list of electronic devices or other uses of electricity that are essential to our daily lives. o Smartphones, television, lights, subway, medical devices, computers, etc. • Choose four devices as options for the following writing assignment.	Students should explain that electrical current is a force, and that the energy in electricity can be changed into other 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 well as Nikola Tesla's improvements on the delivery of electricity.

ELECTRIC CONNECTIONS: ESSAY 	• Read biographies of Thomas Edison and Nikola Tesla, pp. 24 and 25.
	  o Discuss overlaps in the two genius's work.
	• Students write essays discussing:
	  o How their chosen device uses electricity
	  o The specific contributions of both Edison and Tesla to that device; inventions that served as precursors to their device
		Nikola Tesla in his lab 1899 

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