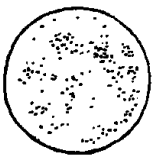
Who Was Galileo Galilei?



Galileo was a man of many interests. Unlike today's scientists who become experts in very specialized areas, Galileo studied a wide range of topics from mathematics to astronomy to physics. He was also a teacher, inventor, and writer.

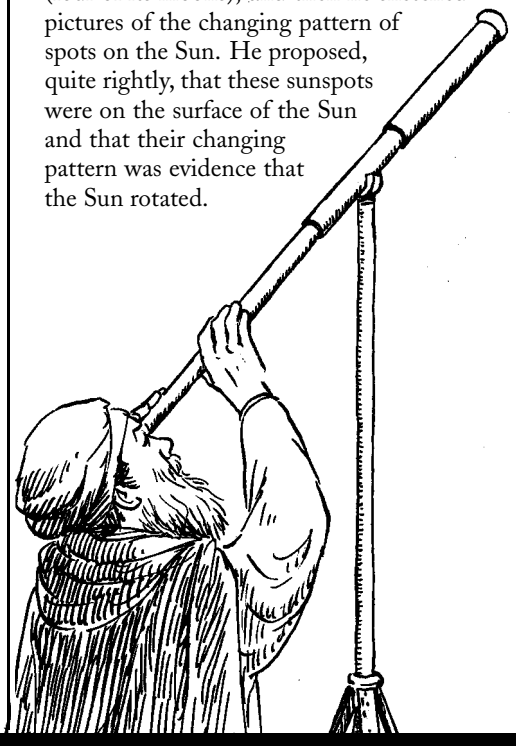
Galileo may be best known for opposing the Catholic Church's view that Earth was the center of the universe, but he was in fact a religious person. As a teenager, he attended school in a monastery and dreamed of becoming a monk.

In 1581, Galileo's father sent him to the University of Pisa, Italy, to study medicine. He wanted Galileo to become a doctor so he could make a good living and eventually support his younger siblings. Galileo had other ideas. While at the University, he became fascinated with mathematics. He left the University to become a tutor of mathematics and then a professor.

Galileo next became interested in falling bodies. Whether or not he dropped cannonballs from the Leaning Tower of Pisa is not known, but he did discover that the speed at which objects fall depends on air resistance, not on how much they weigh.

At around this time, Galileo's love for tinkering with mechanical things led to his invention of a simple thermometer, a geometric and military compass, and an improved telescope.

He observed the surface of the Moon and found it to be surprisingly similar to Earth; he witnessed four objects circling around Jupiter (four of its moons); and then he sketched pictures of the changing pattern of spots on the Sun. He proposed, quite rightly, that these sunspots were on the surface of the Sun and that their changing pattern was evidence that the Sun rotated.



Unfortunately, one of the books Galileo published included a strong argument that the Sun and not Earth was at the center of the solar system.This went against church teachings, and Galileo was brought before a church organization known as the Inquisition.

In 1633, the Inquisition placed Galileo under house arrest,where he stayed until he died in 1642. Although Galileo was old and sick at this point, he continued scientific experimentation. Going blind, he could no longer study astronomy. Instead, he returned to his studies on motion. Galileo's studies of inclined planes, falling bodies, projectiles, and other laws of motion became the foundation of modern physics.Throughout his life, Galileo was strongly supported by his eldest daughter, Virginia (Sister Maria Celeste), who entered into a convent in 1613 and corresponded with him regularly.

By following his many interests and pursuing questions that intrigued him, Galileo contributed greatly to science. He made many discoveries in astronomy and laid the foundation for modern physics.

1564 Born in Pisa,Italy, on February 15.
1579 Studies at a Benedictine monastery and considers becoming a monk.
1581 Begins studies at the University of Pisa,Italy.
1585 Leaves Pisa without a degree.
1589 Takes a teaching position at Pisa.Three years later, begins teaching at the University of Padua.
1597 Develops a geometric and military compass.
1599 Enters a relationship with Marina Gamba,who bears his three children.
1600 Daughter, Virginia (1600–1634),is born.
1601 Daughter, Livia (1601–1659), is born.
1602 Conducts experiments with a pendulum.
1604 Begins experimenting with accelerated motion on an inclined plane.
1606 Son, Vincenzio (1606–1649), is born.
1609 Improves the telescope and becomes first to use it for serious astronomical observation.
1610 Discovers the moons of Jupiter; appointed chief mathematician and philosopher to the Grand Duke of Tuscany, Cosimo II.
1632 Publishes Dialogue on the Two Chief World Systems: Ptolemaic and Copernican.
1633 Submits to trial for heresy by The Holy Office of the Inquisition and abjures his views;is allowed to retire to his villa in Arcetri near Florence, Italy, where he spends the remainder of his life under house arrest.
1638 Becomes blind.
1642 Dies on January 8 in Arcetri, Italy.
1892 Awarded honorary degree from the University of Pisa.
1981 Pope John Paul II establishes the Galileo Commission to study the Galileo case.
1992 Pope John Paul II officially closes the work of the commission,affirming that his predecessor, Pope Urban VIII (1568–1644),had unfairly condemned Galileo for his beliefs.

Galileo Resources

Galileo's Battle for the Heavens.
WGBH Boston Video, 2002.

Find out more about Galileo's discoveries, his clash with the Catholic Church, and more in the two-hour NOVA program that airs October 29, 2002. Call 1-800-949-8670 or visit **main.wgbh.org/wgbh/shop/nova.html** to order. (YA)(A)

In a companion Web site, learn about Galileo's life, his place in the world of science, his experiments, and his mistaken belief that Earth's daily rotation and its annual orbit around the Sun trigger ocean tides. (YA)(A)
www.pbs.org/nova/galileo/

Discover more at your local library.

The following icons indicate whether a resource is recommended for children, young adult, and/or adult audiences.

(C) children
(YA) young adult
(A) adult

Learning More

Rubin, Vera C.
Bright Galaxies,Dark Matter.
Woodbury, NY: American Institute of Physics Press, 1997.

Rubin narrates her research in such areas as galactic motion and dark matter and the course of her own career. (A)

Women in Astronomy: An Introductory Resource Guide
www.astrosociety.org/education/resources/womenast_bib06.html
Provides a reading list of books about women in astronomy. (YA)(A)

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Tyson, Neil de Grasse
The Sky Is Not the Limit: Adventures of an Urban Astrophysicist.
New York: Doubleday, 2000.

Offers Tyson's perspectives and experiences—from his childhood in the Bronx to his current post as director of Hayden Planetarium. (A)

Neil de Grasse Tyson
www.wnyc.org/legacy/shows/survivalkit/tyson042802.html
In this National Public Radio interview, find out what Tyson would put in a survival kit if he were stranded somewhere.(Requires RealPlayer plug-in.) (A)

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McDaniel, Melissa and Jerry Lewis.
Stephen Hawking: Revolutionary Physicist.
New York: Chelsea House Publishers, 1994.

Relates Hawking's life from his childhood to the present.This book is part of the series, Great Achievers:Lives of the Physically Challenged. (YA)(A)

Stephen Hawking's Web Site
www.hawking.org.uk/home/hindex.html
Profiles personal and professional information about Hawking. (YA)

Scientists Today

Astronomy and physics are much different today than they were in Galileo's time. Today's scientists are much more likely to subspecialize in a main area of interest. For example, physicists interested in subatomic objects are called particle physicists. Astronomers interested in the origin of life in the universe are called astrobiologists.

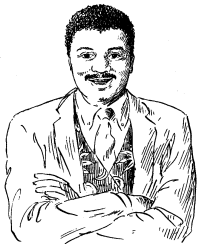
Almost anyone can become a scientist. Here are brief biographies of some of the scientists who are making contributions to astronomy and physics today.

Vera Cooper Rubin

Vera Rubin's interest in stars began when she was 10 years old. Her father helped her build a telescope from scratch and attended amateur astronomy club meetings with her. In the early 1960s, Rubin became the first woman permitted to observe at the Palomar Observatory, which is run by the California Institute of Technology. One of her major contributions to astronomy was finding evidence to support the theory that there may be large amounts of unseen matter, known as dark matter, in the universe.

She is currently an astronomer at the Carnegie Institution of Washington (D.C.) for the Department of Terrestrial Magnetism. In 1993, she was awarded the National Medal of Science. She has four children, all of whom have pursued careers in science. In addition, she has been very active in encouraging women and minorities to pursue science careers.

Neil de Grasse Tyson



Neil de Grasse Tyson is an astrophysicist who has pursued science and spent years helping others understand it.

Tyson first looked up at the sky from the rooftop of his Bronx, New York,apartment house with a pair of binoculars. He was 9 years old. He would later become the youngest-ever director of the Hayden Planetarium at the American Museum of Natural History in New York City. He also spends time as a visiting research scientist in astrophysics at Princeton University, New Jersey.

Since 1995, Tyson has written a monthly essay "Universe" for Natural History magazine. He has also written numerous books to help others understand the universe. His research interests include star formation, exploding stars, dwarf galaxies, and the structure of our Milky Way. He has two children.

Stephen Hawking

Stephen Hawking likes to think big. He spends time working as a cosmologist, a person who studies the origin, present state, and future of the universe. One of his greatest contributions has been in the understanding of black holes, which are thought to be places in space where there is so much concentrated mass that anything nearby is sucked into their gravitational pull.

Hawking has also had to overcome great physical challenges. For most of his adult life, he has had a disease called amyotrophic lateral sclerosis,or ALS. Also known as Lou Gehrig's disease, this illness makes it progressively more difficult to move, speak, breathe, and swallow. Adaptive technologies have allowed him to continue to write and deliver scientific papers and lectures worldwide. He has three children and one grandchild.

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In the Swing of Things

For ages 10 and older.

It is thought that Galileo first started studying pendulums when, in 1583, he watched a suspended lamp swing back and forth in the cathedral of Pisa. He used his pulse to time the swings and discovered that the duration of each swing was the same.This would later become an important concept in regulating clocks. Do this experiment with a pendulum and see whether you can learn what makes it work.

You will need

- cotton string
- flat metal washers
- ruler
- scissors
- tape
- watch with a second hand
- notepaper
- ballpoint pen

What to do

1. Measure out an 18-inch length of string. Tie a washer to one end. Measure and mark the string 12 inches from the washer. Find a surface from which you can freely swing the pendulum, such as the corner of a table or desk. Tape the string to the edge of the surface, making sure that the marked part of the string sits right on the edge.
2. Raise the washer to the height of the table. As you drop the washer, start your timing. Count how many times the pendulum swings in 15 seconds. Record the number on a sheet of notepaper.
3. Add a second washer to your pendulum and repeat the experiment. Count the number of swings in 15 seconds and record that number.
4. Add two more washers (for a total of four) and repeat the procedure one more time.
5. Cut a new piece of string 30 inches long and create a pendulum that is 24 inches long, twice as long as in your first experiment. Repeat the experiment above.
6. Now take a look at your results. What affects the timing of the swing? What do you think would happen if you started the pendulum from different heights?

Learning More

Bonnet , Robert L. and Dan Keen.
Science Fair Projects: Physics.
New York: Sterling Publishing, 1999.

Presents projects and experiments that use easy-to-find materials to explore the world of physics, covering such topics as temperature, energy flow, acceleration, sound, pendulums, momentum,magnetism, and solar heat.

Galileo's Pendulum Experiments
es.rice.edu/ES/humsoc/Galileo/Student_Work/Experiment95/galileo_pendulum.html
Relates the observations Galileo made in his pendulum experiments, reproduces the experiments, and reports the results.

How Pendulum Clocks Work
www.howstuffworks.com/clock.htm
Describes the workings of the pendulum clock, the first clock made that had any accuracy.

The Pendulum
muse.tau.ac.il/museum/galileo/pendulum.html#a1
Explains the mechanism that drives the pendulum,why Galileo became interested in pendulums, and Galileo's conclusions about the pendulum.

You're Getting Very Sleepy

Have you ever seen a hypnotist swing a watch back and forth to put somebody in a very relaxed state? The watch on a chain is a type of pendulum.The idea is that the swinging motion is so regular that the person looking at it will become so entranced that she will be susceptible to anything you tell her. Whether this is true is debatable. But how a pendulum works is not. Galileo discovered the laws under which pendulums work, one of the main principles being that they swing in an almost constant, steady interval. Later, scientists used those principles to design pendulum clocks.

The Tick Tock of a Water Clock

For ages 10 and older.

Water clocks measure time by using the fact that water will flow at a constant rate through a certain size hole.The same amount of water flows into its receiving container every second. By measuring the amount of water in the container, it is possible to measure how much time has passed. In this experiment, you will build a water clock that measures time.

You will need

- cardboard shoebox top
- 1 paper cup
- 1-liter flat-bottomed clear plastic bottle
- 1-cup measuring cup
- 1/2 cup of water
- scissors
- clear tape
- stop watch or watch with second hand
- notepaper
- ballpoint pen

What to do

1. On a sheet of paper, start from the bottom and mark up four inches, drawing lines at every half inch. Label the lines and cut out your ruler.
2. Have an adult help you remove the bottle label and cut the bottle in half. Tape your paper ruler onto the bottle so that the bottom of the ruler lines up with the bottom of the bottle. Tape the bottle onto the front of the cardboard shoebox top.
3. Use the ballpoint pen to make a small hole in the bottom of the paper cup. Make the hole about a quarter-inch from the outer edge of the bottom. Use tape to secure the cup to the shoebox lid so that the hole in the cup is closest to you.
4. Hold your finger under the hole in the top container and pour in about 1/2 cup of water.
5. Remove your finger and begin timing. Time how long it takes the water to fill the bottom container a half inch. Can you make a scale that measures time periods of one minute? How accurate is your clock? What affects the accuracy? Try changing the variables, such as the size of the hole or the number of cups you use. What happens? Make observations and note what you see. What are some ways you could use your clock?

Learning More

Llewellyn, Claire.
My First Book of Time.
New York: DK Publishing, 1992.

Covers such topics as days, seasons, simple fractions, clocks, measuring time, and time zones.

A Walk through Time: Early Clocks
physics.nist.gov/GenInt/Time/early.html
Provides a descriptive look at the history of timekeeping from ancient to modern methods.

Clock a History
www.ernie.cummings.net/clock.htm
Includes information on who invented the clock, the world's official timekeepers, and various types of clocks, such as the sand, Sun, water, and candle clocks, and more.

Telling Time

Today it is difficult not to be conscious of time. Wall clocks, radio announcements, computer monitors, watches, and cell phones all tell us how much time is passing. Thousands of years ago, measuring time was more difficult.The ancient Egyptians, Greeks, Romans, and Chinese used clocks that depended on nature. For instance, the sundial kept track of the time during daylight hours. To measure smaller increments of time, or when the Sun was not shining, ancient people used different variations of clocks, such as water, sand, or candle clocks.

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