‘AND YET IT MOVES!’

By Charles Apple | THE SPOKESMAN-REVIEW

Mathematician, astronomer, philosopher and scientist Galileo Galilei ran into trouble with the Catholic Church with his views that the Sun, not the Earth, was the center of the solar system.

Twice he faced Roman inquisitions. Both times he tried to back down enough to satisfy the Church but also tried to hang on to his scientific principles.

Galileo faced the first of these charges of heresy on Feb. 26, 1616 — 410 years ago. He’d continue to have problems with Rome until his death a quarter-century later.

CUTTING A WIDE SWATH IN SEVERAL FIELDS OF SCIENCE

Galileo Galilei was born in Pisa, Italy, in 1564, as the son of an accomplished musician. His father wanted him to study medicine, but Galileo followed his passion for mathematics instead.

One day in medical school, Galileo noticed a lamp swinging from the ceiling of a cathedral. He studied the motion, worked out the math and worked out what would later become a pendulum clock.

As his studies continued, Galileo created the thermoscope — an early thermometer — and published his first book, on a field of fluid mechanics. In 1589, he was appointed to chair the mathematics department at the University of Pisa.

Galileo in his 40s

As time went on, Galileo indulged his scientific interests in the fields of geometry, mechanics and astronomy. After hearing about the invention of the telescope in the Netherlands, he worked up one of his own design and eventually made a telescope with 30x magnification. He discovered sunspots, that the moon was covered with mountains and craters, the moons of Jupiter and the fact that Venus had phases like Earth’s moon.

Galileo corresponded with other scientific leaders of the day and published books containing his theories and discoveries.

APPLYING MATH TO MOTION

Galileo was fascinated by the application of mathematics to the science of mechanics and worked in a method that was unheard of at the time: He’d take a problem, break it down into a series of simple steps and then perform experiments on those parts. Only after analyzing the results would he begin to describe them in mathematical terms.

Galileo disagreed with a commonly accepted notion of the day — that heavier objects fell to the ground faster than lighter objects. Legend has it that Galileo dropped objects of different weights from the Leaning Tower of Pisa. In fact, most of his experiments along these lines involved rolling objects down inclined planes. Galileo proved objects all fell at the same speed, regardless of their weight.

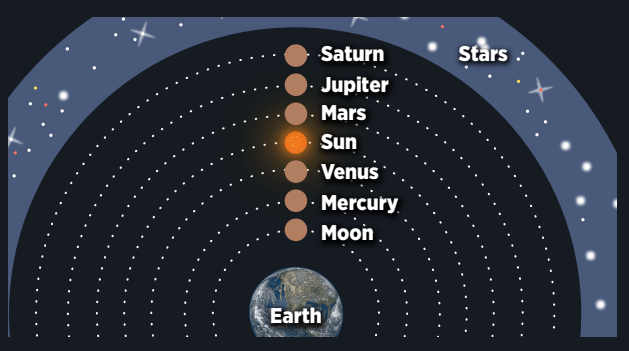
Galileo also expanded on Aristotle’s theories — from 350 B.C. or so — and suggested that a thrown stone had two separate forces acting on it: “momentum,” pushing it horizontally and a completely separate force pulling it downward. Today, we’d call that gravity. Galileo’s writings would be picked up and developed into laws of motion by English scientist Isaac Newton.

Galileo also proposed the laws of physics are the same in any system that is moving at a constant speed and in a straight line, regardless of that speed or direction. Albert Einstein would use some of Galileo’s notions when developing his special theory of relativity.

ATTRACTING THE ATTENTION OF THE CATHOLIC CHURCH

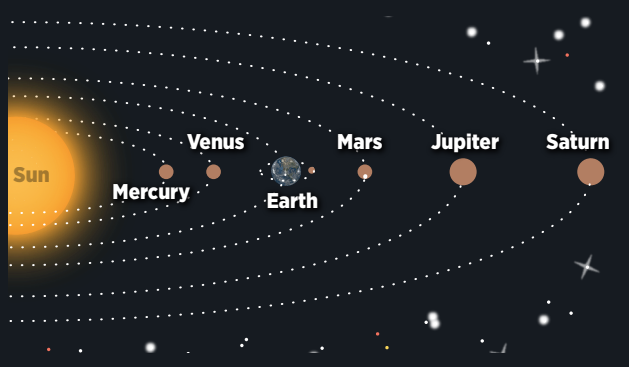
With his telescope, Galileo discovered the moons of Jupiter and proved they circled Jupiter. What’s more, he discovered Venus had phases over time — much like Earth’s moon — proving it circled the sun and not the Earth.

This brought Galileo into conflict with the Catholic Church, which taught the Earth was the center of the universe. By 1614 and 1615, Galileo had written a number of letters to scientists about his findings.



In the Bible, the book of Joshua tells the story of how God commanded the sun — and not the Earth — to stand still over the Canaanite city of Gibeon. The Catholic Church stood behind this story and others and considered anyone who spoke or wrote otherwise a heretic. This could be a problem for those making scientific inquiries or discoveries the disputed church canon. The Church was known to arrest, imprison and torture heretics.

In January 1616, Church officials opened an inquisition on Galileo and his writings about heliocentricism: the sun being the center of the universe. Pope Paul V ordered their judgment to be issued to Galileo.



On Feb. 26, 1616, Galileo was ordered “to abstain completely from teaching or defending this doctrine and opinion or from discussing it ... either orally or in writing.” On March 11, Galileo met with the Pope himself, who assured him he would not be prosecuted — as long as he complied with their orders.

AN ATTEMPT TO EXPLAIN THE TIDES

Even as the Church was working on its case to suppress his astronomical findings, Galileo continued to explore natural phenomenon.

No one at the time understood what caused the Earth’s tides. Galileo made observations, came up with theories and worked on math. He felt that tides would be caused by the same forces at work in a heliocentric universe.

While riding a barge in Venice in 1595, Galileo noticed that whenever the vessel changed direction, sped up or slowed down, the water inside sloshed accordingly.

It occurred to Galileo that the Earth’s dual motion — a daily rotation on its axis and an annual rotation around the sun — might create that effect on Earth’s oceans.

His theory was that when the ocean was moving in the same direction as the Earth’s orbit, would be faster. It would be slower when that side of the Earth moved in opposition to its orbit.

The big flaw in his theory: It would explain one high tide a day. In fact, any coastal spot on Earth experiences two high tides a day.

Galileo felt his theory made more sense than the other leading theory — that tides were caused by the moon. Galileo published his tidal theories in 1616 but admitted privately he still had doubts about his work on tides.

ON TRIAL FOR A SECOND TIME

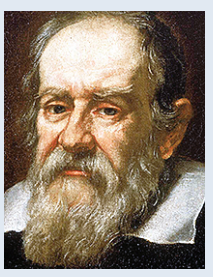
Following the 1616 inquisition, the Church banned some of Galileo’s writings that promoted heliocentricism be banned and that publication of one of his books should be held up until it was “corrected.”

Galileo complied. For a decade and a half. In 1632, his book “Dialogue Concerning Two World Systems” was published and held in high regard.

The book had originally been titled “Dialogue on the Ebb and Flow of the Sea” but Galileo was obligated to submit all his published work to the Church for approval. He was ordered to remove the reference of the tides from the title and to add a preface in which he necessarily making a case for Copernican heliocentricism.

The book itself was a fictional account of four days of conversations about science among two philosophers and a layman. While the structure of the universe is included, it’s just one topic covered in the book.

While the Pope and his staff signed off on the book and its content, church officials became uneasy with the book after its publication. In 1633, Galileo was summoned back to Rome for heresy and for breaking the conditions of his 1616 inquisition.



Galileo in his 70s

A panel of theologians poured over the book and interrogated the 69-year-old Galileo — threatening him with torture if they didn’t like his replies.

On June 22, 1633, the panel found Galileo guilty of heresy.

- He was ordered to “abjure, curse and detest” the opinion that the Sun, and not the Earth, is at the center of the universe.
- The book was banned and publication of any of his works, past or present, was banned.
- Galileo agreed to plead guilty in exchange for a lighter sentence, so the panel sentenced him to house arrest. Galileo would remain under house arrest the rest of his life.

As he accepted his sentence while kneeling before the panel, he proclaimed the Earth, not the Sun, was at the center of the universe.

Legend has it that, as he rose, he muttered loud enough for some to hear: “Eppur si muove” — “And yet it (the Earth) moves!”

Galileo spent the rest of his days in his villa in Arcetri, near Florence. After a few years, he became blind. He died in January 1642 at age 77.

Einstein would refer to Galileo as the “father of modern physics.”

Sources: “100 Great Scientists Who Changed the World” by Jon Balchin, “Science: 50 Essential Ideas” by Anne Rooney, “The Astronomy Book: Big Ideas Simply Explained” by Dorling Kindersley, Library of Congress, the Galileo Project of the Rice University Library, the BBC, PBS’s “Nova,” History.com

ART OF PANEL TRIAL FROM WIKIMEDIA COMMONS. RENDERINGS OF GALILEO FROM ROYAL MUSEUMS, GREENWICH.