**Overview featuring João Magueijo**

**Setting the Scene**

The literature in Unit 6 springs from some of the greatest minds of the Renaissance and of the Age of Rationalism. One of those minds, that of Galileo Galilei, is the subject of author João Magueijo’s essay in the introduction to this unit. Later, the literature of Unit 6 samples the brilliance of poets and scientists alike who wrote to inspire, to question, and to amuse.

**João Magueijo Talks About the Time Period**

**Introducing João Magueijo** (b. 1967) Born in Portugal, Magueijo is currently a professor of theoretical physics at Imperial College, London. His ideas are often viewed as radical—his varying speed of light theory conflicts with long-standing theories of one of the world’s most respected scientists, Albert Einstein.

**The Father of Modern Science**

Galileo Galilei is frequently credited as the father of modern science; yet some of his findings even today look like those of a magician. His hat tricks would, centuries later, make space travel possible. He made these curious discoveries against all odds, when common sense made everyone think they were nonsense. That he managed to break through the smokescreen is his incredible accomplishment.

**Renaissance Science Was Ahead of Today’s Science Fiction**

Current science fiction films would have us believe a lot of junk about the dynamics of dog-fights in space. Invariably they portray spaceships grinding to a halt when their rockets malfunction or they are hit by enemy fire. Furious acceleration appears to be required just to maintain a respectable speed. It all makes sense. It’s intuitive. It’s just what happens with car chases on Earth—or horse chases, in Galileo’s time.

But it’s wrong.

Amazing as it might sound at first, if you turn off the engines of a spaceship, you just keep moving at the same speed—you get a free ride. The Pioneer spacecrafts ran out of fuel long ago but they’re still moving out into deep space. Without fuel you don’t accelerate, but neither do you stop. Magic at play? Not at all. That's how the world appears to work.

Which leaves us with a mystery. How did Galileo work this out without the benefit of televised space travel? Was he abducted by aliens?

The answer is not quite so spectacular, but Galileo was indeed a man with a secret. He grew up reading the Greek classics, in particular two giants at odds with each other, Aristotle and Plato.

Two thousand years later, Aristotle, unknowingly, would act as a scientific adviser to misguided SciFi films. He’s the man who proposed the notion that absence of a force means absence of motion. His philosophy is based upon experiment, but not of the sort you see present-day scientists perform in labs. For him experiment was human experience, our common sense.

The trouble is that our common sense is polluted by the pervasiveness of friction on Earth. Absence of force is never absence of friction. If we stop pushing a cart it grinds to a halt because the force of friction drives it to rest. In space, without friction, the cart would just go on forever.

**Modern Science: Marrying Aristotle and Plato, and Going Beyond Them**

Galileo didn’t need to go to space to get this intuition. He applied Plato’s philosophy instead: to seek mathematical perfection and idealized forms beyond our often confused senses. If you oil up the wheels of a cart, it takes longer to stop because you reduce friction. If you idealize perfectly oiled wheels, the cart would go on for ever. Just like in space.

So, here’s Galileo’s secret: to combine Aristotle’s focus on sensory experience—without his trust in “common sense”—with Plato’s search for perfection. He married Aristotle and Plato, in the process contradicting both and creating modern science and experimentation. As a famous astronomer admirably put it, “Galileo built a telescope from an iron tube, attaching to one side a very small one-inch lens, and to the other a very large brain.”

**João Magueijo Introduces *from “Astronomical Messages” and from The Assayer by Galileo Galilei***

**Challenging Einstein**

A few years ago a group of physicists, including myself, came up with an idea that unceremoniously contradicted Albert Einstein’s theory of relativity. We suggested that the speed of light might vary rather than be the constant of nature that provides the solid framework of Einstein’s theory. Our proposal envisaged that such variations can only occur under very extreme circumstances—such as the flash at the beginning of the Universe (the so-called Big Bang), or the vicinity of cosmic black holes. VERY extreme circumstances. We never entertained the notion that the great Albert is wrong altogether—merely that his theory might show its limitations by fraying around the edges when things get too hot.

**The Anarchy of Science** Nevertheless our theory—the varying speed of light theory—caused consternation in part of the scientific community. The press reaction was even more dramatic. We were labeled—I quote—“the punk rockers of physics.” I have to admit that I’m not offended by this description. Indeed it’s not even completely incorrect. You may think that anarchy plays no role in science; but that’s because . . . well, let me break the news to you—that’s because the real world of science is not limited to what you've been taught in school. Science in the making is a world of chaos and uncertainty. It’s a mad game of hit and miss, a continuous struggle against what has been said before. In this process scientists behave emotionally and irrationally, like grown-up kids. It’s all most unbecoming. I chronicled this process, in reference to “the punk rockers of physics,” in my book Faster Than the Speed of Light. But the story of this process is far from new. It’s also the story of how past physicists were led to their own theories.

**Discovering the Rules of Nature** Science is always the result of an argumentative and emotional process in which whenever you propose something new, everyone thinks you’ve gone out of your mind. What distinguishes the scientific search for novelty, however, is that the scientist is ultimately humbled by Nature. At the end of the day, if experiments show that a groundbreaking new idea is wrong, then the game is over. Scientists have to accept defeat gracefully. They can’t take themselves too seriously. This attitude was present right at the start of modern science, when Galileo rejected authority as a criterion for truth. He unveiled a new world because he had the guts to question what he’d been taught. Perhaps the best introduction to this idea is the fairy tale you’re about to read in “The Assayer.” In Galileo’s time it was still considered respectable for a scientist to explain his views by means of fairy tales. Galileo’s tale, these days, might get him labeled a punk rocker of science, too.

**Thinking About the Commentary**

**1. (a)** **Recall:**What is the idea behind the theory that Magueijo and his fellow physicists developed?**(b)** **Compare and Contrast:**What is the primary difference between Magueijo’s theory and Einstein’s?**(c)** **Infer:**Why might the scientific community be shocked by a challenge to Einstein’s theroies?

**2. (a)** **Recall:**According to Magueijo, what response do many scientists receive when they propose new ideas?**(b)** **Draw Conclusions:**Besides humility, what qualities must scientists possess to manage both the discovery process and the criticism they may receive along the way? **(c) Make a Judgment:**Would you enjoy a career in science? Why or why not?

**As You Read from “Astronomical Messages” and from The Assayer . . .**

**3.**Consider ways in which Galileo struggled with the same scientific processes identified by Magueijo.

**4.**Be ready to explain how Galileo was a “punk rocker” in his own day.

**Primary Sources**

### *from* Starry Messenger: *from* Astronomical Message • *from* The Assayer

### Galileo Galilei

**(1564–1642)**

As a sixteenth-century philosopher, mathematician, and astronomer, Galileo Gallilei insisted that the proper language of science was mathematics and that the experimental method was the key to unlocking nature’s secrets. These fundamental features of scientific study have remained constant over the past 400 years.

## Early Life and Career Beginnings

Born in Pisa in northern Italy, Galileo was the oldest son of a musician who shared with his son a curiosity about science. According to tradition, father and son may have performed some experiments on the connection between the tension of the strings of musical instruments and the pitch, or sounds, that the strings make. After attending the University of Pisa, where he shifted his studies from medicine to mathematics, Galileo became a private tutor for a few years in his early twenties. At the age of twenty-five, he took a professorship at the University of Pisa. In some of his important early experiments, conducted at the famous Leaning Tower of Pisa, Galileo demonstrated that the speed of a heavy falling object is not necessarily proportional to its weight. By challenging theories held for centuries, Galileo increased his reputation for brilliance. Discoveries like these, however, would make him a controversial figure both during his lifetime and later.

## A Momentous Turn

In his middle years, Galileo continued his studies on motion. He discovered the Law of Falling Bodies, which states that falling objects will accelerate at the same, constant rate as a result of gravity. He also demonstrated that the trajectory of a projectile—for example, a cannon ball—will always follow the same path, a geometric form called a parabola.

In the spring of 1609, momentous news of a new invention in Holland attracted Galileo’s attention: a telescope, possibly first constructed by spectacle maker Hans Lippershey. Swiftly analyzing the instrument’s design, Galileo constructed his own telescopes and demonstrated one of them to the Venetian Senate. The officials were so impressed that they gave him life tenure at the University of Pisa.

With increasingly powerful telescopes, Galileo discovered the craters of the moon’s surface and four satellites on Jupiter. Galileo described his observations in a book entitled *Starry Messenger,* which he dedicated to Cosimo de Medici, the Grand Duke of Florence. Galileo was promptly rewarded with an appointment as mathematician and philosopher to the court.

## Troubles With the Church

Galileo was soon convinced that the Polish astronomer Nicolaus Copernicus (1473–1543) had been right: Earth revolves around the sun. While this truth seems self-evident today, Copernicus’s theory was extremely controversial in Galileo’s day. By 1613, Galileo had to confront questions from the office of the Inquisition in Rome. Two years later, Church authorities denounced the Copernican theory as heresy, and Copernicus’s book was officially banned.

Over the next twenty years, Galileo and the Church authorities settled into an uneasy standoff. In his book *The Assayer* (1623), Galileo boldly described the new approach to science as a mathematical, objective enterprise. In 1632, he published his *Dialogue Concerning the Two Chief World Systems,* in which he championed Copernicus’s theory. Summoned to Rome, Galileo was condemned to life imprisonment on suspicion of heresy. He was forced to renounce publicly his own scientific proofs and beliefs.

Galileo refused to be broken by this setback, however. For his ten remaining years, he continued to experiment and write on the sciences of motion.

## Preview

## Connecting to the Literature

In this age of modern technology, it is easy to take for granted the scientific advances that led to space exploration and travel. Centuries before any person could walk on the moon, however, one man saw its craters for the very first time.

## Literary Analysis

## Narrative Accounts

A **narrative account** tells the story of real-life events and is usually written in prose. Typically, narrative accounts use the first-person point of view and focus on personal experience. In addition to their literary qualities, many narrative accounts are useful to historians and other researchers as primary or secondary sources. Because of the writer’s firsthand involvement, however, these works are sometimes subjective, or limited by the feelings and experiences of the writer. As you read, notice clues in Galileo’s writing that convey the thrill of discovery and his personal investment in his work.

## Connecting Literary Elements

**Narrative Style**

Narrative accounts are often shaped in important ways by features of**narrative style,** or the distinctive ways in which an author chooses to tell his or her story.

* *Diction,* or word choice, and *syntax,* or word order, give a narrative account its unique flavor and tone.
* *Examples* of different types may affect the reader’s response
* *Sentence structure* may shape the total effect of a narrative account.

As you read Galileo’s accounts, note both the content of his ideas and the narrative style he used.

## Reading Strategy

## Breaking Down Long Sentences

You can analyze meaning by **breaking down long sentences** and considering one section at a time. Separate a sentence’s key parts (the *who*and the *what* ) from the difficult language to get to the main idea. Use a diagram like the one shown to analyze long sentences.

## Vocabulary Builder

* manifest *adj.* clear; evident
* conspicuous *adj.* easy to see or perceive
* multitude *n.* a great number
* impelled *v. used here as adj.* pushed or driven forward
* derive *v.* to get or receive from a source

* diffidence *n.* lack of confidence in oneself

##

## from Starry Messenger

Background

The astronomical discoveries that Galileo describes in his book *Starry Messenger* were landmarks in the scientific revolution of the Renaissance. They confirmed the truth of the highly contested Copernican theory that the Earth revolves around the sun. Until Copernicus’s time, two or three generations before Galileo, scientists believed in a cosmological assumption that dated back to the philosopher Aristotle (384–322 b.c. ). According to this theory, all of the celestial bodies, including the sun, revolved around a motionless Earth, which was located at the center of the universe. With the help of a groundbreaking device called a telescope, Galileo and the scientific world stepped into the future of cosmology.

*from* ASTRONOMICAL MESSAGE,

Which contains and explains recent observations made with the aid of a new spyglass concerning the surface of the moon, the Milky Way, nebulous stars, and innumerable fixed stars, as well as four planets never before seen, and now named THE MEDICEAN STARS

Great indeed are the things which in this brief treatise I propose for observation and consideration by all students of nature. I say great, because of the excellence of the subject itself, the entirely unexpected and novel character of these things, and finally because of the instrument by means of which they have been revealed to our senses.



Surely it is a great thing to increase the numerous host of fixed stars previously visible to the unaided vision, adding countless more which have never before been seen, exposing these plainly to the eye in numbers ten times exceeding the old and familiar stars.



It is a very beautiful thing, and most gratifying to the sight to behold the body of the moon, distant from us almost sixty earthly radii, as if it were no farther away than two such measures—so that its diameter appears almost thirty times larger, its surface nearly nine hundred times, and its volume twenty-seven thousand times as large as when viewed with the naked eye. In this way one may learn with all the certainty of sense evidence that the moon is not robed in a smooth and polished surface but is in fact rough and uneven, covered everywhere, just like the earth’s surface, with huge prominences, deep valleys, and chasms.



Again, it seems to me a matter of no small importance to have ended the dispute about the Milky Way by making its nature **manifest** to the very senses as well as to the intellect. Similarly it will be a pleasant and elegant thing to demonstrate that the nature of those stars which astronomers have previously called “nebulous” is far different from what has been believed hitherto. But what surpasses all wonders by far, and what particularly moves us to seek the attention of all astronomers and philosophers, is the discovery of four wandering stars not known or observed by any man before us. Like Venus and Mercury, which have their own periods about the sun, these have theirs about a certain star that is **conspicuous** among those already known, which they sometimes precede and sometimes follow, without ever departing from it beyond certain limits. All these facts were discovered and observed by me not many days ago with the aid of a spyglass which I devised, after first being illuminated by divine grace. Perhaps other things, still more remarkable, will in time be discovered by me or by other observers with the aid of such an instrument, the form and construction of which I shall first briefly explain, as well as the occasion of its having been devised. Afterwards I shall relate the story of the observations I have made.

About ten months ago a report reached my ears that a certain Fleming**1**had constructed a spyglass by means of which visible objects, though very distant from the eye of the observer, were distinctly seen as if nearby. Of this truly remarkable effect several experiences were related, to which some persons gave credence while others denied them. A few days later the report was confirmed to me in a letter from a noble Frenchman at Paris, Jacques Badovere, which caused me to apply myself wholeheartedly to inquire into the means by which I might arrive at the invention of a similar instrument. This I did shortly afterwards, my basis being the theory of refraction.**2**First I prepared a tube of lead, at the ends of which I fitted two glass lenses, both plane on one side while on the other side one was spherically convex and the other concave. Then placing my eye near the concave lens I perceived objects satisfactorily large and near, for they appeared three times closer and nine times larger than when seen with the naked eye alone. Next I constructed another one, more accurate, which represented objects as enlarged more than sixty times. Finally, sparing neither labor nor expense, I succeeded in constructing for myself so excellent an instrument that objects seen by means of it appeared nearly one thousand times larger and over thirty times closer than when regarded with our natural vision. . . .