VIRTUAL PATHWAYS

Galileo’s New World

Pre-visit

(High school, age 14-18)

Introduction

This is the support document for the pre-visit phase of the Educational Pathway "*Galileo's New World*" aimed at both teachers and students.

Short description
The activity, structured in three phases (pre-visit, visit and post-visit) is an excursus on the history of astronomy from pre-telescopic era to the first Scientific Revolution, with a focus on Galileo's observations with the telescope.

Target audience
Teachers and students of High school (age 14-18)

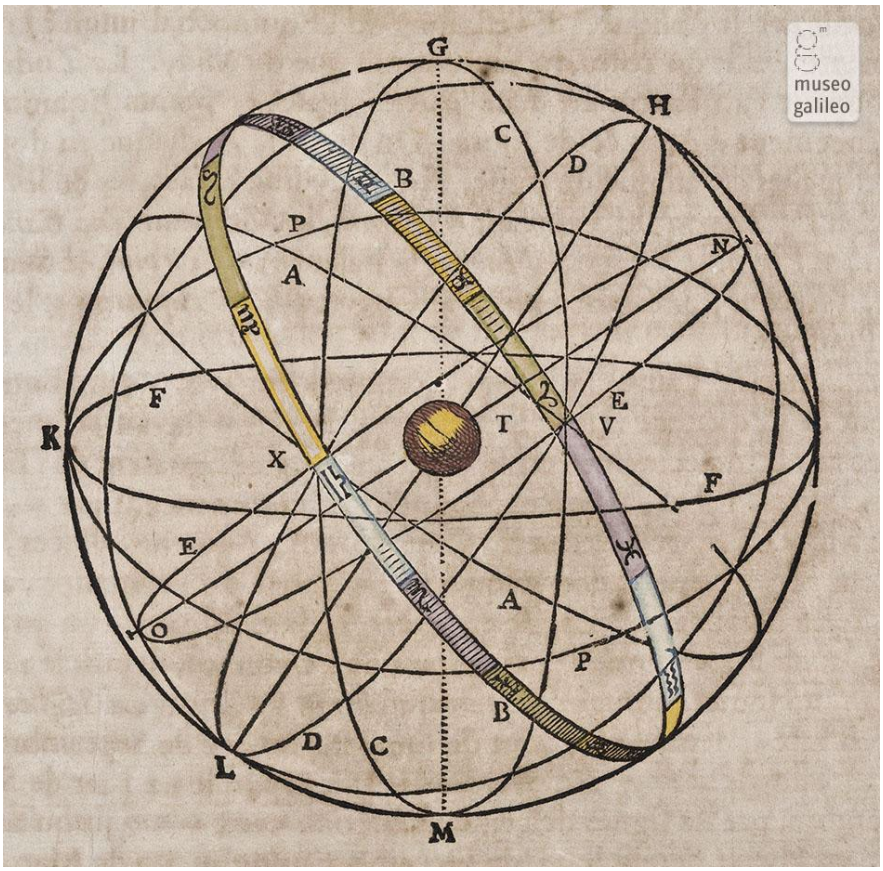
Estimated time required for the activity
In school: 5-6 hours (2-3 pre-visit and 3 post-visit)
In the museum (on site or virtually): 1,5 hour

For more information visit:
https://www.virtualpathways.eu/

https://www.museogalileo.it/en/library-and-research-institute/projects/european-projects/2134-virtual-pathways.html

A Bit of Astronomical Geography: The Celestial Sphere

The celestial sphere is an imaginary sphere that holds the Earth at its center. It rotates around an axis called the axis of the world, which is an extension of the Earth's axis. Its movement is an apparent motion: observing the celestial sphere from Earth it seems to move but this is due to the fact that the Earth turns on itself below the sky. Furthermore, since our planet spins from west to east, the apparent motion of the celestial sphere goes from east to west.



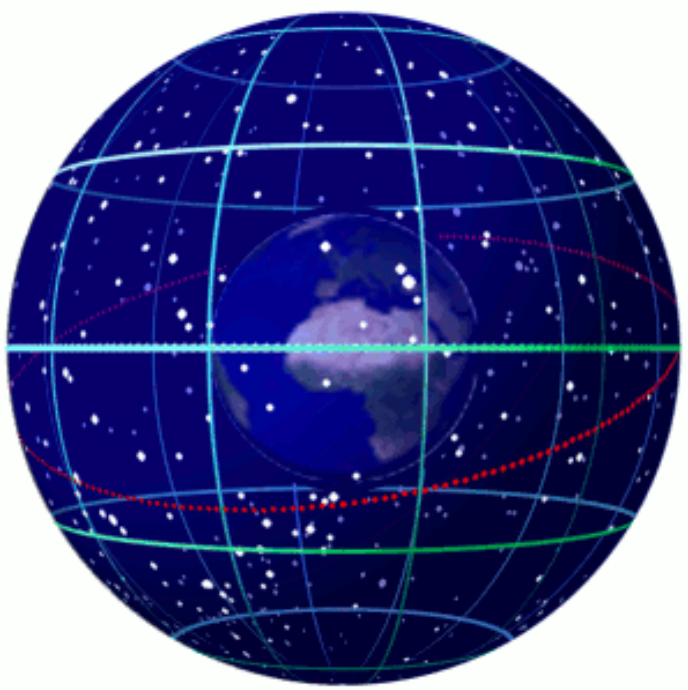
Blaeu, Willem Janszoon, *Le grand atlas, ou, Cosmographie Blaviane.*
Representation of the celestial sphere

The celestial sphere
https://catalogue.museogalileo.it/indepth/CelestialSphere.html

Why is it important to know about the celestial sphere?

Because the celestial sphere is used in astronomy to determine the distance of a point from the Earth and its celestial coordinates which, just like the terrestrial ones, are latitude, longitude and altitude. The terrestrial equator is also ideally prolonged on the celestial sphere and called the celestial equator which divides it into two hemispheres, the northern one and the southern one. The same happens also for the meridians and for the terrestrial parallels that are extended to the celestial sphere and are therefore also considered as "celestial".

The apparent trajectory path made by the Sun on the celestial sphere over the course of a year is called the ecliptic. It is inclined about 23 ° with respect to the celestial equator that intersects it at points called equinoctial points. The former represent the points where the Sun is found at the spring equinox and the autumn equinox, that is when the day and night have exactly the same duration; the second identify instead the two points where the Sun is found during the summer solstice and the winter solstice, that is, when the Sun reaches its maximum and minimum height above the horizon at noon in the year.



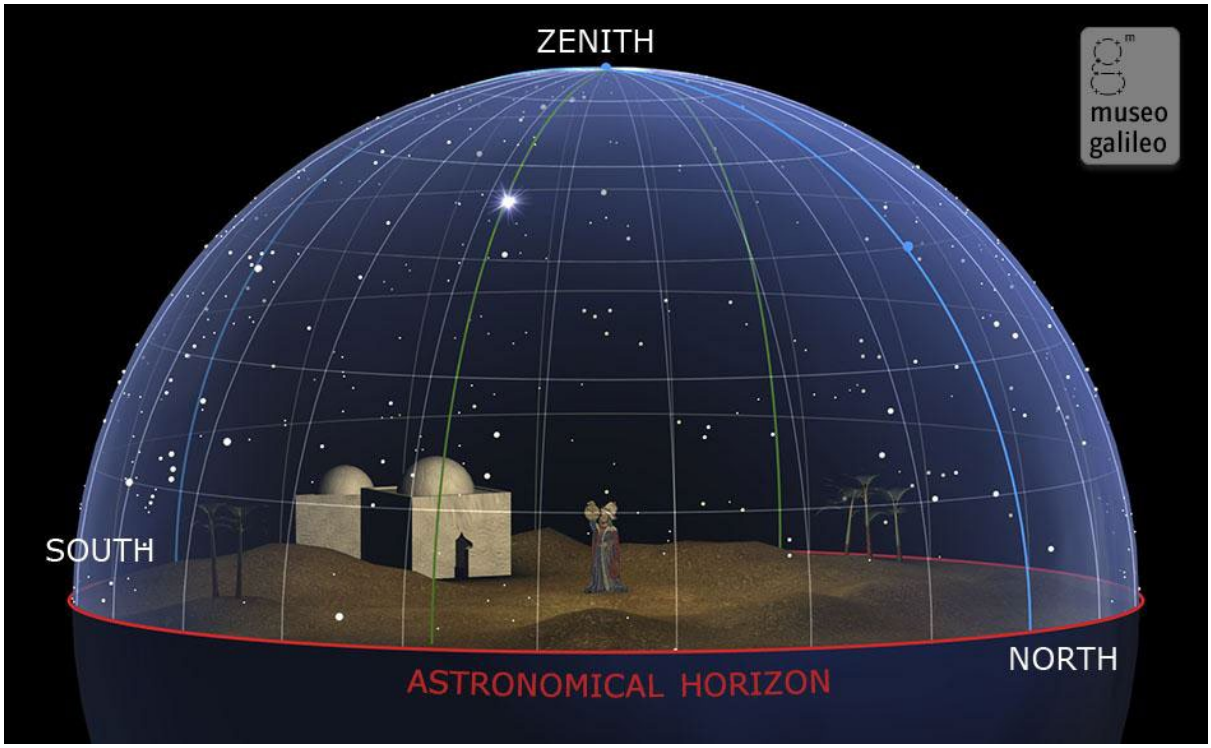
Earth spinning within a celestial sphere.
CC BY-SA 3.0 Tfr000

Systems of celestial coordinates

To determine the position of a star is it important to know the celestial coordinates?

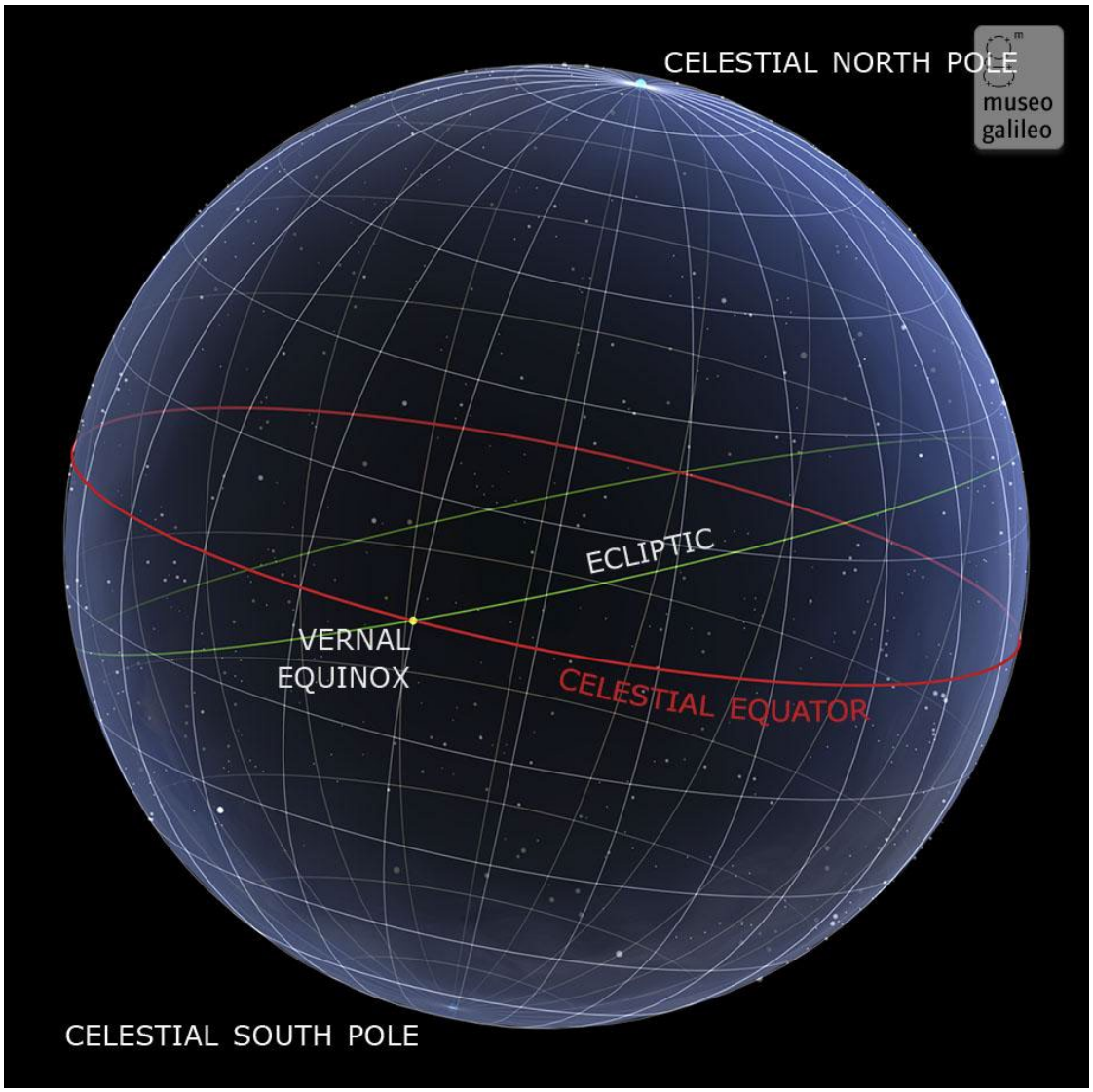
On Earth, to locate a point, we use the two well-known geographical coordinates: latitude and longitude. Two coordinates are also needed to identify the position of any star in the sky, but to respond to the different needs and principles more than one type has been identified: the altazimuth coordinates, the equatorial coordinates and the ecliptic coordinates.

The horizontal, or altitude-azimuth, system is based on the position of the observer on Earth. The main great circle of reference used in altazimuth coordinates is the astronomical horizon, *locus* of the intersection between the celestial sphere and the horizontal plane passing through the eye of the observer.



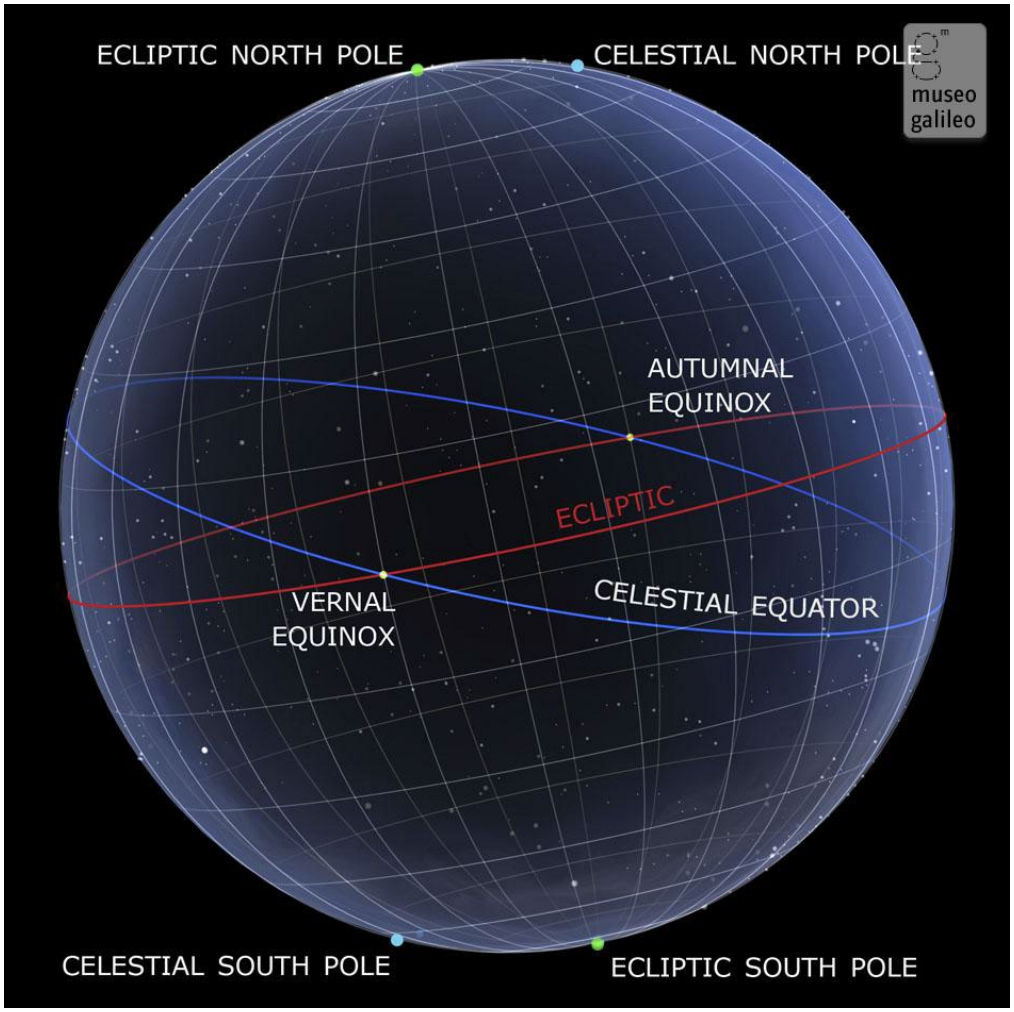
Astronomical horizon. Museo Galileo, Florence

In the equatorial coordinate system the main great circle of reference is the celestial equator. In the modern heliocentric system it represents the projection of the terrestrial equator on the celestial sphere.



Equinoctial circle (celestial equator). Museo Galileo, Florence

In the ecliptic coordinates the main great circle of reference is the ecliptic. It corresponds to the Sun's annual path across the zodiac.



Ecliptic. Museo Galileo, Florence

▶	*Systems of celestial coordinates* https://catalogue.museogalileo.it/multimedia/SystemsCelestialCoordinates.html
T	*Altazimuth coordinates* https://catalogue.museogalileo.it/indepth/AltazimuthCoordinates.html
T	*Equatorial coordinates* https://catalogue.museogalileo.it/indepth/EquatorialCoordinates.html
T	*Ecliptic coordinates* https://catalogue.museogalileo.it/indepth/EclipticCoordinates.html

The sky in antiquity

How did people imagine the sky in ancient times?
How was the sky observed in ancient times?
Who were the first observers?

Pythagoras (5th century BC) and his circle of followers are recognized as being the first in conceiving the sphericity of the cosmos and the regularity of the circular motions of the celestial bodies.

Plato, Eudoxus and Aristotle later elaborated their own ideas destined to exert a great influence on the subsequent developments of astronomy.

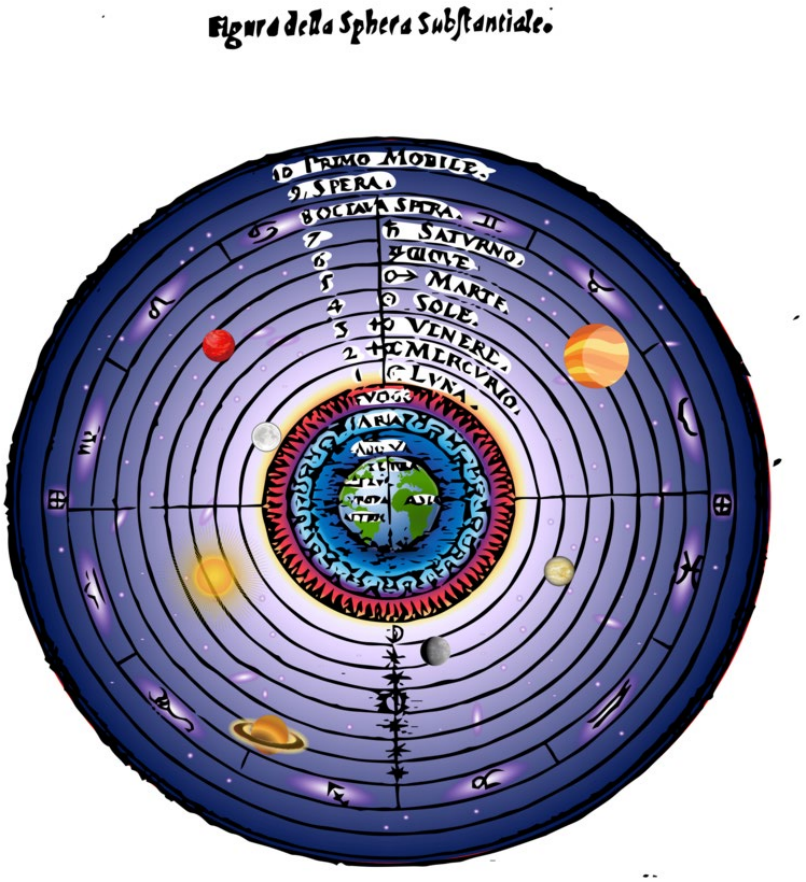
Aristotle believed that the Earth was at the center of the universe and was composed of the four elements: earth, water, air and fire, which naturally moved in straight upward or downward motion. Instead, he believed that celestial bodies were composed of a fifth essence, ether, and that they moved in a uniform circular motion. The theory of the earthly four elements exerted a great influence on Western and Arabic culture for many centuries.

In the 3rd century BC astronomical research moved to Egypt, in particular to Alexandria. The relationships between the planets and the Earth became the main focus of astronomical research. Hipparchus and Ptolemy, great observers of the celestial sphere, accumulated data that enabled them to achieve extraordinary results.

Claudius Ptolemy linked his name to a model of the cosmos, with the Earth immobile in a central position and the Sun in orbit around it, destined to dominate through the end of the 16th century. Ptolemy composed an astronomical compendium known as The Almagest, from the title of the medieval Arabic translation, in which he described the celestial vault by analyzing its movements. The catalog of 1025 stars found in Book VIII of the work continued to be for many centuries the reference point for any new map of the sky.

From the 8th to the 15th century, the most advanced astronomical research developed in the Arab world. Islamic astronomers devoted themselves to the study of astronomy, achieving great results including being the first to measure time by means of the Sun and the stars. Astronomical observatories were set up

in various regions of the Arab world, producing data that were also used by Western scholars, including Copernicus.



The celestial spheres in the geocentric view of the universe, which distinguished the four elementary circles of the sublunary world (earth, water, air, fire), from the nine skies above, corresponding to the orbits of the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, of the fixed stars (eighth sphere), and the *Primum Mobile.*
CC BY-SA 4.0 Alvaro Marques Hijazo

Pretelescopic astronomy
https://catalogue.museogalileo.it/multimedia/PretelescopicAstronomy.html

Arab astronomy
https://catalogue.museogalileo.it/multimedia/ArabAstronomy.html

Introduction to Galileo

Who was Galileo?

Born in Pisa on February 15, 1564, Galileo is considered the father of modern science for a number of reasons:

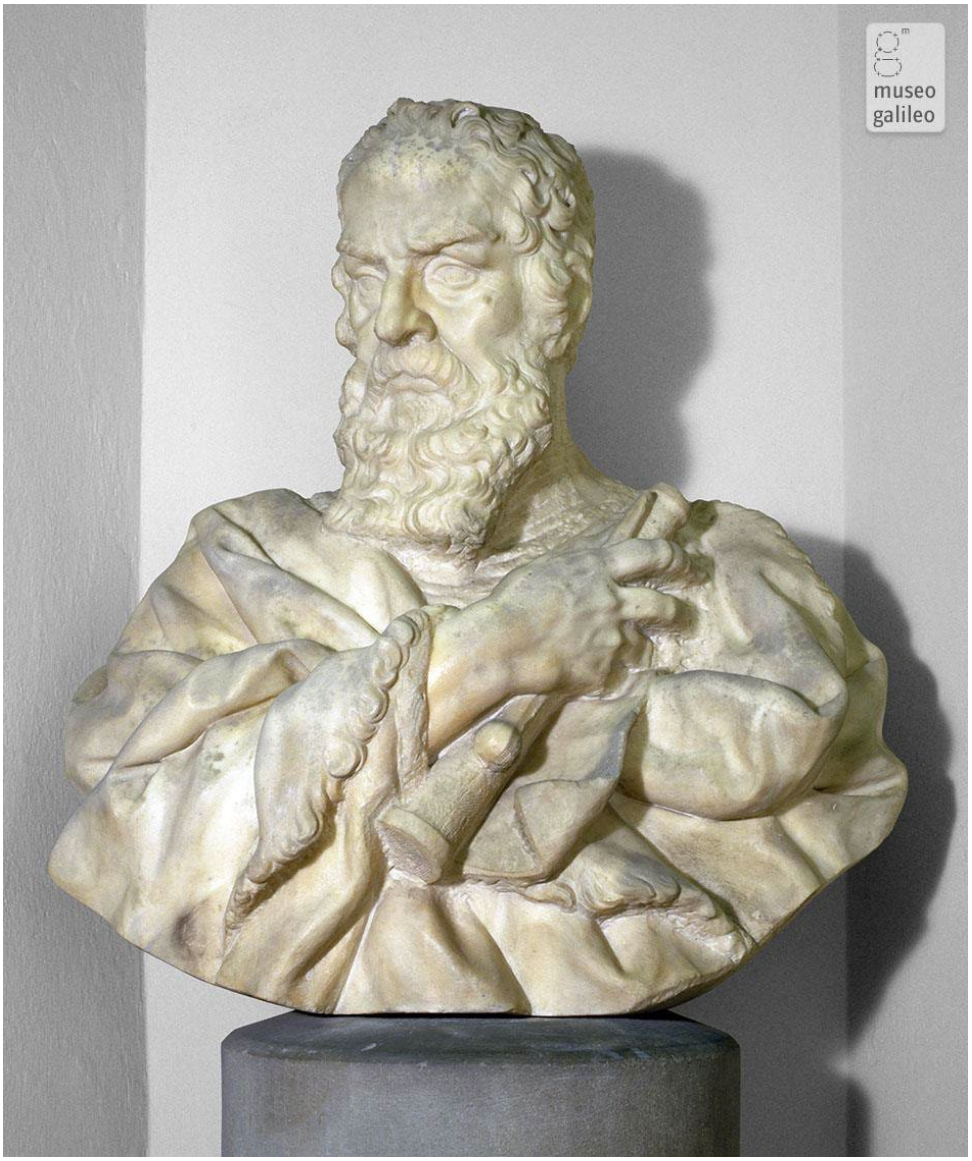
- the importance of his astronomical discoveries
- his intuitions about the motion of bodies
- his idea and ability to demonstrate experimentally the direct observation of phenomena

His life also inspired and fascinated writers and film directors because he is a symbol of the contrast between science and faith and between freedom of thought and political and religious authority.

Galileo began his training in Pisa, where he held the chair of mathematics from 1589 to 1592 and continued in the same role at Padua until 1610. Very stimulating was the period the scientist passed in Padua "...where I consumed the eighteen best years of all my life", as Galileo wrote in a letter dated June 23, 1640 addressed to Fortunio Liceti, to whom he suggested to take advantage of "...this freedom and the many close contacts that you made there."

In the spring of 1609 Galileo came into possession of an innovative object that was sold in Venice as a toy: a short tube with two lenses at each end that allowed distant objects to be seen as if they were at a closer distance.

He was fascinated by it and set about perfecting it, quickly achieving very positive results. As early as November of the same year, he succeeded in making a telescope capable of magnifying 20 times, far more powerful than any other telescope circulating in Europe at the time.



Carlo Marcellini, Bust of Galileo Galilei. Museo Galileo, Florence

Galileo Galilei
https://catalogue.museogalileo.it/biography/GalileoGalilei.html

Life of Galileo
https://www.museogalileo.it/en/museum/explore/meet-galileo/37-life.html