

# Astronomy Through the Ages 3: Galileo Galilei and Telescopic Astronomy

ASTR 101

10/5/2016

Assignment:

Watch the movie "**Galileo's Battle for the Heavens**"

can be viewed online at:

<http://www.pbs.org/wgbh/nova/ancient/galileo-battle-for-the-heavens.html>

or

<https://www.youtube.com/watch?v=jvIr2iMWQyc>

(no commercial breaks)



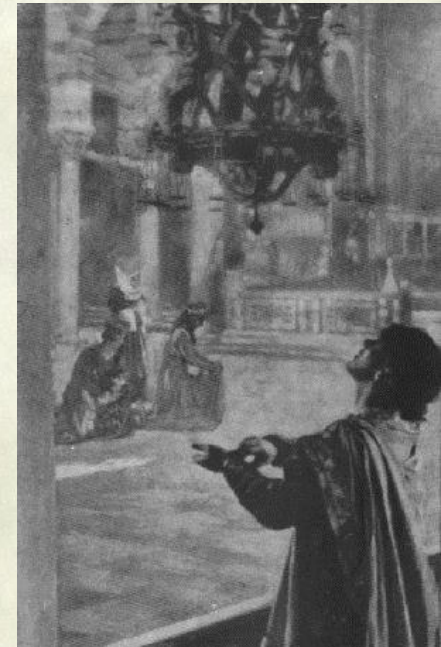
# Galileo Galilei

- Italian astronomer, physicist, mathematician, and natural philosopher. Often referred to as the "father of modern astronomy and physics".
- Born in Pisa in 1564.
- In 1581, enrolled at the University of Pisa for a medical degree.
- It was during that time (1583) he made his famous discovery on pendulums.

While watching a chandelier swing back and forth at the Cathedral of Pisa, Galileo noticed that regardless how far it swung, the time it took to swing back and forth was always the same.

This principle was later used to build pendulum clocks.

- While at the University of Pisa, he became interested in mathematics, and began studying mathematics on his own.
- He dropped out of the University in 1585.
- Appointed to Chair of Mathematics at Pisa in 1589.
- Became the Chair of Mathematics at the University of Padua in 1592. Remained at Padua for the next 18 years.



Galileo used his pulse to time the duration of swing

# The Telescope



- In 1608 Hans Lipperhey, a Dutch spectacle-maker found out that distant objects could be seen closer when looked through a combination of lenses. Based on this he built a small telescope.
- In 1609 Galileo had heard about it. He figured out how it worked and set about building one of his own.
- He was able to build better quality telescopes, using lenses he ground himself, with magnifications 8-30, and apertures about 1 inch.
- In August that year, Galileo demonstrated his telescope to the Venetian Senate.
- They were impressed, and understood the military potential of the invention.
- His professorship at Padua was confirmed for life and salary was doubled (as Galileo requested.)



*Galileo Galilei, a most humble servant of Your Serene Highness, being diligently attentive, with all his spirit, not only to discharging the duties pertaining to the lecturing of mathematics at the University of Padua, but also to bringing extraordinary benefit to Your Serene Highness with some useful and remarkable invention, now appear before You with a new contrivance of glasses, drawn from the most recondite speculations of perspective, which render visible objects so close to the eye and represent them so distinctly that those that are distant, for example, nine miles appear as though they were only one mile distant. This is a thing of inestimable benefit for all transactions and undertakings, maritime or terrestrial, allowing us at sea to discover at a much greater distance than usual the hulls and sails of the enemy, so that for two hours or more we can detect him before he detects us...*

*....(the telescope is) one of the fruits of the science which he has professed for the past 17 years at the University of Padua, with the hope of carrying on his work in order to present You greater ones, if it shall please the Good Lord and Your Serene Highness that he, according to his desire, will pass the rest of his life in Your service.*

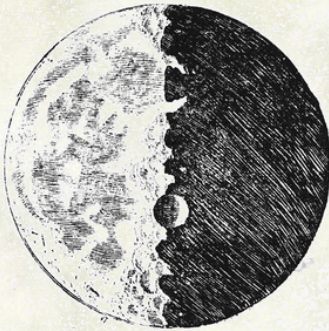
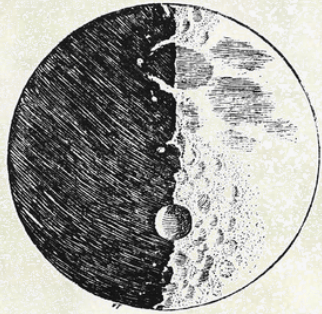
from Galileo's letter to the Doge (leader) of Venice



Galileo demonstrating his telescope to the Doge of Venice and the members of Senate



# Telescopic Observations of the Sky

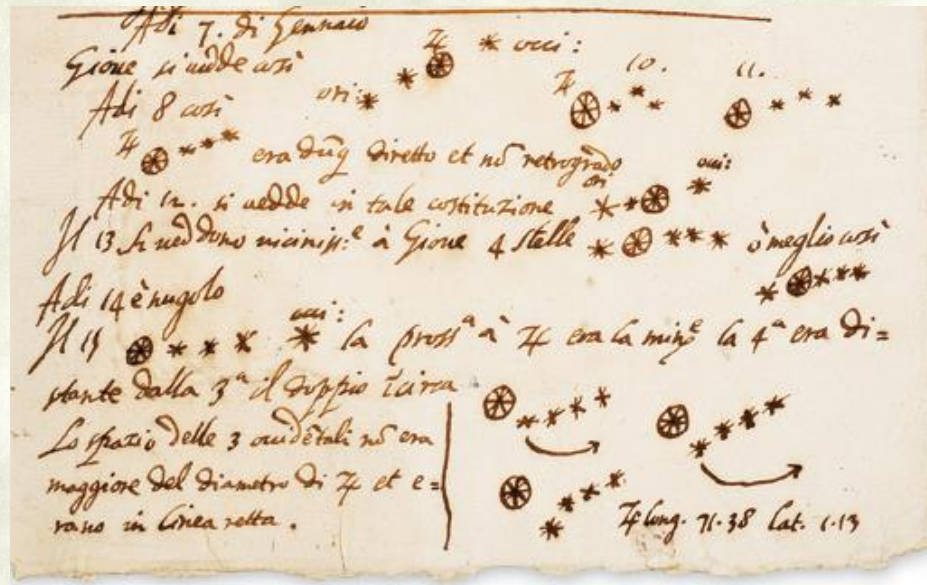


From National Geographic - August 25, 2009  
400 year anniversary of Galileo's telescopic observations

- Soon Galileo turned his telescope to sky, his first target was the Moon.
- Contrary to the belief that Moon was a perfect sphere, what he saw was a rugged mountainous surface.
  - He estimated the height of mountains from the length of their shadows.
- Galileo's observations of rugged mountainous, Earth like moon surface directly contradicted Aristotle's cosmological descriptions of perfect and unchanging heavenly bodies.



# Moons of Jupiter

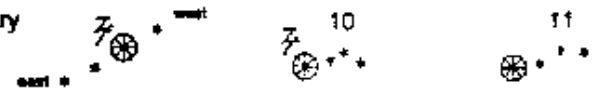


Galileo's notes on first observations of Jupiter in 1610.



Galilean moons:  
**Io, Europa, Ganymede, and Callisto** as visible through a small telescope

On the 7th of January  
Jupiter is seen thus



On the 8th thus

It was therefore direct and not retrograde

On the 12th day it is seen in this arrangement

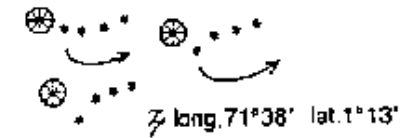


The 13th are seen very close to Jupiter 4 stars

On the 14th it is cloudy

The 15th the nearest to Jupiter was smallest the 4th was distant from the 3rd about double.

The spacing of the 3 to the west was no greater than the diameter of Jupiter and they were in a straight line.



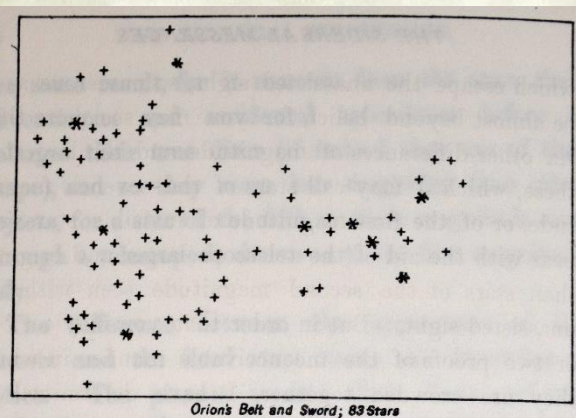
- on January 7, 1610 when Galileo pointed his telescope at Jupiter He saw three tiny stars very close to it, strung out in a line.
  - When he observed again next day he saw the same stars, but their positions had changed.
  - He continued to observe Jupiter and the stars. On January 13, a fourth star appeared.
  - After a few weeks, Galileo noticed that the stars were moving along with Jupiter across the sky, while changing their positions with respect to Jupiter.
- Soon, he realized those were not stars, but planetary bodies that were orbiting around Jupiter.
- Thus Galileo discovered the four largest satellites (moons) of Jupiter.



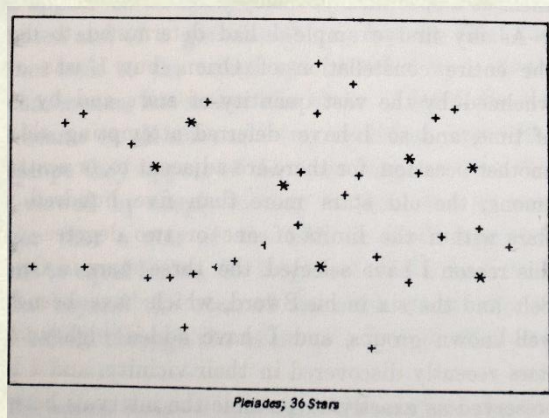
video: Galileo discovering Jupiter's moons

[www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.galileomoon/galileo-discovering-jupiters-moons/](http://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.galileomoon/galileo-discovering-jupiters-moons/)



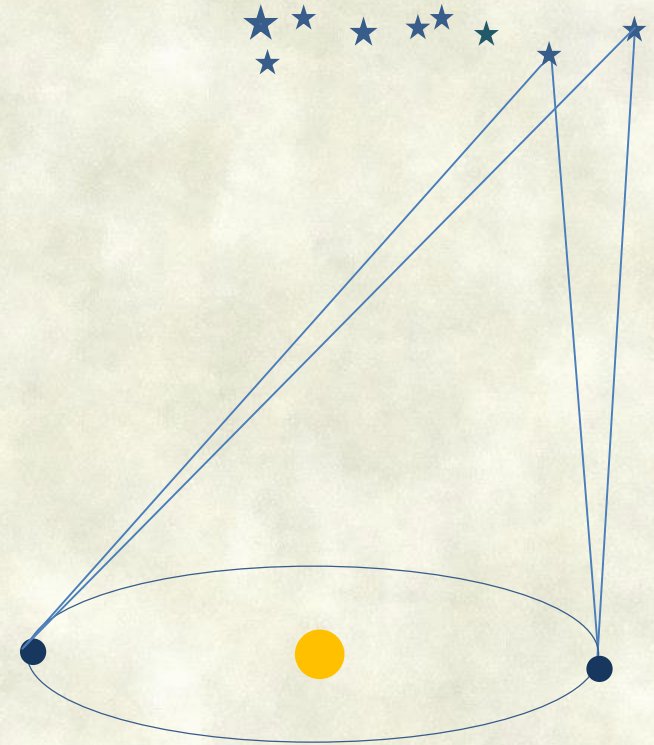


Orion's Belt and Sword; 83 Stars



Pleiades; 36 Stars

Galileo's sketches of stars in Orion and (from *Sidereus Nuncius*)

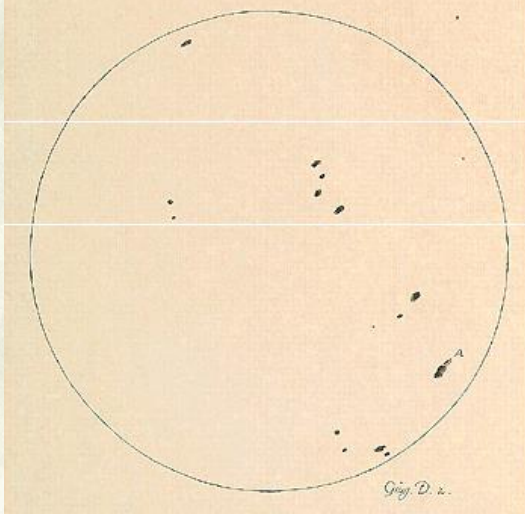


- Galileo observed the Milky Way through his telescope:
  - He saw that the Milky Way was made up of countless stars.
  - He explained that the Milky way looked nebulous to the naked eye because there were so many stars, far away than anyone previously imagined.
- This eliminated a main argument against heliocentric theory since Greek times:
  - non observability of stellar parallax.

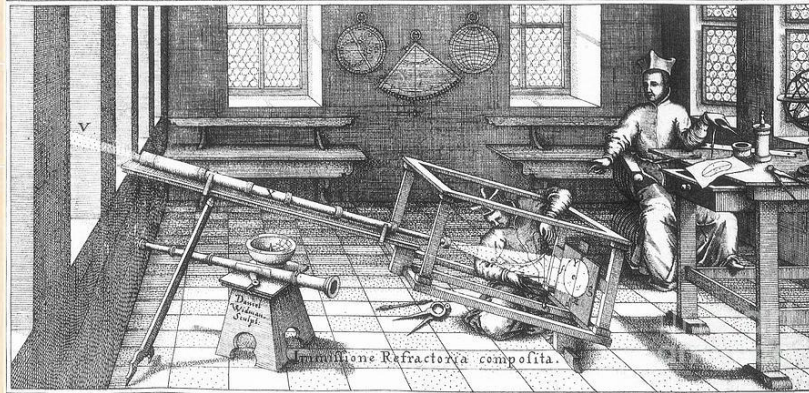
Stars do not show parallax as the Earth goes around the Sun because stars are very far away. The earth's orbit is very small in comparison to their distances.



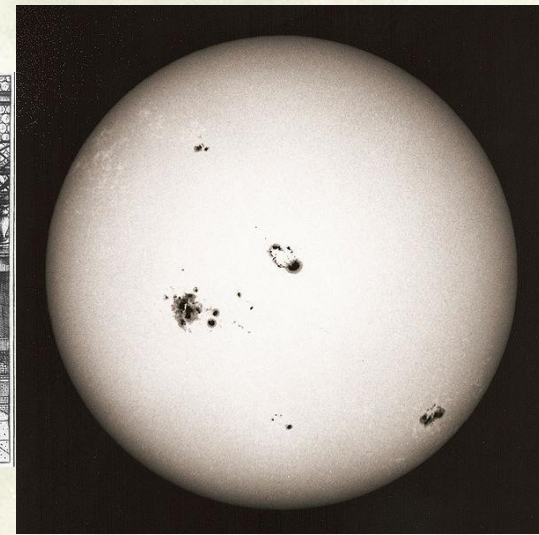
# Sunspots



Galileo's drawings of sunspots



Christopher Scheiner (1573-1650)  
observing sunspots



A modern telescopic view of sunspots

- In 1612 Galileo (and many others) observed sunspots, dark patches on the surface of the Sun.
  - Those "blemishes" on the Sun refuted the basic principles of Aristotelian doctrine of an unchanging perfect nature of the heavenly objects.
- Furthermore, Galileo observed motion of the sunspots indicating that the Sun was rotating.
  - This made it less strange that the Earth might rotate on an axis too, as required in the Copernican model.
- Christopher Scheiner, an astronomer and a priest who supported the geocentrism, also observed sunspots.
  - He claimed the spots must be tiny undiscovered planets circling close to the Sun, which would occasionally pass in front of its disk.
  - Galileo showed that it was wrong, since spots were not permanent and their shape changed.

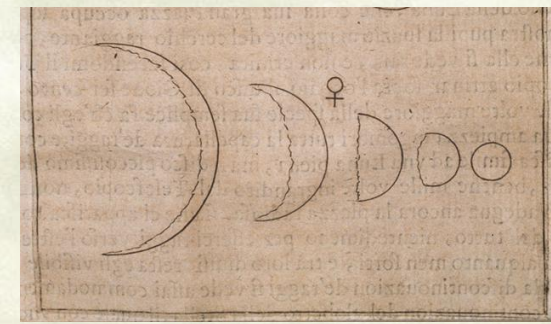




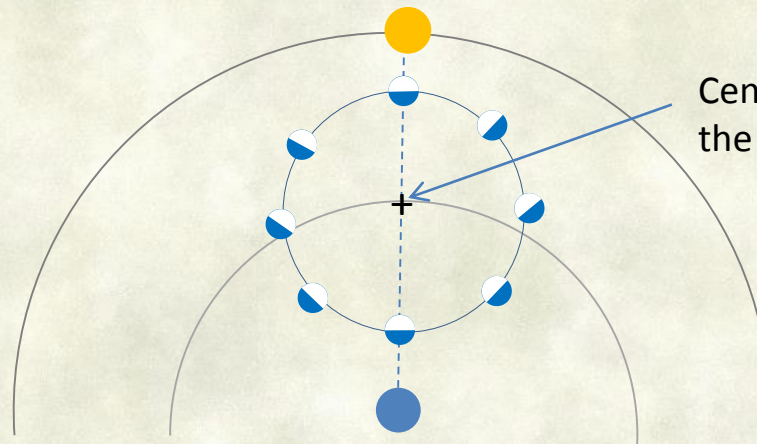
## Galileo on sunspots

- <http://mpb.pbslearningmedia.org/resource/ess05.sci.ess.eiu.galileosun/galileo-sunspots/>

## Phases of Venus



Galileo's illustrations of Venus

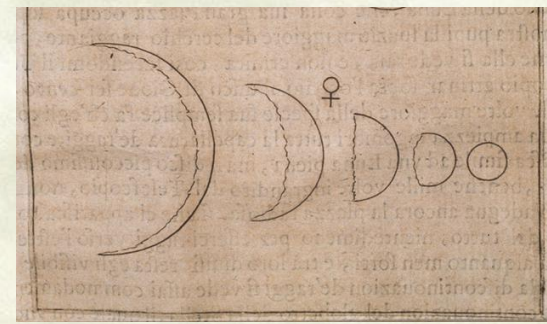


According to Ptolemaic system only crescent phase is visible

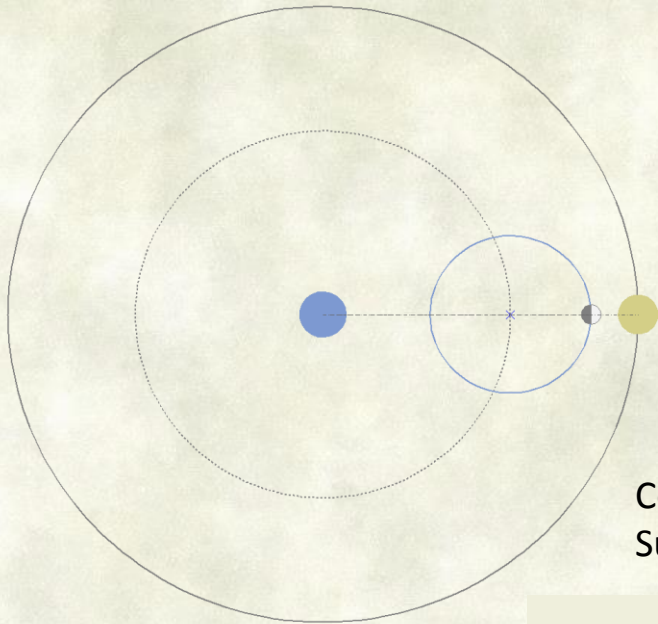
- Angular separation between Venus and the Sun never exceeds  $\sim 48^\circ$ .
  - Ptolemaic geocentric system explained this by putting Venus on an epicycle, and the epicycle goes around the earth at the same rate as the Sun. (center of epicycle is always in the same direction as the Sun).
- But if that was true, Venus would never be in full phase, only crescent phase would be visible from the Earth.



## Phases of Venus

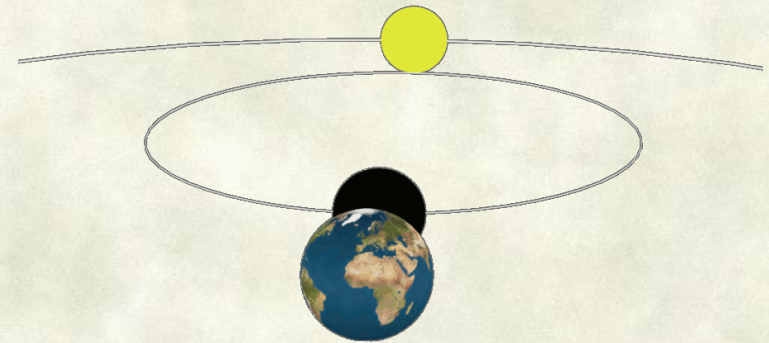


Galileo's drawings of Venus



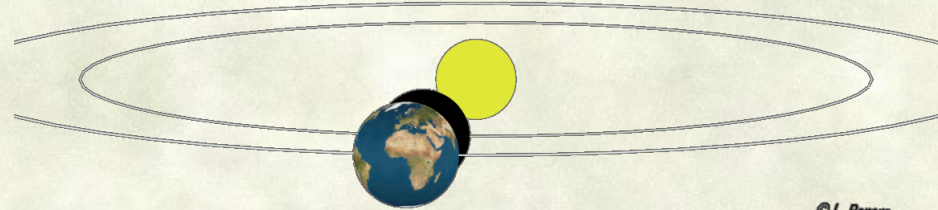
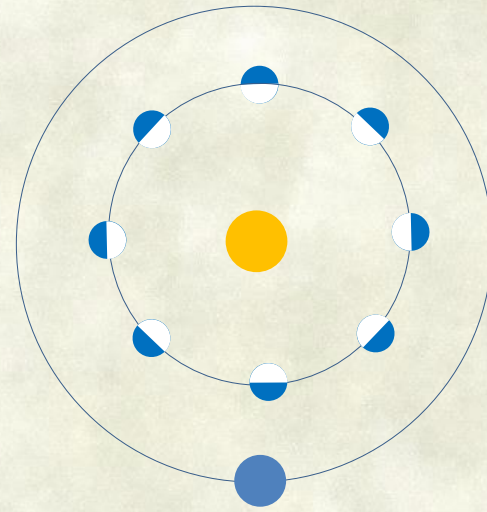
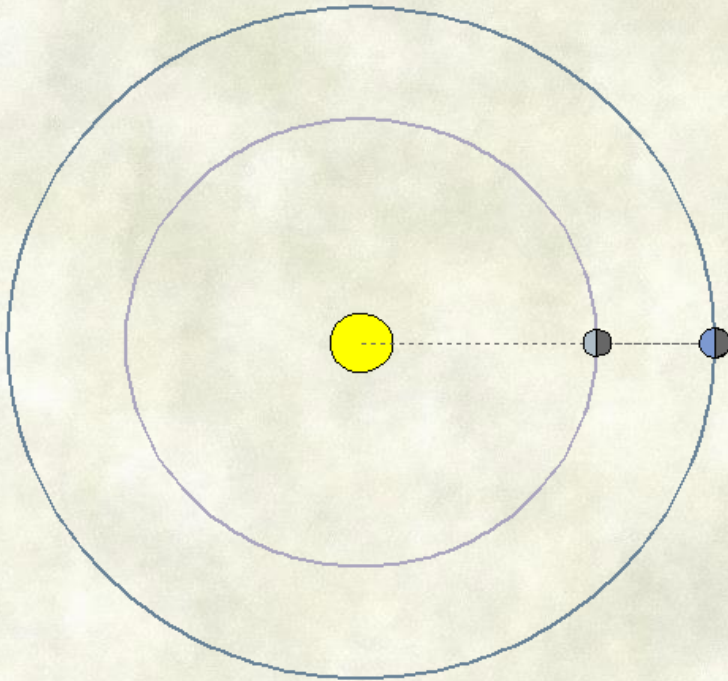
Center of Venus' epicycle always in the same direction as the Sun, only the crescent phase would be visible

[www.phy.olemiss.edu/~perera/animations/venus\\_phases.html](http://www.phy.olemiss.edu/~perera/animations/venus_phases.html)



- Angular separation between Venus and the Sun never exceeds  $\sim 48^\circ$ .
  - Ptolemaic geocentric system explained this by putting Venus on an epicycle, and the epicycle goes around the earth at the same rate as the Sun. (center of epicycle is always in the same direction as the Sun).
- But if that was true, Venus would never be in full phase, only crescent phase would be visible from the Earth.

# Phases of Venus



© L. Perera

[www.phy.olemiss.edu/~perera/animations/venus\\_phases.html](http://www.phy.olemiss.edu/~perera/animations/venus_phases.html)

According to Copernican system all phases are possible

- Copernicus' heliocentric system allowed all phases of Venus visible from the Earth.
- **Full phase cycle of Venus thus ruled out the Ptolemaic geocentric system.**





Phases of Venus:

<http://mpb.pbslearningmedia.org/resource/ess05.sci.ess.eiu.galileosys/galileo-sun-centered-system/>

- By that time Church, which embraced the geocentric view and Aristotelian doctrine, viewed the Copernican idea as a hypothesis,
  - A mathematical device to calculate positions of planets, not as the real picture and a threat to the views of the church.
- But more and more evidence were gathering in favor of the Copernican view through telescopic observations:
  - Craters and mountains on the Moon, and sunspots refuted the Aristotelian view of unchanging perfect nature of the heavens.
  - Phases of Venus could not be explained in terms of the Ptolemaic/Aristotelian system.
  - Moons of Jupiter showed that planetary bodies could move around objects other than the Earth.
  - Rotation of the Sun showed planetary objects could rotate as required in the Copernican model.
  - Resolution of the Milky way to stars proved that stars were at a greater distance than earlier thought.
- Still many rejected the heliocentric theory, and refused to believe what was seen though telescopes were real. They considered them as just artifacts due to optical defects in his telescope.







Galileo was being questioned by the Church authorities in 1616.  
(19<sup>th</sup> century Painting)

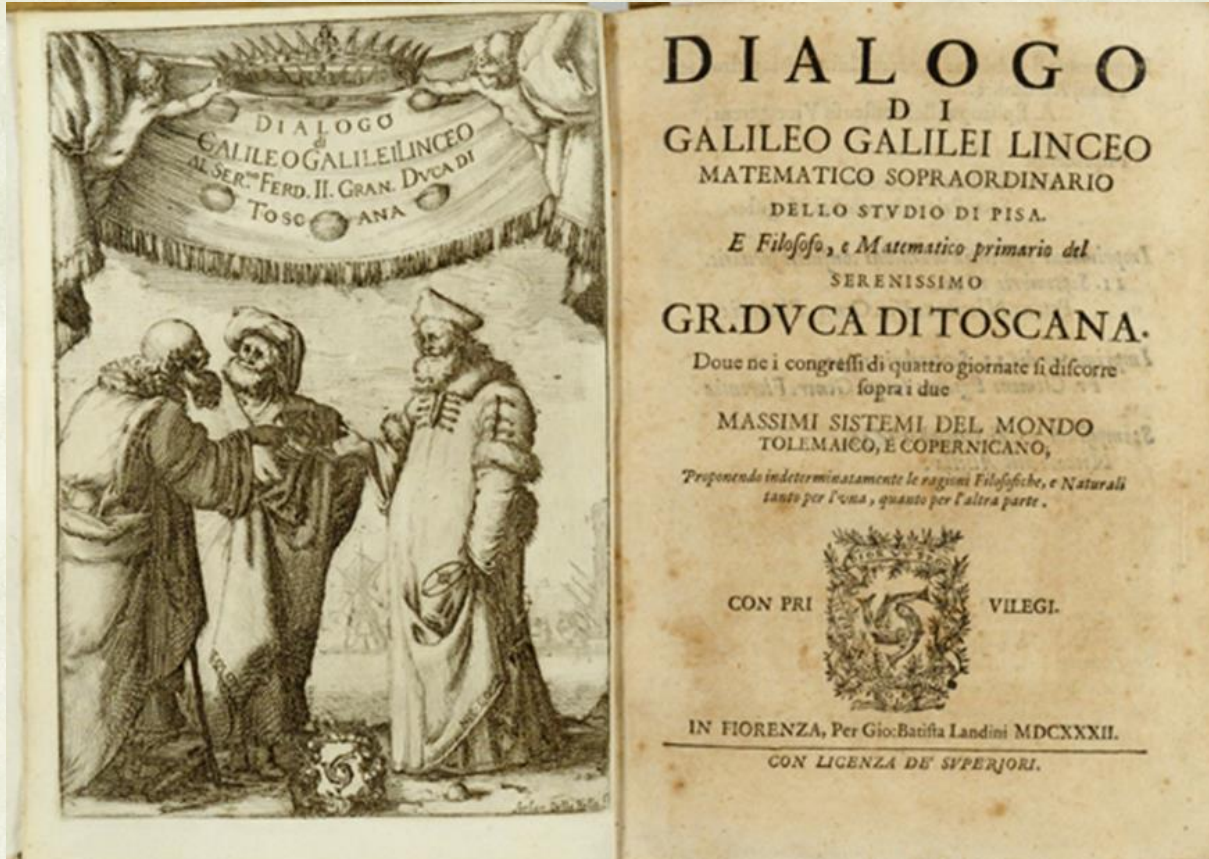
- Frustrated by this, Galileo began openly expressing his ideas in support of the Copernican system.
- “The Bible was written to show us how to go to heaven, not how the heavens go”
  - Galileo in a letter to the Grand Duchess of Tuscany in 1615(Galileo was a devoted catholic all his life.)
- Alarmed by the growing activism, in 1616 Galileo was summoned to Rome
  - He was cautioned against speaking out on behalf of the Copernican claim and was forbidden to discuss the theory orally or in writing.
  - Copernicus’ book “The Revolutions” was banned as the Sun centered system was contrary to the teachings of Scripture, a heresy.



# *Dialogues*

- In 1623 a Galileo's supporter and friend, Cardinal Maffeo Barberini, who generally held a favorable view on the art and science, was elected Pope Urban VIII.
- Soon Galileo met with Pope Urban III, during which they discussed the Copernican theory.
- Pope gave permission to Galileo to write about the Copernican theory as long as:
  - he gives a balanced view for and against the helio-centrism.
  - treats Copernican theory only as a mathematical hypothesis.
- Galileo completed the book '*Dialogues*' in 1629. It was published in Florence in 1632. All 1000 copies were sold out within months.
- It was a witty and brilliant work. The book was presented as a series of Dialogues over a span of four days among three participants - Salviati, Sagredo and Simplicio:
  - Salviati: An intellectual, with keen insights who seems to speak for Galileo and argues for the Copernican theory.
  - Sagredo: An intelligent layman who is seeking truth. Initially impartial, gradually comes to accept Salviati's arguments.
  - Simplicio: A follower of Aristotelian ideas, presents arguments against the Copernican theory. Speaks for Galileo's opponents, who puts up ineffectual, simplistic arguments for Salviati to knock down, often contradicting himself.
  - A nice summary is at: [web.calstatela.edu/faculty/kaniol/a360/galileo\\_dialogue.htm](http://web.calstatela.edu/faculty/kaniol/a360/galileo_dialogue.htm)





- In spite of scrutiny by the Church officials, book was biased and supported Copernican ideas.





Galileo facing the Roman inquisition, (a 19th-century painting)



Statue of Giordano Bruno, Dominican priest and a philosopher. Erected at the place he was executed in 1600 CE by the Roman Inquisition for spreading heretic views (among were sun centered system and plurality of worlds, infinite universe)

- Shortly afterwards the sale of the book was banned, Galileo was summoned by the Roman Inquisition.
- After a two week trial he was condemned.
  - Galileo agreed to plead guilty to a lesser charge in exchange for a lenient sentence.
  - He had to confess that the Copernican case was made too strongly in his book *Dialogue* and agreed to modify his opinions in his next work, and he believed and always will believe that what church recognizes and teaches was true.
- Galileo was sentenced to prison for an indefinite term, later was allowed to return to his house in Florence, where he lived under house arrest until his death in 1642.



## Vatican Science Panel Told By Pope: Galileo Was Right

Published: November 1, 1992

Moving formally to rectify a wrong, Pope John Paul II acknowledged in a speech today that the Roman Catholic Church had erred in condemning Galileo 359 years ago for asserting that the Earth revolves around the Sun.

The address by the Pope before the Pontifical Academy of Sciences closed a 13-year investigation into the Church's condemnation of Galileo in 1633, one of history's most notorious conflicts between faith and science. Galileo was forced to recant his scientific findings to avoid being burned at the stake and spent the remaining eight years of his life under house arrest.

John Paul said the theologians who condemned Galileo did not recognize the formal distinction between the Bible and its interpretation.

"This led them unduly to transpose into the realm of the doctrine of the faith, a question which in fact pertained to scientific investigation.

Though the Pope acknowledged that the Church had done Galileo a wrong, he said the 17th-century theologians were working with the knowledge available to them at the time.

- Papal Inquisition was abolished in 1822
- In 1835 Galileo's book *Dialogue* was taken off the Vatican's list of banned books. (later published as *Dialogue Concerning the Two Chief World Systems*)
- Heliocentrism gradually gained acceptance, but still there were many who accepted geocentric theory on religious grounds. In the US both Yale and Harvard had taught the geocentric theory until early eighteenth century.
- In 1992 Vatican formally admitted that Galileo's views on the solar system were correct.

**MR. RUGGLES AT NEW HAVEN.**

On the 27th of July a semi-centennial address was delivered before the alumni of Yale College, by Samuel B. Ruggles, LL.D., and it has been published by D. Appleton & Co. in a neat pamphlet. We find it filled with interesting statements, some of which we extract:—

**THE PTOLEMAIC THEORY ONCE TAUGHT AT YALE.**

The fact is strange and curious, that even here in emancipated America, the Ptolemaic or geocentric theory, enforced by Papal assumption on the dark ages, was actually taught for several years, within these very walls. It was not until 1718, that the light of the heliocentric system was first let in, through the efforts of the clear-sighted Doctor Samuel Johnson, then a tutor in the College, and who in due season would have become its President, but for his ill-timed doubts of the validity of Presbyterian ordination. A copy of the "Principia," sent out from Europe, had reached the little college library, upon which the youthful Johnson entered with great avidity, after studying the higher mathematics for the purpose. "Till then," says his biographer, "the Ptolemaic system of the world was as strongly believed as the Holy Scriptures; but Johnson was soon able to overthrow it, and establish on its ruins the doctrine of Copernicus." The heliocentric system at once illuminated the College, and here it will continue to pour forth its magnificent light until the College, and the earth, and the sun, and the stars, shall be no more. Poor old Copernicus, who in his dying hours had sought, by a letter of dedication, to disarm the opposition of the Pope, was lying in his grave on the Baltic, carefully covered by the Papal excommunication, which was not formally annulled by the Vatican until the year 1821, seven years after our class left college. Since that time, the Church of Rome, claiming to be the chosen keeper and interpreter of Holy Writ, together with the residue of the Christian world, have permitted the students of the Pentateuch to read the Genesis by the light of Copernicus and Newton.

**THE FIRST NOTIONS OF GEOLOGY.**

**R. RUGGLES AT NEW HAVEN.** On the 27th of July a semi-centennial address was delivered before the alumni of Yale College, by Samuel B. Ruggles, LL.D., and it has been published by D. Appleton & Co. in a neat pamphlet. We find it filled with interesting statements, some of which we extract:—

**THE PTOLEMAIC THEORY ONCE TAUGHT AT YALE.** The fact is strange and curious, that even here in emancipated America, the Ptolemaic or geocentric theory, enforced by Papal assumption on the dark ages, was actually taught for several years, within these very walls. It was not until 1718, that the light of the heliocentric system was first let in, through the efforts of the clear-sighted Doctor Samuel Johnson, then a tutor in the College, and who in due season would have become its President, but for his ill-timed doubts of the validity of Presbyterian ordination. A copy of the "Principia," sent out from Europe, had reached the little college library, upon which the youthful Johnson entered with great avidity, after studying the higher mathematics for the purpose. "Till then," says his biographer, "the Ptolemaic system of the world was as strongly believed as the Holy Scriptures; but Johnson was soon able to overthrow it, and establish on its ruins the doctrine of Copernicus." The heliocentric system at once illuminated the College, and here it will continue to pour forth its magnificent light until the College, and the earth, and the sun, and the stars, shall be no more. Poor old Copernicus, who in his dying hours had sought, by a letter of dedication, to disarm the opposition of the Pope, was lying in his grave on the Baltic, carefully covered by the Papal excommunication, which was not formally annulled by the Vatican until the year 1821, seven years after our class left college. Since that time, the Church of Rome, claiming to be the chosen keeper and interpreter of Holy Writ, together with the residue of the Christian world, have permitted the students of the Pentateuch to read the Genesis by the light of Copernicus and Newton.





Will LeBron James Return Home to Haters?



John Legend and Taye Diggs Had a Sexy Voicemail Sing-Off



LATEST

MAGAZINE

VIDEOS



1 in 4 Americans Apparently Unaware the Earth Orbits the Sun

but still

Apple: Your Data Is Safe

Tracy Morgan Released From Medical Rehab After Deadly Crash

Will the Germany vs. Argentina World Cup Final Be Any Good?

Christie: Gay Marriage "Settled" In New Jersey But Republicans Shouldn't Give Up Fight

3D ASSAULT SYSTEMES

The 3DEXPERIENCE Company

3DS.COM

AMC: Better Call Saul Will Be Set in 2002

CONTENT FROM LVCVA  
Vegas Eye Candy

Study: Organic Produce Has Fewer Pesticides, More Antioxidants

Kerry: Afghan Candidates Agree to Audit Results

NEWSFEED SCIENCE

# 1 in 4 Americans Apparently Unaware the Earth Orbits the Sun

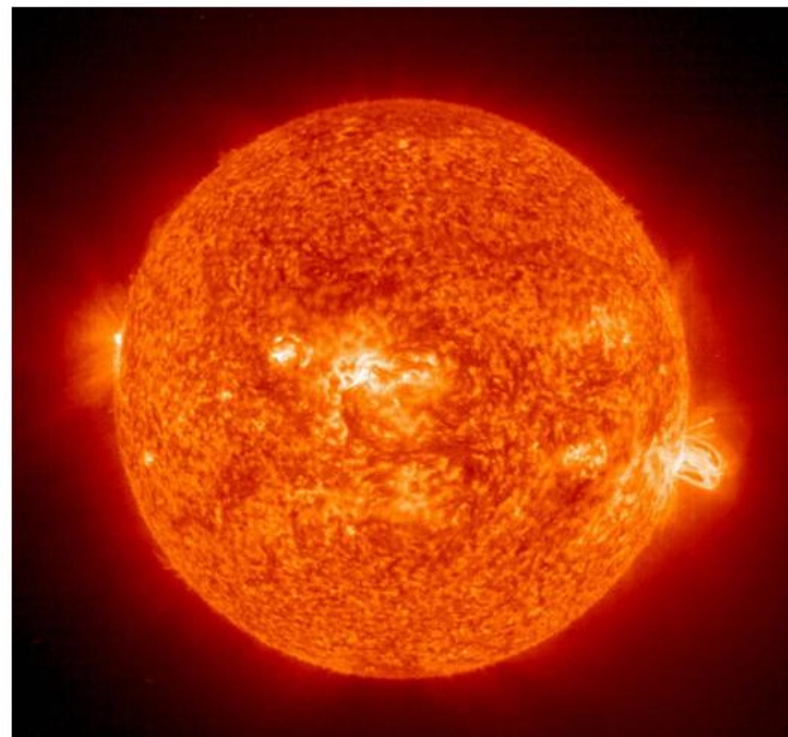
Samantha Grossman @sam\_grossman | Feb. 16, 2014



**A National Science Foundation study involving 2,200 participants find that about 25 percent of Americans got this question wrong: 'Does the Earth go around the sun, or does the sun go around the Earth?'**

*Does the Earth go around the sun, or does the sun go around the Earth?*

When asked that question, 1 in 4 Americans surveyed answered incorrectly. Yes, 1 in 4. In other words, a quarter of Americans do not understand one of the most fundamental principles of basic science. So that's where we are as a society right now.



Getty Images

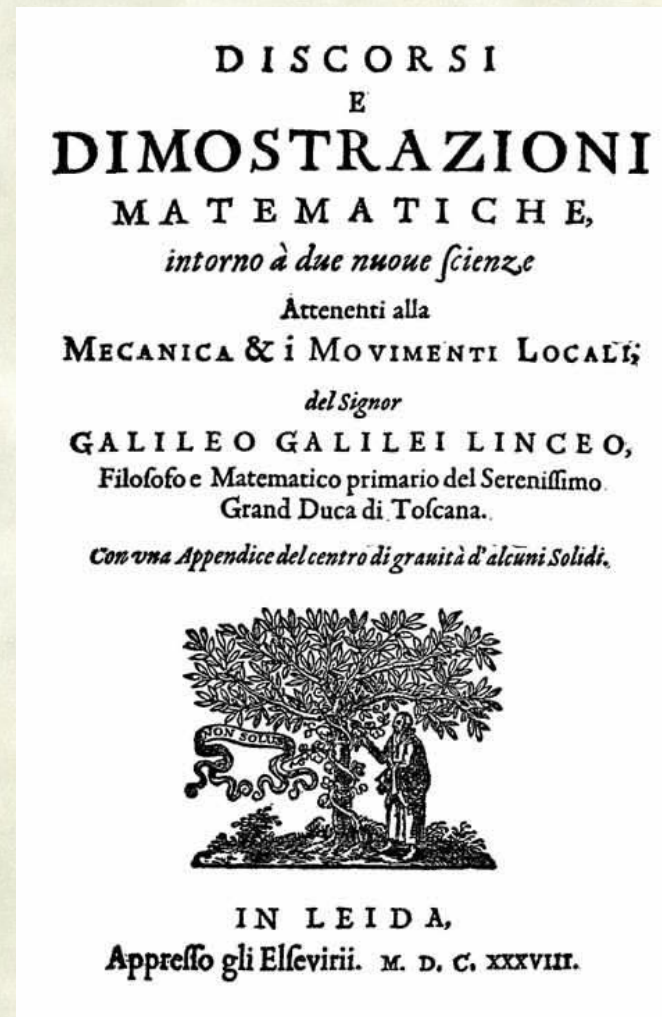
# Galileo on the laws of Motion

Galileo made extensive contributions to the understanding of the laws governing the motion of objects.

- He published those findings in '*Dialogues Concerning Two New Sciences*', the book he wrote during the final years of his life while under house arrest.

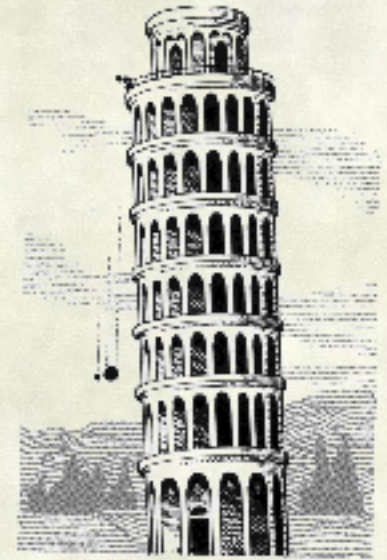
Prevailing ideas of the time on motion were mainly Aristotle's ideas:

- Each object has a natural motion, the tendency to move toward their natural place with a speed decided by its nature.
  - Earthly objects fall because they move towards the center of the Earth (universe), their natural place.
  - Air and fire move (lift) linearly upward.



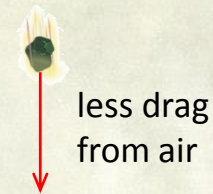
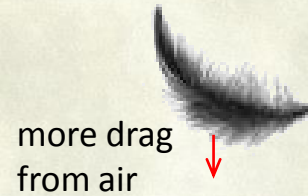
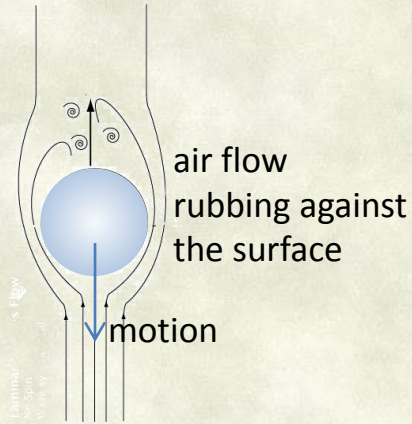


# Galileo on falling objects



- This implied if an object is dropped it would fall at a constant speed determined by its weight and nature
  - **Heavier objects falls faster, lighter objects slower,** according to Aristotelian view.
- Galileo showed that it was wrong. He showed that all objects falls at the same rate regardless of the weight.
  - Contrary to the popular belief, it is unlikely that he showed this by dropping two different sized objects off the tower of Pisa. (Not mentioned in his writings).
- Galileo did a number of experiments to study the nature of motion of falling bodies.
- **He came to the conclusion that a freely falling body has a uniform accelerated motion regardless of its nature.**
  - its speed increases at a uniform rate, regardless of the weight of the object.

# Galileo on falling objects- Friction



- In real life this is not exactly true, if we drop a stone and a feather stone falls faster.
- Galileo correctly identified that such differences were due to friction.
  - When an object moves it rubs against a surface, and rub against air. The force due to rubbing action acts against the motion is called the **friction**.
- This is what makes the difference in motion for different types of objects.
  - When a stone and a feather are dropped, feather falls slower because due to its shape it is subjected to more friction from air.
  - If a stone and a feather are dropped in a vacuum, they would fall at the same rate.





It was done on the Moon by Apollo 15 astronauts:

[http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo\\_15\\_feather\\_drop.html](http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo_15_feather_drop.html)

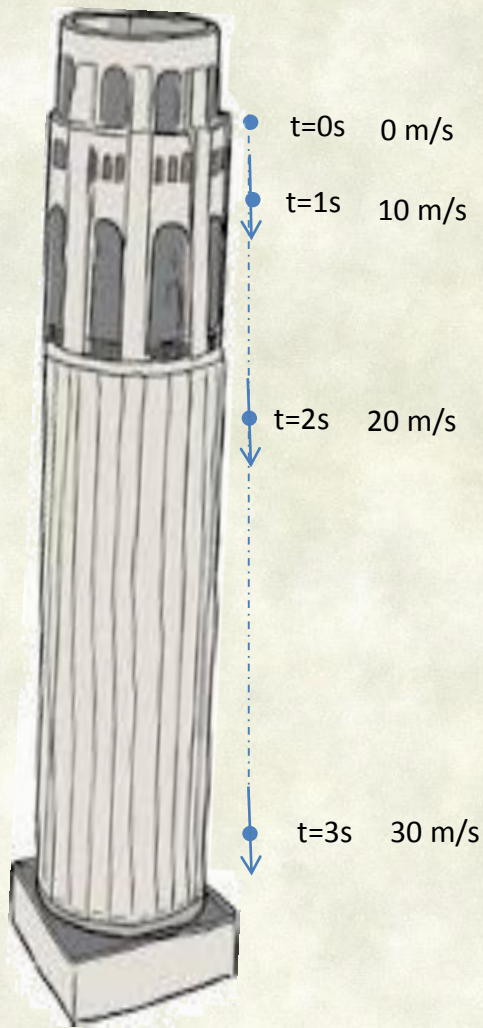
BBC TWO



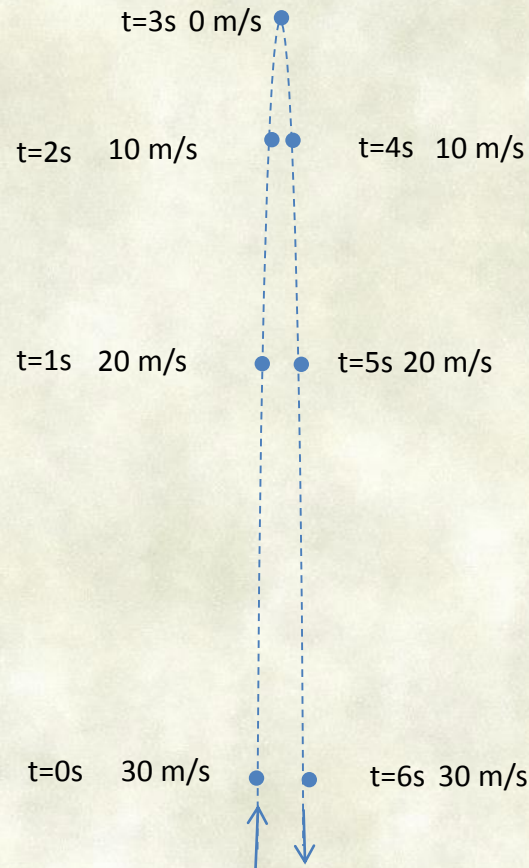
And in vacuum chambers: <https://www.youtube.com/watch?v=E43-CfukEgs>



# Galileo on falling objects



speed of an object falling freely



Speed of an object thrown vertically upward

- Speed of a freely falling object increases at a rate 10 m/s each second (9.8 m/s more accurately).
  - ie. an object accelerates 9.8 m/s per second when they fall freely (without air resistance)

# Galileo on Motion

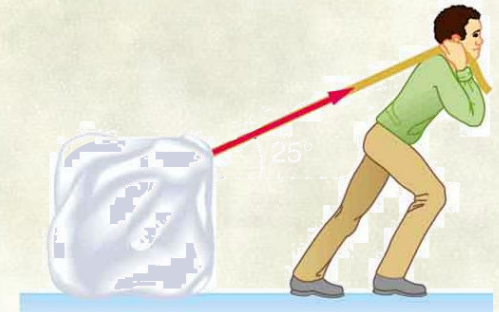
- In addition to vertical motions (falls or rises), Aristotle described another type of motion, Forced motions.
  - Produced by external forces (pushes, pulls) on objects. In such motions objects only moved as long as a force is applied.



A rock won't move without a cause



has to be pushed



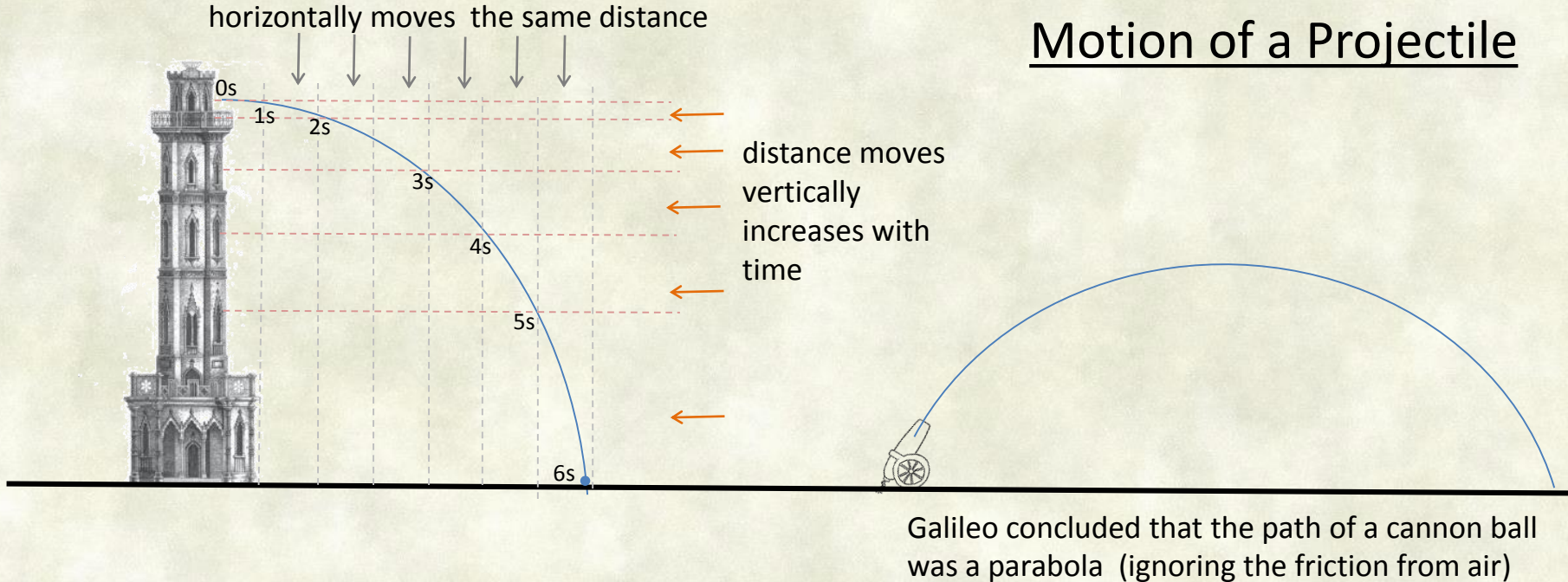
or pulled

According to Aristotle a force is needed to keep objects moving

- It was on this ground that Aristotelians rejected the idea that the Earth was rotating or moving around the Sun.
- Again Galileo pointed out that it was wrong. Moving objects stop because of friction.
  - according to Galileo, if there is no friction a moving object would keep moving at the same speed.
  - no other force is needed to keep it moving as Aristotle envisioned.



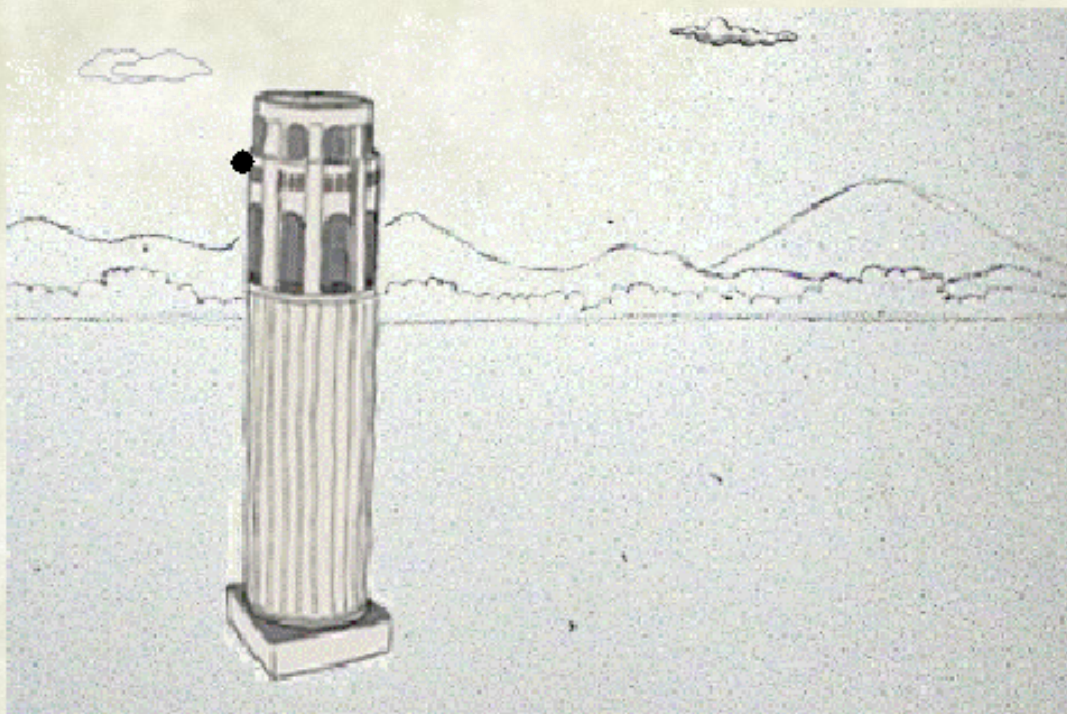
# Motion of a Projectile



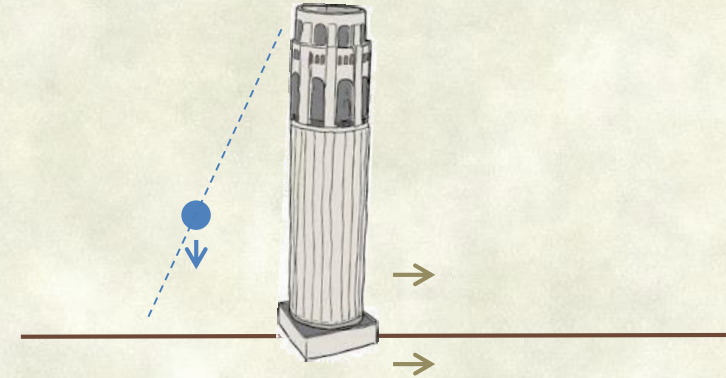
- Suppose a ball is thrown horizontally (ignore air friction for now):
  - According to Galileo, vertically it has a uniformly accelerated motion so the vertical speed and the distance it moves vertically in a given time interval increases with time.
  - since there is force acting horizontally on the ball, it will move at uniform speed horizontally, same distance in a given time interval.
  - Combining those two motions Galileo came to the conclusion that path of a projectile would be a parabolic curve.



## Falling Objects on the Moving Earth according to Aristotle



[www.phy.olemiss.edu/~perera/animations/falling.html](http://www.phy.olemiss.edu/~perera/animations/falling.html)

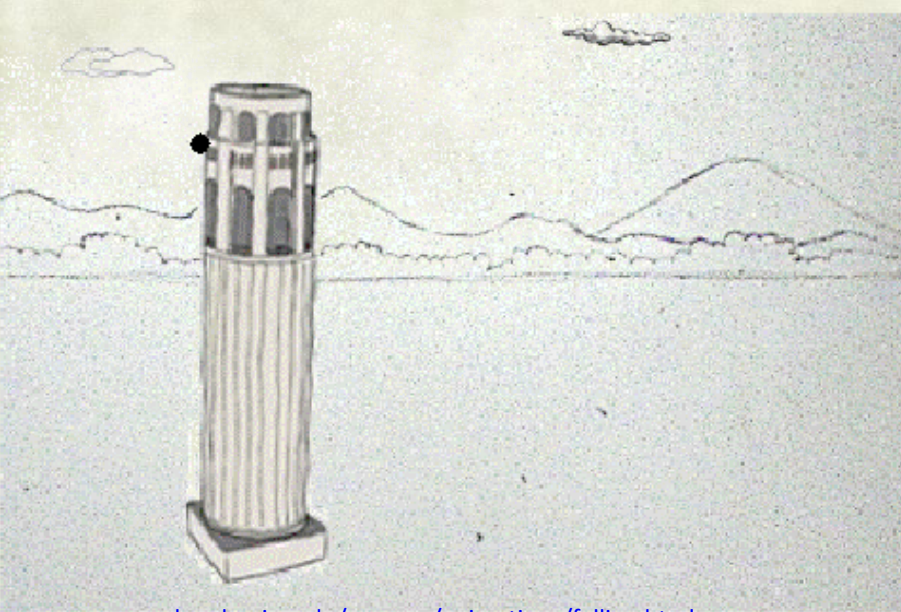


Suppose a ball is dropped from a tall tower (on the moving Earth)

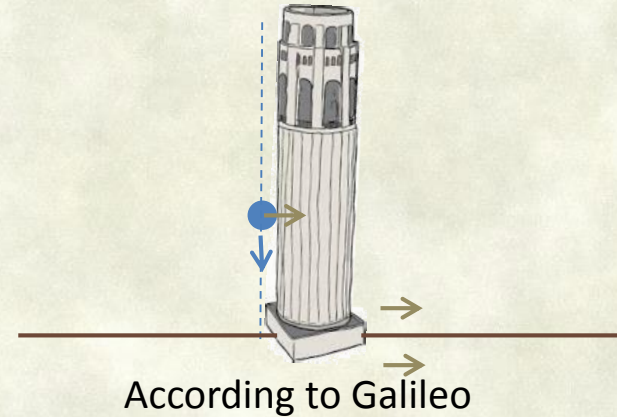
- According to Aristotle:
  - Before the ball is dropped everything was moving with the Earth.
  - When the ball is dropped, its horizontal movement ceases (no horizontal force)
  - Ball moves vertically down while the tower moves with the Earth.
  - So if the earth is moving the ball has to strike the ground away from the tower.



## Falling Objects on the Moving Earth According to Galileo



[www.phy.olemiss.edu/~perera/animations/falling.html](http://www.phy.olemiss.edu/~perera/animations/falling.html)



Suppose a ball is dropped from a tall tower (on the moving Earth)

- According to Galileo:
  - Both ball and the tower are moving horizontally with the same speed.
  - When the ball is dropped, while it is moving downward, it continues to move horizontally with the same speed with the Earth as before.
    - (since there is no force acting horizontally to stop it)
  - Ball falls vertically and strike ground right bellow where it was dropped.
  - An observer in the tower does not see any horizontal movement of the ball.

A close-up portrait of Julian Barbour, an older man with thinning grey hair and a serious expression. He is wearing a dark collared shirt under a red jacket. The background is a blurred interior with a large window on the right.

**NOVA** **JULIAN BARBOUR**  
Theoretical Physicist



# Review Questions

- Who invented the telescope?
- What were the Galileo's telescopic observations that challenged the Ptolemaic geocentric system and how? What was the strongest evidence against it?
- Why is it not possible to see phases other than a crescent of Venus according to the Ptolemaic model ?
- Copernicus' book "The Revolutions" did not made much controversy when it was published. Why was it banned in 1616, more than 80 years later?
- Why did supporters of the Ptolemaic system were reluctant to believe that sunspots were real?
- Why is the argument against the motion of the Earth by Aristotle that falling objects would fall at an angle wrong?
- According to Galileo what is the natural state of motion of an object?
- Why does a feather fall slower than a stone on Earth even though according to Galileo they should fall at the same rate.
- Suppose somebody is throwing a baseball vertically upward from a pickup truck moving at a uniform speed. What is the path of the ball
  - As seen from the truck?
  - As seen by somebody on the ground?
- In the example of the falling ball from a tower, according to Galileo ball continue moving horizontally after it was released. What about the friction from air? Isn't the horizontal motion of the ball slows down due to air friction?