1566 Dec. 27: Tycho has argument possibly over some bad astrological predictions. Swords drawn, Tycho loses nose.

Recall...

Tycho’s System from the late 16th Century.

1572: Tycho’s Nova 1573: De nova stella
1576: Uraniburg founded on Danish island of Hven 1577: Tycho’s Comet 1588 Tycho's On the Most Recent Phenomena of the Aetherial World
Tycho's Comet of 1577
Paralax argument put the comet beyond the moon, near Venus.
Nova Mendani Sistematis Hypotyposis

ab Authore siuper admente, quorum vetustia Ptolemiasca redundantia & necessemum, non eam recent Coper-

niana in morte Terra Physica absurditas, exclu-
duntur, omnia quse Apparentus Caelestibus

apposite correspondent.
Eppur[e] Si Muove

And yet she/it moves (herself)
This makes more sense to me, but if seen out of context it might seem to be pointing to Satan…

What’s the story?
The Catholic religion, as practiced in Renaissance Italy, loves its body parts behind glass.

Here is a reliquary containing a tooth, reputedly that of Saint Apollonia, in the treasury of the cathedral of Porto, Portugal. She died in 249 in Alexandria.
This is supposedly St. Lawrence the Librarian.
Galileo Galilei

1604 Nova: New Star seen in the sky

1605: Galileo, under a pseudonym, publishes *Dialogue of Cecco di Ronchitti da Bruzene with regard to the New Star*

Cecco di Ronchetti- roughly translates as *blindman with coughs* (a.k.a. Galileo)

Galileo compared observations from around Europe and found no apparent parallax. But the moon displayed parallax. Thus, he concluded, the nova must be beyond the moon. Others were not so sure.

Here is an Earth-Moon paralax illustration. Open file for better view.[inverted above]
Enter the telescope.

**ca. 1580:** Leonard and Thomas Digges report on telescopic device. If you recall, The Diggeses were involved in nested geometric solids and proposed an infinite Copernican cosmos in the 1570s.

In his book *Natural Magik* (1st ed. 1558), Della Porta claims to have first developed the arrangement of lenses that make a "looking glass."

**1608:** Hans Lippershey- reference to optical telescope is recorded, but the telescope may go back a few years. This is the standard history-text "first."

**1609:** Galileo sets about improving the telescope. He called it a *perspicillum; a look around device.*
One of Galileo’s early lenses. It is only a couple of inches in diameter. It’s been mounted in gold and framed in some sort of carved monstrosity… and it’s broken.
The modern tools for grinding a lens by hand differ little from the old tools.
Grinding the lens on the “tool.” The tool is charged with abrasive powder. It is a slow process.

These images actually show people shaping a concave Newtonian reflector rather than a convex lens, but grinding is grinding.
By 1610 Harriot was pretty good at observing the moon with his x6. See above.
Harriot drawings.

Modern image
In 1610 Galileo publishes

Siderius Nuncius

or in English…

The Starry Messenger
or
The Star Messenger
or
The Starry Message
or
The Star Report
or
The Starry Announcement

... It’s rather ambiguous, but not terribly relevant.
Kepler loved this book. He wrote fan mail to Galileo but it was never acknowledged.
Patauini Gymnasij Publico Mathematico

PERSPICILLI

Neque a se reperti beneficia sunt observata in unae faciei fixis in numeris, acteo circulo, stellis nebulois. Apprime vero in milio way nebulois stars.

QUATVOR PLANETIS

Circa IOVIS Stellam dispastibus interellus, atque periodis, celatate mirabilis circumculatus; quis, nemini in hanc viscer diem cognitos, nouissime Author deprehendit primus; atque

MEDICEA SIDERAC

Nuncupandos decrevit.

VENETIIS, Apud Thomam Baglionum. MDCCX.

Superiorum Permissu, & Privilegio.
By December of 1609 Galileo has made a x20 scope. The moon had never looked better. He saw mountains and craters.

Crescent moon shadow edge is uneven suggesting hills or mountains. But the overall outer edge is seemingly very, very smooth.
Galileo argued that the edge seems smooth because of the combined overlap of all the mountains seen from the side, like the waves on the ocean...

He also suggests the smoothness could be from a lunar atmosphere smoothing out the irregularities as seen at its most dense from the side.
Modern image
Rough interior line, smooth exterior line.
The following are some photographs taken through a telescope similar to those made by Galileo. [Take the accuracy of these images with a grain of salt. I don’t believe that these lenses were hand ground. Note the limited field of vision.]
Drawing/etching by Galileo.
The Galilean telescope had a small field of vision.
Galileo argued that if the moon were a perfectly smooth and reflective sphere (as the straw-men Aristotelians that Drake describes claimed) the sun would reflect in it as a tiny dot.

M.C. Escher
1898-1972
The lights that hang around Jupiter. They orbited a non-terrestrial center. [See .gif animation.]
From about 1609-1610 Galileo also observed the “ears of Saturn” and the phases of Venus. (These observations are not in *Sidereus nuncius*.)
Venus, seen through a Galilean Telescope
Kepler stood behind Galileo’s observations and even coined the word, “satellite” to describe the Medecian moons. Kepler published two [perhaps more?] pamphlets in support of Galileo.

Galileo only barely acknowledged Kepler, and only when is served his purposes. He never mentioned any of Kepler’s three planetary laws or his optical theory. Galileo remained a Copernican epicycle-man to the end.

Galileo’s significant addition to physical theory was yet to come.
The early 17th century was hot for the *perispicillium*.

A brief interlude on the popularity and excessive obsessions of the telescope.
2. Five comets seen in England, 1664–82

6. Aristotle, Hevelius and Kepler dispute the orbits of comets
Telescopes Gone Wild

Here is a 60-footer by Hevelius (1611-87) the master lens grinder…
…and professional brewer. I’m dubious. It looks too short.
His 12-footer magnified ca. x50. I couldn’t find any numbers on the 140’ scope. Imagine aiming it. Imagine the jiggles.
Claude Mellan, artist French, 1598 - 1688 The Face of Christ on the Sudary, 1649 engraving 42.6 x 31.8 cm
Claude Mellan made the engraving on the left in 1636. The one on the right is a photograph made using a Galilean telescope.
Lodovico Cigoli's 
Assumption of the 
Virgin (1622) 
Rome, Santa Maria Maggiore

The moon gets craters.
Opium

No wonder she looks so blissful.
Tycho with Medecian Planets
Sunspot motion led Galileo to conclude that the Sun rotated about once per month. Others had different ideas. Kepler thrilled with this idea.

Galileo proclaims Copernican astronomy in this work.
The Galileo affair.

Cardinal Robert Bellarmine:
Jesuit leader
The last word in Biblical controversy.
Promoted the idea of a R. C. superstate that would overpower even monarchies.
Very well educated and versed in astronomy.
Participated in Bruno trial which led to his being burnt in 1600. Bruno denied the divinity of Jesus and also promoted the idea of an infinite universe and the idea of multiple worlds with people on them.

In a nutshell, in April of 1615 Bellarmine wanted proof that the cosmos was arranged in the Copernican fashion. If no proof, then the default went to the biblical descriptions, which were hardly definitive, but nonetheless in the Bible. Recall, Copernicus not only didn’t really prove his system, but that preface by Ossiander disclaimed the whole thing as a hypothesis. He appeared to be open to proof.
The Bible –
On the the motions of the sun, the earth, and the moon.

...One generation goes and another comes; but the earth is for ever. The sun comes up and the sun goes down, and goes quickly back to the place where he came up. The wind goes to the south, turning back again to the north; circling round for ever.-- Ecclesiastes 1:4-6 (Basic English Bible)

The sun hath gone out on the earth, and Lot hath entered into Zoar,.-- Genesis 19:23- (Young’s Literal Translation)

... the arch of the sky makes clear the work of his hands. ... In them has he put a tent for the sun, Who is like a newly married man coming from his bride-tent, and is glad like a strong runner starting on his way. His going out is from the end of the heaven, and his circle to the ends of it; there is nothing which is not open to his heat. -- Psalms 9:1-6. (Basic English Bible)

The Lord is King; he is clothed with glory; the Lord is clothed with strength; power is the cord of his robe; the world is fixed, so that it may not be moved.. -- Psalms 93:1 (Basic English Bible)
He has made the earth strong on its bases, so that it may not be moved for ever and ever. -- Psalms 104:5 (Basic English Bible)

Then Isaiah the prophet made prayer to the Lord, and he made the shade go back ten degrees from its position on the steps of Ahaz. -- 2 Kings 20:11 (Basic English Bible)

Then Joshua spoke to the LORD in the day when the LORD delivered up the Amorites before the sons of Israel, and he said in the sight of Israel, "O sun, stand still at Gibeon, And O moon in the valley of Aijalon." So the sun stood still, and the moon stopped, Until the nation avenged themselves of their enemies. Is it not written in the book of Jashar? And the sun stopped in the middle of the sky and did not hasten to go down for about a whole day. There was no day like that before it or after it, when the LORD listened to the voice of a man; for the LORD fought for Israel.-- Joshua 10:12-14 (New American Standard)

…but thou hast ordered all things in measure and number and weight. -- Wisdom of Solomon 11:20. (King James)
Galileo’s response in May 1615 to Bellarmine’s demand that there must be proof:

-The Peripatetetics were too dim witted to understand his proof of the Copernican system.

-Problem: Bellarmine would have considered himself a Peripatetic.

Galileo held that his theory of tides would prove the motions of the earth. His theory had the tidal motions as a function of the earth’s motions. Turns out that tidal motions are more a function of the moon’s attraction (and the sun’s) and Kepler had figured this out. But Galileo thought Kepler’s theory was mumbo jumbo… all that talk of force and effects at a distance… just occult crap.
On Feb. 23, 1616 an “opinion” was reached by the higher ups at the Vatican on the questions of the sun’s centrality and the earth’s motions. It was ruled to be heretical to hold to such beliefs. However this ruling was not published or known to anyone until 1633.

The official “decree” from March 5, 1616 called the “Pythagorean Doctrine” false and contrary to scripture. Copernicus was to be put on the banned book index pending corrections and all proponents of this theory were condemned. The theory was not considered heretical, just bad. Galileo not specifically mentioned.

Galileo not worried since his only published mention of Copernicus’ theory, in *Letters on Sunspots*, called it a hypothesis.

[aside: By 1620 Copernicus had been corrected. All of 9 sentences had to be reworked or deleted.]
After the decree, Galileo was summoned to the pope. He was reprimanded and warned, but just how severe the warning was and how explicitly the prohibitions against Copernicanism were is subject to much debate. The sources on this meeting are not clear.

The Inquisition file on Galileo notes that he was told not to even discuss Copernicanism and threatened him with imprisonment if he did.

Other sources are more wishy washy. Perhaps he could discuss it, so long as it stayed hypothetical.

Making matters worse was a letter that Cardinal Bellarmine wrote on Galileo’s behalf dating May 26, 1616 more or less stating that Galileo wasn’t really in trouble with the Inquisition. Galileo was worried about his reputation. They just wanted to go over Copernicus’ mistakes with Galileo and to reinforce the Aristotelian cosmic order as stated in the Bible. This letter does not suggest that discussing Copernicus’ theory was off limits. [This is Koestler’s reading of things.]
In a nutshell:

It’s not clear if Galileo was told never to mention Copernican theory or if it was ok to do so, so long as it was kept in the abstract.

However, Galileo got the hint. He didn’t publish anything for several years.
At night the earth’s rotation was accentuated by the overall annual orbit of the earth around the sun, and during the day it was diminished by it. As a result the oceans sloshed around trying to keep up or they were left behind by this change in the earth’s angular velocity. [Choose a coordinate system. Stick to it.]
In 1618 Galileo speculates on a Copernican fantasy in a letter to a friend/sponsor in Austria on his theory of tides, or so he calls it in order to not look like he is promoting Copernicus’ theory.

Also in 1618, three comets appear in the sky and all the astronomers are abuzz.
Father Horatio Grassi (Salonensi) Jesuit Priest, fl. ca. 1615

Chair of Mathematics at the Collegium Romanum where until 1612 Clavius was a professor of mathematics

Architect of Church of St. Ignatius (the founder of the Jesuit order)

Designed a submarine based on ideas proposed by Leonardo.

He was considered an expert in the field of optics.
Grassi anonymously published a lecture on the Three Comets that appeared in 1618. By not acknowledging Galileo, he essentially dissed him, even though he was promoting a Tychonic system that Galileo would not have liked.

- He considered the comets to be cyclic, superlunar orbiters, like planets, in a Tychonic system.

- Even the ‘lynx-eyed’ (meaning Galileo and friends) failed to see how comets transversed the cosmos.

- He didn’t use any of Galileo’s work to construct his arguments.
The following were written in the margins of Galileo’s copy of Grassi’s Comet Publication of 1618

- “piece of asininity”
- “elephantine”
- “buffoon”
- “evil poltroon”
- “ungrateful villain”

Galileo clearly was not a big fan.
In 1619
‘Guioducci’ publishes a reply to Grassi titled, *Discourse on the Comets*.

Mario Guioducci, a student of Galileo’s and also educated at the Collegio Romano.

Manuscript of this work clearly shows Galileo’s hand in the majority of the writing.

Anti-Tycho and thus by association, anti-Jesuit.

In this work Galileo played to the anti-Jesuit crowd in Rome and amused Cardinal Barberini.

-aside; Galileo was an incredible debater and entertainer. He would argue the other sides point often better than his opponent. This was often too much for his enemies to bear. He mopped the floor with them, and they had had enough.
In reality this book is Galileo responding to Grassi, but the names of the published authors are disguised to protect the guilty/innocent(?).

Galileo (a.k.a. Guiducci) vs. Anonymous (Grassi)
Later in 1619 Grassi publishes *Libra Astronomica* -*Astronomical Scales*- under the name Lothario Sarsi Sigensano.

Grassi is no longer really anonymous. Now he is writing under the name Sarsi, Lothario Sarsi… Nobody was really fooled by this, but this period is known for all sorts of word games and silly puns.
Sarsi’s book *Astronomica Libra*  
or *Astronomical Scales*  
or *Astronomical and Philosophical Balance*

-A direct attack on Galileo and his theories.

-Also attack on Copernican theory via Tychonic theory.

-Attack on Galileo through association with Telesio, Cardano, and Campanella (who defended Galileo’s Copernicanism from jail in 1616) [I’ll bet Galileo was thrilled about this endorsement by a man known for sorcery and his radical political leanings.

-Grassi obviously very offended by Galileo’s attacks on the Jesuit order.
Galileo’s Delayed Response to “Sarsi”

Galileo’s response not immediate.

A new member of the Lincean Academy, Virginio Cesarini, hoped Galileo would crush the Jesuit.

Guiducci wrote an ascerbic letter defending “his” lecture on the comets.

Keep in mind that *De Revolutionibus* was “pending correction”
Finally, four years later, Galileo responds to Grassi-Sarsi with

*Il Saggiatore*

or

*The Assayer*

(The Weigher of Gold)

Rome - 1623
Structured as a letter to Virginio Cesarini, the Lincean

An attack on Sarsi (a.k.a. Grassi)

Spells out a method of scientific investigation that appeals to the modern scientist and historian.

Unfortunately Galileo’s theory of comets in this work has not stood up well. Sarsi’s is actually more suggestive of our modern conception.

-Notice that many compilations of Galileo’s writings omit these theories. They make him look bad. Galileo is pretty good at making himself look bad on many levels.

Galileo writes, “You cannot help it, Signor Sarsi, that it was granted to me alone to discover all the new phenomena in the sky and nothing to anybody else. This is the truth which neither malice nor envy can suppress.”
Koestler’s main point is that Galileo annoyed the Jesuits and they got payback. Galileo spent a lot of time writing polemical texts and making enemies, when, perhaps, he could have been less abrasive. His own personality made his trouble, not so much his natural philosophy.
Assayer is a frontal assault on Grassi/Sarsi. Galileo systematically took him apart, limb from limb.

For example... Sarsi claimed that telescope magnification was a function of distance. Here is an arbitrary example:

Let $M = \frac{30}{d}$, where $M$ is magnification, 30 is an arbitrary scaling factor for a “Sarsian lens,” and $d$ is distance in miles.

Thus
if $d=1$ mile, then $M=x30$.  
if $d=30$ miles, then $M=x1$  
if $d=3000$ miles, then $M=x0.01$
Inertia

[pp. 264-266]
In discussing Copernicus’ 3rd motion for the earth, the motion that keeps the earth’s axis pointing at the north star, Galileo lands upon inertia.

First he seems to describe this.
Then he describes this…

Copernicus, he states, was wrong to give it a “motion” when it is actually staying put, so to speak.
“If Sarsi wants me to believe with Suidas that the Babylonians cooked their eggs by whirling them in slings, I shall do so;

but I must say that the cause of this effect was very different from what he suggests. To discover the true cause I reason as follows: "if we do not achieve an effect which others formerly achieved, then it must be that in our operations we lack something that produced their success. And if there is just one single thing we lack, then that alone can be the true cause."
“Now we do not lack eggs, nor slings, nor sturdy fellows to whirl them; yet our eggs do not cook, but merely cool down faster if they happen to be hot. And since nothing is lacking to us except being Babylonians, then being Babylonians is the cause of the hardening of eggs, and not friction of the air." And this is what I wished to discover. Is it possible that Sarsi has never observed the coolness produced on his face by the continual change of air when he is riding post? If he has, then how can he prefer to believe things related by other men as having happened two thousand years ago in Babylon rather than present events which he himself experiences?”
“...And note that the tenuous material which produces heat is even more subtle than that which causes odor, for the latter cannot leak through a glass container, whereas the material of heat makes its way through any substance.”

p. 274 Primary Qualities [Lockean term, not Galileo’s. This is hardly a discovery for Galileo. Many before him made similar observations.]

Paraphrase of section: In what sense is motion the cause of heat
People tend to think that heat is a real property that resides in the warm object.

A corporeal substance has dimension (geometry or shape), location, and temporality. It is either in motion or not in motion, touching another body or not. It has quantity... one or two or several.

But color, taste, sound, etc, are all unnecessary “accompaniments.” These would not exist if not for our senses.... “names ... [that] reside only in the consciousness.”
Secondary Qualities [A Lockean term, not Galileo’s]

“When touched upon the soles of the feet, for example, or under the knee or armpit, [our body] feels in addition to the common sensation of touch a sensation on which we have imposed a special name, "tickling."

This sensation belongs to us and not to the hand. Anyone would make a serious error if he said that the hand, in addition to the properties of moving and touching, possessed another faculty of "tickling," as if tickling were a phenomenon that resided in the hand that tickled. A piece of paper or a feather drawn lightly over any part of our bodies performs intrinsically the same operations of moving and touching, but by touching the eye, the nose, or the upper lip it excites in us an almost intolerable titillation, even though elsewhere it is scarcely felt. This titillation belongs entirely to us and not to the feather…”
Atoms?

“…Perhaps the origin of two other senses lies in the fact [p.276] that there are bodies which constantly dissolve into minute particles, some of which are heavier than air and descend, while others are lighter and rise up. The former may strike upon a certain part of our bodies that is much more sensitive than the skin, which does not feel the invasion of such subtle matter. This is the upper surface of the tongue; here the tiny particles are received, and mixing with and penetrating its moisture, they give rise to tastes, which are sweet or unsavory according to the various shapes, numbers, and speeds of the particles. And those minute particles which rise up may enter by our nostrils and strike upon some small protuberances which are the instrument of smelling; here likewise their touch and passage is received to our like or dislike according as they have this or that shape, are fast or slow, and are numerous or few.”
The 5 Senses

“To excite in us tastes, odors, and sounds I believe that nothing is required in external bodies except shapes, numbers, and slow or rapid movements. I think that if ears, [p.277] tongues, and noses were removed, shapes and numbers and motions would remain, but not odors or tastes or sounds… And as these four senses are related to the four elements, so I believe that vision, the sense eminent above all others in the proportion of the finite to the infinite, the temporal to the instantaneous, the quantitative to the indivisible, the illuminated to the obscure— that vision, I say, is related to light itself. But of this sensation and the things pertaining to it I pretend to understand but little; and since even a long time would not suffice to explain that trifle, or even to hint at an explanation, I pass this over in silence.”

- Now he gets all humble….
“Having shown that many sensations which are supposed to be qualities residing in external objects have no real existence save in us, and outside ourselves are mere names, I now say that I am inclined to believe heat to be of this character.”

Finally… back to his original issue… What is heat?

“Those materials which produce heat in us and make us feel warmth, which are known by the general name of "fire," would then be a multitude of minute particles having certain shapes and moving with certain velocities. Meeting with our bodies, they penetrate by means of their extreme subtlety, and their touch as felt by us when they pass through our substance is the sensation we call ‘heat.’”

Question: Are there heat atoms or is it that only certain subtle atoms moving at the right speed are heat whereas others of the same dimension but not moving fast enough are not heat?
Galileo answers me: “Since the presence of fire-corpuscles alone does not suffice to excite heat, but their motion is needed also, it seems to me that one may very reasonably say that motion is the cause of heat. . . .”
Heat is a ‘secondary quality’ like color or odor.

“I do not [p.278] believe that in addition [to] shape number, motion, penetration, and touch there is any other quality in fire corresponding to "heat"; this belongs so intimately to us that when the live body is taken away, heat becomes no more than a simple name. . . .”
Light

[p. 278]
“...but when their [heat particles’] ultimate spaces by its- I know not whether to and highest resolution into truly indivisible atoms is arrived at, light is created.” (20)

“This may have an instantaneous motion, or rather an instantaneous expansion and diffusion (21) rendering it capable of occupying* immense spaces by its- I know not whether to say its subtlety, its rarity, its immateriality, or some other property which differs from all these and is nameless.”
“This lucky guess [at light] should entitle Galileo to consideration as having anticipated many modern scientific discoveries-I n about the same sense as that in which medieval philosophers anticipated Galileo in the discovery of the principle of inertia. At present it is customary to praise their happy conjectures and to overlook his. But perhaps that is because they made so many unsupported guesses, and he so few.”
Grassi then later responded to Galileo’s *Il Saggiatore (Assayer)* with *Assagiatore (Winetaster)*, punningly insinuating that Galileo had been drinking when he wrote it.…

…and on and on….

… Ecco!

In 1623, Galileo’s friend becomes pope; Maffeo Barberini becomes Urban VIII. Urban was super sophisticated and almost secular in his attachments. He even had good words for Copernicus at one point, but as pope he wouldn’t overturn the anti-Copernican stance.
Urban seems to have given permission to Galileo to write on Copernican things so long as he didn’t stray into theological discussions and so long as he continued calling it a hypothesis. Galileo could argue for Copernicus but in the end, God could do whatever He liked and all the rational and empirical evidence couldn’t compete with that.

In effect, Galileo’s leash was lengthened under Urban.
So as not to let Koestler’s theory be the only one out there, here are some other enemies of Galileo

Ludovico delle Colombe

Ludovico of the Pigeon[s]

Puns flew every which way…

He was anti-Galileo.

Pro-Galilean partisans called Colombe’s allies the Pigeon League.
The Dominicanes
Very Conservative
Very Aristotelian
Domini-canines
Dogs of the Lord
This nickname was actually embraced by the Order

Pun by Dominican firebrand, Caccini
“Viri Galilei”
Men of Galilee
or
Men of Galileo
1630 finished (published 1632): *Dialogue Concerning the Two Chief World Systems* (Ptolemy and Copernicus)

**3 Characters**
Salviati- the supersmart hero type (certianly Galileo)
Sagredo- a smart layperson
Simplicio- an Aristotelian simpleton (probably Urban)

**4 Days**
1) Refutation of Aristotelian and Platonic cosmology
2) Relative motion (anti Aritsotle) arguments building to Copernicus
3) Astronomical arguments for Copernicus: no math, just qualitative descriptions. Rather misleading in its simplicity. Also sunspots.
4) Galileo’s theory of tides. Disses Kepler’s concept of lunar gravity.

His representation of Copernican theory is a charicature. This book is more rhetoric than substance in so far as cosmology is concerned, but this aspect of science should not be overlooked. It is convincing and it has some good physics in it.
DIALOGO
DI
GALILEO GALILEI LINCEO
MATematico Sopraordinario
dello studio di Pisa.
E Filosofo, e Matematico primario del
Serenissimo
GR. DVCA DI TOSCANA.

Dove ne i congressi di quattro giornate si discorre
sopra i due

MASSIMI SISTEMI DEL MONDO
TOLemaico, E COpernicano;
Propendendo indeterminatamente le ragioni Filosofiche, e Naturali.
tanto per l’una, quanto per l’altra parte.

CON PRI
VILEGI.

IN FIORENZA, Per Gio: Batta Landini MDCXXXII.
CON LICENZA DE’ SUPERIORI.
I have grown as my descendants. Fortunately the initials, GBL, are of the printer for this motto was seen by some to suggest that the pope gave out too many favors to his family.
The pope himself was too busy to read this long manuscript. The task was given to Father Niccolo Riccardi. He was supposed to supervise the printing in Rome and to make necessary corrections. He couldn’t figure it out and to make a long story shorter… Due to a variety of circumstances, Galileo was able to move the printing to Florence, closer to his home and further from the Vatican. Galileo played Riccardi like a cheap violin and got his way on most major decisions. In 1632 the first copies of the *Dialogue* made it to the Vatican and they realized that Galileo had gotten away with something. He was summoned… he delayed… he arrived in Rome in 1633.

Simplicius was the voice of Urban VIII. It was hard not to miss (according to Koestler), for Simplicius made some of the same arguments that Urban made in his private conversations with Galileo before he was the pope. Urban was very angry and felt betrayed and perhaps a little humiliated.

Galileo is good at doing this to people.
DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuove scienze
Attenenti alla
Mecanica & i Movimenti Locali,
del Signor
GALILEO GALILEI LINCEO,
Filosofo e Matematico primario del Serenissimo
Grand Duca di Toscana.
Con una Appendice del centro di gravità d’aluni Solidi.

IN LEIDA,
Appresso gli Elsevirii. M. D. C. xxxviii.
Topics include:
- Cohesion
- Local motion
- Naturally Accelerated Motion (Uniform Acceleration)
- Pendula
- Proto-Inertia concept
- Parabolic trajectories as orthogonal vectors… this is analytically huge.

   If describing artillery trajectories, one speed component is constant
   (his inertial concept), and the other exhibits uniform acceleration.
   The inertial variable will be linear and the falling one squared.
   A parabola. He can’t say it this way. He doesn’t have algebra.

- Conic sections to describe parabolic curves.

He treats force and weight as the same thing. See Newton and Einstein. It’s all about the quadratic equations, done using geometry and ratios. Proto-conservation theories (Maupertouis, Euler, Lagrange, Laplace…) The second power and the second derivative relationship is evident in his geometric demonstrations.
Galileo’s inclined plane set-up for gravitational experiments. Note the bells.
Roll a ball down the incline. In three seconds it vertically drops 9 units of measure. Its average velocity over that time is 3x/s. He noticed that the distance is always the square of the times and that it didn’t matter how steep the incline was.

\[
\begin{array}{c|c|c|c|c|c}
\text{at} & \text{vert.} \\
\hline
1s & 1x \\
2s & -1x \\
3s & 9x \\
\end{array}
\]
Recall that distance is velocity times time. So you can figure out distance by finding the areas of rectangles. Eg. 3s times 3m/s is 9 meters. [assuming meters]
Using only geometry he figured out all sorts of other things about motion. For example, he figured that all of the descent times derived from this circle for inclined planes (as shown below) are equal.

Galileo gets more mileage out of Euclid than could ever be imagined. He doesn’t actually have to experiment on everything. He can do geometry and find more relationships. He uses geometry to extend his results. To deduce more results.
Discorsi e Dimostrazioni Matematiche, intorno à due nuove scienze

Attinenti alla Mecanica e i Movimenti Locali, del Signor Galileo Galilei Linceo, Filosofo e Matematico primario del Serenissimo Grand Duca di Toscana.

Con una Appendice del centro di gravità d'alcuni Solidi.

IN LEIDA,
Appresso gli Elsevirii. M. D. C. xxxviii.

Galileo Galilei
Lincean Academician
Chief Philosopher and Mathematician to the Most Serene Grand Duke of Tuscany

Discourses &
Mathematical Demonstrations Concerning

Two New Sciences

Pertaining to
Mechanics & Local Motions

With an Appendix
On Centers of Gravity of Solids

Leyden
At the Elzevirs, 1638

* * *

To which is added a further dialogue
On the Force of Percussion
What is this man doing?

Who is he?

Why is he “not alone?” (non solus)

Why the tree?
Assayer thoughts

- aside; Stillman Drake’s hagiographic tendency is apparent in his *Discoveries and Opinions of Galileo*. Considering how this work was inspired by the controversy of the comets of 1618, it is amazing how Drake does not include the parts on comets.
- Philosophy is not in a book, it is rather in nature, written in mathematics and geometry. This is very similar to the philosophy of Telesio (1508-1588) the inspiration for the Accademia Segreta of both Della Porta and Ruscelli. Test theories, don’t just read books.
- Mentions Sarsi’s mentioning Kepler’s refutation of earlier presumably sublunar cometary theories.
- attacks Sarsi’s telescopic theory that magnification is a function of distance. The farther away the less magnification.
- Lastly Galileo makes some interesting but not detailed observations about heat and light. Also a distinction between Primary (size, shape, location, motion) and secondary (reside in the mind, like taste, color, odor, heat) qualities. Secondary caused by primary. This discussion of qualities was not unique to Galileo. Locke is usually the one given credit for this… in the late 17th century.
- The Babylonian sling egg story. “We do not lack eggs, slings, or sturdy fellows… only lack being Babylonian.” Therefore being Babylonian causes eggs to harden, not friction with the air.
Galileo never accepted Kepler’s theories. He stuck with Copernicus and all the circles. In fact, when Kepler attempted to strike up a correspondence with Galileo (Kepler was very excited about the observation of sun spots) he was totally snubbed.

Having a book on the Index was not unusual. Cardinal Bellarmini had one of his on the list for a while.
1616 On orders of the Pope Paul V, Cardinal Bellarmine called Galileo to his residence and administers a warning not to hold or defend the Copernican theory. The Congregation of the Index suspends Copernicus's *On the Revolutions* until corrected.

1620 The Congregation of the Index issued the corrections that must be made to Copernicus' *On the Revolutions* before it can be read.

1623 *Assayer* published.


1632 Printing of the *Dialogue* is completed. Galileo is formally interrogated by the Inquisition. Pope Urban VIII decided that Galileo will be imprisoned for an indefinite period. With a formal threat of torture, Galileo is examined by the Inquisition. The next day he is sentenced to prison as the pleasure of the Inquisition and to religious penances. Galileo arrived in Siena. Here worked on his *Discourse on Two New Sciences*. He is allowed to return to his villa in Arcetri, near Florence, where he is under house arrest for the remainder of his life. Louis Elsevier, a Dutch publisher, visited Galileo in Arcetri, and agreed to publish the *Discourse on Two New Sciences* in Leiden.

1642 January 8: Galileo dies.