From Copernicus to Newton
For many centuries books were precious and expensive.

The university library in Paris had only 1017 books in 1289.
Johann Gutenberg from Mainz perfected printing from movable metallic cast and in 1455 printed the first Bible.

Until the end of the XV\textsuperscript{th} century some 35-40 thousand books were printed in the total number of about 10 million copies!
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>19 II 1473</td>
<td>Born in Thorn (Toruń)</td>
</tr>
<tr>
<td>1491-1495</td>
<td>Studied in Cracow</td>
</tr>
<tr>
<td>1496-1501</td>
<td>Studied in Bolonia, visit to Rome</td>
</tr>
<tr>
<td>1501-1503</td>
<td>Studied in Padua, doctorate in Ferrara</td>
</tr>
<tr>
<td>after 1503</td>
<td>in church administration in Ermland</td>
</tr>
<tr>
<td>(Warmia)</td>
<td>- mainly in Frauenberg (Frombork)</td>
</tr>
<tr>
<td>before 1514</td>
<td>Commentariolus</td>
</tr>
<tr>
<td>1526-1528</td>
<td>Monetae cunendae ratio</td>
</tr>
<tr>
<td>1540</td>
<td>Narratio prima by Rheticus</td>
</tr>
<tr>
<td>1542</td>
<td>De lateribus et angulis triangulorum</td>
</tr>
<tr>
<td>1543</td>
<td>De revolutionibus orbium coelestium</td>
</tr>
<tr>
<td>24 V 1543</td>
<td>Died in Frauenberg (Frombork)</td>
</tr>
</tbody>
</table>
"...by St. Anne’s church there is a university renowned for its many distinguished and learned scholars, who teach the liberal arts, rhetoric, poetics, philosophy, and physics. Astronomy is the most highly developed science. In the whole of Germany (and I know it from more than one source) one can not find a more famous school."

Hartman Schedelius, *Opus de historiis aetatum mundi* [Chronicle of the World (1493)]
Commentariolus by Copernicus
Postulates:

1. There is no one centre of all the celestial spheres
2. The centre of the earth is not the centre of the universe
3. All spheres surround the sun and therefore the centre of the universe is near the sun
4. The distance between the sun and the earth is imperceptible compared with the great height of the sphere of the fixed stars
5. Whatever motion appears in the sphere of the fixed stars belongs not to it but to the earth
6. Whatever motions appear to us to belong to the sun are not due to the sun but to the motion of the earth
7. The retrograde and direct motion that appears in the planets belongs not to them but to the motion of the earth. Thus the motion of the earth by itself accounts for a considerable number of apparently irregular motions in the heavens
"And so altogether, Mercury moves on seven circles, Venus on five, the earth on three and the moon about it on four, and finally Mars, Jupiter and Saturn on five each. Therefore, taken as a whole, 34 circles are sufficient to represent the entire structure of the heavens and the entire choric dance of the planets."

*Commentariolus*
De revolutionibus orbium coelestium

Book I  Introduction and plane and spherical trigonometry
Book II  Catalogue of fixed stars
Book III  Theory of precession
Books III-VI  Orbits of the earth, moon and planets
NICOLAI COPEPNICCI TORNINENSIS
DE REVOLUTIONIBUS ORBIS UNUM CELESTIUM, LIBRI VI.

Habes in hoc operi iam recens nato, exedito, studiose lector, Motus stellarum, tam fixarum, quam erraticarum, cum ex uteribus, tum etiam ex recensibus observationibus restitutis; & no-
tuis inuper ac admirabilibus hypothetibus ornati. Habes etiam Tabulas expeditissimas, ex que-
bis eosdem ad quoduis tempus quae factili me calculare poteras. Igitar emc, lege, fruere.

Noricmorci a pudi loh. Petreium
Anno M. D. XLIII.

NICOLAI COPEPNICCI
net, in quo terram cum orbis lunari tanquam epicyclo contineri
diximus. Quito loco Venus nono nune rediuitur, Sexum
denique locum Mercurius tener, octuginta dieum spacio circu-
currens. In medio uero omnium residi Sol. Quis enim in hac

philcherimo templo lampadem hanc in aliue meliori loco po-
neret, quam unde rotum simul posit illuminare: Viquidem non
enepe quidam lucernam mundi, aliuj mentem, aliuj rectorem uoce-
ante. Trimegistus uisibilem Deum, Sophocis Electra intumet
omnia, et profection tanquam in solito regali Sol residiens circum
agentem gubernat Astrorum familiam. Tellus quosque minime
fraudatur lunari ministerio, sed ut Aristoteles de animalibus
uki, maximam Luna cu terra cognitio ne habet, Concipit interea 
Sole terra, & impregnatur annuo partu. Inuenimus igitur sub
hac
Instruments of Copernicus

Triquetrum
*De revolutionibus*
(Edition of 1617)

Quadrant (reconstruction)
Copernican system was **heliostatic**, not heliocentric
Chapter I. That the universe is spherical

First we must remark that the universe is globe-shaped, either because that is the most perfect shape of all, needing no joint, an integral whole; or because that is the most capacious of shapes, which is most fitting because it is to contain and preserve all things; or because the most finished parts of the universe, I mean the Sun, Moon and stars, are observed to have that shape, or because everything tends to take on this shape, which is evident, in drops of water and other liquid bodies, when they take on their natural shape. There should therefore be no doubt that this shape is assigned to the heavenly bodies.”

Copernicus, *De revolutionibus*, Book I
“Chapter IV. That the motion of the heavenly bodies is uniform, circular, and perpetual, or compounded of circular motions

The next point is that the motion of the heavenly bodies is circular. For the movement of a sphere is a revolution in a circle, expressing its shape by the very action, in the simplest of figures, where neither beginning nor end is to be found, nor can the one be distinguished from the other, as it moves always in the same place. Yet a number of motions are possible for a multiplicity of spheres.”

Copernicus, *De revolutionibus*, Book I
"The most obvious of all is the daily revolution, which the Greeks call νύχθηµέρον, that is, the duration of a day and a night. By this motion the whole universe is thought to glide from east to west, except the Earth. This is accepted as the common measure of all motions, since we generally measure time itself by the number of days. Then we see other revolutions tending as it were in the opposite direction, that is from west to east, I mean those of the Sun, Moon and five wandering stars. Thus the Sun marks out the year for us, and the Moon the months, which are very common units of time; and the other five planets each make their own circuit."

Copernicus, De revolutionibus, Book I
"But they have differences in their various motions. First, they do not revolve on the same axes, but round the zodiac which is set at an angle. Secondly, they do not seem to move uniformly in their own orbits, for the sun and moon are observed to be sometimes slow and sometimes quicker in their movement; whereas we notice that the other five wandering stars sometimes even retrace their steps and come to a halt on each side. And though the Sun always travels strictly along its own path, the others wander in various ways, diverging now to the south and now to the north, which is why they are called planets. Furthermore they are sometimes nearer to the Earth, and are said to be in perigee, and sometimes further from it, when they are said to be in apogee."

Copernicus, *De revolutionibus*, Book I
"Nevertheless it must be admitted that their motions are circular, or compounded of a number of circles, because they pass through irregularities of this kind in accordance with a definite law and with fixed returns to their original positions, which could not happen if they were not circular. For only a circle can repeat a previous state of affairs, for example in the following way: it is by a motion compounded of circles that the Sun repeats for us the cycle of lengthening and shortening of the nights and days, and the four seasons of the year. In this several motions are detectable, since it is impossible for a heavenly body which is simple to move irregularly in a single sphere.”

Copernicus, *De revolutionibus*, Book I
"That would have to be due either to changes in the moving power, whether derived from elsewhere or from its intrinsic nature, or on account of unevenness in the revolving body. Both these possibilities are unacceptable to the reason, and it is inappropriate to attribute such a thing to bodies which are established in an ideal state. It must therefore be agreed that though their motions appear to us irregular they are regular, either because the axes of their circles are different, or perhaps because the Earth is not in the middle of the circles in which they revolve, and to us observing from the Earth the transits of these stars it comes about that because of the different distances they seem larger when they are nearer than when they are further away."

Copernicus, *De revolutionibus*, Book I
VS/ES = sin 46° = 0.72

\[ x / 365 = (\beta + \gamma) / 2\pi \]
\[ x / 687 = \gamma / 2\pi \]
\[ (\beta + \gamma) 365 = \gamma 687 \]
<table>
<thead>
<tr>
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<th>Distance</th>
<th>Period</th>
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<tbody>
<tr>
<td></td>
<td>Copernicus</td>
<td>present</td>
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<tr>
<td>Mercury</td>
<td>0,376</td>
<td>0,387</td>
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<tr>
<td>Venus</td>
<td>0,719</td>
<td>0,723</td>
</tr>
<tr>
<td>Earth</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Mars</td>
<td>1,520</td>
<td>1,524</td>
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<tr>
<td>Jupiter</td>
<td>5,219</td>
<td>5,203</td>
</tr>
<tr>
<td>Saturn</td>
<td>9,174</td>
<td>9,539</td>
</tr>
</tbody>
</table>
Theory of Saturn according to Copernicus

The drawing shows only the orbit of the earth with its centre at $E$ and the deferent of Saturn with its centre at $D$; $N$, $O$ and $P$ indicate three positions of the planet in its epicycle.

The sun and other planets are not shown.
Explanation of planetary loops in the Copernican system
"I myself consider that gravity is merely a certain natural inclination with which parts are imbued by the Architect of all things for gathering themselves together into unity and completeness by assembling into the form of a globe. It is easy to believe that the sun, moon and other luminaries among the wandering stars have this tendency also, so that by its agency they retain the rounded shape in which they reveal themselves, but nevertheless go round their orbits in various ways."

Copernicus, *De revolutionibus*, Book I, Ch. IX
"The principle of attraction, in the Newtonian sense of it, it seems was first surmised by Copernicus"

Ch. Hutton,
*A Mathematical and Philosophical Dictionary*,
v. 1, London, 1795
The system of Copernicus depicted in the *Atlas* of Cellarius (1661)
Tycho Brahe (1546-1601)

Astronomical observatories Uraniborg and Stjerneborg

*De Stella Nova* (1572)

*De Mundi aetherei recentioribus Phaenomenis* (1588)

*Astronomiae Instauratae Mechanica* (1598)

*Astronomiae Instauratae Progymnasmata* (1598-1602)
Tycho’s observatories
Uraniborg and Stjerneborg
The instruments of Tycho Brahe
Tycho Brahe and measurements of a parallax
Tycho Brahe

System of the world proposed by Tycho Brahe

New star of 1572
Johannes Kepler

27 XII 1571  Born in Weil
1589-1594  Studied in Tübingen
1594-1600  Teacher in Graz
1596  *Mysterium Cosmographicum*
1600-1612  Prague
1604  *Ad Vitellionem paralipomena*
1604  *De stella nova*
1609  *Astronomia nova*
1611  *Dioptrices*
1612-1626  Linz
1618-1621  *Epitome astronomiae Copernicanae*
1619  *Harmonices mundi*
1626-1628  Ulm
1627  *Tabulae Rudolphinae*
1628-1630  Sagan
15 XI 1630  Died in Regensburg
Prodromus

DE ADMIRABILI
PROPORTIONE ORBIVM
COELESTIVM, DEQVE CAUSIS
COELORVM NUMERI, MAGNITUDINIS, MOTUMQVE PERIODECORVM GENUINIS & PROPRIIS,
DEMONSTRATVM, PER QVINQUE REGULARVM CORPORA GEOMETRICVM,

A M. IOANNNE KEPLERO, VVITREGM.

TVINGA

Excudebat Georgius Gruppenbachus,
ANNO MD XCVI.
"Dear Reader, it is my intention in this small treatise to show that the almighty and infinitely merciful God, when he created our moving world and determined the order of the celestial bodies, took as the basis for his construction the five regular bodies which have enjoyed such great distinction from the time of Pythagoras and Plato down to our own days, and that he coordinated in accordance with their properties the number and proportions of the celestial bodies, as well as the relationships between the various celestial motions."

Kepler, *Mysterium cosmographicum*
"The Earth is the measure for all the other spheres. Circumscribe a Dodecahedron about it, then the surrounding sphere will be that of Mars; circumscribe a Tetrahedron about the sphere of Mars, then the surrounding sphere will be that of Jupiter; circumscribe a Cube about the sphere of Jupiter, then the surrounding sphere will be that of Saturn. Now place an Icosahedron within the sphere of Earth, then the sphere which is inscribed is that of Venus; place an Octahedron within the sphere of Venus, and the sphere which is inscribed is that of Mercury. There you have the reason for the number of the planets."

Kepler, *Mysterium cosmographicum*
Kepler, *Harmonices Mundi*, Book 5
The order of planets

- **Saturn**
- **Cube**
- **Jupiter**
- **Tetrahedron**
- **Mars**
- **Dodecahedron**
- **Earth**
- **Icosahedron**
- **Venus**
- **Octahedron**
- **Mercury**
"There were three things above all others the cause of which I sought without wearying, namely, the number, size and motion of the orbits."

Kepler – *Mysterium cosmographicum*
"I built my whole astronomy upon Copernicus’ hypotheses concerning the world, upon the observations of Tycho Brahe, and lastly upon the Englishman, William Gilbert’s philosophy of magnetism."

*Epitome astronomiae Copernicanae*, Book IV
"The reflective and intelligent reader will see, that this opinion among astronomers concerning the perfect eccentric circle of the orbit involves a great deal that is incredible in physical speculation... My first error was to take the planet’s path as a perfect circle, and this mistake robbed me of more time, as it was taught on the authority of all philosophers, and consistent in itself with Metaphysics."

Kepler, *Astronomia nova* (1609)
New astronomy based on causes, or celestial physics, explained in commentaries on the motions of the star Mars, from the observations of the noble Tycho Brahe, by the order and expense of the Roman Emperor Rudolph II...
"A mathematical point, be it the centre of the world or not, cannot move heavy bodies... As for the true theory of gravity, it is based upon these axioms: all corporeal substance insofar as it is corporeal is apt to remain at rest at any place in which it is placed alone, outside of the virtue of a cognate body...Gravity is a mutual corporeal affection of cognate bodies toward their reunion or conjunction (of a similar kind is also the magnetic faculty) such that the Earth drags the stone much more that the stone tends towards the Earth. Heavy bodies (even if we place the Earth in the centre of the world) do not move toward the centre of the world as to the centre of the world, but toward the centre of a cognate round body, that is, the Earth."

Kepler, *Astronomia nova*, Introduction
"If two stones were placed in a certain place of the world, near each other and outside the orb of the virtue of a third cognate body, these stones, in a manner similar to two magnetic bodies, would meet in an intermediate place, each nearing the other by an interval proportional to the bulk of the other.

If the Moon and the Earth were not retained each in its circuit by an animal [vital] force, or by some other, equivalent, the Earth would ascend toward the Moon by a fifty-fourth part of the interval [separating them] and the Moon would descend by fifty-three parts, or about, of this interval; provided, however, that their substance is of the same density."

*Astronomia nova, 1609*
Kepler’s second law (law of areas)

The radius vector (the line from the sun to the planet) to a planet sweeps out equal areas in equal intervals of time as the planet revolves in its orbit.
“With your ellipse you abolish the circularity and uniformity of the motions, which appears to me the more absurd the more profoundly I think about it... If you could only preserve the perfect circular orbit, and justify your elliptic orbit by another little epicycle, it would be much better.”

David Fabricius to Kepler, January 20, 1607
"Concerning the motion of the moon you write you have traced all the inequalities to physical causes; I do not quite understand this. I think rather that one should leave physical causes out of account, and should explain astronomical matters only according to astronomical method with the aid of astronomical, not physical, causes and hypotheses. That is, the calculation demands astronomical bases in the field of geometry and arithmetic..."

Michael Mästlin to Kepler, October 1, 1616
"In trying to prove the Copernican hypothesis from physical causes, Kepler introduces strange speculations which belong not in the domain of astronomy, but of physics"

Petrus Crüger, Dantisci (Piotr Krüger, Gdańsk)
Ioannis Keppleri

HARMONICES MUNDI

LIBRI V. QUORUM

Primus Geometricus, De Figurarum Regularium, que Proportiones Harmonicas constituant, ortu & demonstracionibus.

Secundus Architectonicus, seu ex Geometria Figureata, De Figurarum Regularium Congruentia in plano vel solido:

Tertius proprius Harmonicus, De Proportionum Harmonicarum ortu ex Figuris: deque Natura & Differentiorum rerum ac cantum pertinentium, contra Veteres:

Quartus Metaphysicus, Psychologicus & Astrologicus, De Harmoniarum mentali Effentia earumque generibus in Mundi praefertim de Harmonia radiorum, ex corporibus celestibus in Terram descendentibus, eiusque effectu in Natura seu Anima sublunari & Humana:

Quintus Astronomicus & Metaphysicus, De Harmoniis absolutissimis motuum celestium, ortuque Eccentricitatum ex proportionibus Harmonicos.

Appendix habet comparationem huius Operis cum Harmonicis Cl. Ptolemaei libro II. cumque Roberti de Fluctibus, dicti Flud Medici Oxonienis speculacionibus Harmonicis, operi de Macrocosmo & Microcosmo insertis.

ACCESSIT VNC PROPTER COGNITIONEM MATERIA eiusdem Authoris liber ante 23 annos editus Tubinga, eius titulus Prodrumus, seu Astronomorum Cosmographicum de causis Coelestium Numerorum, Proportionis motuumque Periodicerum ex quinque Corporibus Regularibus.

Cum S.C.M. Privilegio ad annos XV.

Lincii Austriæ,

Sumptibus Godofredi Tampachii Bibli. Francos. Excudebat Ioannes Planckvs.

ANNO M. DC. XIX.
"For after finding the true intervals of the spheres by the observations of Tycho Brahe and continuous labour and much time, at last, at last the right ratio of the periodic times to the spheres though it was late, looked to the unskilled man, yet looked at him, and, after much time, came, and, if you want the exact time, was conceived mentally on the 8th of March in this year One Thousand Six Hundred and Eighteen but unfelicitously submitted to calculation and rejected as false, finally, summoned back on the 15th of May, with a fresh assault undertaken, outfought the darkness of my mind by the great proof afforded by my labor of seventeen years on Brahe’s observations and meditation upon it uniting in one concord, in such fashion that I first believed I was dreaming and was presupposing the object of my search among the principles. But it is absolutely certain and exact that the ratio which exists between the periodic times of any two planets is precisely the ratio of the $3/2$ power of the mean distances, i.e., of the spheres themselves; provided, however, that the arithmetic mean between both diameters of the elliptic orbit be slightly less than the longer distance."

Kepler, *Harmonices Mundi*, Book. 5, Ch. 8
"And so if any one take the period, say, of the earth, which is one year, and the period of Saturn, which is thirty years, and extract the cube roots of this ratio and then square the ensuing ratio by squaring the cube roots, he will have as his numerical products the most just ratio of the distances of the earth and Saturn from the sun. For the cube root of 1 is 1, and the square of it is 1; and the cube root of 30 is greater than 3, and therefore the square of it is greater than 9. And Saturn, at its mean distance from the sun, is slightly higher than nine times the mean distance of the earth from the sun."

Kepler, *Harmonices Mundi*, Book. 5, Ch. 8
Kepler’s third law

Cube of the semimajor axis

Square of the orbital period

Earth

Venus

Mercury

Jupiter

Mars

Saturn

Uranus

Neptune

Pluto
"Tellus canit MI, FA, MI, ut vel ex syllaba conjicias, in hoc nostro domicilio MIseriam ut FAmen obtinere."

(The Earth sings MI, FA, MI so that you may infer even from the syllables that in this our domicile MIsery and FAmine obtain.)

Kepler, *Harmonices Mundi*, Book V, Ch.6.
Kepler’s explanation of elliptical orbits by magnetic forces

Epitome astronomiae Copernicanae
Progress in the science of magnetism
NATURAL MAGICK
by
John Baptista Porta,
A NEapolitanE:
IN TWENTY BOOKS:

1 Of the Causes of Wonderful things.
2 Of the Generation of Animals.
3 Of the Production of new Plants.
4 Of increasing Herbs and Seeds.
5 Of changing Metals.
6 Of contriving Gold.
7 Of the Wonders of the Lodestone.
8 Of Magnetic Cures.
9 Of Beautifying Women.
10 Of Distillation.
11 Of Perfuming.
12 Of Artificial Fires.
13 Of Tempering Steel.
14 Of Cookery.
15 Of Fishing, Bowling, Hunting, &c.
16 Of Invisible Writing.
17 Of Strange Glasses.
18 Of Statick Experiments.
19 Of Prometric Experiments.
20 Of the Chase.

Wherein are set forth
All the Riches and Delights
Of the NATURAL SCIENCES.

LONDON,
Printed for Thomas Young, and Samuel Speed, and are to be sold at the three Pigeons, and at the Angel in St. Paul's Church-yard. 1692.
Giambattista della Porta – *Magia naturalis*, Book VII, Chapter XLVIII

Whether Garlic can hinder the Virtues of the Loadstone

"Now I shall pass on to other properties of the Loadstone. And first, whether the Loadstones attraction can be in any way hindered. Plutarch says, that Garlic is at great enmity with the Loadstone. And such antipathy and hatred there is between these insensible creatures, that if the Loadstone be smeared with Garlic, it will drive away Iron from it. Ptolemy confirms the same. That the Loadstone will not draw Iron, if it be anointed with Garlic... It is a common opinion among Seamen, that Onions and Garlic are at odds with the Loadstone..."
Giambattista della Porta – *Magia naturalis*, Book VII, Chapter XLVIII

"...But when I tried all these things, I found them to be false. For not only breathing and belching upon the Loadstone after eating Garlic, did not stop its Virtues. But when it was all anointed over with the juice of Garlic, it did perform its office as well as if it had never been touched with it. And I could observe almost not the least difference, lest I should seem to make void the endeavors of the Ancients. And again, when I inquired of Mariners, whether it were so, that they were forbid to eat Onions and Garlic for that reason. They said, they were old wives fables, and things ridiculous. And that Seamen would sooner lose their lives, than abstain from eating Onions and Garlic."
William Gilbert (1544-1603)
Three editions of Gilbert’s *De magnete*
"The terrella sends its force abroad in all directions, according to its energy and its quality. But whenever iron or other magnetic body of suitable size happens within its sphere of influence it is attracted; yet the nearer it is to the loadstone the greater the force with which it is borne toward it. Such bodies tend to the loadstone not as toward a centre nor towards its centre: that they do only at its poles..."

_De magnete_, Book II, Chapter 6
"The magnetic force is given out in all directions around the body; around the terrella it’s given out spherically; around loadstones of other shapes unevenly and less [...] The loadstone simply excites magnetic bodies situated at convenient distance. And as light – so opticians tell us – arrives instantly in the same way, with far greater instantaneousness, the magnetic energy is present within the limits of its force; and because its act is far more subtile than light, and it does not accord with non-magnetic bodies, it has no relations with air, water, or other non-magnetic body [...] And as light impinges on whatever confronts it, so does the loadstone impinge upon a magnetic body and excites it.”
„Here we must express wonder at a manifest error of Baptista Porta, who though he properly refuses assent to the inveterate falsehood about the force the opposite of the magnetic, imparts a still falser opinion, to wit that iron rubbed with diamond turns to the north. ‘If – he writes – we rub an iron needle on diamond, and then put it in a boat or on a straw or suspend it properly with a thread, at once it turns to the north like iron rubbed on a lodestone, or perhaps a little more sluggishly’ […]. Now this is contrary to our magnetic rules, and hence we made the experiment ourselves with seventy-five diamonds in presence of many witnesses, employing a number of iron bars and pieces of wire, manipulating them with the greatest care while they floated in water, supported by corks; yet never was it granted me to see the effect mentioned by Porta.”

_De magnete_, Book III, Ch. 13
<table>
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<tr>
<td>1564</td>
<td>Born in Pisa</td>
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<tr>
<td>1581</td>
<td>Began studies in Pisa</td>
</tr>
<tr>
<td>1589-1592</td>
<td>Professor in Pisa</td>
</tr>
<tr>
<td>1592-1610</td>
<td>Professor in Padua</td>
</tr>
<tr>
<td>1609</td>
<td>Constructed telescope</td>
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<tr>
<td>1610</td>
<td>Discovery of &quot;Medicean Stars&quot;</td>
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<tr>
<td>1610</td>
<td>Sidereus nuncius</td>
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<tr>
<td>1610</td>
<td>Court mathematician of the Grand Duke of Tuscany</td>
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<tr>
<td>1613</td>
<td>Istoria e dimostrazioni intorno alle macchie solari</td>
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<td>1623</td>
<td>Il Saggiatore</td>
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<td>1632</td>
<td>Dialogo</td>
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<tr>
<td>1633</td>
<td>Condemnation</td>
</tr>
<tr>
<td>1638</td>
<td>Discorsi e dimostrazioni</td>
</tr>
<tr>
<td>1642</td>
<td>Died in Arcetri</td>
</tr>
</tbody>
</table>
"You must know then, that it is nearly two months since news was spread here that in Flanders there had been presented to Count Maurice a spy-glass, made in such a way that very distant things are made by it to look quite close, so that a man two miles away can be distinctly seen. This seemed to me so marvellous an effect that it gave to me occasion for thought; and as it appeared to me that it must be founded on the science of perspective, I undertook to think about its fabrication; which I finally found, and so perfectly that one which I made far surpassed the reputation of the Flemish one..."

---

Galileo’s letter of 29 VIII 1609 to his brother-in-law, Landucci
"And word having reached Venice that I had made one, it is six days since I was called by the Signoria, to which I had to show it together with the entire Senate, to the infinite amazement of all; and there have been numerous gentlemen and senators, who, though old, have more than once scaled the stairs of the highest campaniles in Venice to observe at sea sails and vessels so far away that, coming under full sail to port, two hours or more were required before they could be seen without my spy-glass. For in fact the effect of this instrument is to represent an object that is, for example, fifty miles away, as large and near as if it were only five.”
STARRY MESSENGER
revealing great and very wonderful
sights and displaying to the gaze of
everyone, but especially philosophers
and astronomers, the things that were
observed by GALILEO GALILEI,
Florentine patrician and public
mathematician of the University
of Padua, with the help of a spyglass
lately devised by him, about the face
of the Moon, countless fixed stars,
the Milky Way, nebulous stars,
but especially about four planets swiftly
revolving around Jupiter at differing
intervals and periods and known to
no one before the Author recently
detected them and decided that
they should be named
MEDICEAN STARS
SIDEREVS NVNCIUS
MAGNA, LONGEQUE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vniciuique, præfertim vero
PHILOSOPHIS, ac ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasi Publico Mathematico
PERSPICILLI
Nuper ad se repetis beneficiis sunt observata in LUNÆ FACIE, FIXIS IN
NUMERIS, LACTEO CIRCULO, STELLIS NEBULOSIS,
Apprimo vero in
QUATVOR PLANETIS
Circ只 IOVIS Stellam dispersus interuella, ætque periodis, celesti
tate mirabili circumvolutis; quos, nemini in bunc visque
diem cognitos, nouissime Author deprehendi primus; æque
MEDICEA SIDER A
NVNCVPANDOS DECREVIT.

VENETIIS, Apud Thomam Baglionem. M DC X.
Superiorum Fornix, Et Privilegio.

SIDEREVS NVNCIUS
MAGNA, LONGEQUE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens vniciuique, præfertim vero
PHILOSOPHIS, ac ASTRONOMIS, quæ à
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Circ只 IOVIS Stellam dispersus interuella, ætque periodis, celesti
tate mirabili circumvolutis; quos, nemini in bunc visque
diem cognitos, nouissime Author deprehendi primus; æque
MEDICEA SIDER A
NVNCVPANDOS DECREVIT.

M. D. C. X.
Proflat Francissin Pattheniano.
Galileo’s drawings of the moon (1610)
Measurement of the height of lunar mountains

Sidereus nuncius (1610)
OBSERVAT. SIDEREAE
cœtum offendes. Amplius (quod magis mirabilis) Stellæ
ab Astronomis singulis in hanc visque dié NEBVLOSÆ
appellatae, Stellularum mirum inmodum confitatur grc
gesunt; ex quarum radiorum commixtione, dum vna-
queque ob exilatatem, seu maximam à nobis remotionem,
oculorum aciem fugit, candor illæ confugit, qui densior
pars coeli, Stellærum, aut Solis radios retorquere valens,
hucusque creditus est. Nos exillis nonnullas observam-
imus; & durum Afterfimos subneciere voluimus.
In primo habes NEBVLOSAM Capitis Orionis appel-
litam, in qua Stellas vigintivas numeramur.
Secundus NEBVLOSAM PRAESPE nuncupatam
continet, quæ non vna tantù Stella est, sed congeries Stell-
lularum plarium quam quadraginta; nos præter Asellos
trigintalex notauimus in hunc, qui sequitur ordinem di-
positas.

NEBVLOSA PRAESPE.

NEBVLOSA ORIONIS.
"I have now finished my brief account of the observations which I have thus far made with regard to the moon, the fixed stars, and the Milky Way. There remains the matter, which seems to me to deserve to be considered the most important in this work, namely, that I should disclose and publish to the world the occasion of discovering and observing four PLANETS, never seen from the very beginning of the world up to our own times, their positions, and the observations made during the last two months about their movements and their changes of magnitude..."
"On the 7th day of January in the present year, 1610, at the first hour of the night, when I was viewing the heavenly bodies with a telescope, Jupiter presented itself to me; and because I had prepared for myself a very excellent instrument, I perceived (as I had not before, on account of the weakness of my previous instrument) that beside the planet there were three little stars, small but very bright. Though I believed them to belong to the number of the fixed stars, yet they made me somewhat wonder, because they seemed to be arranged exactly in a straight line, parallel to the ecliptic, and to be brighter than the rest of the stars, equal to them in magnitude. Their position with reference to one another and to Jupiter was as follows:

On the east side there were two stars, and a single one towards the west. The star which was furthest towards the east, and the western star, appeared larger than the third. I paid no attention to the distances between them and Jupiter, for, as I have already said, at first I believed them to be fixed stars. But when on January 8th, led by what, I do not know, I turned again to look at the same part of the heavens, I found a very different state of things..."
In the *Sidereus nuncius* Galileo published his observations of the four Jupiter’s satellites performed every night free from clouds. The last observation was registered on March 2, and the book was published in Venice on March 12.
"Now touching the occurrents of the present, I send herewith unto His Majesty the strangest piece of news (as I may justly call it) that he hath ever yet received from any part of the world; which is the annexed book (come abroad this very day) of the Mathematical Professor at Padua, who by the help of an optical instrument (which both enlargeth and approximateth the object) invented first in Flanders, and bettered by himself, hath discovered four new planets rolling about the sphere of Jupiter, besides many other unknown stars; likewise, the true cause of the Via Lactea, so long searched; and lastly, that the moon is not spherical, but endued with many prominences, and, which is of all the strangest, illuminated with the solar light by reflection from the body of the earth, as he seemeth to say. So as upon the whole subject he hath first overthrown all former astronomy - for we must have a new sphere to save the appearances - and next all astrology. For the virtue of these new planets must needs vary the judicial part, and why may there not yet be more? These things I have been bold thus to discourse unto your Lordship, whereof here all corners are full. And the author runneth a fortune to be either exceeding famous or exceeding ridiculous. By the next ship your Lordship shall receive from me one of the above instruments, as it is bettered by this man."

Letter of Sir Henry Wotton, the British Ambassador to Venice, March 13, 1610
In England Thomas Harriot made drawings of moon’s surface based on observations with his telescope already in July, 1609. He later saw sunspots and the satellites of Jupiter but did not publish anything on these subjects.

The four satellites of Jupiter were discovered independently by Simon Mayr in Germany, but he published the results later than Galileo.

Thus Galileo’s fame was earned justly.
JOANNIS KEPLERI
Mathematici Cæsarei

DISSERTATIO
Cum
NUNCIO SIDEREOS
nuper ad mortales misso

GALILEO GALILEO
Mathematico Patavino.

Alcinous

Da Φαινόμενα μή μελλοντικά φιλοσοφήν.

Hic accessit Phænomenon singulare de
Mercurio ab eodem Keplerio
in Sole deprehensō.

Florentiae, Apud Io. Antonium Canzęm.
Superiorum permisso. 1610.

IOANNIS KEPLERI S.

NARRATIO
DE OBERVATIS A SE
quatuor Iouis satellitisus erronibus,

QUOS GALILEAVS GALILEAVS MA-
thematicus Florentinus, iure inventionis Me-
DICALA sidera nuncupavit,

CVM ADVNCNTA DISSERTATIONE DE
Nuncio sidereo nuper ad mortales misso.

FLORENTIAE.

Apud Cosmum Juncsum. 1611.
There are seven windows in the head, two nostrils, two ears, two eyes and a mouth; so in the heavens there are two favourable stars, two unpropitious, two luminaries, and Mercury alone undecided and indifferent. From which and many other similar phenomena of nature such as the seven metals, etc., which is more tedious to enumerate, we gather that the number of planets is necessarily seven.... Besides, the Jews and other ancient nations, as well as modern Europeans, have adopted the division of the week into seven days, and have named them from the seven planets; now if we increase the number of planets, this whole system falls to the ground... Moreover, the satellites are invisible to the naked eye and therefore can have no influence on the earth and therefore would be useless and therefore do not exist.”

Francesco Sizi
ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESI IN TRE LETTERE SCRITTE
ALL'ILLUSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DIVVMIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filosofo Matematico Primario del Sereniss.
D. COSIMO IL GRAN DVCA DI TOSCANA.
Si aggiungono nel fine le Lettere, e Disquisizioni del santo Apelle.

IN ROMA, Appresso Giacone Msacardi. MDCXIII.
CON LICENZA DE' SUPERIORI.
"Philosophy is written in that grand book – I mean the universe – which stands forever open before our eyes; but it cannot be read until we have learnt to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly impossible to comprehend a single word of it; without these, one is wandering about in a dark labyrinth."

Galileo, *Il Saggiatore*
DIALOGO
DI
GALILEO GALILEI LINCEO
MATHEMATICO SOPRAORDINARIO
DELL'OUDIO DI PISA.
E FILOSOFI, E MATHEMATICO PRIMARIO DEL
SBERNISSIMO
GR. DUCA DI TOSCANA.
DONE NEI CONGRESSI DI QUATTRO GIORNATE SI DISCORRE
SOPRA I DUE
MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO;
PROPONSIND INDETERMINATAMENTE LE RAGIONI FILOSOFICHE, E NATURALI
TANTO PER L'UNA, QUANZO PER L'ALTRA PARTE.

CON PRI
VILEGI.

IN FIORENZA, PER GIO: BARTOLO IDEINI MDCXXXII.
CON LICENZA DE' SUPERIORI.
"There remains what seemed to be a great difficulty with the earth’s movement; that is, unlike all the other planets that revolve around the sun, it alone does so (in one year) accompanied by the moon together with the whole elemental sphere, while the same moon moves every month around the earth. Here we must, once again, proclaim and exalt the admirable perspicacity of Copernicus and at the same time pity his misfortune; for he does not live in our time when, to remove the apparent absurdity of the shared motion of the earth and moon, we can see that Jupiter (being almost another earth) goes around the sun in twelve years accompanied not by one moon but by four moons, together with all that may be contained within the orbs of the four Medicean stars.”
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Event</th>
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<tbody>
<tr>
<td>1614</td>
<td>XII</td>
<td>First denunciation of Galileo</td>
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<td>1616</td>
<td>II</td>
<td>Galileo meets Bellarmino</td>
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<td>1616</td>
<td>III</td>
<td>Condemnation of Copernicanism</td>
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<td>1623</td>
<td></td>
<td>Publication of <em>Il Saggiatore</em></td>
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<tr>
<td>?</td>
<td></td>
<td>Another denunciation of Galileo</td>
</tr>
<tr>
<td>1632</td>
<td>II</td>
<td>Publication of <em>Dialogo</em> with necessary <em>Imprimatur</em></td>
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<tr>
<td>1632</td>
<td>XI</td>
<td>Galileo summoned to Rome</td>
</tr>
<tr>
<td>1633</td>
<td>IV</td>
<td>First session of the tribunal; Galileo presented the document concerning the meeting of 25 II 1616; he was shown the document of 26 II 1616 (fabricated?)</td>
</tr>
<tr>
<td>1633</td>
<td>IV</td>
<td>Mysterious meeting of Galileo with Vincenzo Firenzuola</td>
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<tr>
<td>1633</td>
<td>IV</td>
<td>Resumption of the trial, Galileo pleaded guilty</td>
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<td>1633</td>
<td>VI</td>
<td>Sentence (signed by only 7 of 10 judges)</td>
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<tr>
<td>1642</td>
<td>I</td>
<td>Death of Galileo (under house arrest)</td>
</tr>
<tr>
<td>1992</td>
<td>X</td>
<td>Pope John Paul II rehabilitated Galileo in the speech to the Pontifical Academy of Sciences</td>
</tr>
</tbody>
</table>
E D I C T A.

Et quia etiam ad notitiam presfatae Sacre Congregationis pertenit, saltam illum do-
ctrinam Pithagoricam, divinae, scripturae
omnino adversantem, de mobilitate Terra,
& immobilitate Solis, quam Nicolau Cope-
pernicus de revolutionibus orbis coelstium,
& Didaci Aslunica in toto etiam docent,
sanctum & multis receptis & sicut vide-
tur est ex quadam epistola impressioni cuiusdam
Patris Carmelitae, cui titulus, Lettera del R.
Padre Maestro Paolo Antonio Foscarini Car-
melitano, supra l'opinione de Pithagorici,
e del Copernico, della mobilità della Terra,
e stabilità del Sole, & il nuovo Pithagorico
Sistema del Mondo, in Napoli per Lazzaro
Scorigno 1616 in qua dictus Pater ostende-
tre conatur, presfatae doctrinam de immob-
ilitate Solis in centro Mundi, & mobilitate
Terra, conoscan esse veritatis, & non adver-
sari Sacrae Scripturae : Ideo ne velintis bu-
lesmodi opinio in pericelium Catholicae veri-
tatis serpat, censunt dictum Nicolau Cop-
pernicum de revolutionibus orbis, & Didaci
Aslunica in toto, suspendendos esse donec cor-
rigantur. Librum vero Patris Pauli Antenii
Foscarini Carmelitae omnino prohibendum,
a quse damnandum, aliosque omnes Libros pa-
riter
"...This Holy Congregation has also learned about the spreading and acceptance by many of the false Pythagorean doctrine, altogether contrary to the Holy Scripture, that the earth moves and the sun is motionless, which is also taught by Nicolaus Copernicus's *On the Revolutions of the Heavenly Spheres* and by Diego de Zuñiga's *On Job*...

Therefore, in order that this opinion may not creep any further to the prejudice of Catholic truth, the Congregation has decided that the books by Nicolaus Copernicus (*On the Revolutions of Spheres*) and Diego de Zuñiga (*On Job*) be suspended until corrected; ...and that all other books which teach the same be likewise prohibited, according to whether with the present decree it prohibits, condemns, and suspends them respectively. In witness thereof, this decree has been signed by the hand and stamped with the seal of the Most Illustrious and Reverend Lord Cardinal of St. Cecilia, Bishop of Albano, on 5 March 1616.."
“Whereas you, Galileo, son of the late Vincenzio Galilei, Florentine, aged seventy years, were denounced to this Holy Office in 1615 for holding as true the false doctrine taught by some that the sun is the centre of the world and motionless and the earth moves even with diurnal motion; for having disciples to whom you taught the same doctrine; for being in correspondence with some German mathematicians about it; for having published some letters entitled *On Sunspots*, in which you explained the same doctrine as true; for interpreting Holy Scripture according to your own meaning in response to objections based on Scripture which were sometimes made to you; and whereas later we received a copy of an essay in the form of a letter, which was said to have been written by you to a former disciple of yours and which in accordance with Copernicus's position contains various propositions against the authority and true meaning of Holy Scripture;”
Excerpts from the sentence in the trial of Galileo

"And whereas this Holy Tribunal wanted to remedy the disorder and the harm which derived from it and which was growing to the detriment of the Holy Faith, by order of His Holiness and the Most Eminent and Most Reverend Lord Cardinals of this Supreme and Universal Inquisition, the Assessor Theologians assessed the two propositions of the sun's stability and the earth's motion as follows:
That the sun is the centre of the world and motionless is a proposition which is philosophically absurd and false, and formally heretical, for being explicitly contrary to Holy Scripture;
That the earth is neither the centre of the world nor motionless but moves even with diurnal motion is philosophically equally absurd and false, and theologically at least erroneous in the Faith..."
"And whereas a book has appeared here lately, printed in Florence last year, whose inscription showed that you were the author, the title being *Dialogue by Galileo Galilei on the two Chief World Systems, Ptolemaic and Copernican*; and whereas the Holy Congregation was informed that with the printing of this book the false opinion of the earth's motion and sun's stability was being disseminated and taking hold more and more every day, the said book was diligently examined and found to violate explicitly the above-mentioned injunction given to you; for in the same book you have defended the said opinion already condemned and so declared to your face, although in the said book you try by means of various subterfuges to give the impression of leaving it undecided and labeled as probable; this is still a very serious error since there is no way an opinion declared and defined contrary to divine Scripture may be probable..."
"Therefore, by our order you were summoned to this Holy Office, where, examined under oath, you acknowledged the book as written and published by you. You confessed that about ten or twelve years ago, after having been given the injunction mentioned above, you began writing the said book, and that then you asked for permission to print it without explaining to those who gave you such permission that you were under the injunction of not holding, defending, or teaching such a doctrine in any way whatever."
"...We say, pronounce, sentence, and declare that you, the above-mentioned Galileo, because of the things deduced in the trial and confessed by you as above, have rendered yourself according to this Holy Office vehemently suspected of heresy, namely of having held and believed a doctrine which is false and contrary to the divine and Holy Scripture: that the sun is the centre of the world and does not move from east to west, and the earth moves and is not the centre of the world, and that one may hold and defend as probable an opinion after it has been declared and defined contrary to Holy Scripture."
“Consequently you have incurred all the censures and penalties imposed and promulgated by the sacred canons and all particular and general laws against such delinquents. We are willing to absolve you from them provided that first, with a sincere heart and unfeigned faith, in front of us you abjure, curse, and detest the above-mentioned errors and heresies, and every other error and heresy contrary to the Catholic and Apostolic Church, in the manner and form we will prescribe to you.”
Furthermore, so that this serious and pernicious error and transgression of yours does not remain completely unpunished, and so that you will be more cautious in the future and an example for others to abstain from similar crimes, we order that the book *Dialogue* by Galileo Galilei be prohibited by public edict. We condemn you to formal imprisonment in this Holy Office at our pleasure. As a salutary penance we impose on you to recite the seven penitential Psalms once a week for the next three years. And we reserve the authority to moderate, change, or condone wholly or in part the above-mentioned penalties and penances..

Three out of ten judges, cardinals Gasparo Borgia, Francesco Barberini, and Laudivio Zacchia did not sign the sentence.
“If Galileo had known how to retain the affection of the Fathers of this College, he would have lived gloriously before the world, and none of his misfortunes would have happened, and he would have been able to write as he chose about everything, including the motion of the earth…”

Father Grienberger, professor of astronomy at the Collegio Romano
Anonymous denunciation that Galileo propagated false and dangerous atomistic ideas in *Il Saggiatore*.
"Having in past days perused Signor Galileo Galilei's book entitled *The Assayer* I have come to consider a doctrine already taught by certain ancient philosophers and effectively rejected by Aristotle, but renewed by the same Signor Galilei. And having decided to compare it with the true and undoubted Rule of revealed doctrines, I have found that in the Light of that Lantern which by the exercise and merit of our faith shines out indeed in murky places, and which more securely and more certainly than any natural evidence illuminates us, this doctrine appears false, or even (which I do not judge) very difficult and dangerous... Therefore, the aforesaid Author, in the book cited (on page 196, line 29), wishing to explain that proposition proffered by Aristotle in so many places - that motion is the cause of heat - and to adjust it to his intention, sets out to prove that these accidents which are commonly called colours, odours, tastes, etc., on the part of the subject, in which it is commonly believed that they are found, are nothing but pure words and are only in the sensitive body of the animal dial feels them..."
"...Now if one admits this philosophy of accidents as true, it seems to me, that makes greatly difficult the existence of the accidents of the bread and wine which in the Most Holy Sacrament are separated from their substance; since finding again therein the terms, and the objects of touch, sight, taste, etc., one will also have to say according to this doctrine that there are the very tiny particles with which the substance of the bread first moved our senses, which if they were substantial (as Anaxagoras said, and this author seems to allow on page 200, line 28), it follows that in the Sacrament there are substantial parts of bread or wine, which is the error condemned by the Sacred Tridentine Council, Session 13, Canon 2."
"Or actually, if they were only sizes, shapes, numbers, etc., as he also seems clearly to admit, agreeing with Democritus, it follows that all these are accidental modes, or, as others say, shapes of quantity. While the Sacred Councils, and especially the Trident Council in the passage cited, determine that after the Consecration there remain in the Sacrament only the Accidents of the bread and wine, he instead says that there only remains the quantity with triangular shapes, acute or obtuse, etc., and that with these accidents alone is saved the existence of accidents or sensible species - which consequence seems to me not only in conflict with the entire communion of Theologians who teach us that in the Sacrament remain all the sensible accidents of bread, wine, colour, smell, and taste, and not mere words, but also, as is known, with the good judgment that the quantity of the substance does not remain. Again, this is inevitably repugnant to the truth of the Sacred Councils..."

(from the book *Galileo Heretic* by Redondi)
"I think that tastes, odours, colours, and so forth are no more than mere names so far as it pertains to the subject wherein they reside, and that they have their habitation only in the sensorium. Thus if the living creature were removed, all those qualities would be removed and annihilated. Yet since we have imposed upon them particular names which differ from the names of those other previous real attributes, we wish to believe that they should also be truly and really different from the latter...

I do not believe that for exciting in us tastes, odours, and sounds there are required in external bodies anything but sizes, shapes, numbers, and slow or fast movements, and I think that if ears, tongues, and noses were taken away, shapes and numbers and motions would remain but not odours or tastes or sounds. These, I believe, are nothing but names..."

Galileo, *Il Saggiatore*
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>1347, 25 XI</td>
<td>Nicolas of Autrecourt forced to publicly burn in Paris his books on atoms</td>
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<tr>
<td>1543</td>
<td>A short passage on atoms in <em>De revolutionibus</em>, erased by censors, did not appear in the printed book</td>
</tr>
<tr>
<td>1551</td>
<td>The Council of Trent proclaimed the dogma of Eucharist</td>
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<tr>
<td>1624, 23 VIII</td>
<td>In Paris Jean Bitaud, Antoine de Villon and Etienne de Clave announced a public defense of the thesis that <em>omnia componi ex Atomis et indivisibles</em>. One of the organizers was arrested, and the debate forbidden. It was declared that further attempts of discussion on similar topics will be punished by death.</td>
</tr>
<tr>
<td>1633, 22 VI</td>
<td>Galileo sentenced to prison – formally for teaching heliocentrism, but possibly for propagating atomistic ideas</td>
</tr>
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<td>1691</td>
<td>Grand Duke of Tuscany Cosimo III: „No professor of the University of Pisa may read or teach, either publicly or privately, whether in writing or by speech, the Democritan philosophy, namely about atoms, but only the Aristotelian, and whoever should in any way transgress the wish of the Grand Duke may consider himself dismissed.”</td>
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</table>
"But its position is also still to be sought for, and is even less certain from what has been said above. For that proof has no other consequence than the indefinite size of the heaven compared with the earth. But it is far from settled how far this immensity extends. As conversely occurs in the smallest and inseparable corpuscles (minimis corpusculis ac insectibilibus), which are called atoms, not being perceptible [even if] duplicated or multiplied several times, they do not immediately form a visible body, but can be multiplied until at last they are sufficient to come together in a size that can be seen. Thus, also on this place the earth, although it is not the centre of the world, its distance from the centre is not comparable in particular with the sphere of the fixed stars."

De revolutionibus, Book I, Chapter 6

A passage erased by censors did not appear in the printed book
Powerful weapon of the Inquisition
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.
Illustrations from the *Discorsi*

Considerations of the resistance of beams to fracture

Parabolic trajectory of a projectile thrown horizontally

Conservation of mechanical energy
Salviati: ...I greatly doubt that Aristotle ever tested by experiment whether it be true that two stones, one weighing ten times as much as the other, if allowed to fall, at the same instant, from a height of, say, 100 cubits, would so differ in speed that when the heavier had reached the ground, the other would not have fallen more than 10 cubits.

Simplicio: His language would seem to indicate that he had tried the experiment, because he says: We see the heavier; now the word see shows that he had made the experiment.

Sagredo: But I, Simplicio, who have made the test can assure you that a cannon ball weighing one or two hundred pounds, or even more, will not reach the ground by as much as a span ahead of a musket ball weighing only half a pound, provided both are dropped from a height of 200 cubits.

Salviati: But, even without further experiment, it is possible to prove clearly, by means of a short and conclusive argument, that a heavier body does not move more rapidly than a lighter one provided both bodies are of the same material and in short such as those mentioned by Aristotle. But tell me, Simplicio, whether you admit that each falling body acquires a definite speed fixed by nature, a velocity which cannot be increased or diminished except by the use of force [violenza] or resistance?
Simplicio: There can be no doubt but that one and the same body moving in a single medium has a fixed velocity which is determined by nature and which cannot be increased except by the addition of momentum [impeto] or diminished except by some resistance which retards it.

Salviati: If then we take two bodies whose natural speeds are different, it is clear that on uniting the two, the more rapid one will be partly retarded by the slower, and the slower will be somewhat hastened by the swifter. Do you not agree with me in this opinion?

Simplicio: You are unquestionably right.

Salviati: But if this is true, and if a large stone moves with a speed of, say, eight while a smaller moves with a speed of four, then when they are united, the system will move with a speed less than eight; but the two stones when tied together make a stone larger than that which before moved with a speed of eight. Hence the heavier body moves with less speed than the lighter; an effect which is contrary to your supposition. Thus you see, how, from your assumption that the heavier body moves more rapidly than the lighter one, I infer that the heavier body moves more slowly.

Simplicio: I am all at sea because it appears to me that the smaller stone when added to the larger increases its weight and by adding weight I do not see how it can fail to increase its speed or, at least, not to diminish it.
Salviati: Here again you are in error, Simplicio, because it is not true that the smaller stone adds weight to the larger.

Simplicio: This is, indeed, quite beyond my comprehension.

Salviati: It will not be beyond you when I have once shown you the mistake under which you are laboring. Note that it is necessary to distinguish between heavy bodies in motion and the same bodies at rest. A large stone placed in a balance not only acquires additional weight by having another stone placed upon it, but even by the addition of a handful of hemp its weight is augmented six to ten ounces according to the quantity of hemp. But if you tie the hemp to the stone and allow them to fall freely from some height, do you believe that the hemp will press down upon the stone and thus accelerate its motion or do you think the motion will be retarded by a partial upward pressure? One always feels the pressure upon his shoulders when he prevents the motion of a load resting upon him; but if one descends just as rapidly as the load would fall how can it gravitate or press upon him? Do you not see that this would be the same as trying to strike a man with a lance when he is running away from you with a speed which is equal to, or even greater, than that with which you are following him? You must therefore conclude that, during free and natural fall, the small stone does not press upon the larger and consequently does not increase its weight as it does when at rest...
"A piece of wooden moulding or scantling, about 12 cubits long, half a cubit wide, and three finger-breadths thick, was taken; on its edge was cut a channel a little more than one finger in breadth; having made this groove very straight, smooth, and polished, and having lined it with parchment, also as smooth and polished as possible, we rolled along it a hard, smooth, and very round bronze ball. Having placed this board in a sloping position, by lifting one end some one or two cubits above the other, we rolled the ball, as I was just saying, along the channel, noting, in a manner presently to be described, the time required to make the descent. We repeated this experiment more than once in order to measure the time with an accuracy such that the deviation between two observations never exceeded one-tenth of a pulse-beat. Having performed this operation and having assured ourselves of its reliability, we now rolled the ball only one-quarter the length of the channel; and having measured the time of its descent, we found it precisely one-half of the former. Next we tried other distances, comparing the time for the whole length with that for the half, or with that for two-thirds, or three-fourths, or indeed for any fraction;"

Galileo, *Discorsii* (1638)
“in such experiments, repeated a full hundred times, we always found that the spaces traversed were to each other as the squares of the times, and this was true for all inclinations of the plane, i.e., of the channel, along which we rolled the ball. We also observed that the times of descent, for various inclinations of the plane, bore to one another precisely that ratio which, as we shall see later, the Author had predicted and demonstrated for them. For the measurement of time, we employed a large vessel of water placed in an elevated position; to the bottom of this vessel was soldered a pipe of small diameter giving a thin jet of water, which we collected in a small glass during the time of each descent, whether for the whole length of the channel or for a part of its length; the water thus collected was weighed, after each descent, on a very accurate balance; the differences and ratios of these weights gave us the differences and ratios of the times, and this with such accuracy that although the operation was repeated many, many times, there was no appreciable discrepancy in the results.”

Galileo, *Discorsi* (1638)
Selected results of Galileo concerning mechanics:

- Principle of (Galilean) relativity
- Correct law of free fall
- Isochronism of pendulums
- The path of a projectile is a parabola
- (Incorrect) principle of inertia
Simon Stevin (1548-1620)
I. LIVRE DE LA STATIQUE

On pourra se référer à la figure 1, en particulier aux figures 2 à 5, qui illustrent les principes de base de la statique.

**Corollaire.**

Il est important de noter que les résultats obtenus dans la figure 1 sont également applicables à la situation représentée dans la figure 2.

JUSQU'ICI ON TROUVE DES EXEMPLES D'APPLICATION DES PRINCIPES DE LA STATIQUE.

**Théorème XVI. Proposition XIX.**

C'est ainsi que, à partir des données de la figure 3, on peut déterminer les forces qui agissent sur la structure représentée.

**Corollaire I.**

Soit ABC un triangle équilatéral dans lequel on a tracé un carré de même côté. On peut alors déterminer les forces qui agissent sur chacun des sommets du carré.

**Corollaire II.**

Soit ABCD un rectangle dans lequel on a tracé un cercle de même diamètre. On peut alors déterminer les forces qui agissent sur les sommets du rectangle.

**Corollaire III.**

Soit ABCD un parallélogramme dans lequel on a tracé un losange de même côté. On peut alors déterminer les forces qui agissent sur les sommets du losange.

**Nota.**

Les théorèmes et propositions précédentes sont fondamentaux pour la compréhension du chapitre suivant.

IV. LIVRE DE LA STATIQUE

La colonne est celle qui est composée comme le fond pour la base E. On peut donc la considérer comme le fond principal de la structure.

**Démonstration.**

Si on a une colonne de longueur supérieure à la hauteur du fond, on peut considérer que cette colonne est également une colonne de base.

**Corollaire IV.**

Si on a une colonne de longueur inférieure à la hauteur du fond, on peut considérer que cette colonne est également une colonne de base, mais dans ce cas, la longueur de la colonne sera supérieure à la hauteur du fond.

**Corollaire V.**

Si on a une colonne de longueur égale à la hauteur du fond, on peut considérer que cette colonne est également une colonne de base, mais dans ce cas, la longueur de la colonne sera égale à la hauteur du fond.

**Nota.**

Les théorèmes et propositions précédentes sont fondamentaux pour la compréhension du chapitre suivant.
René Descartes (1596-1650)

1637 *Discours de la méthode*

1644 *Principia Philosophiae*
"...instead of the great number of precepts of which Logic is composed, I believed that the four following would prove perfectly sufficient for me...

The first was never to accept anything for true which I did not clearly know to be such...
The second, to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution.
The third, to conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex;
And the last, in every case to make enumerations so complete, and reviews so general, that I might be assured that nothing was omitted."
"....Laws of nature, of which the first is that every thing, considered as simple and undivided, perseveres, as far as it can, in the same state and never changes [its state] but for external causes... If it is at rest, we do not believe that it will ever begin to move if not compelled by some cause. Nor is there any reason to think that, if it moves... and is not impeded by anything, it should ever by itself cease to move with the same force. It is therefore to be concluded that a thing which moves, will move forever as far as it can... The first law of nature, that everything, as much as in it lies, perseveres always in the same state; thus that which once started to move will continue to move forever. Second law: that every motion by itself is along a straight line and therefore every body which is moved circularly tends perpetually to recede from the centre of the circle which it describes."

Descartes, *Principia philosophiae* (1644)
Principle of inertia:
Every isolated body remains in its state, at rest or in rectilinear motion. Hence bodies in a circular motion always tend to recede from the centre (conatus recedendi a centro)

Descartes, *Principia philosophiae* (1644)
Descartes: Conatus recedendi a centro
Cartesian vortices, *Principia philosophiae*, 1644
Natural motion

Copernicus
A quantitative expression for conatus

\[ v = \frac{2\pi r}{T} \]

\[ v^2 \sim \frac{r^2}{T^2} = \frac{r^3}{rT^2} \rightarrow v^2 \sim \frac{1}{r} \]

\[ r^3 \sim T^2 \quad \text{(Kepler)} \]

\[ F \sim \frac{v^2}{r} \sim \frac{1}{r^2} \]
Borelli
Hooke
"I shall...explain a system of the world differing in many particulars from any yet known, but answering in all things to the common rules of mechanical motions. This depends upon three suppositions: *First*, That all celestial bodies whatsoever have an attraction or gravitating power towards their own centres, whereby they attract not only their own parts, and keep them from flying from them, as we may observe the Earth to do, but that they also do attract all other celestial bodies that are within the sphere of their activity, and consequently that not only the Sun and Moon have an influence upon the body and motion of the Earth, and the Earth upon them, but that Mercury, Venus, Mars, Jupiter, and Saturn also, by their attractive powers, have a considerable influence upon its motion, as in the same manner the corresponding attractive power of the Earth hath a considerable influence upon every one of their motions.”
"The second supposition is this, that all bodies whatsoever that are put into a direct and simple motion, will so continue to move forward in a straight line till they are, by some other effectual powers, deflected, and sent into a motion describing a circle, ellipsis, or some other more compounded curve line. The third supposition is, that these attractive powers are so much the more powerful in operating by how much the nearer the body wrought upon is to their own centre. Now, what these several degrees are, I have not yet experimentally verified, but it is a notion which, if fully prosecuted, as it ought to be, will mightily assist the astronomers to reduce all the celestial motions to a certain rule..."
”The importance of Hooke’s statement of the mechanical elements of orbital motion cannot be exaggerated. Following the pattern established by Descartes, every student of circular motion before him had spoken of the tendency of bodies in circular motion to recede from the centre. It was Hooke who broke the tyranny that pattern exercised and reconceptualized the problem. If the principle of inertia is given, the question is what constrains a body to follow a curved path and not the tendency to recede that it exhibits when so constrained. It is not too much to say that Hooke taught the science of mechanics this fundamental lesson and set it on the way to a satisfactory dynamics of circular motion.”

Richard Westphall, *Force in Newton’s Physics*
The list is given of 77 arguments against the Copernican system and only 20 arguments in its support (which are anyway rejected). Thus, by counting the arguments the falsity of the Copernican system is "proven".
Anagrams

Galileo (1610) SMAISMRMILMEPOETAEVMBVNVENVGTTAVIRAS
Solution: ALTISSIMUM PLANETAM TERGEMINUM OBSERVARI

Huygens (De Saturni Luna Observatio Nova, 1656)
AAAAAAA CCCCC D EEEEE G H I I I I I LLLL MM N N N N N N N N N N N N N
OOOO Q RR S TTTTT UUUU
Solution (Systema Saturni, 1659): Annulo cingitur, tenui, plano, nusquam cohaerente, ad eclipicam inclinato

Hooke (1676) ceiiinossstttuu
Solution (1678): Ut tensio sic vis

Newton in a letter to Leibniz (1676)
6a cc d ae 13e ff 7i 3l 9n 4o 4q rr 4s 9t 12v x
Solution: Date equatione quotcunque fluentes quatititates involvente, fluxiones invenire et vice-versa
Scientific academies

Academia Secretorum Naturae - 1560
Naples, Giambattista della Porta

Accademia dei Lincei - 1603-1630
Rome, Prince Federico Cesi

Accademia del Cimento - 1657-1667
Florence, Prince Leopold de Medici

Royal Society (of London for Improving Natural Knowledge) - 1660, 1662, London

Académie des Sciences - 1666
Paris, Jean Baptiste Colbert

Scientific periodicals

Journal des Scavans (I 1665, Paris)

Philosophical Transactions (III 1665, London)

Acta Eruditorum (1682, Leipzig)
Philosophical Transactions: giving some account of the present undertakings, studies, and labours of the ingenious in many considerable parts of the world.

Vol. I.
For Anno 1665, and 1666.

In the Savoy,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duddingston.
Printers to the Royal Society.

Le Journal des Scavans.
Du Lundi V. Janvier, M. DC. LXV.
Par le Sieur de Hedoivre.

A Paris,
Chez Jean Cysson, rue S. Jacques, à l’image de S. Jean Baptiste.

M. DC. LXV.
Avec privilège du roy.
King Louis XIV visiting the Académie des sciences
Colbert presenting members of the Academy to king Louis XIV