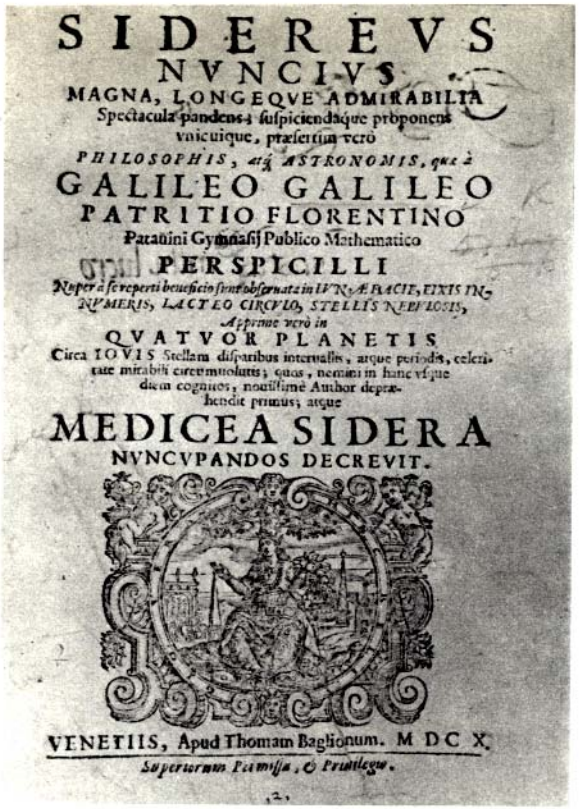
The Starry Messenger (I)



SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suſpiciendaque proponens
vnicuique, præſertim verò
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnaſij Publico Mathematico
PERSPICILLI
Nuper à ſe reperti beneficio ſunt obſeruata in IVNÆ FACIE, VIXIS IN-
NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprimè verò in
QVATVOR PLANETIS
Circa IOVIS Stellam diſparibus interuallis, atque periodis, celeri-
tate mirabili circumuolutis; quos, nemini in hanc vſque
diem cognitos, nouiſſimè Author deprę-
hendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permiſſu, & Priuilegio.

THE
STARRY MESSENGER

Revealing great, unusual, and remarkable spectacles, opening these to the consideration of every man, and especially of philosophers and astronomers;
as observed by Galileo Galilei
Gentleman of Florence
Professor of Mathematics in the University of Padua,
With the Aid of a Spyglass
lately invented by him,
In the surface of the Moon, in innumerable Fixed Stars, in Nebulae, and above all in Four Planets
swiftly revolving about Jupiter at differing distances and periods, and known to no one before the Author recently perceived them and decided that they should be named
The Medicean stars

Venice
1610

Title page, together with translation, of Galileo's *Sidereus Nuncius*. Published in 1610, it announced the first impact of the telescope on the exploration of the heavens.

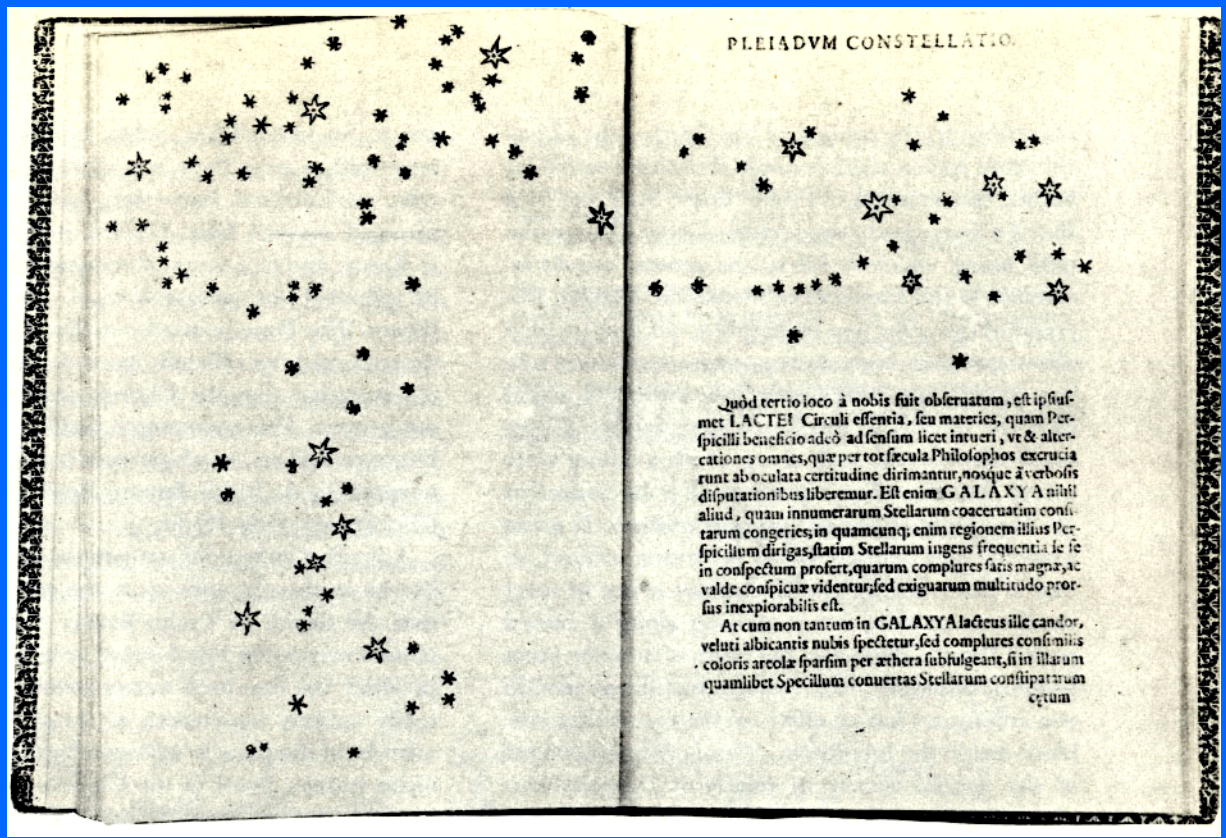
Galileo's 1st telescope only magnified 3 times. However he was quickly able to make ones with 30x magnification.

Galileo Galilei (1564-1642)

Galileo was a mathematics professor from Pisa who became famous after the publication in 1610 of 'Siderius Nuncius' (the 'starry messenger'). He was the first to use the newly invented telescope to observe the sky. His very carefully recorded results caused a sensation amongst intellectuals in Europe.

The Starry Messenger (II)

About as powerful than today's binoculars, his instruments allowed him to discern a multitude of stars beyond the visible. This was already rather troublesome for orthodox belief, since it indicated that the starry firmament was more extensive than previously believed. Giordano Bruno had been burnt at the stake by the inquisition (after a 7-yr trial) for promoting such ideas only 10 Yrs earlier.



The region of Orion's belt & sword (LHS); and the Pleaides (RHS)

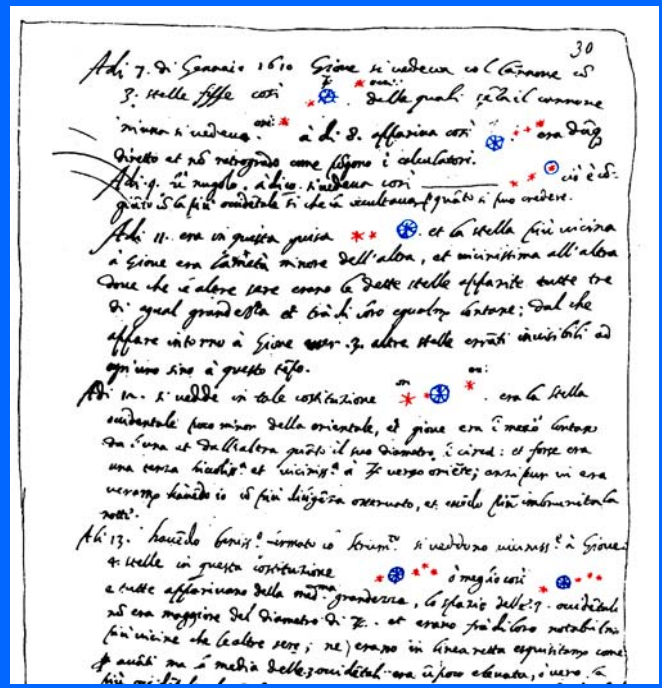
Galileo's moon

Worse was to come. The Heavenly bodies were held to be perfect by the church, so that the discovery of craters on the moon was a shock to Rome- and it lent further credibility to the ideas of Bruno. Galileo was happy to show the cardinals the view through his looking glass.

The Starry Messenger (III)

By projecting the sun's light onto paper, he found It was covered with spots which came and went, and moved with the sun's rotation. When he turned his telescope on Jupiter the most shattering conclusion came- he found 4 stars associated with it, which moved from night to night in a way that could only be explained by assuming they were in orbit around the planet.

At the time Galileo was content, with the example of Bruno in mind, to merely report his results- thereby avoiding Bruno's fate.

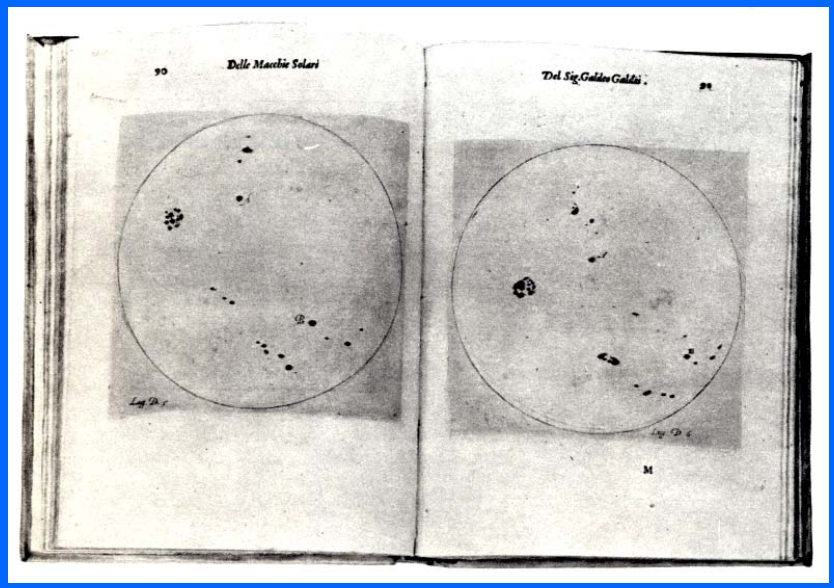


On the 7th of January 1610 Jupiter was seen in my telescope with 3 fixed stars thus: east ∗∗O ∗ west. These were invisible without the telescope. On the 8th they appeared thus: O∗∗∗.

They were therefore direct and not retrograde, as previously calculated. On the 9th it was cloudy. On the 10th I saw them again, like this: ∗∗O. The most westerly seemed to be occulted. On the 11th they were arranged thus: ∗ ∗ O, and the nearest star to Jupiter was half the size of the other and close to it; whereas on other nights they appeared of equal size and equidistant.

From this it appears there are 3 wandering stars around Jupiter, previously invisible to everyone.

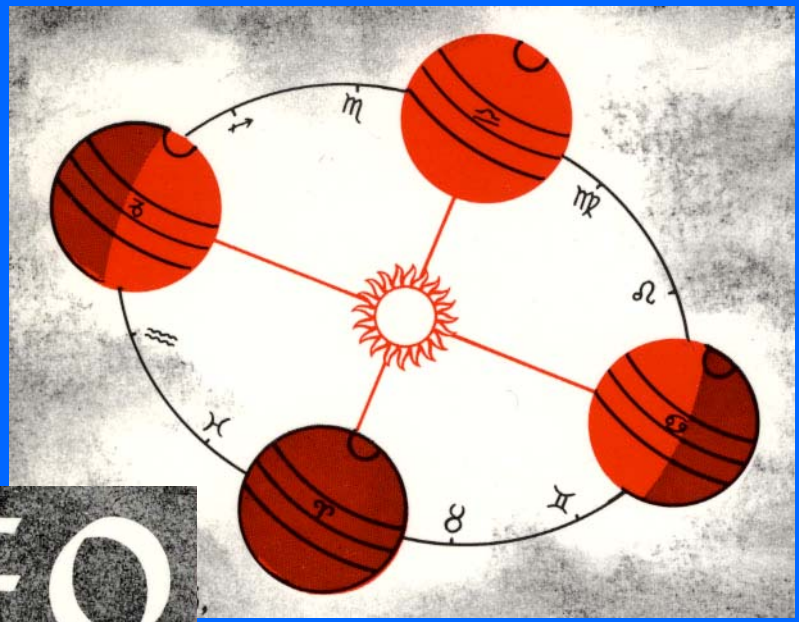
1st observation of Jupiter's 4 major moons (the 'Galilean satellites')



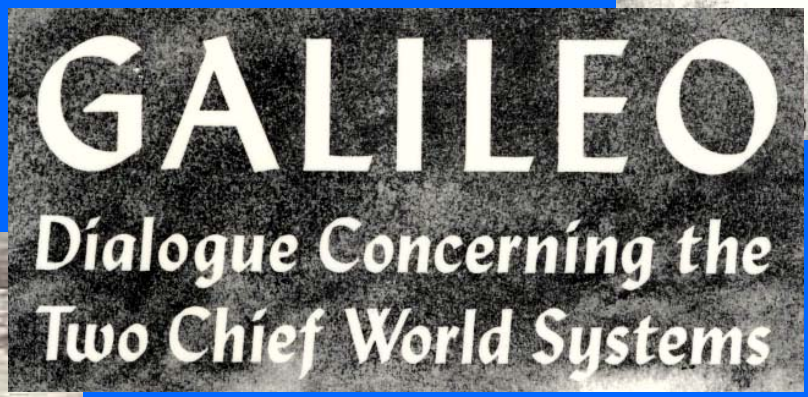
Galileo's sun (with changing sunspots)

Galileo vs. the Inquisition (I)

Although Galileo did not hide his opinions after the publication of his observations in 1610, he was not so foolish as to publish these. However in 1632, emboldened by the election of Urban VIII as Pope, he published his famous set of dialogues, in which the 2 world systems (Copernican and Aristotelian) are compared. The role of the Aristotelian was taken by Simplicius, who discussed the questions Salviati and Sagredo



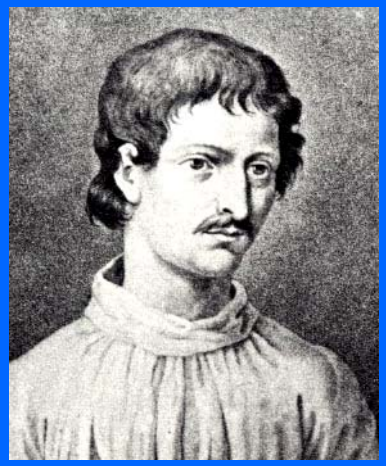
Motion of the earth around the sun, according to Galileo (from the "dialogue").



One of Galileo's later telescopes

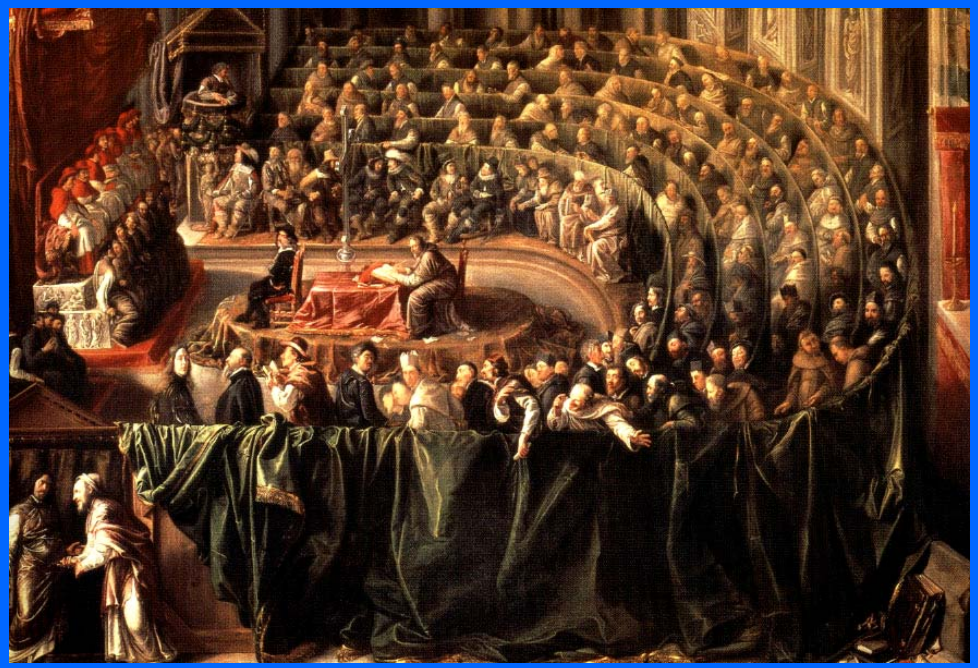
The essential purpose of the dialogues was to demonstrate the superiority of the Copernican system in its description of the heavens, and also to highlight the deficiencies of the Aristotelian system in its discussion of dynamics. Thus the book (a rather long one) is written deliberately in the form of a philosophical dialogue, reminiscent of Socrates. The emphasis on the results of experimental science, as opposed to 'first principle' arguments, is a notable feature of this and earlier writings of Galileo.

Galileo vs the Inquisition (II)



G. Bruno (1548-1600)

Galileo's book sold out. 5 months later, Galileo was called before the Holy Office & tried by the Inquisition. Under threat (cf. G. Bruno) he was forced to recant, and kept under house arrest for the rest of his life. At the end of the 20th century, 360 yrs later, the Church admitted its mistake.



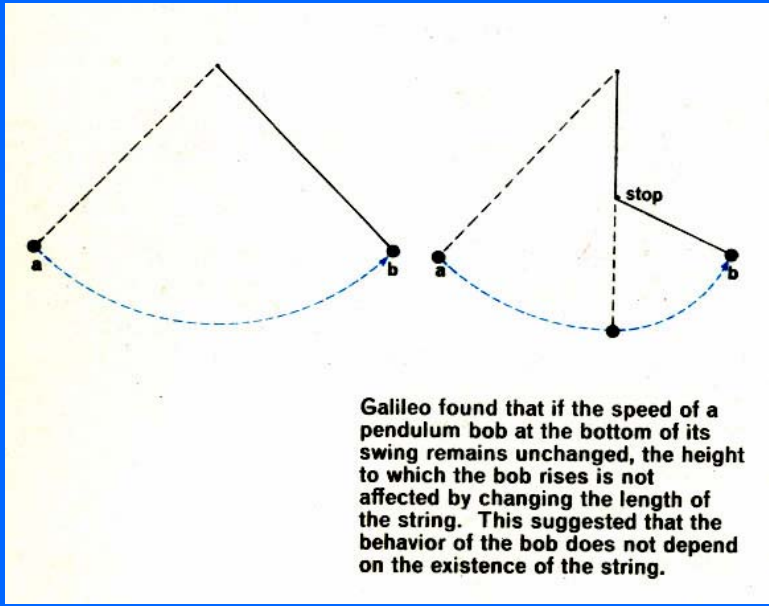
Trial of Galileo (1632)

"I, Galileo, son of the late Vincenzo Galilei, Florentine, aged seventy years, arraigned personally before this tribunal and kneeling before you, Most Eminent and Reverend Lord Cardinals Inquisitors-General against heretical pravity throughout the entire Christian commonwealth, having before my eyes and touching with my hands the Holy Gospels, swear that I have always believed, do believe, and by God's help will in the future believe all that is held, preached, and taught by the Holy Catholic and Apostolic Church. But, whereas—after an injunction had been judicially intimated to me by this Holy Office to the effect that I must altogether abandon the false opinion that the Sun is the center of the world and immovable and that the Earth is not the center of the world and moves and that I must not hold, defend, or teach in any way whatsoever, verbally or in writing, the said false doctrine, and after it had been notified to me that the said doctrine was contrary to Holy Scripture—I wrote and printed a book in which I discuss this new doctrine already condemned and adduce arguments of great cogency in its favor without presenting any solution of these, I have been pronounced by the Holy Office to be vehemently suspected of heresy, that is to say, of having held and believed that the Sun is the center of the world and immovable and that the Earth is not the center and moves:

Therefore, desiring to remove from the minds of your Eminences, and of all faithful Christians, this vehement suspicion justly conceived against me, with sincere heart and unfeigned faith I abjure, curse, and detest the aforesaid errors and heresies and generally every other error, heresy, and sect whatsoever contrary to the Holy Church, and I swear that in future I will never again say or assert, verbally or in writing, anything that might furnish occasion for a similar suspicion regarding me; but, should I know any heretic or person suspected of heresy, I will denounce him to this Holy Office or to the Inquisitor or Ordinary of the place where I may be. Further, I swear and promise to fulfil and observe in their integrity all penances that have been, or that shall be, imposed upon me by this Holy Office. And, in the event of my contravening (which God forbid!) any of these my promises and oaths, I submit myself to all the pains and penalties imposed and promulgated in the sacred canons and other constitutions, general and particular, against such delinquents. So help me God and these His Holy Gospels, which I touch with my hands."

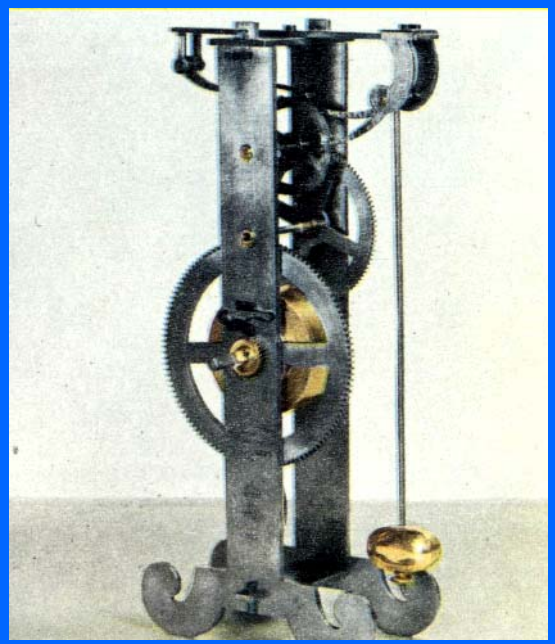
‘Discourses & Demonstrations concerning 2 New Sciences’,

by Galileo Galilei (Leiden, 1638)

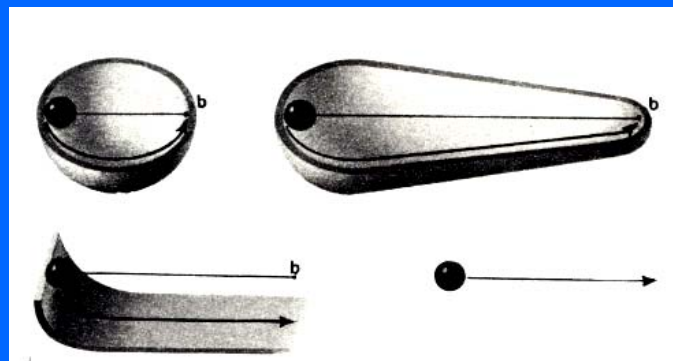


Galileo found that if the speed of a pendulum bob at the bottom of its swing remains unchanged, the height to which the bob rises is not affected by changing the length of the string. This suggested that the behavior of the bob does not depend on the existence of the string.

Galileo did not waste his time between 1633 and 1642 (when he died, by then blind for 4 yrs). With the help of a disciple (Viviani) he organized his work over a period of 40 yrs, and systematized it into a description of experimental philosophy and its results. This included a discussion of the results of his many experimental investigations of the dynamics of moving bodies, and the underlying principles he thought he had found.



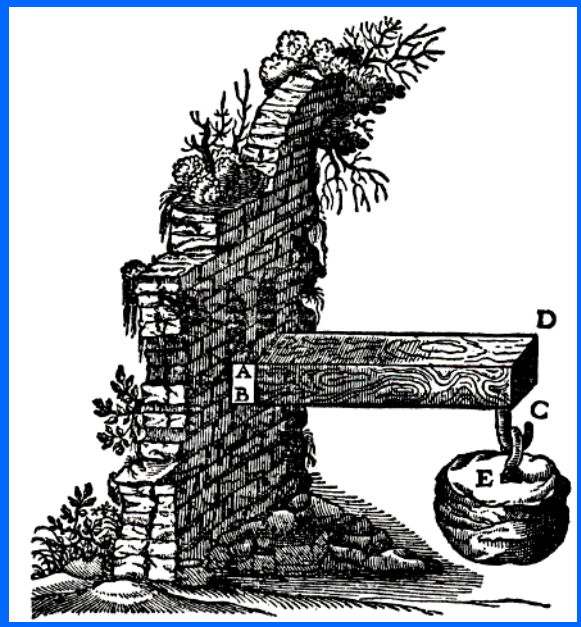
It is hard to appreciate now what a mammoth task he had set himself. It involved an emancipation from the idea that one attempted to understand the world starting from a priori principles- which required not only ideas but new tools (such as the clock shown at left).



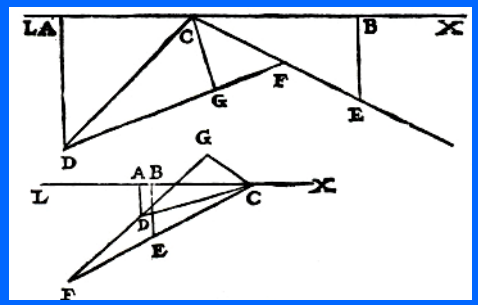
A ball rolling without slipping in a bowl behaves in the same way. However much the two sides of the bowl differ in steepness, it always tries to reach the same height on both sides. If one "side" becomes horizontal, the ball therefore rolls on indefinitely in the same direction.

The 2 New Sciences (II)

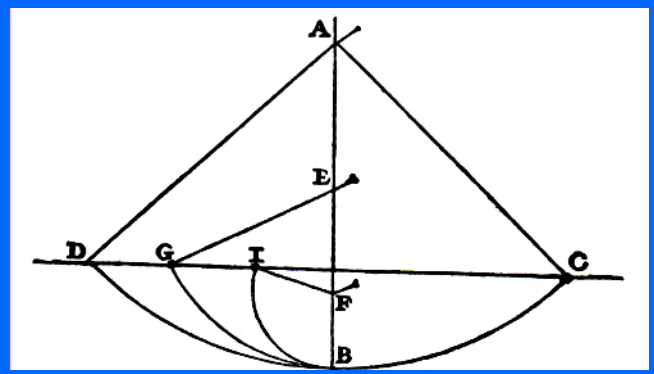
Galileo' last work is actually collects together many different problems on mechanical systems. These include questions about geometry & the structure of matter; the slippage, breakage and fracture of beams, tubes, ropes, etc; the rolling & sliding of objects on inclined planes, & friction between surfaces; the production of sound & music by various processes; vibrational & oscillatory motion; the dynamics of objects falling through various media; the motion of swinging pendula, & of projectiles; the change in momentum of accelerating objects; and so on…



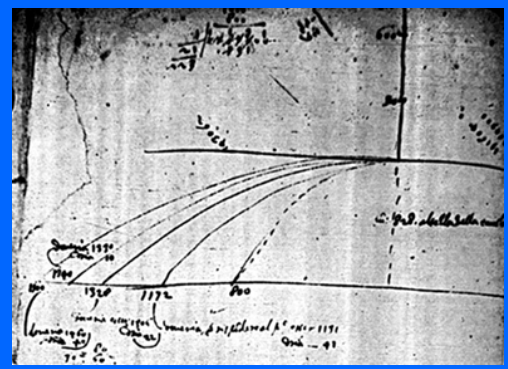
Stress in a weighted beam



The work of Galileo marks the transition between ancient & modern thought in so many ways. It is written in dialogue, and demonstrations attempt to be deductive as far as possible- often using geometric proofs. But- he describes detailed experiments on projectiles (in dialogue form!), & the wealth of correctly analysed examples, even if not organised by a coherent set of theoretical principles, utterly demolishes 2000 yrs of misunderstanding, & opens the way to modern science.



TOP: geometry of rolling on a tilted plane BELOW: pendulum dynamics



Parabolic motion of projectiles