Storia della fisica ed epistemologia

Corso AA 2022-2023 –responsabili Proff. A.Pluchino e A.Rapisarda

Lezione I: introduzione e breve excursus (Docente A.Pagano)

Paradigma

s. m. [dal lat. tardo paradigma, gr. parádeigma, der. di paradéiknymi "mostrare, presentare, confrontare", comp. di para- "para-²" e déiknymi "mostrare"] (pl. -i). - 1. [ciò che costituisce un termine generale di riferimento, che ha valore esemplare:...

Nel linguaggio filos., termine usato da Platone(Atene, 428/427 BC. – Atene, 348/347 BC. per designare le realtà ideali concepite come eterni modelli delle transeunti realtà sensibili, e da Aristotele per indicare l'argomento, basato su un caso noto, a cui si ricorre per illustrare uno meno noto o del tutto ignoto.

Con altro sign., il termine è stato recentemente introdotto nella sociologia e filosofia della scienza per indicare quel complesso di regole metodologiche, modelli esplicativi, criterî di soluzione di problemi che caratterizza una comunità di scienziati in una fase determinata dell'evoluzione storica della loro disciplina: a mutamenti di paradigma sarebbero in tal senso riconducibili le cosiddette «rivoluzioni scientifiche».

Convenzione: BC= Before Christ

Una breve introduzione di storia della fisica & epistemologia

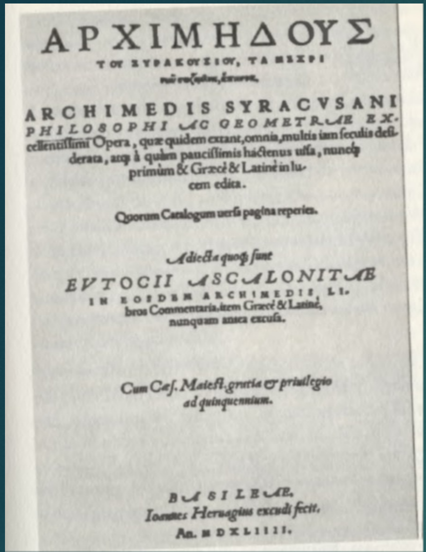
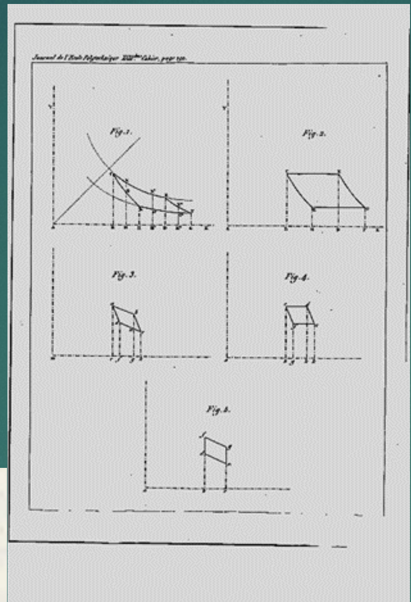
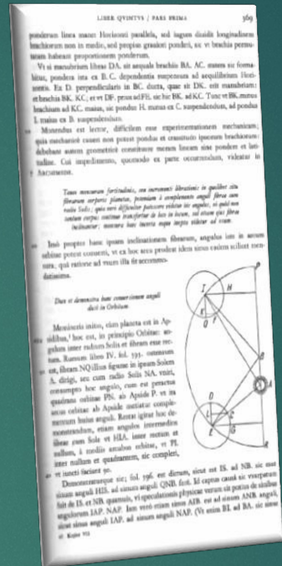


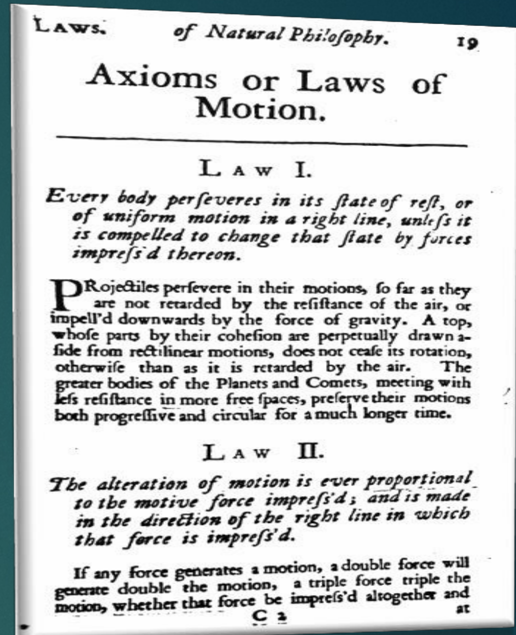
Fig. 18 Frontespizio della prima edizione moderna di Archimede, pubblicata a Basilea nel 1544. Essa conteneva tutte le sue opere note fino a quel momento in greco con il commento tardo-antico di Eutocio e una traduzione completa in latino. Da quel momento i lettori di Archimede in tutta Europa poterono moltiplicarsi e formarono in pochi anni una comunità scientifica fortemente innovativa.



Clapeyron (1834): *Mémoire sur la puissance motrice de la chaleur*. Journal de l'École royale polytechnique Vol. XIV: 153–190 (and 191)



(KGW ([1618-1621]1937–2009) *Epitome Astronomiae Copernicanae*, VII, Book V, p. 369)

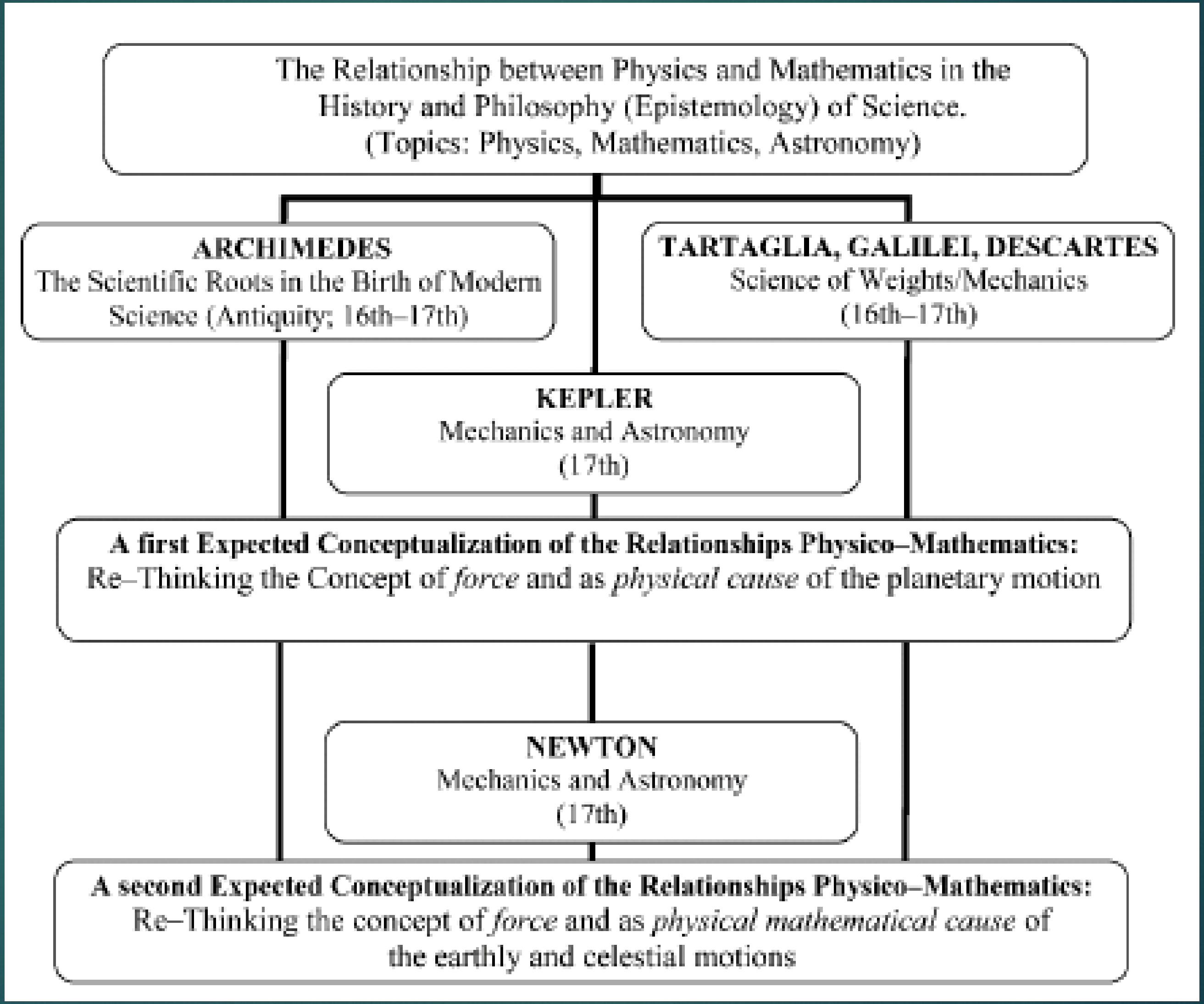


Newton ([1687]1803) *Principia*, I, p. 19

Per la redazione di questo PT ho attinto liberamente da un seminario di storia della fisica esposto dal

Prof. Raffaele Pisano, Lille University, France |

The Relationship between Physics and Mathematics

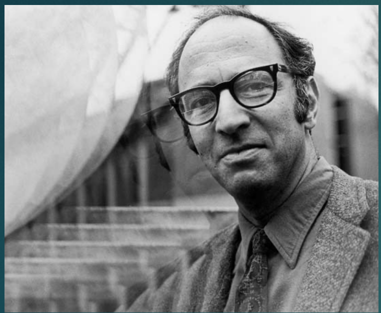


Why History and Philosophy of science (physics)????

Ernst Mach (1838 – 1916)

Eì stato un fisico e filosofo austriaco, nonché un neuro-scienziato ante litteram.
Mach fu positivista. Assertore della pura sperimentazione.

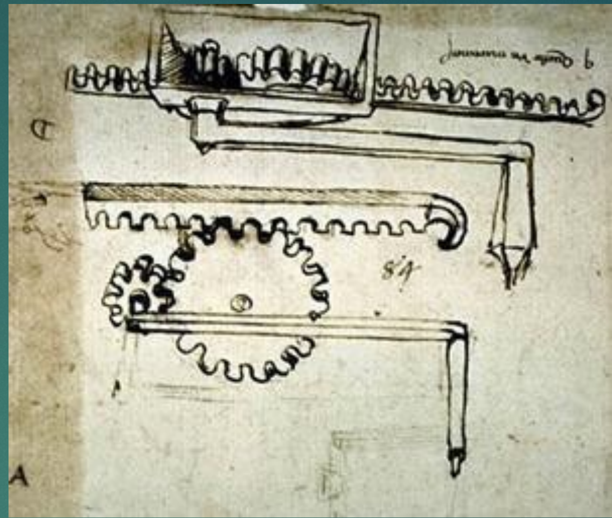
Thomas Samuel Kuhn (1922-1996)



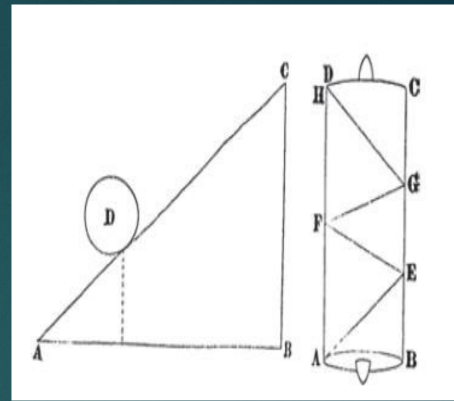
E' stato un fisico, storico e filosofo statunitense. Epistemologo, scrisse diversi saggi di storia della scienza, sviluppando alcune fondamentali nozioni di filosofia della scienza.
Formulò un'epistemologia alternativa a quella del falsificazionismo di Karl Popper,

Aleksandr V. Kojre(Koyré) (1892-1964)
Russo Naturalizzato FR
Koyré divenne uno dei protagonisti dell'epistemologia storica francese.

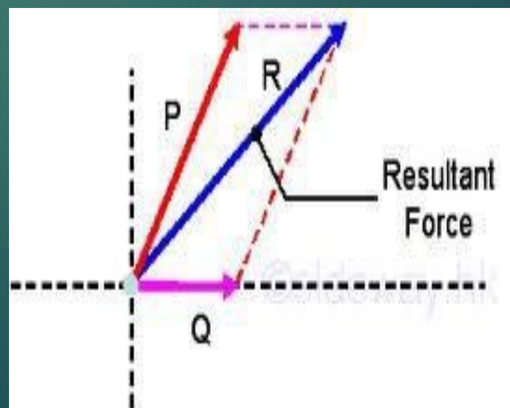
Negli anni Trenta Koyré iniziò la ricerca. Divenne uno dei più eminenti storici del pensiero scientifico del ventesimo secolo. Pubblicaz tre volumi degli Studi galileiani. Notevole la sua interpretazione della matematica galileiana non come mero strumento per descrivere la realtà, bensì come matematicismo ontologico. Postumi furono pubblicati gli Studi newtoniani.

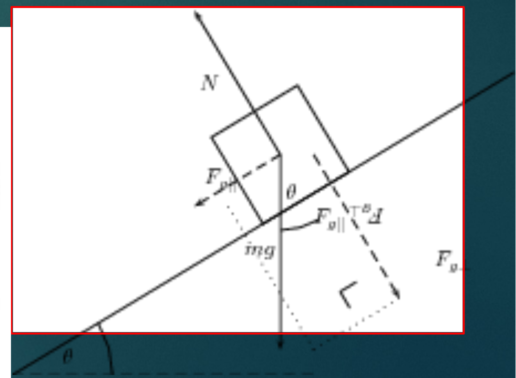


The mechanism for the transformation and rotation movement by Leonardo da Vinci .



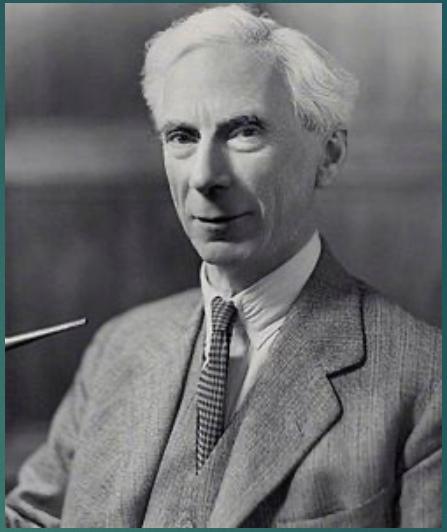
Geometric representation of the inclined plane as abstract object, and the geometric model by the Galileo screws, Le mechaniche, Opere II, p.184





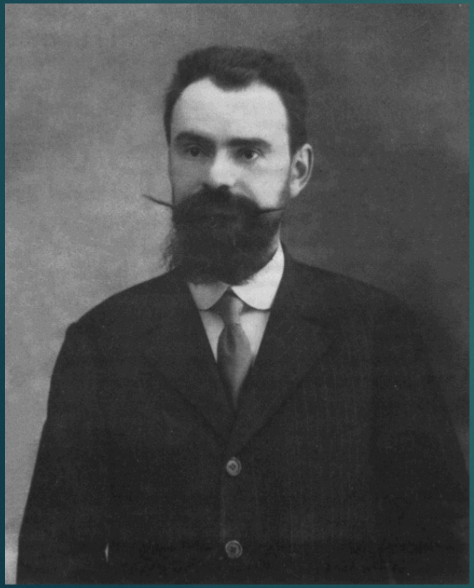
Eduard Jan Dijksterhuis (1892 – 1965)
He was a Dutch historian of science.

Alcune opere:
1929 - The Elements of Euclid
1924 - Free Fall and Projectile Motion
1938 - Archimedes
1943 – Simon Stevin (II 1960)
1952 - Blaise Pascal
1953 – "Christiaan Huygens",
1961 - The Mechanization of the World Picture
1963 - (with R. J. Forbes) History of Science and Technology



Bertrand A. W. Russell (1872-1970) è stato un filosofo, logico, matematico, attivista e saggista britannico.

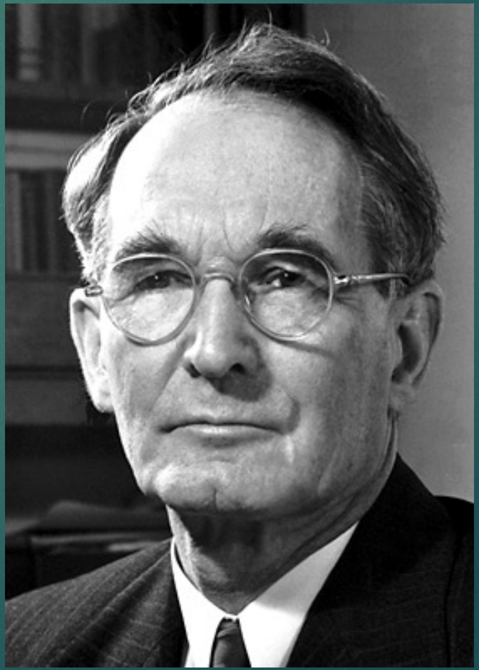
Fu anche un autorevole esponente del movimento pacifista e un divulgatore della filosofia. In molti hanno guardato a Russell come a una sorta di profeta della vita creativa e razionale; al tempo stesso la sua posizione su molte questioni fu controversa. Russell è stato avvicinato alle correnti filosofiche del razionalismo, dell' antiteismo e del neopositivismo.[1]



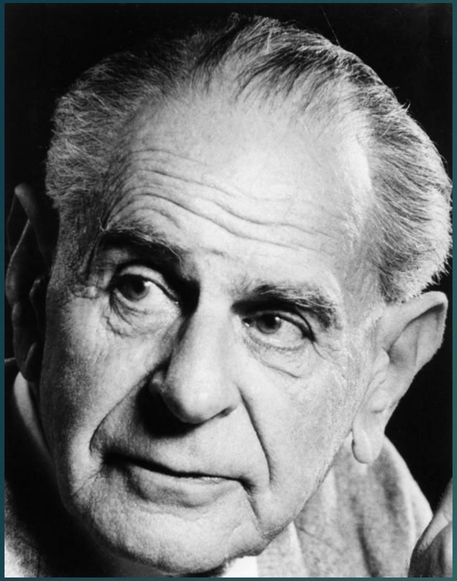
Federigo Enriques (1871-1946)

Nelle sue opere sviluppò una corrente di pensiero vicina al razionalismo. Assieme a Giuseppe Peano si può considerare uno dei principali scienziati italiani che si sono dedicati allo studio della logica e della filosofia della scienza nella prima metà del Novecento.

Fondamentale: Problemi della scienza, Zanichelli, Bologna 1906.



Percy W. Bridgman (1882 –1961) è stato un fisico e filosofo della scienza statunitense. Vinse il Premio Nobel per la fisica nel 1946 «per l'invenzione di un apparecchio per la produzione di pressioni estremamente alte e per le scoperte fatte nel campo della fisica ad alta pressione.» Fu inoltre un pioniere dell'analisi dimensionale.



Karl R. Popper (1902 – 1994) è stato un filosofo e epistemologo austriaco naturalizzato britannico. E' anche considerato un filosofo politico di statura considerevole, liberale, difensore della democrazia e dell'ideale di libertà e avversario di ogni forma di totalitarismo. Egli è noto per la proposta della falsificabilità come criterio di demarcazione tra scienza e non scienza e la difesa della "società aperta".

«Ogni qualvolta una teoria ti sembra essere l'unica possibile, prendilo come un segno che non hai capito né la teoria né il problema che si intendeva risolvere.»

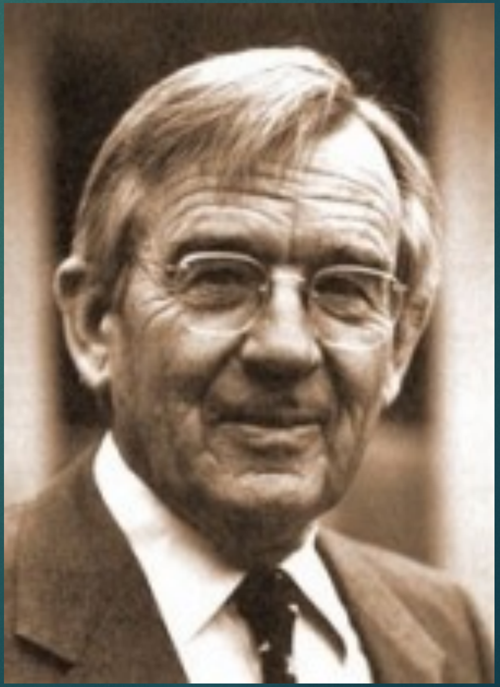
(Karl Popper, Conoscenza oggettiva: un punto di vista evoluzionistico.)

Ludovico Geymonat (1908 – 1991) è stato un filosofo, matematico, storico della filosofia, epistemologo e accademico italiano, uno tra più importanti del Novecento. Ebbe uno stile di pensiero razionalista ateo. La sua opera può essere inquadrata nel filone del neopositivismo da lui rielaborato nell'ottica della tradizione marxista. Interpretò la concezione della matematica di Galileo Galilei come strumento d'interpretazione della realtà. Rimarchevole pure il suo lavoro di alta divulgazione del pensiero scientifico.

Alistair C. Crombie (1915 – 1996) was an Australian historian of science who began his career as a zoologist. He was noted for his contributions to research on competition between species before turning to history.

During his career as a historian of science, Crombie identified thematic threads or "styles" in the development of European approaches to science. He published his ideas in 1994 in a definitive 3-volume work, entitled, Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation especially in the Mathematical and Biomedical Sciences and Arts.

The main argument about six distinct styles of scientific thinking in the history of Western science was also published in the brief 1995 article Commitments and styles of European scientific thinking.



How about Exact Sciences of the Past & and how <u>Write</u> its History ?

<u>History by *facts (vanno interpretati)*</u>

- Historical objective facts, experiments, dates of discoveries
- Primary sources and the early theories
- Birth of new experimental apparatus
- Academic context, societies, academies
- Etc.

<u>History built by *events (teorie)*</u>

- (Foundations of scientific theories)
- Biography and correspondence
- Concepts (e.g.: intuitive and surrogate concepts)
- Mathematical content of a theory
- Etc.

Differenze tra '' Fatto'' ed ''Evento''

A choice: Inquiring History of Science (Physics)

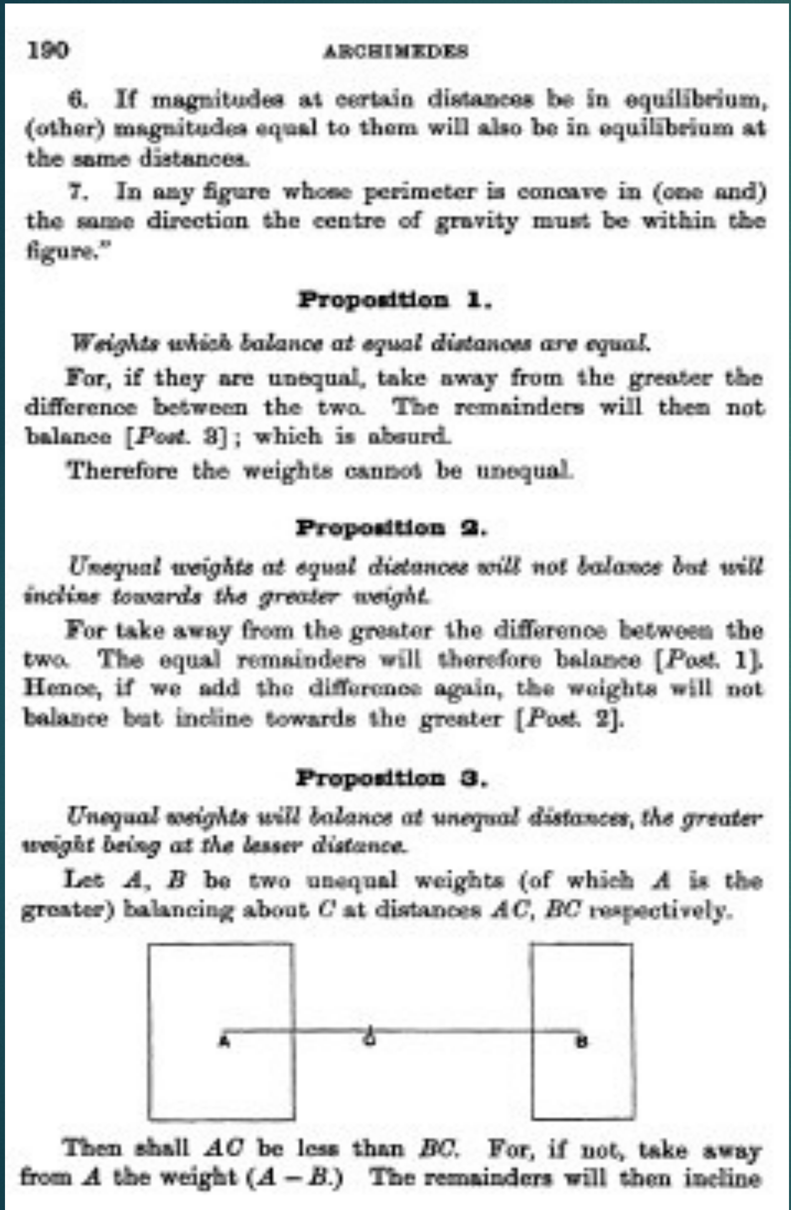
Needs

Historical and epistemological structures of a scientific theory

Inquiring

- By Logic (classical, non-classical),
- By Analogies
- By Mathematic (relationship physics-mathematics, theorems and results, etc.)
- By geometrical figures of speech/styles (figures and describing phenomena, rhetoric, etc.),
- By experimental/theoretical data,
- By impact (paradigms etc.)
- By Context
- By Foundations
- By diagrams

Archimedean Science: *On the Equilibrium of Planes.*


190 ARCHIMEDES

6. If magnitudes at certain distances be in equilibrium, (other) magnitudes equal to them will also be in equilibrium at the same distances.

7. In any figure whose perimeter is concave in (one and) the same direction the centre of gravity must be within the figure."

Proposition 1.

Weights which balance at equal distances are equal.

For, if they are unequal, take away from the greater the difference between the two. The remainders will then not balance [*Post.* 3]; which is absurd.

Therefore the weights cannot be unequal.

Proposition 2.

Unequal weights at equal distances will not balance but will incline towards the greater weight.

For take away from the greater the difference between the two. The equal remainders will therefore balance [*Post.* 1]. Hence, if we add the difference again, the weights will not balance but incline towards the greater [*Post.* 2].

Proposition 3.

Unequal weights will balance at unequal distances, the greater weight being at the lesser distance.

Let A, B be two unequal weights (of which A is the greater) balancing about C at distances AC, BC respectively.

Then shall AC be less than BC. For, if not, take away from A the weight $(A - B)$. The remainders will then incline

1st *Supposition* and 1st *Proposition*

- 1st Sup. Equal weights [suspended] at equal distances [from fulcrum] are in equilibrium; equal weights suspended at unequal distances [from fulcrum] are not in equilibrium [state] but [they] incline towards the weight is [suspended] at the greater distance [from fulcrum].

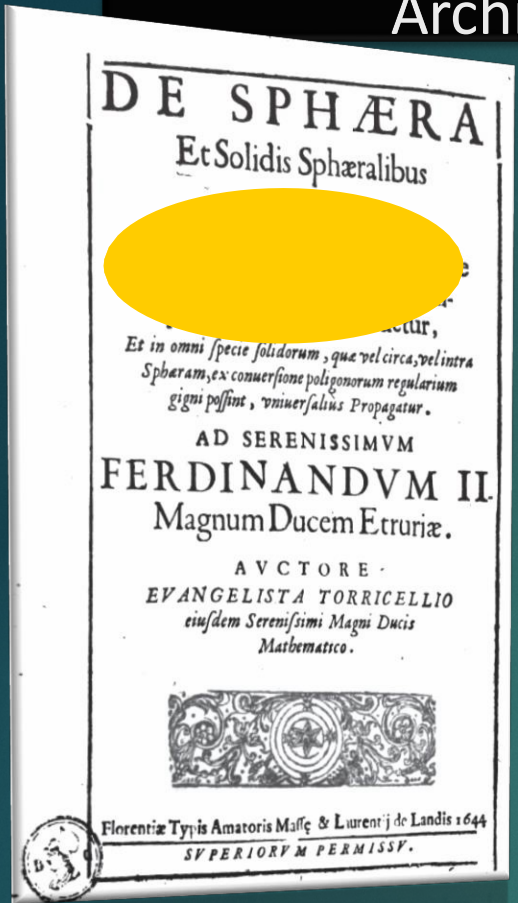
- 1st Prop. [If] Weights [suspended] at equal distance [from fulcrum are] in equilibrium, [then they are] are equal [between them]. [proved by *red. ad ab.* by Supp. 3].

Archimedes, *On the Equilibrium of Planes*, edited by T. L. Heath. book I, pp. 189-190.

"Il grande Archimede", Mario Geymonat, III ed. F.M. Alfani, 2008-)

E.J.Dijsksterhuis, Archimedes, Copenhagen, 1956 (classic Work)

Archimedean Approach in Torricelli's Reasoning


DE SPHÆRA
Et Solidis Sphæralibus
...tur,
Et in omni specie solidorum, quæ vel circa, vel intra Sphæram, ex conuersione poligonorum regularium gigni possint, vniuersalius Propagatur.
AD SERENISSIMVM
FERDINANDVM II.
Magnum Ducem Etruriæ.
AVCTORE
EVANGELISTA TORRICELLIO
eiusdem Serenissimi Magni Ducis Mathematico.
Florentiæ Typis Amatoris Massę & Laurentij de Landis 1644
SVPERIORVM PERMISSV.

Archimedes
On equilibrium of planes

Torricelli
Opera Goemetrica

(Early)
Torricelli Principle of Virtual Work

***Praemittimus*. Duo gravia simul coniuncta ex se moveri non posse, nisi centrum commune gravitatis ipsorum discenda.**

***Premise*. Two heavy bodies linked together cannot move by themselves unless their common centre of gravity does not descend.**

Torricelli 1644, Liber primus De motu gravium naturaliter descendentium, p. 99, line 4

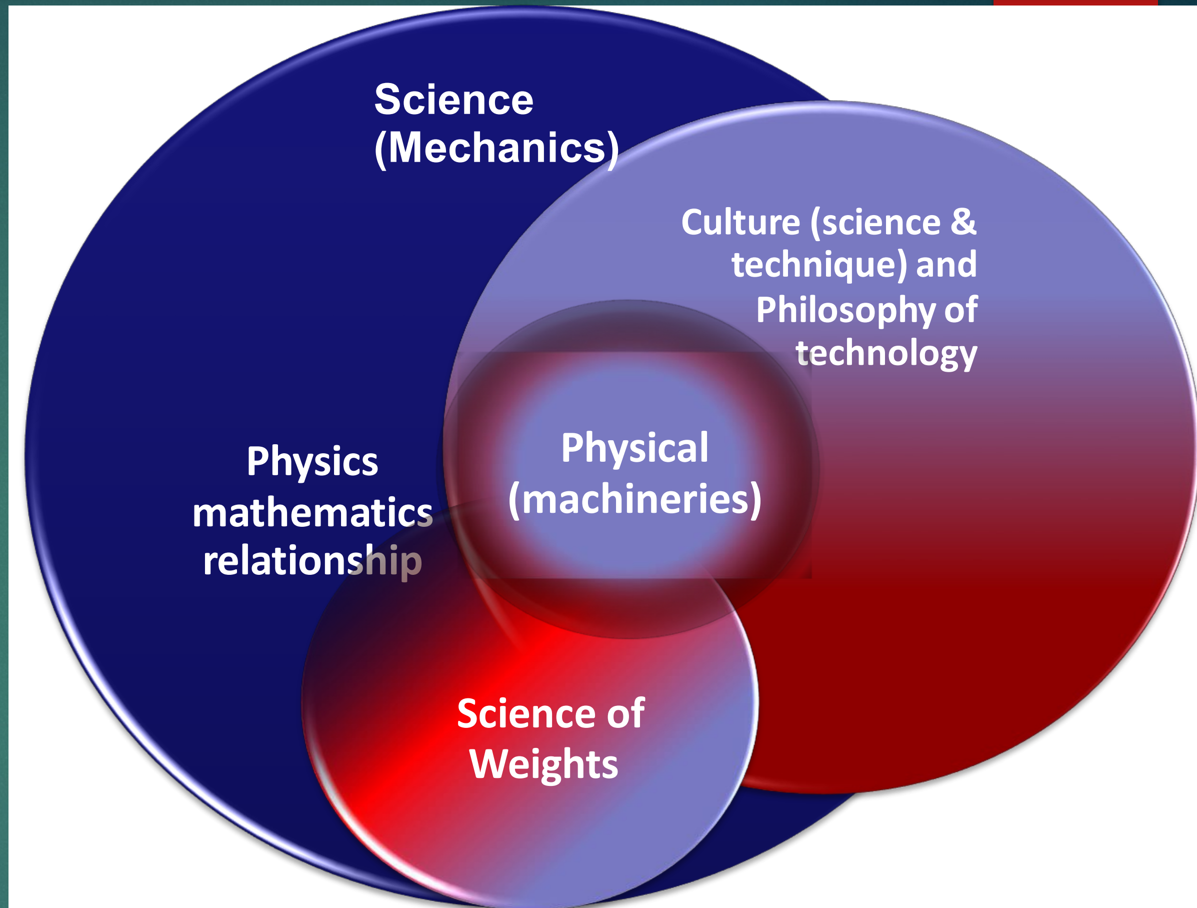
(Modern) Principle of Virtual Work

The necessary and sufficient condition for equilibrium of a mechanical system without friction is that the virtual work done by the externally applied forces *f* is zero.

Heath T.L. 2002. "On the Spiral - Proposition 10", 162,.
Galileo G. 1954. *Dialogues Concerning Two New Sciences*, 1914, 146; Ed. 1890-1909, 286-294, op. cit. (Discorsi e dimostrazioni matematiche sopra due nuove scienze", Vol. VIII, II, 176-183; IV, 306 et sgg)
Cavalieri B. 1635. *Geometria Indivisibilius continuo rum nuova quadam ratione promota*, Theorema I- Proposizione I, Libro IV, Ferrone, Bologna, 285
Valerio L. 1606. *Quadratura parabolae per simplex falsum et altera quam secunda Archimedia expeditur*,

Lo sviluppo delle macchine

1662. The Frontispieces from Georg Andreas Böckler's *Theatrum Machinarum Novum*

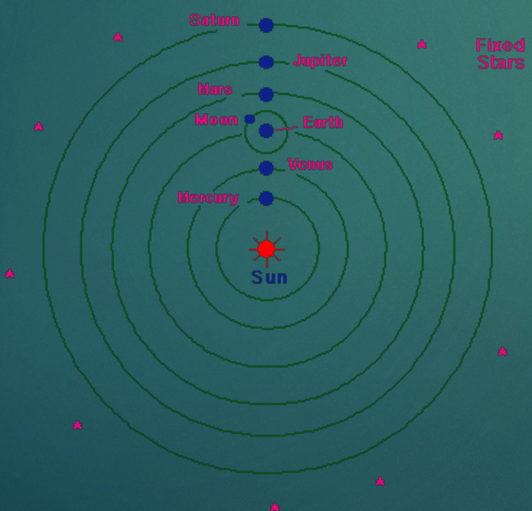


pubblicato nel 1662 a colonia da henrici schmitz, composto da 154 tavole illustrative a piena pagina con la completa descrizione in lingua latina, completato dal testo della legge tedesca sui molini in vigore a quel tempo. le tavole illustrano tutti i possibili sistemi di mulini per i cereali, delle ruote idrauliche per la lavorazione della carta e dei minerali, per le segherie ed altri usi.

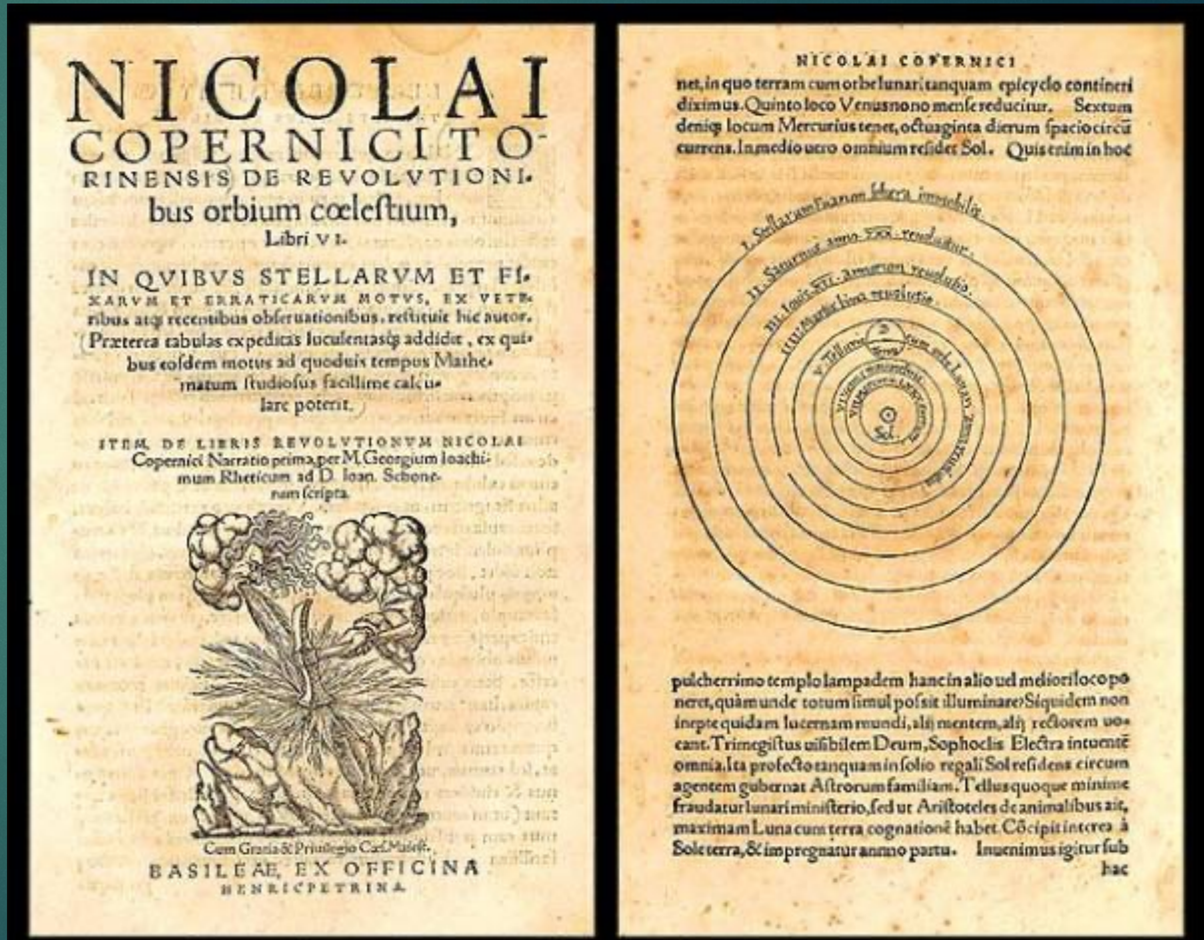
Si veda : Pisano R, Bussotti P (2014) Historical and Philosophical Reflections on the Culture of Machines around the Renaissance. How Science and Technique Work? *Acta Baltica Historiae et Philosophiae Scientiarum* 2/2 [see also 2015 3/1]

Int. Symposium on History of Machines and Mechanisms Proceedings HMM2004
Edited by Marco Ceccarelli

Nascita della meccanica celeste : NON SOLO CINEMATICA



Stesura: tra il 1507 e il 1512,



NICOLAI COPERNICI TORINENSIS DE REVOLVTIONIbus orbium cœlestium, Libri VI.

IN QVIBVS STELLARVM ET FIXARVM ET ERRATICARVM MOTVS, EX VETERibus atq; recentibus obseruationibus, restituit hic autor. Præterea tabulas expeditas luculentasq; addidit, ex quibus eosdem motus ad quoduis tempus Mathematum studiosus facillime calculare poterit.

ITEM, DE LIBRIS REVOLVTIONVM NICOLAI Copernici Narratio prima, per M. Georgium Ioachimum Rheticum ad D. Ioan. Schonerum scripta.

Cum Gratia & Priuilegio Cæs. Maiest.

BASILEAE, EX OFFICINA HENRICPETRINA.

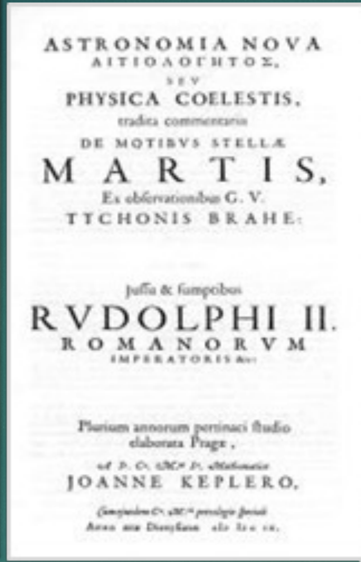
NICOLAI COPERNICI

net, in quo terram cum orbe lunari tanquam epicyclo contineri diximus. Quinto loco Venus nono mense reducitur. Sextum deniq; locum Mercurius tenet, octuaginta dierum spacio circu currens. In medio uero omnium residet Sol. Quis enim in hoc pulcherrimo templo lampadem hanc in alio uel meliori loco poneret, quàm unde totum simul possit illuminare? Siquidem non inepte quidam lucernam mundi, alij mentem, alij rectorem uocant. Trimegistus uisibilem Deum, Sophoclis Electra intuentē omnia. Ita profecto tanquam in solio regali Sol residens circum agentem gubernat Astrorum familiam. Tellus quoque minime fraudatur lunari ministerio, sed ut Aristoteles de animalibus ait, maximam Luna cum terra cognationē habet. Cōcipit interea à Sole terra, & impregnatur annuo partu. Inuenimus igitur sub hac

De Revolutionibus Orbium Coelestium. l'oeuvre majeure de Copernic ...

Kepler (1571-1630) Force Conceptualization: an Interplay between Physics, Mathematics and Metaphysics

1596; 1621



1609

1618; 1621

1619

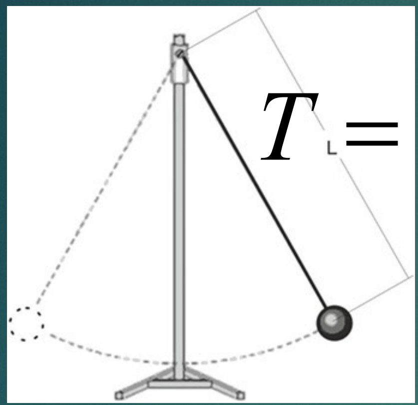
The main geometrical-mathematical problem to solve and move versus a (sort of) physical astronomy was: <u>What kind of force make the paths elliptical geometrically? (Tycho Brahe 1546-1601)</u>

<u>Keplero cercò di fondare le tre leggi su una spiegazione di natura fisica, ipotizzando che il Sole fosse un magnete capace di esercitare sui pianeti una forza motrice di intensità variabile con la distanza. Anche i pianeti venivano concepiti come magneti orientati sempre verso la stessa direzione:</u>

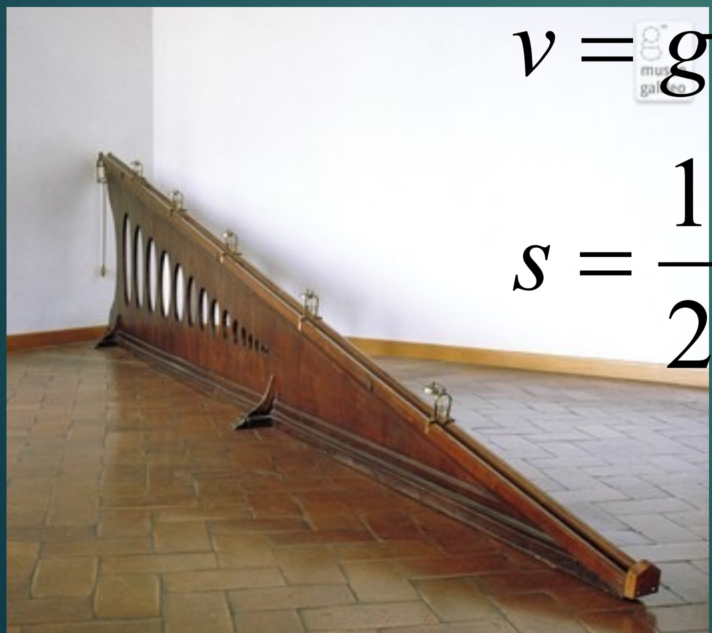
I had then reached the point of ascribing to the same Earth the motion of the Sun, but where Copernicus did so through mathematical arguments, mine were physical, or rather Metaphysical.

(Mysterium, 1596, KGW, I, p. 9, lines 17-19).

GALILEO: Il moto del pendolo: un fenomeno mai risolto nella fisica aristotelica: UN ENIGMA

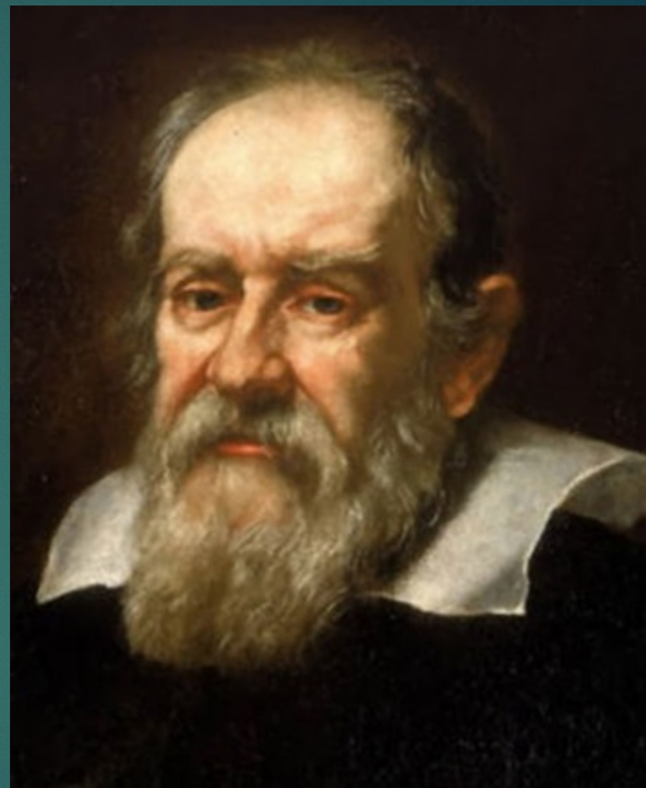


$$T = 2\pi\sqrt{\frac{l}{g}}$$

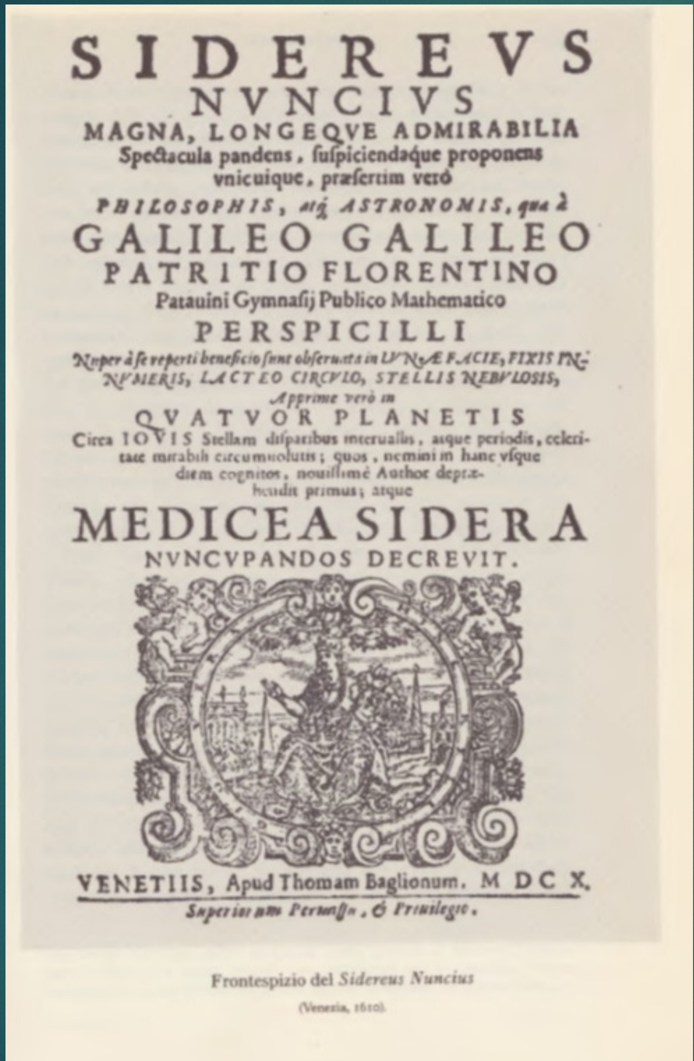


$$v = gt$$

$$s = \frac{1}{2}gt^2$$



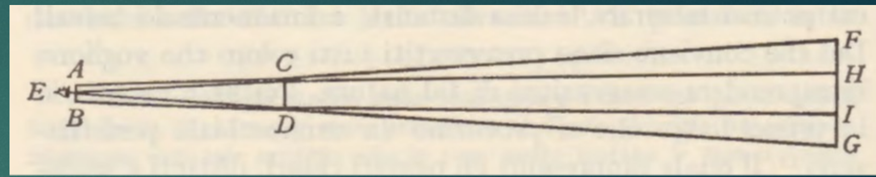
-Approfondisce l'osservazione astronomica e costruisce il Cannocchiale (1609)



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 LVNÆ FACIE, FIXIS IN-
NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeri-
tate mirabili circumuolutis; quos, nemini in hanc vsque
diem cognitos, nouissimè Author depræ-
hendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.

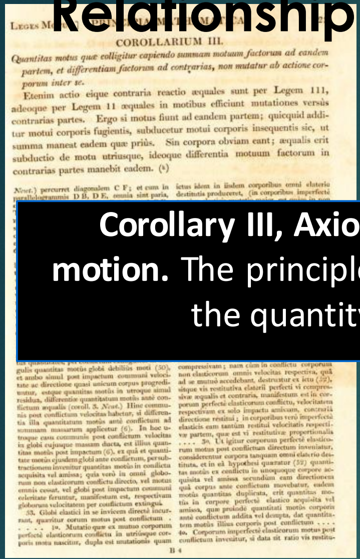
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

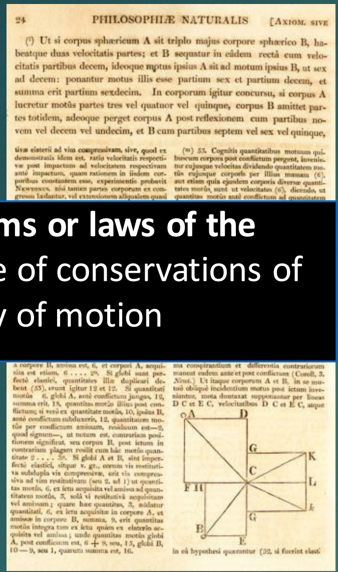
Frontespizio del *Sidereus Nuncius*
(Venezia, 1610).



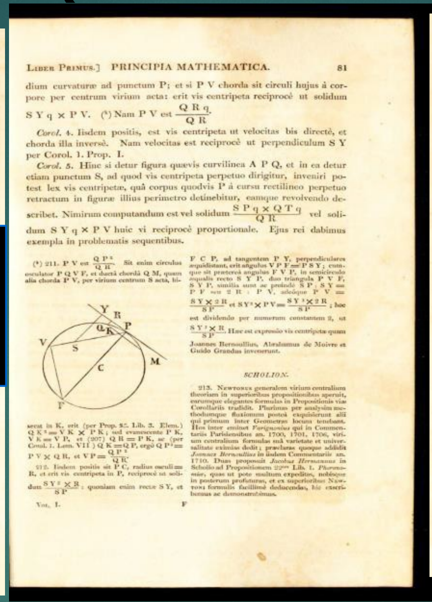
Sidereus Nuncius(immagini adattate da
Galilei-classici-UTET(ed.1996)

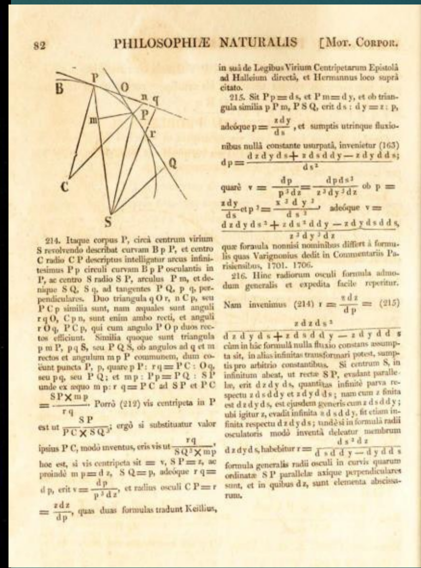
Newtonian Geneva edition (1739-1742 -1822) & Physics Mathematics Relationship





Corollary III, Axioms or laws of the motion. The principle of conservations of the quantity of motion



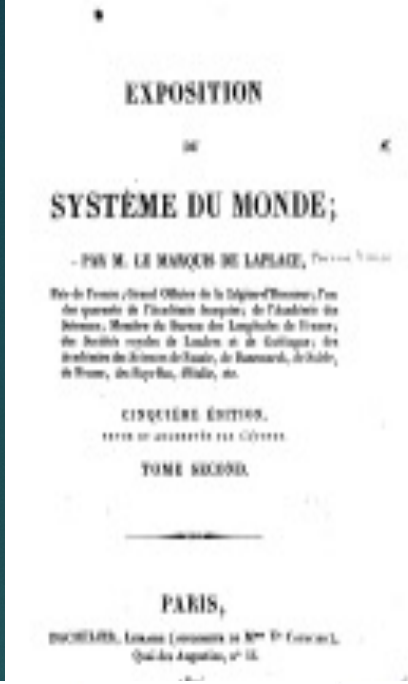


After the initial six propositions in which Newton supplied the foundations of central forces' theory, the commentators add a *Scholium* in which they refer the results by Keill, Hermann, Varignon, Johann Bernoulli, obtained between 1700 and 1714

Many are the cases in which rethinking by new notes is necessary to explain and clarify:

- **the concept and the mathematical procedures used by Newton;**
- **to provide physical and astronomical explanations of the phenomena dealt with by Newton**
- **understandingof Newton's methods and its transcription into more analytical terms.**

Bussotti P, Pisano R (2014) Newton's Philosophiae Naturalis Principia Mathematica "Jesuit" Edition: The Tenor of a Huge Work. History of Mathematics section. *Accademia Nazionale Lincei Rendiconti Lincei Matematica e Applicazioni* 25:413–444


EXPOSITION

SYSTÈME DU MONDE;

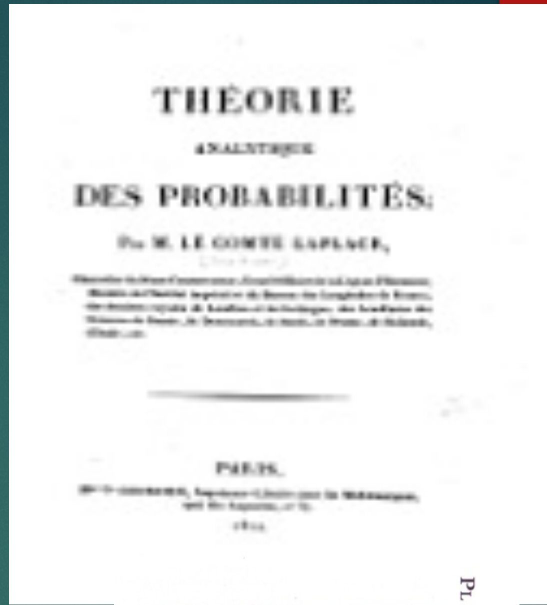
PAR M. LE MARQUIS DE LAPLACE,

CINQUIÈME ÉDITION,

TOME SECOND.

PARIS,

CERTEZZA


THÉORIE

ANALYTIQUE

DES PROBABILITÉS;

Par M. LE COMTE LAPLACE,

PARIS.

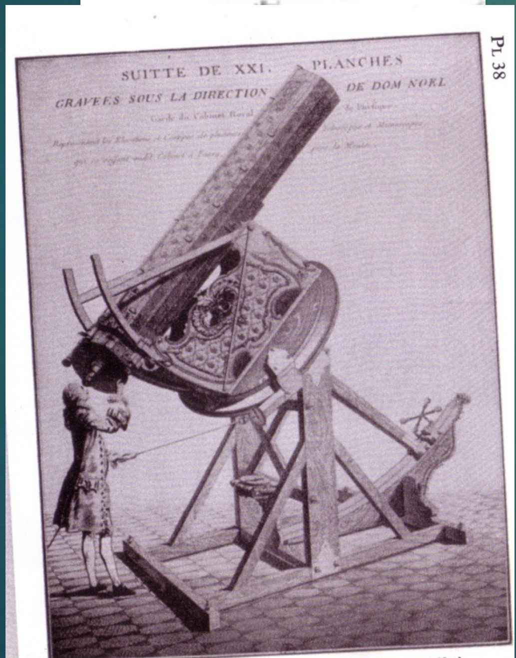
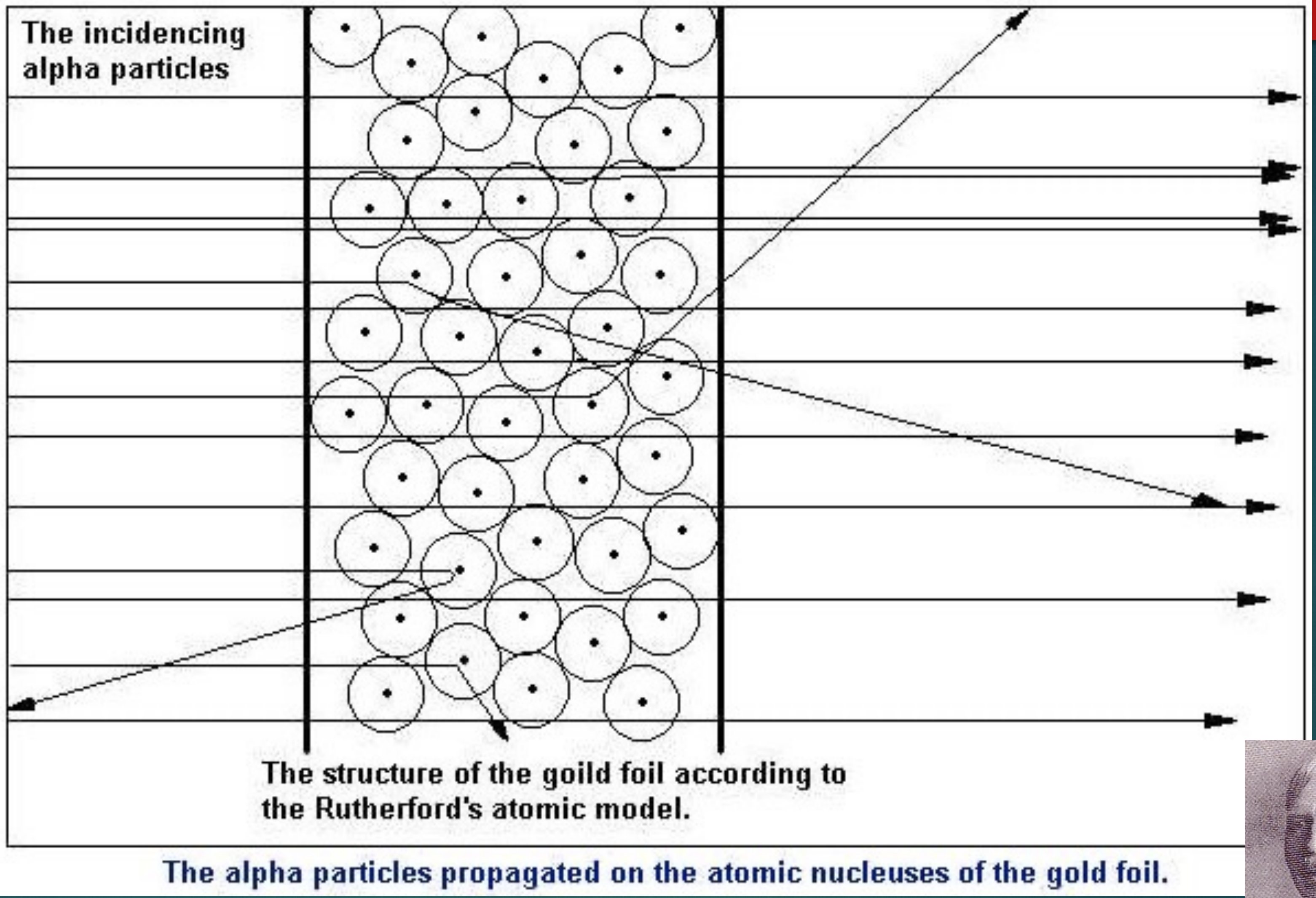


Fig. 90. — Télescope du type Cassegrain, construit par Dom Noel au cabinet d'optique de La Muette, vers 1772.

INCERTEZZA

Fig. 86. — Microscope de John Gilbert à pilier cylindrique, 1760 environ (Oxford)

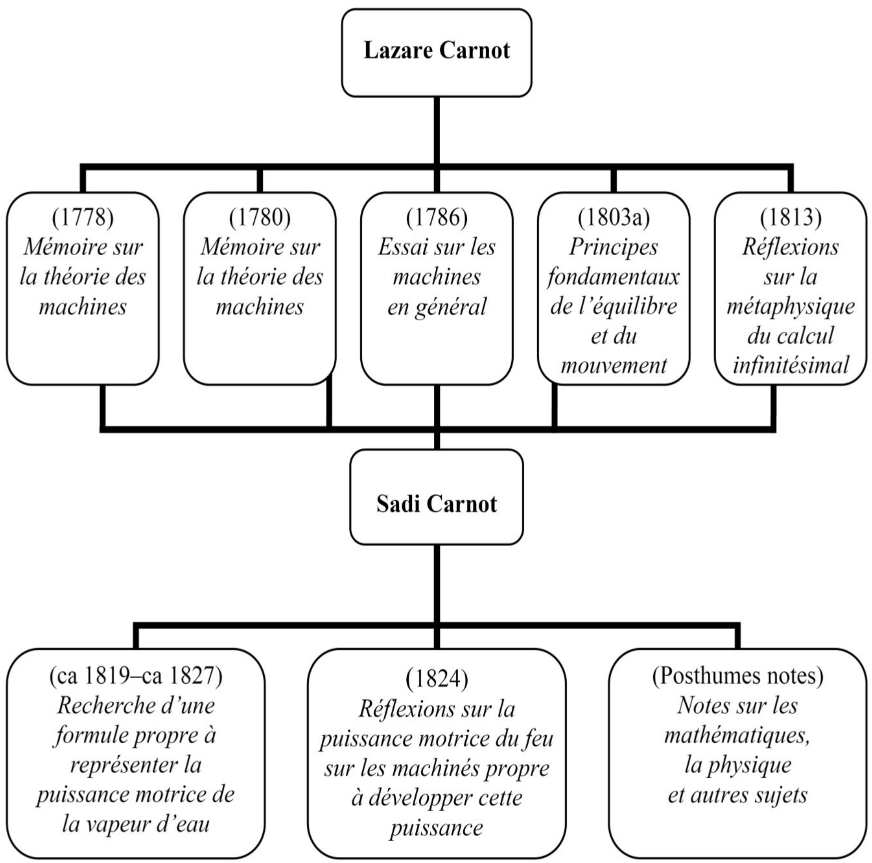
Con il novecento ha inizio la fisica atomica/nucleare



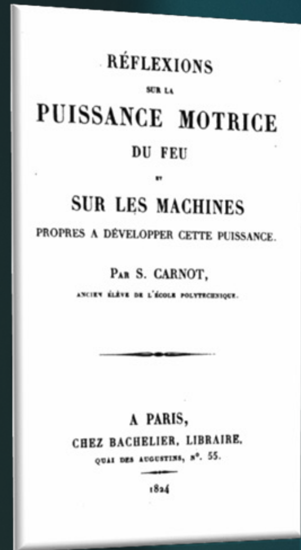
E.Rutherford, Phil. Mag.21,669 (1911)

Termodinamica

Lazare and Sadi Carnot. A Filial and Scientific Relationship



Lazare and Sadi Carnot's scientific filial



RÉFLEXIONS
SUR LA
PUISSANCE MOTRICE
DU FEU
ET
SUR LES MACHINES
PROPRES A DÉVELOPPER CETTE PUISSANCE.
PAR S. CARNOT,
ANCIEN ÉLÈVE DE L'ÉCOLE POLYTECHNIQUE.

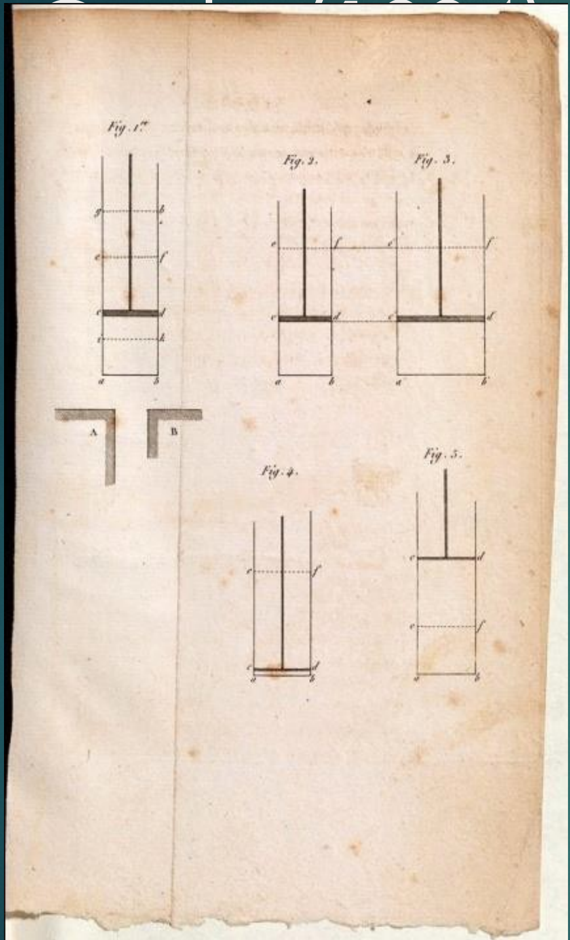
A PARIS,
CHEZ BACHELIER, LIBRAIRE,
QUAI DES AUGUSTINS, Nº. 55.
1824

Recherche d'une formule propre à représenter la puissance motrice de la Vapeur d'Eau, in Carnot, S. 1978, *op. cit*., pp. 223-225, op. cit.

Gabbey A. W., Herivel J. W. 1966. « Un manuscrit inédit de Sadi Carnot » In: *Revue d'histoire des sciences et de leurs applications*, Tome 19 n°2. pp. 151-166.

[redacted]

S. Carnot's Theorem (1824) and the

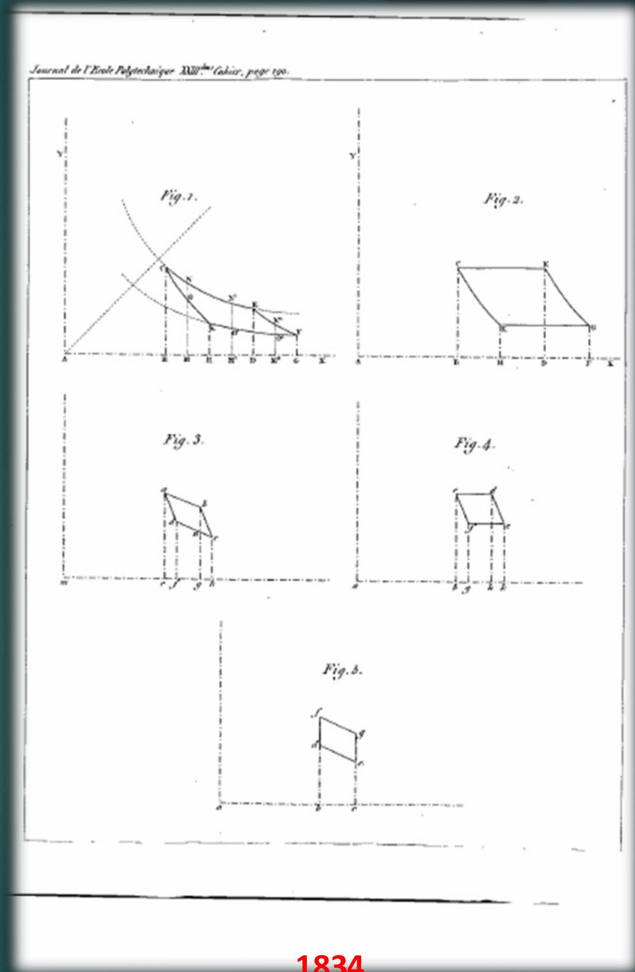


[Carnot S., 1824, folio 118] Numéro de BL : LIV-1006-006278
Date : 23/06/2010 - Devis n° : DEV-1005-00835
Client : R. Pisano CLI-048007,

The *tentative* calculus for $d\eta$ in a footnote (*Ivi*, pp. 73-79)

- The cycle is composed by two isotherm (as in all of his cycles) and two isochors by W=0. (Carnot S. 1978. *Réflexions sur la puissance motrice du feu*, pp.39-40)
- The cycle is composed by two isotherm and two adiabatics by *Q=0*. (*Ivi*, pp. 29-38)

$$\eta = \frac{W_{\max}}{Q} = f(\Delta t)$$



1834

Clapeyron: Mémoire sur la puissance motrice de la chaleur, «*Journal de l'Ecole royale polytechnique*» *Vol. XIV*, 1834, pp. 153–190(-191).

Teoria cinetica dei gas e termodinamica

Boltzmann's Legacy

At the center of Boltzmann's lifelong struggles in physics and philosophy was the question of the reality of atoms. In the 1870s, when Boltzmann was at the zenith of his intellectual powers, there was no conclusive experimental evidence for the existence of atoms. He had to fight his lonely battle on two fronts: for his belief in the reality of atoms against Mach and the empiricists, and for his statistical interpretation of the second law of thermodynamics, his most revolutionary and lasting contribution to physics, against Loschmidt and others. Boltzmann's struggle on these two fronts was ironic in retrospect, as pointed out by the American theoretical physicist Leo Kadanoff:

> Mach was wrong about atoms and wrong in demanding that science only include the immediately visible, but right in demanding a different philosophic outlook for kinetic theory. Boltzmann was right about atoms but utterly wrong in believing that atoms provided a necessary basis for thermodynamics. The second law does not require atoms.[37]

Thermodynamics, in other words, is neutral with respect to models of the microphysical world.

Boltzmann's goal of translating the behavior of the physical world into rigorously defined mathematical entities that obey well-defined rules remains an open game today, one that is still centered upon the second law of thermodynamics, a law that Albert Einstein regarded as an unshakeable and fundamental pillar of the physical world. As he wrote:

> A theory is the more impressive the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore the deep impression which classical thermodynamic made upon me. It is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown (for the special attention of those who are skeptics on principle).[38]

As Elliott H. Lieb and and Jakob Yngvason have remarked, to derive the second law from statistical mechanics is "a goal that has so far eluded the deepest thinkers."[39]

Fig. 1. Ludwig Boltzmann (1844–1906) as Professor of Mathematics at the University of Vienna in 1875. *Credit:* Courtesy of the Österreichische Zentralbibliothek für Physik.

[10] 1873. *A Treatise on Electricity and Magnetism* (Vol. II)

When the values of all the variables (q) are given, the position of each of the moveable pieces is known, and, in virtue of the imaginary mechanism, the configuration of the entire system is determined.

The Velocities.

556.] During the motion of the system the configuration changes in some definite manner, and since the configuration at each instant is fully defined by the values of the variables (q), the velocity of every part of the system, as well as its configuration, will be completely defined if we know the values of the variables (q), together with their velocities $\left(\frac{dq}{dt}\right.$, or, according to Newton's notation, $\left.\dot q\right)$.

The Forces.

557.] By a proper regulation of the motion of the variables, any motion of the system, consistent with the nature of the connexions, may be produced. In order to produce this motion by moving the variable pieces, forces must be applied to these pieces.

We shall denote the force which must be applied to any variable q_r by F_r. The system of forces (F) is mechanically equivalent (in virtue of the connexions of the system) to the system of forces, whatever it may be, which really produces the motion.

The Momenta.

558.] When a body moves in such a way that its configuration, with respect to the force which acts on it, remains always the same, (as, for instance, in the case of a force acting on a single particle in the line of its motion,) the moving force is measured by the rate of increase of the momentum. If F is the moving force, and p the momentum,

$$F = \frac{dp}{dt},$$

whence

$$p = \int F\,dt.$$

The time-integral of a force is called the Impulse of the force; so that we may assert that the momentum is the impulse of the force which would bring the body from a state of rest into the given state of motion.

In the case of a connected system in motion, the configuration is continually changing at a rate depending on the velocities ($\dot q$), so

and the work spent in producing the motion is equivalent to the kinetic energy. Hence

$$T_{p\dot q} = \tfrac{1}{2}(p_1\dot q_1 + p_2\dot q_2 + \&c.), \quad (13)$$

where $T_{p\dot q}$ denotes the kinetic energy expressed in terms of the momenta and velocities. The variables q_1, q_2, &c. do not enter into this expression.

The kinetic energy is therefore half the sum of the products of the momenta into their corresponding velocities.

When the kinetic energy is expressed in this way we shall denote it by the symbol $T_{p\dot q}$. It is a function of the momenta and velocities only, and does not involve the variables themselves.

563.] There is a third method of expressing the kinetic energy, which is generally, indeed, regarded as the fundamental one. By solving the equations (3) we may express the momenta in terms of the velocities, and then, introducing these values in (13), we shall have an expression for T involving only the velocities and the variables. When T is expressed in this form we shall indicate it by the symbol $T_{\dot q}$. This is the form in which the kinetic energy is expressed in the equations of Lagrange.

564.] It is manifest that, since T_p, $T_{\dot q}$, and $T_{p\dot q}$ are three different expressions for the same thing,

$$T_p + T_{\dot q} - 2T_{p\dot q} = 0,$$

or

$$T_p + T_{\dot q} - p_1\dot q_1 - p_2\dot q_2 - \&c. = 0. \quad (14)$$

Hence, if all the quantities p, q, and $\dot q$ vary,

$$\left(\frac{dT_p}{dp_1} - \dot q_1\right)\delta p_1 + \left(\frac{dT_p}{dp_2} - \dot q_2\right)\delta p_2 + \&c.$$
$$+\left(\frac{dT_{\dot q}}{d\dot q} - p_1\right)\delta \dot q_1 + \left(\frac{dT_{\dot q}}{d\dot q_2} - p_2\right)\delta \dot q_2 + \&c.$$
$$+\left(\frac{dT_p}{dq_1} + \frac{dT_{\dot q}}{dq_1}\right)\delta q_1 + \left(\frac{dT_p}{dq_2} + \frac{dT_{\dot q}}{dq_2}\right)\delta q_2 + \&c. = 0. \quad (15)$$

The variations δp are not independent of the variations δq and $\delta \dot q$, so that we cannot at once assert that the coefficient of each variation in this equation is zero. But we know, from equations (3), that

$$\frac{dT_p}{dp_1} - \dot q_1 = 0, \ \&c., \quad (16)$$

so that the terms involving the variations δp vanish of themselves.

The remaining variations $\delta \dot q$ and δq are now all independent, so that we find, by equating to zero the coefficients of $\delta \dot q_1$, &c.,

$$p_1 = \frac{dT_{\dot q}}{d\dot q_1}, \quad p_2 = \frac{dT_{\dot q}}{d\dot q_2}, \ \&c.; \quad (17)$$

In the whole chapter V (Maxwell 1873, II, Pt IV, V, 184–194) - contrary to Newtonian mechanics - Maxwell expressed motion and energy relationships within the system as a whole, rather than in terms of laws of motion governing the actions of forces.

Thus, after several methods proposed, he announced **a *third method* related with Lagrange.**

Pisano R (2013) On Lagrangian in Maxwell's electromagnetic theory. Scientiatum VI. The Federate University of Rio de Janeiro Press, Rio de Janeiro, pp. 44–59

Maxwell 1873, II, Pt IV, V, pp. 184–186, p. 191; see Chap. VI for describing physical

MECCANICA
Galileo& Newton

RELATIVITA'
Einsten

ELETTROMAGNETISMO
J. C. Maxwell

(1916)

GENERALE

Teoria della gravitazione

(1905)

SPECIALE

ESPERIMENTI
(≈ 1920)

-Deflessione luce

-Correzioni planetarie

-Cosmologia

-Buchi neri(quantistica)

-Onde gravitazionali

OGGI

''GAP SPERIMENTALE ''
(1905-1930)

Michelson-Morley
(1888-1950)

Effetti Relativistici ≈ 1930

-Decadimenti-

-Reazioni nucleari-

-Acceleratori di particelle-

-scoperta di nuove particelle (p,e,γ,(ν))-

n (1932) -e^+(1933)-$\pi^\pm$, $\mu^\pm$, π^0 (1936-1951)…..

Gli sviluppi (impressionanti) del ‘900

A development

[...]

1900-1901. Planck: black body (Einstein ad hoc hypothesis)

1905-1917. Einstein: Relativity, etc.

1913. Bohr: atomic model, energy, etc.

1925-1927. Schroedringer: wave equation and wave develops the processing of quantum mechanics, electron wave.

1927. Heisenberg: *the uncertainty principle.*

1927. Bohr: *complementarity principle, Copenhagen interpretation*

[...]

Kuhn: relation quantitative relationship among electromagnetic fields and matter's properties (electrons and atoms). *What about the use of the Planck's constant in classical physic and in modern physics?*

2. The energy of (classical) harmonic oscillator is quantized (?)

3. Thus, if the energy of harmonic oscillator is quantized (?)...that is out from classical physics ... does it mean that we accept this result .... as an application of modern physics to classical physics ?

Left to right: Max Planck, Albert Einstein, Niels Bohr, Louis de Broglie, Max Born, Paul Dirac, Werner Heisenberg, Wolfgang Pauli, Erwin Schrödinger, Richard Feynman.

http://en.wikipedia.org/wiki/File:10_Quantum_Mechanics_Masters.jpg

Quantum Mechanics & Shared Cross-References Knowledge

1923. Louis de Broglie (1892-1987): On 10 Sept. (Ph.D. thesis on 25 Nov.) proposed his theory concerning wave-behavior of the matter.

1924. Satyendra Nath Bose (1894-1974): on 2 July proposed a new analyses statistical procedure

1924. Einstein: on 10 July extended Bose's procedure to a set of gas-particles material and mono-atomics. By reasoning associate energy to a and frequency d making stronger de Broglie's equations.

1924. Max Born (1882-1970) called the new theory: *quantum mechanics*.

1925. Wolfgang Pauli (1900-1958): on 16 January formulated his *principle of exclusion.*

1925. Werner Heisenberg (1901-1976): on 25 July his first article on matrix-interpretation of the mechanics (*Quantum-theoretical interpretation of kinetic and mechanical relations*).

1925. Born-Jordan (1902-1980): on 25 Sept. make stronger Heisenberg's theory.

Pisano R (2013) On the New Boson Higgs's Studies at the CERN–ATLAS Experiment. The Emergency of a Historical Discovery. AHS 2/1:3–5

Quantum Mechanics & Shared Cross-References Knowledge

1925. Paul A. M. Dirac (1902-1984): on 7 Nov. generalized and analyzed and make stronger the mathematical form of Heisenberg's theory (he introduced "commentator" [p; q]).

1925. Born, Heisenberg and Jordan: on 16 Nov. published the first complete treatise of the mechanics using matrix theory.

1926. Pauli: on 17 January utilized matrix mechanics to calculate discrete spectrum of the atom of hydrogen.

1926. Erwin Schrödinger (1887-1961): on 27 Jan. published-open *Quantisierung als Eigenwertproblem* (*Quantization as an Eigenvalue Problem*) road to wave-mechanical interpretation

1926. Enrico Fermi (1901-1954): on 7 Feb. published *Statistic by Fermi-Dirac*.

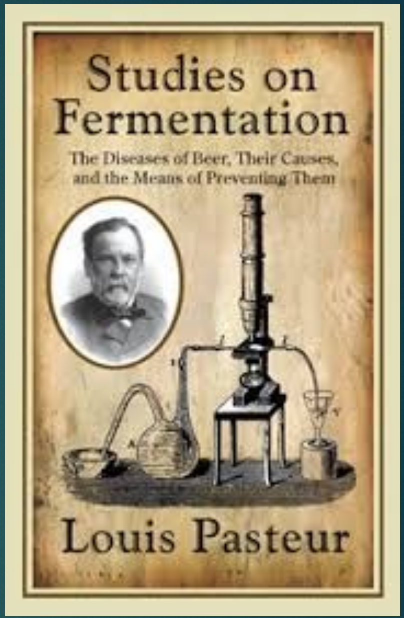
1926. Born: on 25 June published a job concerning the statistical interpretation of wave function.

1926. Dirac: on 26 August re-interpreted Planck's theory and still obtained by another road...*Statistic by Fermi-Dirac*.

1927. Heisenberg: on 23 March presented the relationship of indeterminations within the new mechanics.

Ma non solo Fisica

Il metodo Galileiano ha fortemente influenzato molte altre disciplina



<<…Queste poche linee che ho tracciato sul corso degli studi da me compiuti nel campo dell'economia politica vogliono solo dimostrare che le mie idee, in qualsiasi modo le si voglia giudicare e per quanto poco esse coincidano con gli interessi delle classi dominanti, sono il risultato di lunghi anni di coscienziose ricerche. Sulla porta della scienza, come sulla quella dell'inferno, deve essere posto questo Invito: Qui si conviene lasciare ogni sospetto
Ogni viltà convien che qui sia morta. >>1

Karl Marx, Londra, gennaio 1859 (prefazione a ''per la critica dell'economia politica'')

1 (Inferno, Canto III, vv.14-15)

-J. V. Neumann, Un modello di equilibrio economico generale, tradotto in italiano in '' L' Industria '', n. 1, 1952, pag. 1.

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